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# Examining preferences for prevention of Louisiana's wetland loss

Ross Gordon Moore

# EXAMINING PREFERENCES FOR PREVENTION

# OF LOUISIANA'S WETLAND LOSS

By

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This study analyzed preferences for wetland-loss prevention in coastal Louisiana. Data were obtained through a contingent-valuation mail survey of a random sample of Louisiana households. Results, based on 511 responses, indicate that respondents have a strong preference for a short-run program (72.41% chose this program over a long-run program or no action). Respondents that had higher incomes, were white, had prior knowledge of ongoing restoration efforts, and had confidence in government were more likely to support some program relative to no action, as were those citing hurricane, environmental, and/or climate-change protection as their primary concern. Older respondents and those with negative perceptions of climate change were more likely to prefer the short-run over the long-run program. Median net present value of willingness to pay (assuming 18.37% discount rate) was estimated at $17,491 per household for the multinomial logit model and $3,307 under the Turnbull lower-bound method.

DEDICATION

I would like to dedicate this research to my family.

## ACKNOWLEDGMENTS

I would like to express my gratitude to all those individuals without whose assistance this thesis would have been pressed to come to fruition. First, I would like to thank Dr. Daniel R. Petrolia, my committee chairman, for is time and effort to assist me throughout the master program and the thesis process, and his guidance over the past two years. Appreciation is also due to Dr. Ardian Harri and Dr. Keith H. Coble, the other members of my thesis committee, for the wealth of knowledge and direction that they provided me throughout the thesis process. Appreciation is also due to Dr. Tae-goun Kim for his assistance with our survey and clean-up of data. Finally, I would like to thank all the faculty, staff, and fellow students for making my master program a blessed experience.

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# CHAPTER I

# INTRODUCTION

In April of 2007 the Louisiana Governor signed *Louisiana's Comprehensive Master Plan for a Sustainable Coast*, which details the state's plan for restoring and sustaining the Louisiana coast. This document details the State of Louisiana's position on what steps must be taken to sustain its coast that has lost 1.2 million acres since the 1930s and is, at present, losing 15,300 acres annually (CPRA, 2007). A substantial portion of this land loss is in Louisiana's coastal wetlands. The benefits of preventing further loss of wetlands include storm damage mitigation, providing recreational opportunities, and protecting valuable ecosystems.

The Coastal Wetlands Planning, Protection and Restoration Act (CWPPRA) authorized federal funds for projects designed to restore, maintain, and prevent the future losses of Louisiana's coastal wetlands. Federal and State governments have already begun to prevent the future loss of wetlands, but a positive perception of these efforts by the public is important for the continued progress of these projects. The primary reason for the need of continued support by the public and policymakers is due to the scale of the projects that are being proposed and the cost associated with sustaining these ecosystems into the future. At present there is little to no evidence on whether public support exists.

Another issue that has arisen over recent years is what type of land loss prevention projects should be used to maintain coastal Louisiana's wetlands. Two prominent types of projects that are being compared are rapid land-building projects, which build wetlands rapidly through dredging and placement of sediment, and more natural methods such as river diversions, which take a longer time period to deliver the sediment needed to prevent losses of wetlands. Both approaches have positive benefits and drawbacks depending on the objectives of wetlands maintenance and restoration. Before hurricanes Katrina and Rita, the primary focus of building and preventing the loss of wetlands was the improvement of the coastal ecosystem, and the more natural processes such as river diversions were favored because they were perceived to provide better ecological benefits than does the rapid land-building approach. Due to the devastating effects of hurricanes Katrina and Rita on human life and infrastructure, focus has shifted from being solely concerned with ecological to encompassing human-benefits. Due to this shift more projects have been concerned with restoring and maintaining wetlands quickly so that the benefits of storm damage mitigation can be achieved in the near future rather than in the distant future. Hence, more projects are using the rapid land-building approach to restore and maintain the coastal wetlands of Louisiana. This is consistent with the findings of Aust (2006) in an analysis of the types of projects being selected to for the preservation and restoration of coastal wetlands in Louisiana.

The objective of this thesis is to provide estimates of the value that residents of Louisiana place upon the prevention of projected future wetland loss. In addition to providing estimates of the public's willingness to pay for these projects, this thesis identifies the motivating factors that contribute to public support of the prevention of projected future wetland loss. Possible motives for support include benefits to the environment, storm damage mitigation, recreational benefits, impacts on coastal industries, and combating sea level rise due to climate change.

The research is accomplished through analysis of public preference over three proposals. The first option, termed the "short run" proposal, is for the prevention of future wetland loss that will begin in 2015 and maintain current levels of wetlands through 2050. An alternative, termed the "long run" proposal, is for the prevention of future wetland loss that will begin in 2035 and maintain current levels of wetlands through 2185. These options are compared to no action being taken to prevent future wetland loss. This analysis shows which option between short run projects (where benefits are obtained sooner but do not last as long), long run projects (which take longer to implement and provide benefits farther into the future), and no action is preferred. Also, it shows the factors (and their magnitude) that affect one's decision between the three choices.

# CHAPTER II

# BACKGROUND

This chapter outlines how wetlands are defined, the benefits they provide, the trend of wetland loss in Louisiana, and actions taken to prevent future loss and restore wetlands that have been lost. Louisiana wetlands are some of the most important and largest wetlands in the United States. Louisiana's wetlands make up 25 percent of the nation's total coastal wetlands. Also, 40 percent of the nation's total salt marshes are located in Louisiana (CPRA, 2007).

## *Definition of Wetlands*

A wetland can be defined in many different ways. One of the most basic definitions would be that wetlands are areas where soil is saturated with water either seasonally or year round. This commonly occurs where terrestrial and aquatic ecosystems meet. The Corps of Engineers (COE) and the Environmental Protection Agency (EPA) define wetlands through the relationship of wildlife and water to a land area. "Those areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and do support, a prevalence of vegetation typically adapted for life in saturated soil conditions" (LAC pg. 5, 2004) is another way that wetlands are defined. There are varying types of wetlands that have different soil saturation levels, plant and animal life, and types of water: salt, brackish, and fresh. The coastal wetlands in Louisiana, the object of this thesis, are mostly marshlands. This type of wetland is submerged at least part of the year, supports water-tolerant grasses and aquatic plants, but not trees (LAC, 2004).

*Benefits of Wetlands*

More important than what makes up the wetlands are benefits that wetlands provide. Louisiana's wetlands provide many benefits environmentally, commercially, and socially.  Environmentally these wetlands provide habitat for mammals, amphibians, fishes, and migratory birds. They can also act as nurseries for shellfish and fish. Wetlands also provide valuable nutrients to surrounding habitats. Louisiana's wetlands also provide many functions that improve Louisiana's water availability and quality. A primary function is that they act as natural water collection areas. As water moves through wetlands many processes occur that benefit nature and society. These processes include cleaning pollution out of the water, absorption of excess nitrogen and phosphorous by wetland plants, denitrification, and destruction of intestinal bacteria in wastewater (LAC, 2004).

Wetlands also play a vital role in reducing damage from storms along Louisiana's Gulf Coast. The wetlands provide a natural barrier for the inland by reducing storm surge and decreasing wave energy. This can be seen through a comparison of the damage to Florida's Atlantic Coast and Louisiana's Gulf Coast from Hurricane Andrew in 1992. Florida's coast does not have the wetland barriers that Louisiana's coast has, and Florida received much more damage from the Hurricane Andrew than did Louisiana (LAC, 2004). After the devastation of Hurricanes Katrina and Rita, models were used to examine the role that wetlands play in reducing storm damage. One such model examined the hypothetical situation where the wetlands east of the Mississippi River Gulf Outlet, the Gulf Intracoastal Waterway, and Lake Borgne turned into open water eight feet deep. That model found the if this open water scenario had existed the storm surge from Hurricane Katrina would have been three to six feet higher in St. Bernard Parish and New Orleans East (WGPHPLC, 2006). Wetlands also capture storm water runoff that can cause flooding. Wetlands that make up 15 percent of the acreage in a watershed have the ability to reduce flood peaks up to 60 percent (LAC, 2004).

The wetlands of Louisiana also play a vital role for the state economy. The wetlands provide habitat for harvestable animals and timber. Twenty six percent (by weight) of commercial fish landings in the lower 48 states is provided by Louisiana's wetlands. Also, this area is the nation's largest shrimp, blue crab, and oyster producing areas (USDC, 2005). Almost 30,000 of Louisiana's citizens have a job that is provided through this commercial fishing industry (LDWF, 2005). The wetland timber industry contributes about $2 billion to the state, along with many jobs for the people of Louisiana (LAC, 2004).

Louisiana's wetlands also play an important role in protecting the state's and the nation's energy infrastructure from storm damage. Nearly 9,300 miles of oil and gas pipelines cross the wetlands of coastal Louisiana (USACE, Nov. 2004). Coastal Louisiana is also the home of the pricing point for natural gas throughout North America (Henry Hub), and Port Fourchon is a port and supply point for hundreds of offshore drilling operations in the Gulf of Mexico. A third of the nation's oil and gas supply and

50 percent of the nation's oil refining capacity is produced or transported in or near Louisiana's wetlands (LDNR, 2006).

International commerce infrastructure is also protected by the wetlands. There are ten major navigation routes that are located in southern Louisiana. The ports in this area are some of the largest ports in the United States. These ports handle approximately 469 million tons of cargo each year, which represents 19% of the annual waterborne commerce in the United States (USACE, 2003).

Louisiana's wetlands also provide enjoyment, employment, and revenue through many recreational opportunities. In 2001, hunters spent $446 million, anglers spent $670 million, and wildlife watchers spent $165 million in Louisiana. Much of this can be attributed to the state's coastal wetlands (LAC, 2004).

Though wetlands are extremely valuable, their value has not always been fully appreciated. Governments, business entities, and individuals have undertaken practices that have harmed and decreased the quantity and quality of wetlands. Such practices include the construction of canals and levees; oil and natural gas exploration, production, and pipelines; and agricultural practices. Yet, the responsibility does not fall solely upon humans for damages to wetlands. Natural processes such as subsidence (the sinking of land below sea-level), saltwater intrusion, wave erosion, tropical storms and hurricanes, and sea level rise have also played a role in the decrease in wetlands. The combination of these natural and human activities has been the cause of the wetland loss in Louisiana.

*Historic Wetland Losses*

Louisiana has been the one of the states most affected by wetland loss in the United States. In the colonial days of our country it is estimated that the lower 48 states had 221 million acres of wetlands. Recent estimates are that only about 100 million acres remain. The rate of loss since the 1930 has been about 1500 acres per year (LAC, 2004). Louisiana's total land loss since 1932 has been about 1,216,000 acres, which is about the size of the state of Delaware. In the last 50 years, though, the land loss rates in Louisiana have exceeded 25,600 acres per year, and during the 1990's the rate has been between 16,000 to 22,400 acres per year. This coastal wetland loss in Louisiana accounts for 80 percent of the total wetland loss in the lower 48 states (LCWCRTFWRCA, 1998). Hurricanes Katrina and Rita destroyed approximately 128,000 acres of marshlands in a single hurricane season (CPRA, 2007). If no action is taken to curb this trend, 448,000 acres of wetlands could be lost in Louisiana by the year 2050 (USACE, Apr. 2004). The dollar value of this loss is estimated at $37 billion by 2050 (LCWCRTFWRCA, 1998). Yet, this dollar amount does not encompass the environmental, social, and cultural losses that would be incurred.

*Restoration Efforts*

Actions have been taken by the state and federal government to prevent wetland loss and attempt to restore the wetlands of Louisiana. Some of the key initiatives that have been undertaken are: the Federal Coastal Zone Management Act (1972), Louisiana Coastal Wetlands Conservation Restoration and Management Act (1989), Louisiana Act 6 (1989), Barataria-Terrebonne National Estuary Program (1990), The Gulf of Mexico

Program (1991), and Sections 2004, 206, and 1135 of the Water Resources Development Act (of 1986, 1992, and 1996) (USACE, Apr. 2004).

The most prominent piece of legislation that has addressed Louisiana's coastal wetland loss is the Coastal Wetlands Planning, Protection and Restoration Act (CWPPRA, 1990). CWPPRA, also known as the Breaux Act, became law in November 1990. CWPPRA authorized the Federal government to use funds to address wetland loss across the nation. Louisiana was a major focus of the Breaux Act. CWPPRA is a cost sharing program between the federal government and states to fund projects that restore, maintain, and prevent loss of wetlands in the United States. In Louisiana, projects are sponsored by five federal agencies (U.S. Army Corps of Engineers, Natural Resources Conservation Service, National Marines Fisheries Service, U.S. Fish and Wildlife Service, U.S. Environmental Protection Agency) and the State of Louisiana. The total cost over the life of the program is estimated to reach $2 billion (USACE, 2005). From 1990 to 2006, CWPPRA funding averaged approximately $60 million for each coastal restoration projects. As of 2006, there are 78 projects costing $624.5 million that have been constructed, are in the process of being constructed, or have been approved for construction. In addition, 47 projects that cost approximately $913.4 million are in the engineering and design phase. The combined benefits of all of the projects are estimated to be 103,281 acres re-established or protected and 515,213 acres restored. Funding was reauthorized by Congress for CWPPRA through 2019 (LCWCRTF, 2006).

In 1998 a new plan for the Louisiana coast was published. It was entitled "Coast 2050: Toward a Sustainable Coastal Louisiana." The overarching goal of the plan was, "to sustain a coastal ecosystem that supports and protects the environment, economy and culture of southern Louisiana, and that contributes greatly to the economy and well-being of the nation" (LCWCRTFWRCA pg. 2, 1998). The Coast 2050 Plan provides a set of restoration strategies for restoring south Louisiana's wetlands to a sustainable level (LCWCRTF, 2006). The plan emphasized that CWPPRA was improving wetland, but not to the desired level. The Coast 2050 Plan called for $14 billion to be spent over the next 30 years starting in 1998. The plan states that the Breaux Act will only address 22 percent of the land loss problems. Funding was not granted to cover all of the Coast 2050 plans.

The Coast 2050 Plan laid the ground work for the Louisiana Coastal Area study (USACE, Nov. 2004). The study produced the Louisiana Coastal Area Comprehensive Coastwide Ecosystem Restoration study report and Draft Programmatic Environmental Impact Study (DPEIS). Another report on Louisiana's restoration efforts was LCA Near-Term Ecosystem Restoration Plan: Evolution of Coastal Restoration in Louisiana (USACE, Apr. 2004). The report identified plans to rehabilitate Louisiana's coast. The LCA plan would cost approximately $1.9 billion to implement (LCWCRTF, 2006). The LCA plan was not funded.

The Energy Policy Act of 2005 provided Louisiana with $450 million over the following fours years for restoration efforts and to mitigate some impacts of Outer Continental Shelf oil and gas production. The money comes through the Coastal Impact Assistance Program (CIAP) in the 2005 energy bill (LCWCRTF, 2006).

Then in 2005, Hurricane Katrina and Rita devastated coastal Louisiana. Reports estimated that approximately 128,000 acres of wetlands were converted into open water. The hurricanes also had devastating affects on human life, infrastructure, and property. It is estimated that the losses of physical capital from Hurricanes Katrina and Rita totaled between $70 and $130 billion (CPRA, 2007). This prompted the State of Louisiana to restructure the Wetland Conservation and Restoration Authority to form the Coastal Protection and Restoration Authority. Prior to these hurricanes, planning for coastal restoration and hurricane protection were separated. After these hurricanes, the CPRA began considering "hurricane protection and the protection, conservation, restoration and enhancement of coastal wetlands and barrier shorelines or reefs" jointly (CPRA, 2010). Over the next few years CPRA began working on a Master Plan that would outline how to achieve a sustainable coast. In April 2007, the state released the Integrated Ecosystem Restoration and Hurricane Protection: Louisiana's Comprehensive Master Plan for a Sustainable Coast (CPRA, 2007). The hurricanes of 2005 drastically changed the approach to maintaining and restoring Louisiana's coastal wetlands. Pre-Katrina and pre-Rita protection and restoration efforts were primarily focused on environmental and ecological benefits of the wetlands. Post-Katrina and post-Rita efforts have become increasingly more concerned with the protection that wetlands can provide against hurricane and flood damage.

# CHAPTER III

# THEORY

This chapter outlines the theoretical framework and outlines the econometric model utilized in this thesis.

## *Welfare Measures*

### Ordinary and Compensated Demand

The following discussion of demand functions and welfare measures is based upon Kolstad (2000). Demand functions are derived with the individual's utility function, prices for two goods, income, and by assuming the individuals will make decisions that maximize their utility. Depending on whether income or utility is held constant as price changes provides either the ordinary or compensated demand function. Ordinary (Marshallian) demand functions are generated when income is held constant as the price changes for one of the goods. Compensated (Hicksian) demand functions are generated when utility is held constant as the price for one of the goods changes. Figure 1 illustrates one ordinary demand curve ($x_q(p_z,p_q,y)$) and two compensated demand curves ($h_q(p_z,p_q,U_0)$) and ($h_q(p_z,p_q,U_1)$), where two goods are represented by $z$ and $q$, income is represented by $y$, and utility is represented by $U$.

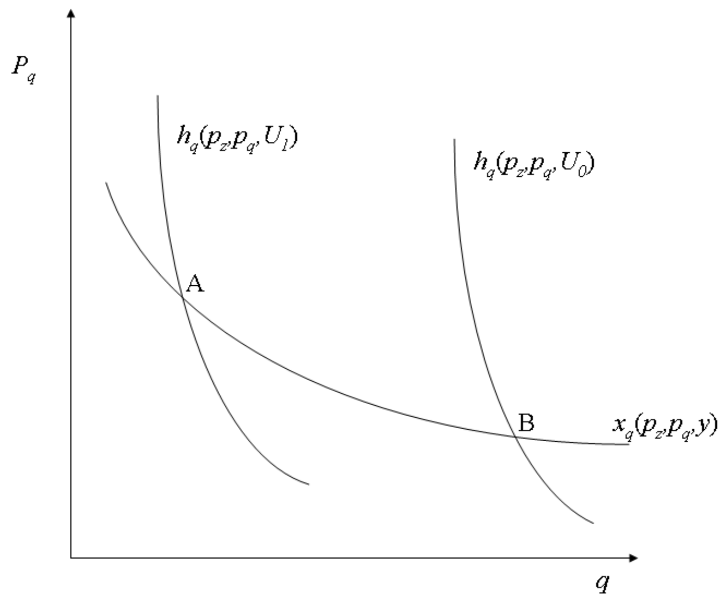


Figure 1 Comparison of Ordinary and Compensated Demand Curves

The reason that both demand curves are used is the fact that the price effect and the income effect on demand are of concern in this thesis. Price effect means that as the price of $q$ goes up individuals consume less $q$ and substitute the decrease with $z$. The income effect means as the price of $q$ increases individuals consume less $q$ because of the decrease to their income. The ordinary demand function encompasses both the price effect and income effect, but compensated demand only encompasses the price effect. These two demand functions provide us with different welfare measures. Ordinary demand functions provide consumer surplus.

Consumer Surplus

Consumer surplus is a typical (Marshallian) measure of economic welfare. It is not the measure that will be used in this thesis, but it is a good place to start to understand the consumer welfare measure that will be used. Consumer surplus is defined as the difference between what an individual is willing to pay for a good and what that individual actually pays for the good. This is illustrated in Figure 2. The original consumer surplus is the area under the demand curve, above the price, $P_0$, and between the origin and the quantity, $Q_0$. Figure 2 also illustrates how consumer surplus changes when price and/or quantity changes. Consider a quantity change $Q_0$ to $Q_1$. After this change, consumer surplus is reduced by the triangle between $Q_1$ and $Q_0$. This change in consumer surplus can also be interpreted as the individual's maximum willingness to pay for an increase in quantity from $Q_1$ and $Q_0$.

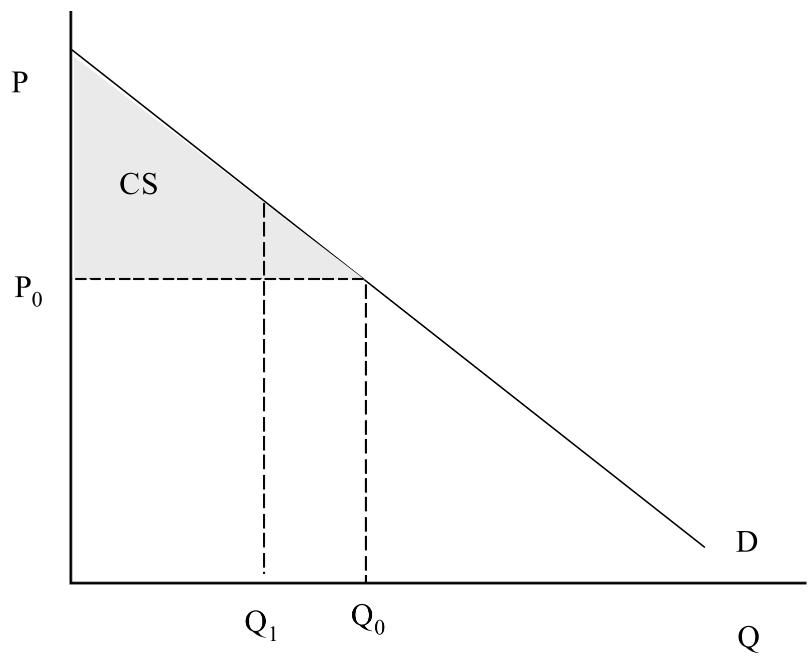


Figure 2 Consumer Surplus

Compensating Variation and Equivalent Variation

The two alternative (Hicksian) measures of consumer welfare, compensating variation and equivalent variation, are provided through the compensated demand function. Compensating variation is the amount of income compensation that would keep the individual at the original level of utility given a change in quantity of the good. Kolstad (pg. 303, 2000) describes compensating variation as "the amount of money that would keep an individual at the original level of utility with the change" in quantity. Equivalent variation is the change in income that is equivalent to the change in quantity. Kolstad (pg. 303, 2000) describes equivalent variation as, "the amount of money that would move the individual to the new level of utility without the change" in quantity.

Using the same demand curves as in Figure 1 a comparison of the consumer surplus (CS), compensating variation (CV), and equivalent variation (EV) can be shown. Figure 3 illustrates the comparison of these three welfare measures.

In this illustration the price of $z$ drops from $p^0$ to $p^1$ which causes the individual to expand consumption of $z$ from $z_0$ to $z_1$. Due to this price change consumer surplus increases by the area ABFD. Compensating variation associated with the reduction in price of $z$ is the area ABED, and ACFD is the equivalent variation associated with the same price reduction. Figure 3 also illustrates that the area of the three measures may be different.

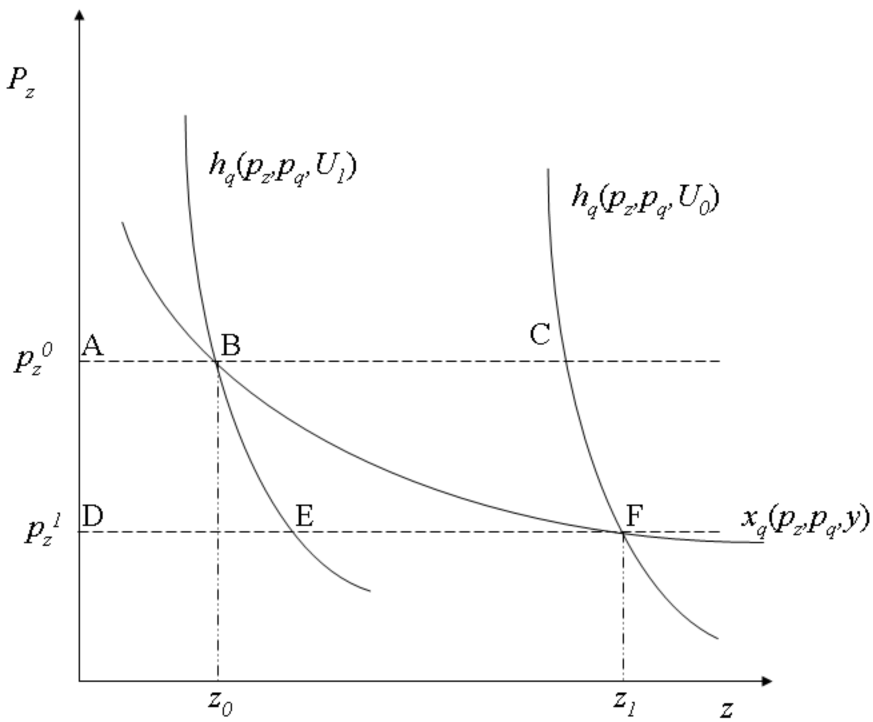


Figure 3 Comparison of Consumer Surplus, Compensating Variation, and Equivalent Variation

Compensating Surplus and Equivalent Surplus

Two very closely related measures are compensating surplus and equivalent surplus. Compensating surplus and equivalent surplus are the same as CV and EV concepts applied to goods for which the consumer cannot choose the quantity. Compensating surplus and equivalent surplus were used to measure consumer welfare in this thesis because the object of study is an environmental good, where quantities are fixed. Equivalent surplus and compensating surplus are illustrated in Figure 4. In Figure 4, income is on the vertical axis (representing consumption of all other market goods) and the non-market environmental good (in this case, coastal wetlands) is on the horizontal axis. Utility is expressed through the two indifference curves $I_{u0}$ and $I_{u1}$, and in this case both are assumed to be functions of income and the quantity of land. Utility at all points on $I_{u0}$ is also assumed to be greater than the utility at all points on $I_{u1}$. $I_{u0}$ is the initial indifference curve that represents the beginning level of utility. As a result of the reduction in the quantity of land from $L_0$ to $L_1$, utility decreases as the consumer moves from $I_{u0}$ to $I_{u1}$. This change moves the individual from the starting point A to point B. Equivalent surplus will be the decrease in income that has the same effect on utility as the decrease in the quantity of land. In this example equivalent surplus is the difference between income levels $I_0$ and $I_1$.

This equivalent surplus is also the individual's maximum *willingness to pay* to prevent the reduction of land from $L_0$ to $L_1$. By paying the difference between $I_0$ and $I_1$ the individual moves from point A to point C. Compensating surplus, on the other hand, is the increase in income that will return the individual to the original utility level given the decrease in the quantity of land. In this example compensating surplus is the difference between income levels $I_0$ and $I_2$. The compensating surplus is also the individual's minimum *willingness to accept* compensation for the reduction of land from $L_0$ to $L_1$. When the difference between $I_0$ and $I_2$ is accepted the individual moves from point A to point D. As with the welfare measures in Figure 3, the equivalent surplus and compensating surplus in Figure 4 do not appear to be equal. This is due to fact that the equivalent surplus and compensating surplus have different reference points. The difference stems from equivalent surplus being a payment by the individual and compensating surplus is compensation to the individual. Willig (1976) addresses the issue of possible differences between these measures, their differences from consumer surplus, and validates the use of these as welfare measures.

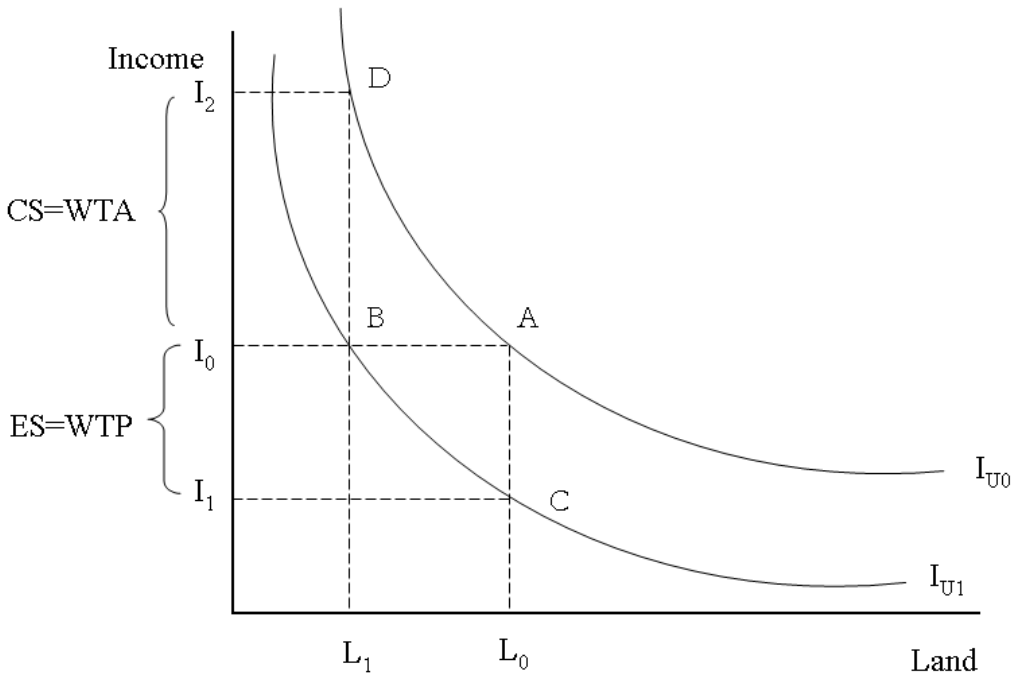


Figure 4 Equivalent Surplus and Compensating Surplus of Income for Land

*Willingness to Pay Versus Willingness to Accept*

This thesis will measure willingness to pay to prevent future coastal wetland loss in Louisiana and willingness to accept to allow for the same wetland loss. This section provides a discussion of the difference between willingness to pay and willingness to accept that is based on Haab and McConnell (2002). One explanation for the difference is prospect theory or loss aversion where an individual's decision is based upon the net change relative to the status quo, but not by the individual's well-being before and after the change is highlighted in Kahneman and Tversky (1979). Another explanation for the disparity between the two when considering public goods is the fact that individuals lack the ability to substitute between public and private goods, Hanemann (1991).

There is empirical evidence indicating that willingness to accept is higher than willingness to pay. Brown and Gregory (1999) report that numerous studies valuing environmental goods have found willingness to accept estimates to be 2 to 5 times higher than that of willingness to pay. Horowitz and McConnell (2002) show that willingness to accept can be up to 27.57 times higher than willingness to pay, with a mean of 10.41 times higher than willingness to pay, for public and non-market goods.

Willingness to pay has become the preferred measure partly because it is believed that stated preferences cannot be obtained through a measure of willingness to accept because it is not incentive–compatible, meaning individuals have no incentive to reveal their true preference. Another reason for using willingness to pay is that willingness to accept does not place a budget constraint on the decision maker. Even though willingness to pay is hypothetical, the respondent is still instructed to consider the loss to income that would occur by giving a willingness to pay value.  The NOAA Blue Ribbon Panel was asked to determine the validity of the contingent valuation method, which commonly utilizes willingness to pay estimates. Their determination and recommendations are outlined in Arrow *et al*. (1993). The NOAA panel addressed this issue of willingness to pay versus willingness to accept in their report.  The NOAA panel states that willingness to pay is the more conservative measure, of the two, and recommends the use of willingness to pay over willingness to accept in contingent valuation studies for this reason. The NOAA panel confirmed the validity of  willingness to pay estimates derived from the contingent valuation methods, but it gave guidelines for the how contingent valuation studies should be performed to provide reliable estimates. These guidelines will be highlighted in the next section.

Both measures are estimated in this thesis and a comparison of the median willingness to pay and median willingness to accept measurements are conducted. The reason that both willingness to pay and willingness to accept measures are used is because it was not obvious as to where the respondents would perceive the property rights of the wetlands to lie. If respondents perceived the property rights of wetland benefits to lie with them then it is necessary to know what they would be willing to accept to give up the rights to those benefits. The reason willingness to accept is used in this scenario is the individual's value is the minimum value that they are willing to accept the loss of the wetlands. Whereas, if respondents do not perceive the property rights to belong to them, then willingness to pay to prevent the loss of wetlands is the measure that should be used because it is being determined what they would pay to gain the rights to the benefits provided by the wetlands. The reason willingness to pay is used in this scenario is the individual's value is the maximum amount of money that the respondent is willing to pay to prevent the loss of the wetlands (Champ, Boyle, and Brown, 2003).

*Contingent Valuation*

Contingent valuation is a technique of deriving demand for a good through asking an individual how much they would be willing to pay for a good. Their willingness to pay is contingent upon a market actually existing for the good (Kolstad, 2000). This procedure is commonly used to value environmental goods because many environmental goods do not actually have a market in which they are traded.  Examples of contingent valuation include asking individuals how much they would be willing to improve their hometown's air or water quality or how much they would be willing to pay to prevent climate change.

Davis (1963) was the first to use contingent valuation in academic research. This study used a contingent valuation survey to elicit the value that hunters and wilderness lovers placed upon a recreational area. Since then the contingent valuation method has been used in many areas of economics. In addition, contingent valuation methods have been improved. Yet, due to the method's importance and the opinion of some researchers that contingent valuation was not a legitimate method of valuing goods, the U.S. government requested that a high-level review of the procedure be undertaken in 1992. Diamond and Hausman (1994) and Hanemann (1994) present two differing views on the legitimacy of the contingent valuation method. This review was partially in response to contingent valuation's proposed use to value the damage from the 1989 Exxon Valdez Oil spill. The National Oceanic and Atmospheric Administration gathered a panel of six highly distinguished economists and survey researchers, lead by Kenneth Arrow. This panel became known as the "NOAA panel." The task of this panel was to review contingent valuation and determine if it was a legitimate method. The NOAA panel decided that the method could be useful, but that certain practices should be adhered to in order to generate reliable willingness to pay values (NOAA, 1993).

Kolstad (2000) provides a discussion of the NOAA panel's recommendations for a successful contingent valuation survey. The six components of a successful contingent valuation are defining the market scenario, choosing the elicitation method, designing the market administration, sample design, designing the experiment, and estimating the willingness to pay function. The NOAA panel made recommendations about the best way to accomplish each of these components.

Defining the market scenario involves conveying to the respondent all the information about the situation on which they will be making the decision. The NOAA panel recommends asking questions that make sure respondents understand the market situation and that the respondent should be reminded of any substitutes. Choosing the elicitation method means establishing how the willingness to pay value will actually be obtained. The four main ways of eliciting are direct questions (open-ended), bidding game, payment card, and referendum choice. The recommended elicitation method is referendum choice. The reason it is recommended is because most people are accustomed to answering such questions (e.g., voting) and it reduces bias introduced by the researcher arbitrarily or systematically choosing prices that may not allow for respondents to indicate values. The market administration is how the respondents take the survey. The main methods are in-person, telephone, internet, and mail. The NOAA panel recommends in-person, but this is the most expensive administration method and often times not financially feasible. Sample design involves two steps. The first is to choose the population from which to draw the sample and the second is to draw a random sample. Experimental design is very important to performing an effective contingent valuation study. Experimental design involves deciding which questions to ask and how to ask them so that will provide the data needed to perform research. The final component is to estimate the willingness to pay function. The estimation of willingness to pay must be kept in mind throughout all planning and design components to insure that all data needed is obtained.

The contingent valuation method has been utilized previously for wetland valuation. Examples include Costanza and Farber (1987), Costanza, Farber, and Maxwell (1989), Bergstrom, Stoll, Titre, and Wright (1990), Whitehead (1990), Farber (1996), Milon and Scrogin (2006), and Petrolia and Kim (2009). Although not a contingent valuation study, Farber (1987) was also reviewed because it was one of the early attempts to value the wetlands of Louisiana. This study attempted to place a value on the Louisiana's coastal wetlands based upon their role in the reduction of wind damage to property due to diminished storm intensities.

The purpose of Farber and Costanza (1987) was to estimate the value of the wetland system in Terrebonne Parish, Louisiana. The study used existing data and methodology for independent contributions that the wetlands provided to ascertain a value of Terrebonne Parish wetlands as a whole. One of the methods used to obtain the value was asking individuals if they were willing to pay to retain the opportunity to use the wetlands for recreation.

Constanza, Farber, and Maxwell (1989) also used willingness to pay estimates for recreational use as part of a calculation of the value of wetland ecosystems in Louisiana. This study used the willingness to pay estimates for recreational use found in Farber and Costanza (1987). The total value of the wetland ecosystem was comprised of the willingness to pay estimates for recreational use, the value of commercial fisheries, the value of fur trapping in the wetlands, and the value from storm protection provided by wetlands. Also, this study states that the total present value of wetlands is greatly affected by the discount rate assumed.

Bergstrom *et al*. (1990) sought to determine the economic value of wetlands-based recreation in Louisiana. This study implored the contingent valuation method to determine the value of recreational benefits of wetlands in Louisiana. The recreational wetland benefits being valued included waterfowl hunting, saltwater fishing, freshwater fishing, recreational crabbing, and recreational shrimping.

Whitehead (1990) utilized the contingent valuation method to determine the willingness to pay of households in Kentucky to preserve hardwood forest wetlands threatened by surface coal mining in Kentucky. Through the survey, respondents indicated how much they were willing to pay to preserve the Clear Creek wetland area. The willingness to pay estimate in this study included the use and non-use value that the households in Kentucky placed on the wetland area. This study also found that older respondents were less willing to pay to preserve the wetlands.

The purpose of Farber (1996) was to estimate the welfare loss that would be incurred due to projected disintegration of Louisiana's coastal wetlands. The study was interested in determining if the benefits from stopping the disintegration would outweigh the cost of projects that would stop the disintegration. The benefits of these projects were estimated using welfare measures from decreases in the quality of commercial fisheries, losses in value of recreational fishing experiences, losses in the value of property subject to increased storm risk, the costs associated with storm protection, and increased cost to maintain water quality if the projected disintegration was not prevented. To obtain the value of lost recreational fishing experiences, this study used willingness to pay estimates for retaining the quality of recreational activities in the coastal zone from wetland users.

The willingness to pay estimates from a contingent valuation study was part of the total value of preventing disintegration of Louisiana's wetlands that was estimated.

Milon and Scrogin (2006) used survey data to estimate the value that Florida residents placed on the restoration of the Greater Everglades ecosystem in Florida. The study also found that structural and functional differences of the restoration plans affected respondents' willingness to pay and their preferences between the different types of plans.

Petrolia and Kim (2009) estimated Mississippi residents' willingness to pay to restore the state's barrier islands. This study used survey data from a random sample of Mississippi households to determine preferences for three different restoration options that provide different levels of land being restored to the state's barrier islands. This study found that there was support for such projects and that perceived protection from hurricanes provided by the islands was the primary reasons for respondent's willingness to support one of the options.

Brander, Florax, and Vermaat (2006) is a comprehensive summary and a met-analysis of the wetland valuation literature. The analysis is very diverse in terms of the wetlands and the benefits of wetlands that were valued and the valuation methods that were used to obtain the value estimates. The different valuation methods included market prices, replacement costs, opportunity costs, production functions, net factor income, travel cost method, hedonic pricing, and the contingent valuation method. In this study the contingent valuation method was found to yield higher values estimates than the other valuation methods.

*Random Utility Model*

This thesis utilizes the contingent valuation method for estimating welfare measures for the prevention of future wetland loss. Data were collected through a survey. One theoretical model that allows for the analysis of a contingent valuation study is the random utility model. The following discussion is based on Haab and McConnell (2002). The random utility model is the fundamental model for analyzing contingent valuation responses. McFadden (1974) laid the groundwork for random utility, which Hanemann (1984) utilized to develop the basic random utility model. Hanemann established the framework that allows for the parameters of responses to dichotomous choice contingent valuation questions to be estimated and interpreted.

In the basic referenda-style contingent valuation scenario the respondent has two choices. The indirect utility for respondent *j* can then be written

$$u_{ij} = u_i(y_j, z_j, \varepsilon_{ij}), \qquad 1$$

where $y_j$ is the $j^{th}$ respondent's income, $z_j$ is an *m*-dimensional vector of household characteristics and choice attributes, and $\varepsilon_{ij}$ is a component of preferences known by the individual, but not known by the researcher, If respondent *j* answers yes to a required payment of $t_j$, then the utility with the proposed change, minus $t_j$, exceeds the utility of status quo

$$u_{1j}(y_j - t_j, z_j, \varepsilon_{1j}) > u_{0j}(y_j, z_j, \varepsilon_{0j}), \qquad 2$$

where $i = 1$ is the state that prevails when the proposed change is implemented, and $i = 0$ is for the status quo. Due to the fact that the researcher does not know the random part of preferences, only a probability statement about the choice can be made. The probability of a “Yes” response is the probability that the respondent believes that he is better off with the proposed change and the required payment. This means that $u_1 > u_0$, and respondent $j$’s probability is

$$\Pr(yes_j) = \Pr(u_{1j}(y_j - t_j, z_j, \varepsilon_{1j}) > u_{0j}(y_j, z_j, \varepsilon_{0j})) . \qquad 3$$

This form is too general to allow for parametric testing, so two decisions must be made that will allow for such testing. First the functional form of utility must be chosen. Secondly, the distribution of $\varepsilon_{ij}$ must be specified. Most approaches specify that the utility function is additively separable in deterministic and stochastic preferences.

$$u_{ij}(y_j, z_j, \varepsilon_{ij}) = v_{ij}(y_j, z_{j0}) + \varepsilon_{ij} . \qquad 4$$

With this additive statement the probability of respondent $j$ can then be written

$$\Pr(yes_j) = \Pr[v_{1j}(y_j - t_j, z_j) + \varepsilon_{1j} > v_{0j}(y_j, z_j) + \varepsilon_{0j}] . \qquad 5$$

Because the random components between the proposed change and status quo cannot be identified there is no reason not to write the random term as $\varepsilon_j \equiv \varepsilon_{1j} - \varepsilon_{0j}$, a single random term. Now let $F_\varepsilon(a)$ be the probability that the random variable $\varepsilon$ is less then $a$. So the probability is

$$\Pr(yes_j) = 1 - F_\varepsilon[-(v_{1j}(y_j - t_j, z_j) - v_{0j}(y_j, z_j))] . \qquad 6$$

Now a more specific utility function is used to estimate the parameters. For this thesis, several functional forms were tested. The linear utility function results when the deterministic part of the preference function is linear in income and covariates

$$v_{ij}(y_j) = \alpha_i z_j + \beta_i y_j \qquad 7$$

where income is $y_j$, the $m$-dimensional vector of variables related to individual $j$ is $z_j$ and a $m$-dimensional vector of parameters is $\alpha_i$, so that $\alpha_i z_j = \sum_{k=1}^{m} \alpha_{ik} z_{jk}$. The deterministic utility for the proposed change scenario is

$$v_{1j}(y_j - t_j) = \alpha_1 z_j + \beta_1 (y_j - t_j) \qquad 8$$

where $t_j$ is the price offered to the $j^{th}$ respondent. The status quo utility is

$$v_{0j}(y_j) = \alpha_0 z_j + \beta_0 y_j . \qquad 9$$

The change in deterministic utility is

$$v_{1j} - v_{0j} = (\alpha_1 - \alpha_0) z_j + \beta_1 (y_j - t_j) - \beta_0 y_j . \qquad 10$$

If it is assumed that the marginal utility of income is constant between the two options, (e.g., if the bids are small relative to income), proposed change and status quo, this implies that, $\beta_0 = \beta_1$ and the utility difference becomes

$$v_{1j} - v_{0j} = \alpha z_j - \beta t_j \qquad 11$$

where $\alpha = \alpha_1 - \alpha_0$ and $\alpha z_j = \sum_{k=1}^{m} \alpha_k z_{jk}$. With the deterministic part of preferences specified, the probability of responding "Yes" becomes

$$\Pr(yes_j) = \Pr[\alpha z_j - \beta t_j + \varepsilon_j > 0] \qquad 12$$

where $\varepsilon_j \equiv \varepsilon_{1j} - \varepsilon_{0j}$ as defined previously.

*Random Willingness to Pay Model*

A similar model to the random utility model that is used to analyze contingent valuation studies is the random willingness to pay model. This model was developed by

Cameron and James (1987) and Cameron (1988). The discussion that follows comes from Haab and McConnell (2002). This technique models the willingness to pay function directly for the contingent valuation question instead of using the indirect utility function that is used in the random utility model.  There are reasons for the use of random willingness to pay instead of random utility model. One is the willingness to pay function is more transparent than the utility difference function, which can lead to more plausible distributions. Also, some simple utility differences could imply unacceptable distributions on the willingness to pay estimate.

The willingness to pay for the contingent valuation scenario comparative to the status quo is defined as

$$v_1(y_i - WTP(y_i, z_i, \varepsilon_i), z_i) + \varepsilon_{1i} = v_0(y_i, z_i) + \varepsilon_{0i} \qquad 13$$

where $v$ is the indirect utility of respondent, $y_i$ is the respondent's income, $t_i$ is the cost of the program and $\mathbf{z}_i$ is a vector of household characteristics, $\varepsilon_i$ is a component of random preferences. The respondent will answer yes when WTP exceeds $t_j$:

$$WTP(y_i, z_i, \varepsilon_i) > t_i, \qquad 14$$

and it is true when

$$v_1(y_i - t_i, z_i) + \varepsilon_{1i} > v_0(y_i, z_i) + \varepsilon_{0i} \qquad 15$$

This also can be shown as equivalent probability statements:

$$\Pr[WTP(y_i, z_i, \varepsilon_i) > t_i] = \Pr[v_1(y_i - t_i, z_i) + \varepsilon_{1i}) > v_0(y_i, z_i) + \varepsilon_{0i})]. \qquad 16$$

This indicates that the probability of receiving a "Yes" response is

$$\Pr(yes_i) = \Pr(WTP > t_i). \qquad 17$$

# CHAPTER IV

# EXPERIMENTAL DESIGN

This chapter encompasses discussions of the factors that were considered in modeling the respondent's willingness to fund the prevention of wetland loss and how they would affect their decision. This chapter also includes a description of the survey methods and responses to questions related to the factors believed to affect respondent choice.

## *The Market Scenario*

At the beginning of the survey respondents were given a brief introduction of wetland loss in Louisiana. The introduction stated, "Coastal Louisiana has lost an average of 34 square miles of land, primarily marsh, per year for the last 50 years. From 1932 to 200 coastal Louisiana lost 1,900 square miles of land, roughly an area the size of the state of Delaware." A map was also provided that illustrated the land loss from1932-2000, predicted land loss from 2000-2050, land gain 1932-2050, and predicted land gain from 2000-2050. Also, they were told, "Hurricanes Katrina and Rita eroded an additional 217 square miles in 2005 alone." Also, "if no action is taken, Louisiana could potentially lose an additional 700 square miles of land, about equal to the size of the greater Washington D.C. – Baltimore area, by the year 2050."

They were provided time frames for the implementation of the two proposals and for how long the land will be maintained once the proposal is completed. The short run proposal would take 5 years to implement and the land loss would be prevented until the year 2050, and in the long run proposal implementation would take 25 years and the wetland loss would be prevented until year 2185.  Each respondent was presented with the same price for both proposals.

*Elicitation Method*

The elicitation method utilized was referendum style.  After the proposals were presented the respondent had to decide whether to support the short run proposal or the long run proposal at the bid value once every year for ten years or to vote for no action being taken. The "Yes" or "No" response for willingness to fund one of the proposals provides a WTP/WTA value. Also, depending on the version the question was either asked in the WTP or WTA format. The WTP format asks respondents if they would be willing to pay a tax once a year for ten years to prevent future wetland loss. While the WTA format asks the respondents if they would be willing not to receive a tax refund once a year for ten years.

There were 20 versions of the survey because of the 10 different bid values for the proposals, half being WTP and half being WTA, and half having the long run proposal presented first and half having the short run proposal presented first. Table 1 shows bid value, WTP or WTA format, and order of the long run and short run proposals for each version. The respondents were asked to evaluate two separate proposals that will prevent future wetland losses.

Table 1

Survey Versions

| Version | WTP/ WTA | Order | Bids | Version | WTP/ WTA | Order | Bids |
|---|---|---|---|---|---|---|---|
| #1 | WTP | SR-LR | $50 | #21 | WTA | SR-LR | $50 |
| #2 | WTP | SR-LR | $71 | #22 | WTA | SR-LR | $71 |
| #3 | WTP | SR-LR | $101 | #23 | WTA | SR-LR | $101 |
| #4 | WTP | SR-LR | $144 | #24 | WTA | SR-LR | $144 |
| #5 | WTP | SR-LR | $204 | #25 | WTA | SR-LR | $204 |
| #6 | WTP | SR-LR | $291 | #26 | WTA | SR-LR | $291 |
| #7 | WTP | SR-LR | $413 | #27 | WTA | SR-LR | $413 |
| #8 | WTP | SR-LR | $588 | #28 | WTA | SR-LR | $588 |
| #9 | WTP | SR-LR | $836 | #29 | WTA | SR-LR | $836 |
| #10 | WTP | SR-LR | $1,189 | #30 | WTA | SR-LR | $1,189 |
| #11 | WTP | LR-SR | $50 | #31 | WTA | LR-SR | $50 |
| #12 | WTP | LR-SR | $71 | #32 | WTA | LR-SR | $71 |
| #13 | WTP | LR-SR | $101 | #33 | WTA | LR-SR | $101 |
| #14 | WTP | LR-SR | $144 | #34 | WTA | LR-SR | $144 |
| #15 | WTP | LR-SR | $204 | #35 | WTA | LR-SR | $204 |
| #16 | WTP | LR-SR | $291 | #36 | WTA | LR-SR | $291 |
| #17 | WTP | LR-SR | $413 | #37 | WTA | LR-SR | $413 |
| #18 | WTP | LR-SR | $588 | #38 | WTA | LR-SR | $588 |
| #19 | WTP | LR-SR | $836 | #39 | WTA | LR-SR | $836 |
| #20 | WTP | LR-SR | $1,189 | #40 | WTA | LR-SR | $1,189 |

*Market Administration and Sample Design*

The NOAA Panel recommends in-person interviews method for administering surveys, but due to finical constraints mail surveys were used to obtain the data for the this thesis. The survey was mailed to a random sample (stratified by population) of 3,000 households in Louisiana in May, 2009, and follow up survey was mailed in June, 2009.

*Survey Design*

This study aims to determine whether individuals are willing to support a short or long run proposal to prevent future wetland loss. The alternative to these two proposals is for the respondent to prefer no action being taken. It also allows us to determine what factors influence an individual to prefer one of the two proposals. These factors are discussed in this section.

The independent variables that are included in the analysis are as follows: income, bid (price of the proposal), climate change perceptions, risk preferences and perceptions, time preference of money, proximity of home to the coast, hurricane expectations, perceived benefits, age, gender, race, and education. Many of these variables are found in almost all contingent valuation analyses.

Income and Bid

Income and bid are needed in the model because the model is determining if and how much an individual is willing to pay to receive a good or the benefits from a good, and economic theory dictates that price and income should influence the decision. Income needs to be in this type of contingent valuation model because it is a hypothetical model and not based on a real transaction where a budget constraint can affect willingness to make a transaction. Income provides a measure of the budget constraint on the respondent's decision. Bid has to be in the model because of the law of demand. As the price for the proposals increases the probability of support should decrease.

Climate Change Perceptions

One of the aspects of this thesis is determining how climate change perceptions affect willingness to pay for projects that will prevent future wetland loss in Louisiana. There has been a substantial amount of work done on how people's perceptions of climate change affect their willingness to pay for climate change mitigation, but there has not been an extensive amount of work done concerning how perceptions of climate change affect individuals' willingness to pay for a specific environmental project that can be affected by climate change.

Cameron (2005) evaluated willingness to pay for climate change mitigation. Cameron (2005) found that people's willingness to pay for climate change mitigation was dependent upon their perceptions of climate change. It was found that if people perceived climate change to be damaging in the future they were more willing to pay to mitigate climate change. Yet, uncertainty about the effects of climate change caused individuals to be less willing to support policies.

We hypothesize that if people have the perception that climate change affects sea level rise and that sea level rise is a threat to respondents, then their willingness to pay for programs that will protect current wetlands and build future wetlands will be affected. There were four questions asked in the survey to obtain the respondents' perceptions about climate change.

Time Preference

Due to the fact that individuals are comparing proposals that provide benefits over different periods of time it is hypothesized that respondent's time preference for money will have an effect of their decision as well. The example that follows is similar to the decision that individuals taking the survey had to make. In this example, individuals have the option to support one of three proposals. Figure 5 below is a representation of the levels of land per year that are provided under each of the three options using the actual acreage predictions. The analysis assumes linear land loss and equal rate of land loss across the three options. This assumption was made because the beginning and end points of land were known, but there was no data to suggest that the rate would not be constant so a linear land loss was assumed.

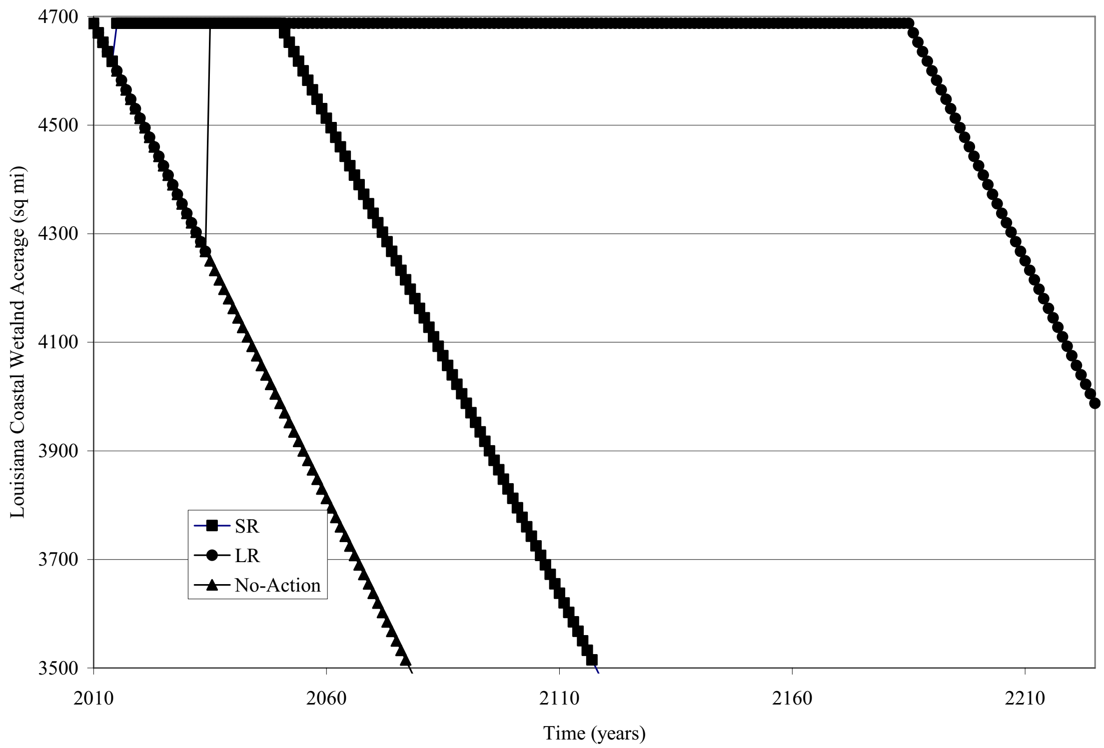


Figure 5 Land per Year for the Three Proposals

The individual would choose between one of the three proposals and the proposal chosen would be enacted today. The "No-action" proposal provides no action to mitigate loss of land and the amount of land loss continues as forecasted. It was assumed that both the short run and long run proposal lose land at the same rate as no action until the point where the proposal is implemented. The "SR" proposal represented in the figure illustrates a short run option that if selected takes until year 2015 to implement fully, and land loss occurs at the same rate as the "no action" until implementation. After implementation in 2010 the short run proposal restores acreage to initial levels, 4700 square miles (sq ml) of land, until 2050 and then land levels begin to decrease again at the same rate. The "LR" proposal is a long run option that would take until year 2035 to implement, with land levels decreasing at the same rate as under "no-action" until implementation. Upon completion in 2035 the proposal would restore initial levels of land until 2185, and after 2185 land levels would begin to decrease at the initial rate. To isolate the time preference and because there was no information to indicate otherwise it was assumed costs were identical for the short and long run proposals.

Figure 5 allows us to make a visual comparison between the three proposals. Assuming that land is the numeriare good, which means the $P_L = 1$, then an acre of land is interpreted as a suite of benefits undiscounted, such that all else equal, more land is preferred to less land. It is clear to see that no action provides fewer aggregate land benefits over time than either the short or long run proposals from the areas under the curves. When the short and long run proposals are compared over the same time period it can be seen that the long run proposal provides more aggregate land than the short run proposal. This implies that, undiscounted, the long run proposal should have a higher value associated with it than the short run proposal and the short run proposal should have a higher value than no action.

Yet, through the decisions that individuals make an inference can be made about the individual's actual value of the proposals and in turn the value of having the different levels of land (at different times) under the proposals. If an individual chooses no action over either of the other proposals, then it was assumed that the cost of implementation incurred is higher than the value that they place on the increase in aggregate land under either of the proposals. If the individual chooses the short run proposal or long run proposal, then their value of the increase in the land is higher than the cost associated with implementation. Because prices for the short run and long run proposals were assumed to be the same, yet the long run proposal provides more aggregate land over time it would be expected that, strictly on the value of the land, an individual willing to support some form of action being taken would always choose the long run proposal. Yet, if individuals do choose the short run over the long run, then it would mean that factors other than maximizing the quantity of land over time is driving their decision to choose the short run proposal over the long run proposal.

In the decision making scenarios just discussed, it could be said that an individual is discounting the value of the land per year in the proposals, and that this discounting of proposals may be the cause of an individual choosing the short run proposal. Reinterpreting Figure 5 as values, it is assumed that if an individual chooses the short run proposal over the long run proposal, then the benefits from that proposal exceed that of the long run proposal. Because the only difference between the two proposals is timing, it is assumed that the difference is due to discounting. This discounting could be caused by the time preference of money, desiring land now as compared to later due to age, assumption of lower probability of receiving the benefits in the distant future, risk perception, risk preference, perceived benefits and perception of climate change.

Figure 6 illustrates such a situation where the proposals have been discounted so that the aggregate benefits are the same for the short run and long run proposals. The proposals in Figure 5 were made equal by applying a discount rate. The applied discount rate was found by weighting each unit of land at time period $t$, $L_t$, by the discount a factor $\frac{1}{(1+r)^t}$ x $L_t$ then solving for the value of $r$ that yields $\int f L_t^{SR} dt = \int f L_t^{LR} dt$. Because there was actual forecasted acreage, the actual value of $r^*$ could be calculated. This yields the implied discount rate $r^* = 0.038115$ such that anybody choosing the short run proposal must have a discount rate greater than, or equal to $r^*$.

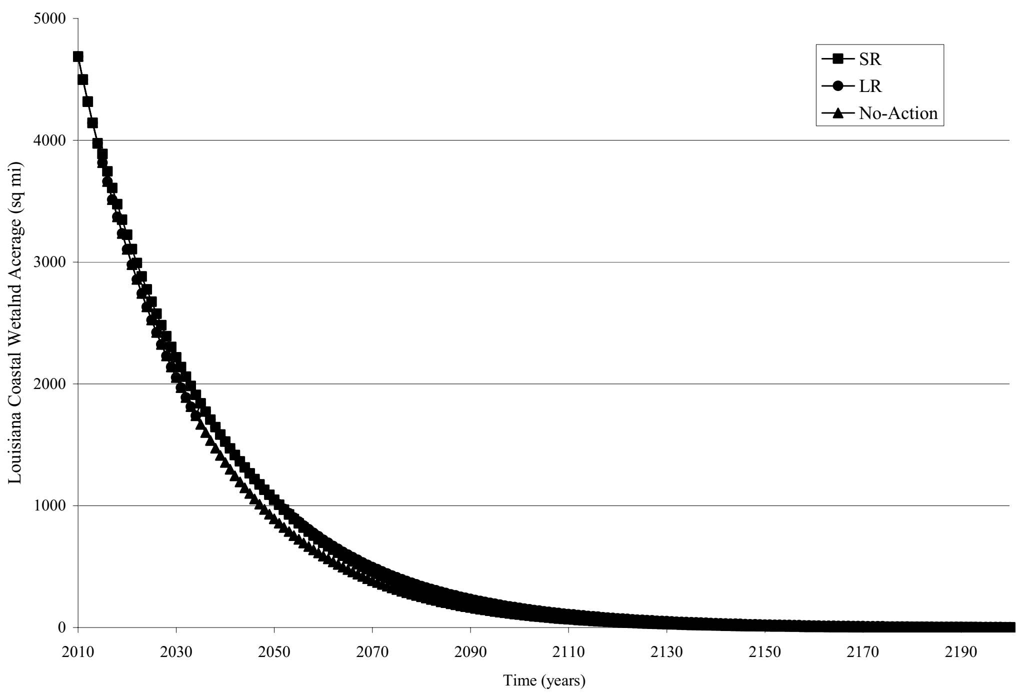


Figure 6 Discounted Land per Year for the Three Proposals

There could be many factors that could cause an individual to discount the proposals in such a way that a proposal that actually provides less aggregate benefits could be chosen over a proposal that provides more aggregate benefits. The factors that could affect discounting were discussed earlier and questions are asked on the survey that provides data to test if they have an affect on the respondent's decision making process.

Risk

Since the decision in question can have implications for improving an individual's safety it is hypothesized that an individual's risk perception and risk preference will have an affect on the decision between the three proposals. The conclusions of Lusk and Coble (2005) imply that both risk preferences and risk perceptions could affect the public's willingness to pay for the prevention of future wetland loss projects. The question is how individuals perceive a risk from the loss of wetlands and if those perceptions affect their willingness to pay for these projects. Information that will allow this hypothesis about risk perception and preferences to be tested was obtained through the survey.

One way of obtaining risk perceptions is to obtain information on the respondents' expectations of how often a category 3 or greater hurricane will affect them. These hurricane expectations are hypothesized to affect a respondent's decision because one proposed benefit of wetland loss prevention is believed to be reduced risk from hurricanes. Risk preferences were obtained through a question asking if respondents would make a gamble. This question will determine respondents' risk preferences and it is hypothesized that their risk preferences will affect their decisions.

### Perceived Benefits

Petrolia and Kim (2009) found that the perceived benefits had an affect on a respondent's willingness to pay for restoration of barrier islands. Due to this it is hypothesized that the benefit that respondents believe they will obtain from the prevention of wetland loss affects their decision in the choice model in this thesis as well. The question that provides this data is discussed in the next chapter.

### Proximity to the Coast

The variable for proximity from the coast is hypothesized to affect a respondent's decision because if an individual lives closer to the coast the benefits of the actions can have more of an impact than it would upon someone who does not live in close proximity to the coast. This was obtained in the survey by asking respondents where they live and their residence information to develop a proxy measurement for distance from the coast.

### Payment Mechanism

The survey also elicits the respondent's willingness to support the prevention of future wetland loss by splitting the survey versions in half based on the payment mechanism used to test for the difference between the willingness to pay and willingness to accept. Thus, this thesis investigates whether the framing of the question as WTP or WTA has any effect on the value that people place on the prevention of future wetland loss.

Question Order

The order in which the long run and short run were presented in the survey was different between the two versions of the survey. Half of the surveys had the long run proposal presented first and then the short run. The order was reversed for the other half. This treatment will also be tested if it had an effect on the decision between the proposals.

*Survey Results*

This section discusses the survey results, the questions that were asked, and the data that were provided to test the previously stated hypotheses.

A total of six-hundred eighty surveys were returned. Of those returned five-hundred one came from the first mailing and one-hundred seventy-nine came from the second mailing, and making up 73.72% and 26.28%, respectively, of the total. The overall response rate was 22.7%.

Table 2 shows a comparison of the sample and the population demographics. Population data is from the 2006-2008 American Community Survey estimates (USCB 2010). The sample is older, whiter, more male, more educated, and wealthier than the population. Twenty four percent of the sample is over the age of 65 where as the percentage of the population over 65 is just 12.60%.The sample is 81% and the population is 64% white. The sample is 60.47% male while the population is 49.30% male. Also, 55.38% of the sample holds an associates degree or higher, whereas only 25% of the population had achieved an associates degree or higher. Additionally, the sample's median income is $16,382 higher than the population median income of $58,911.

Table 2

Comparison of Sample and Population Demographics
Proportions (N = 511)

| | | Sample | Population* |
|---|---|---|---|
| Household size | | 2.51 | 2.63 |
| Age: 65 or over | | 23.87% | 12.60% |
| Education | H.S. diploma | 41.49% | 35.30% |
| | Associates or Bachelor's degree | 37.18% | 18.40% |
| | Graduate or Professional degree | 18.20% | 6.70% |
| Income | | $75,293 | $58,911 |
| Gender | Males | 60.47% | 49.30% |
| Race | White | 81.02% | 64.30% |

*Population data from ACS 06-08 estimates

Kruskal-Wallis and two-sample tests of probability were used to determine if there was a significant difference in demographics across the two previously stated survey treatment groups, WTP/WTA and question order of long and short run proposals. No significance was found across treatment samples except for difference in education and years lived in their stated zip code under the WTP/WTA treatment. The education variable was significant at the 5% probability level ($p = 0.0434$; means for each treatment are 1.77 for WTP and 1.65 for WTA). The variable for how many years the respondent has lived in this zip code was significant at the 5% probability level ($p = .0152$; the mean number of years for WTP treatment = 22.23 and for WTA treatment = 22.94). Although statistically significant, these differences are not considered to be a cause for concern.

Accordingly, this research was carried out under the assumption that the treatment samples are not biased to the extent of being a serious concern.

Table 3 illustrates the respondents' preferences between the long run proposal, short run proposal, and no action being taken. Of the 511 responses 79.06% preferred some action being taken to prevent future wetland loss, while only 20.94% responded that they preferred no action to be taken.

Table 3

Preference Between Long/Short/No Action

| Variables | Frequency | Percent |
|---|---|---|
| Short run | 370 | 72.41% |
| Long run | 34 | 6.65% |
| No action | 107 | 20.94% |
| Total responses | 511 | |

Table 4 shows the number of votes that each proposal received under the ten different bids. The table also separates the WTP from the WTA votes.

Respondents were asked a question to determine what benefits were important to them when they were making their decision.

"*Regardless of how you voted in the previous questions, what potential benefit was of greatest importance when making your decisions?"*

Table 5 shows the different options the respondents were given and the number of votes each one received. The potential benefits that were of the most importance to the respondents were storm protection and protection of the environment/ecosystem, which made up 55.19% and 19.96% of the responses respectively. The next potential benefit that respondents had in mind was actually no potential benefit in mind, and made up 13.11% of the responses to this question.

Table 4

Frequency of "Yes" Responses for Willingness to Pay Responses and Willingness to Accept at Different Bids

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Willingness to Pay | | | | | | | | | | | |
| | $50 | $71 | $101 | $144 | $204 | $291 | $413 | $588 | $836 | $1,189 | Total |
| Short run | 20 | 20 | 13 | 22 | 11 | 16 | 16 | 10 | 15 | 7 | 150 |
| Long run | 1 | 1 | 2 | 3 | 4 | 2 | 1 | 0 | 0 | 4 | 18 |
| No action | 7 | 8 | 7 | 11 | 2 | 9 | 6 | 6 | 12 | 9 | 77 |
| Total | 28 | 29 | 22 | 36 | 17 | 27 | 23 | 16 | 27 | 20 | 245 |
| Willingness to Accept | | | | | | | | | | | |
| | $50 | $71 | $101 | $144 | $204 | $291 | $413 | $588 | $836 | $1,189 | Total |
| Short run | 24 | 18 | 23 | 21 | 18 | 28 | 19 | 15 | 25 | 29 | 220 |
| Long run | 2 | 2 | 1 | 0 | 1 | 0 | 3 | 3 | 1 | 3 | 16 |
| No action | 3 | 3 | 1 | 3 | 2 | 4 | 1 | 4 | 3 | 6 | 30 |
| Total | 29 | 23 | 25 | 24 | 21 | 32 | 23 | 22 | 29 | 38 | 266 |

Table 5

Potential Benefits of Greatest Importance

| Potential benefits | Frequency | Percentage |
|---|---|---|
| Storm protection | 282 | 55.19% |
| Protection of recreational opportunities | 16 | 3.13% |
| Protection against sea-level rise due to climate change | 25 | 4.89% |
| Protection of the environment/ecosystem | 102 | 19.96% |
| Protection of commercial fisheries | 8 | 1.57% |
| Other | 11 | 2.15% |
| No potential benefits in mind | 67 | 13.11% |
| Total | 511 | |

The following four questions obtained data on the respondent's perceptions of climate change and its effects on the respondent's decision between the three proposals. Table 6 shows the results for the question:

*"Scientists believe that climate change is occurring and that it may have significant potential consequences, such as increased temperatures leading to sea-level rise. How strongly do you believe that climate change should be taken seriously?"*

It can be seen from this table 77.1% of respondents believe that climate change should be taken seriously.

Table 6

Belief in Climate Change

| | Frequency | Percentage |
|---|---|---|
| Very strongly | 222 | 43.44% |
| Somewhat strongly | 172 | 33.66% |
| Not at all | 80 | 15.66% |
| I don't know | 37 | 7.24% |
| Totals | 511 | |

The following question was asked to obtain the respondents expectations about how often hurricanes such as Katrina and Rita will make landfall in Louisiana.

*"How often do you expect a Category 3 hurricane (wind speeds of 111 – 130 mph and a storm surge of 9-12 feet) or greater to pass within 80 miles of your home? (As examples, Hurricane Katrina and Rita made landfall as Category 3 hurricanes in 2005.)"*

Table 7 shows the responses to this question. Seventy four percent of respondents believe that a Category 3 hurricane would affect them somewhere in between once a year and once every 10 years. Most of the respondents perceived frequency to be higher than the actual frequency which is approximately once in every 37.5 years (NHC, 2010). Through this hurricane expectation a measure of risk perception is obtained.

Table 7

Category 3 Hurricanes Expectation

| | Frequency | Percentage |
|---|---|---|
| Once a year or more | 69 | 13.50% |
| Once every 2-5 years | 204 | 39.92% |
| Once every 10 years | 105 | 20.55% |
| Once every 20 years | 29 | 5.68% |
| Once every 30 years | 9 | 1.76% |
| Once every 50 years | 7 | 1.37% |
| Once every 100 years or more | 24 | 4.70% |
| I don't know | 64 | 12.52% |
| Total | 511 | |

Table 8 shows the responses to the following question.

*"Suppose you won $50, and had the opportunity to either walk away or gamble to win more money (or lose some). Please read each choice very carefully and choose what you would do."*

The question provides data needed to test the hypothesis that risk preferences affect an individual's decision between proposals. It can be seen that 31.51% were willing to make gamble of some kind.

Table 8

Gamble/Risk Preference

| | Frequency | Percentage |
|---|---|---|
| Walk away with $50 | 350 | 68.49% |
| Gamble the $50 equal chance $70/$30 | 105 | 20.55% |
| Gamble the $50 equal chance $90/$10 | 56 | 10.96% |
| Total | 511 | |

The following question was asked to provide data on how confident they are that the government will be able to carry out the type of proposals outlined in the survey.

"*In general, how much confidence do you have in the ability of government agencies to carry out coastal restoration efforts efficiently and in a timely manner?*" Table 9 shows the results to this question. It can be seen the almost half of the respondents stated having no confidence in government to carry out these proposals.

Table 9

Confidence in Government to
Accomplish Restoration

| | Frequency | Percentage |
|---|---|---|
| Very confident | 32 | 6.26% |
| Somewhat confident | 214 | 41.88% |
| Not at all confident | 233 | 45.60% |
| I don't know | 32 | 6.26% |
| Total | 511 | |

The following question was asked to determine if individuals thought that there responses to the survey would actually have any effect on what actions were taken.

*"Do you think that your votes on the proposals presented here will have any influence on the actual actions taken by the State of Louisiana?"*

Table 10 shows the responses to this question. Almost half of the respondents indicated that they do not believe their responses to this survey would affect policy decisions.

Table 10

Belief that Response Will Influence Actual
Actions by the State of Louisiana

| | Frequency | Percentage |
|---|---|---|
| Yes | 96 | 18.79% |
| No | 239 | 46.77% |
| I don't know | 176 | 34.44% |
| Total | 511 | |

Table 11 shows the responses to the question:

*"Since 1990, the State of Louisiana has been working to restore and to manage coastal wetlands in order to prevent future land losses. Prior to this survey, were you aware of these efforts taking place in Louisiana?"*

This question provides insight into the knowledge that individuals had prior to the survey and allow for testing to see if this knowledge affects their choice. The majority of the population was of aware of previous restoration efforts.

Table 11

Aware of Restoration Efforts

| | Frequency | Percentage |
|---|---|---|
| Yes | 402 | 78.67% |
| No | 109 | 21.33% |
| Total | 511 | |

# CHAPTER V

# ECONOMETRIC ESTIMATION

This chapter describes the multinomial logit model used to estimate the model. This chapter also discusses hypothesis tests that were performed on the model.

*Multinomial Logit Model*

The multinomial logit model was used given the trichotomous unordered discrete dependent variable. The following discussion of the multinomial logit model is based upon Greene (2000). The model below, (18), is a multinomial logit using the model specification shown in equation (34). The model specification being shown in this example allows for a bounded income model. The reason why this specification was used will be discussed in the next section.

$$\text{Prob}(Y = j) = \frac{\exp[(-\mathbf{z}_i\boldsymbol{\gamma} - \ln\left(\frac{y_i - t}{t}\right))/\sigma]}{1 + \sum_{k=1}^{J}\exp[(-\mathbf{z}_i\boldsymbol{\gamma} - \ln\left(\frac{y_i - t}{t}\right))/\sigma]}, j = 0,1,\ldots,J \qquad 18$$

In this equation $\mathbf{z_i}$ is a dimensional vector of characteristics, $\boldsymbol{\gamma}$ is a dimensional vector of parameters, σ is the unknown standard error, $y_i$ is the individual's income, and $t$ is the bid. The estimated equations provide a set of probabilities for the J +1 choices for a decision maker $i$ with characteristics $z_i$. Any indeterminacies in the model must be removed. If any vector of $\mathbf{q}$ is defined as $\boldsymbol{\gamma}_\mathbf{j}^* = \boldsymbol{\gamma}_\mathbf{j} + \mathbf{q}$, then the identical set of probabilities result because the terms involving q all drop out. A normalization that solves this problem is to assume that $\boldsymbol{\gamma}_0 = \mathbf{0}$. The probabilities become

$$\text{Prob}(Y = j) = \frac{\exp[(-\mathbf{z}_i\boldsymbol{\gamma} - \ln\left(\frac{y_i - t}{t}\right))/\sigma]}{1 + \sum_{k=1}^{J} \exp[(-\mathbf{z}_i\boldsymbol{\gamma} - \ln\left(\frac{y_i - t}{t}\right))/\sigma]}, j = 1,...., J, \quad 19$$

$$\text{Prob}(Y = 0) = \frac{1}{1 + \sum_{k=1}^{J} \exp[(-\mathbf{z}_i\boldsymbol{\gamma} - \ln\left(\frac{y_i - t}{t}\right))/\sigma]}. \quad 20$$

The model implies that the J log-odds can be computed

$$\ln\left[\frac{P_{ij}}{P_{i0}}\right] = \mathbf{z}'_j \, \boldsymbol{\gamma}_i . \quad 21$$

This could normalized on any other probability and obtain

$$\ln\left[\frac{P_{ij}}{P_{ik}}\right] = \boldsymbol{\gamma}'_i \, (\mathbf{z}_j - \mathbf{z}_k) . \quad 22$$

The multinomial model estimation is as follows. The log-likelihood can be derived by defining, for each individual, $d_{ij} = 1$ if alternative $j$ is chosen by individual $i$, and 0 if not, for the $\boldsymbol{J} + 1$ possible outcomes. Then, for each $i$, only one of $d_{ij}$'s is 1. Also, $w_{ij}$ is a sample weight that is added to the model. The log-likelihood is a generalization of the multinomial logit model:

$$\ln L = \sum_{i=1}^{n} \sum_{j=0}^{j} w_j d_{ij} \ln \text{Prob}(\text{Y}_\text{i} = j) . \quad 23$$

By differentiating (1), the marginal effects of the characteristics on the probabilities are

$$\delta_j = \frac{\partial P_j}{\partial \mathbf{z}_i} = P_j[\boldsymbol{\gamma}_j - \sum_{k=0}^{J} P_k \boldsymbol{\gamma}_k] = P_j[\boldsymbol{\gamma}_j - \bar{\boldsymbol{\gamma}}]. \quad 24$$

Due to this, every subvector of $\boldsymbol{\gamma}$ enters every marginal effect, through the probabilities and through the weighted average that appears in $\boldsymbol{\delta}_j$. These values are computed with the parameter estimates. Although the usual focus is on coefficient estimates, equation (24) suggests that there is at least some potential for confusion. Note, for example, that for any particular $x_k$, $\partial P_j/\partial \mathbf{z}_k$ need not have the same sign as $\boldsymbol{\gamma}_{jk}$.

In Stata the errors are estimated using the delta method. The delta method described here is presented in the Stata Manual (2009). The maximum-likelihood function can be written

$$\mathbf{G}(\boldsymbol{\gamma}) = \sum_{j=1}^{n} \mathbf{S}(\boldsymbol{\gamma}; y_j, \mathbf{z}_j) = 0 \qquad 25$$

Where $\mathbf{S}(\boldsymbol{\gamma}; y_j, \mathbf{z}_j) = \partial \ln L_j / \partial \boldsymbol{\gamma}$ is the score and $\ln L_j$ is the log likelihood for the $j$th observation. The using the delta method the variance of $\mathbf{G}(\boldsymbol{\gamma})$ can be written as

$$\hat{V}\{\mathbf{G}(\boldsymbol{\gamma})\}\Big|_{\boldsymbol{\gamma}=\hat{\boldsymbol{\gamma}}} = \frac{\partial \mathbf{G}(\boldsymbol{\gamma})}{\partial \boldsymbol{\gamma}}\Bigg|_{\boldsymbol{\gamma}=\hat{\boldsymbol{\gamma}}} = \hat{V}(\hat{\boldsymbol{\gamma}}) \frac{\partial \mathbf{G}(\boldsymbol{\gamma})}{\partial \boldsymbol{\gamma}'}\Bigg|_{\boldsymbol{\gamma}=\hat{\boldsymbol{\gamma}}}. \qquad 26$$

Solving for $\hat{V}(\hat{\boldsymbol{\gamma}})$ yields

$$\hat{V}(\hat{\boldsymbol{\gamma}}) = \left[ \left\{ \frac{\partial \mathbf{G}(\boldsymbol{\gamma})}{\partial \boldsymbol{\gamma}} \right\}^{-1} \hat{V}\{\mathbf{G}(\boldsymbol{\gamma})\} \left\{ \frac{\partial \mathbf{G}(\boldsymbol{\gamma})}{\partial \boldsymbol{\gamma}'} \right\}^{-1} \right] \Bigg|_{\boldsymbol{\gamma}=\hat{\boldsymbol{\gamma}}} \qquad 27$$

Since the Hessian (matrix of the second derivates) of the log likelihood is

$$\mathbf{H} = \frac{\partial \mathbf{G}(\boldsymbol{\gamma})}{\partial \boldsymbol{\gamma}}, \qquad 28$$

$\hat{V}(\hat{\boldsymbol{\gamma}})$ can be written

$$\hat{V}(\hat{\boldsymbol{\gamma}}) = \mathbf{D}\hat{V}\{\mathbf{G}(\boldsymbol{\gamma})\}\big|_{\gamma=\hat{\gamma}}\mathbf{D} \qquad 29$$

where $\mathbf{D} = -\mathbf{H}^{-1}$ is the traditional covariance estimate.

$\mathbf{G}(\boldsymbol{\gamma})$ is simply a sum, and the variance can be estimated the same as it would for the sum of any other variable. Here the scores $\mathbf{u}_j = \mathbf{S}(\boldsymbol{\gamma}; y_j, \mathbf{z}_j)$ are row vectors. Their sum is zero, meaning that their mean is also zero. This yields

$$\hat{V}\{G(\boldsymbol{\gamma})\}\big|_{\gamma=\hat{\gamma}} = \frac{n}{n-1}\sum_{j=1}^{n}\mathbf{u'}_j\mathbf{u}_j\,. \qquad 30$$

The robust variance estimator is

$$\hat{V}(\hat{\boldsymbol{\gamma}}) = \mathbf{D}\left(\frac{n}{n-1}\sum_{j=1}^{n}\mathbf{u'}_j\mathbf{u}_j\right)\mathbf{D}\,. \qquad 31$$

*Income and Bid Specification*

There are multiple options for the modeling of income and bid in a contingent valuation model. The way it was shown earlier in the random utility model discussion assumed a constant marginal utility of income. In a model where linear marginal utility of income is assumed, willingness to pay is not actually a function of income but only bid. The raw results indicated that there was not a point where the number of responses in support of the short run or the long run proposals began to decrease as bid increases. This is contrary to economic theory where as the cost (here the bid) of the good increases then the willingness to purchase the good should decrease (the votes for support). Due to this, a model is needed that also takes income into account. The log-linear utility of income models and Box-Cox models allow income and bid to be accounted for in the model. These models do not restrict the marginal utility of income to be constant.

Another type of log-linear model is a bounded log-linear income model. The use of bounded log-linear income variables is supported by Haab and McConnell (1998) when the upper bound on willingness to pay estimates exceeds income, which was the case when income was not bounded in this model. This method is also recommended because it does not use an arbitrary truncation and allows for consistency between estimation parameters and calculation of WTP. The model being bounded by income forces the upper bound to be equal to income. The random willingness to pay model allows for this type of income variable to be implemented. Haab and McConnell (2002) show a direct way of deriving a model that bounds willingness to pay by income:

$$WTP_j = G(\mathbf{z}_j \boldsymbol{\gamma} + \varepsilon_j) y_j \qquad 32$$

Where $0 \leq G(\mathbf{z}_j \gamma + \varepsilon_j) \leq 1$ and $G'(\mathbf{z}_j \boldsymbol{\gamma} + \varepsilon_j) \geq 0$. The function $G(\mathbf{z}_j \boldsymbol{\gamma} + \varepsilon_j)$ is willingness to pay as a proportion of income. A tractable version of this model is

$$WTP_j = \frac{y_j}{1 + \exp(-\mathbf{z}_j \boldsymbol{\gamma} - \varepsilon \;)}. \qquad 33$$

The mathematical equations of the probability of a yes response using the random willingness to pay model is

$$\Pr(yes_i) = 1 - F_{WTP}(t) = \frac{1}{1 + \exp[(-\mathbf{z}_i \boldsymbol{\gamma} - \ln\left(\frac{y_i - t}{t}\right)) / \sigma]}. \qquad 34$$

The variable $\ln\left(\frac{y_i - t}{t}\right)$ was generated to provide the bounded income variable in the multinomial logit model.

*Econometric Model Specification*

As previously stated this thesis uses a multinomial logit model to measure the effect of factors on the individual decision between one of three proposals. This section discusses which variables are in the final multinomial logit model that is estimated. Also, the specification of the factors of theoretical and primary concern, mentioned in Chapter IV, is discussed here. This section also discusses which survey questions are used to represent these factors in the model and how the variables are specified. Table 12 provide the descriptions and means of the independent variables that are in the model.

The demographic variables that are used in this model are gender, race, age, household size, and education. To obtain a variable that accounted for the respondent's proximity to the coast the zip code they provided was used to identify a corresponding latitude value that was obtained from 2000 Census gazetteer files for counties (USCB, 2010).

Multiple questions were asked in the survey to determine the respondent's perception of climate change. All of the questions were highly correlated with one another. The question that was used to generate the variable in the model was discussed in Chapter IV. This question was chosen out of the four correlated questions to represent respondent's climate change perceptions because it was believed to be the most representative of the respondent's climate change perceptions.

Table 12

Multinomial Logit Model Variables and Descriptions

| Variables | Type | Description | Mean |
|---|---|---|---|
| Income-Bid | Ordered Categorical | $\ln\left[\frac{(y_j - t_j)}{t_j}\right]$ | 5.15 |
| Gender | Binary | 1 if male; 0 if female | 0.56 |
| Race | Binary | 1 if white; 0 otherwise | 0.76 |
| Age | Continuous | Continuous between 19 - 84 | 54.31 |
| Household | Ordered Categorical | Household size 1 if # is 1; 2 if # is 2; 3 if #; 4 if # is 4; 5 if # is 5 or greater | 2.46 |
| Education | Ordered Categorical | Highest level of education 1 if some school or high school; 2 if associates or bachelors; 3 if masters, professional, or doctoral | 1.64 |
| Latitude | Continuous | Latitude based upon zip code of respondent | 30.69 |
| StormBenefit | Binary | 1 if storm protection was most important benefit, 0 if otherwise | 0.54 |
| EnivronmentBenefit | Binary | 1 if environment protection was most important benefit, 0 if otherwise | 0.18 |
| CCBenefit | Binary | 1 if protection against sea-level rise due to climate change was most important benefit, 0 if otherwise | 0.06 |

Table 12 (Continued)

| Variables | Type | Description | Mean |
|---|---|---|---|
| CCperception | Binary | 1 if respondents do not at all believe in climate change; 0 otherwise | 0.13 |
| PreKnowledge | Binary | 1 if respondent had prior knowledge of actions to protect wetlands; 0 otherwise | 0.76 |
| Government | Binary | 1 if no confidence that government agency can accomplish such actions; 0 otherwise | 0.43 |
| Influence | Binary | 1 if respondents believe responses will influence policy; 0 otherwise | 0.20 |
| RiskPref | Binary | 1 if respondents does not take a gamble; 0 otherwise | 0.69 |
| HurrFreqHI | Binary | 1 if respondent believes a Category 3 hurricane will affect them between 1 and 10 years; 0 otherwise | 0.73 |
| LongRunFirst | Binary | 1 if long run proposal was presented first; 0 if short sun was presented first | 0.51 |
| WTP | Binary | 1 if the payment mechanism was willingness to pay; 0 if willingness to accept | 0.47 |

The survey also provided data that allowed for the calculation of discount rates for the respondents. Due to the fact that the proposals presented in the survey span a number of years it was hypothesized that respondents' discount rates could have an effect on the choice among the three options. The discount rate variable was found to be correlated with age. This correlation caused the age parameter to become insignificant when the discount rate was included in the model. Due to this, the discount variable was left out of the model, and the age variable was left in the model.

Risk preferences and risk perceptions were factors that were hypothesized to have an effect on respondent's decision between the three proposals. The risk preference variable was taken from the gamble question on the survey. The category 3 hurricane frequency question on the survey provided the variable for risk perceptions. The responses were split into one of three categories by comparing response sets to actual hurricane frequency. The high frequency group contained those respondents that expected a category 3 hurricane to make landfall once every 1 - 10 years, the low frequency group expected landfall once every 11 - 100 or more years, and the last group were those that responded that they did not know the frequency. The actual frequency at which a category 3 hurricane would affect the respondents is approximately once in every 37.5 years (NHC, 2010). The respondent's hurricane frequency expectations are being assumed to be a proxy of the respondents risk perceptions in this model.

Confidence in government is another factor that is in the model to determine if it affects the respondent's decision. One of the questions in the survey asked respondents if they believed government would be able to accomplish the proposals presented in the survey. This variable is determining if respondent's lack of confidence in government deters them from being willing to support these proposals.

Another factor that is tested in contingent valuation studies is the respondent's prior knowledge of the issue. Though information about the issue of coastal wetland loss and the efforts to prevent it were outlined in the survey, it is important to determine if respondent's prior knowledge of these issues has an effect on the respondent's choice. Carson, Flores and Meade (2001) discuss how prior knowledge of a good can affect contingent valuation studies such as this one. In the survey there was a question that asked individuals if they were familiar with the restoration efforts that had been taking place in Coastal Louisiana. The responses to this question are being used to determine how prior knowledge of the issue affects their decision.

A variable that is typically present in contingent valuation studies is an influence or a consequence variable. The purpose of this type of variable is to determine if the respondent believes that their responses will actually affect policy decisions. Kolstad (2000) and Hanemann (1994) both discuss how this type of hypothetical bias can affect contingent valuation studies and justification for the contingent valuation method. The model includes a variable that reflects whether respondent's decisions were affected by their belief that their responses would or would not affect policies.

Two treatment variables are in the model as well. The order in which the proposals were presented in the survey, either the long run proposal first and the short run proposal second, or vice versa. Also, there is a variable that accounts for the payment mechanism being willingness to pay (tax) or willingness to accept (tax refund).

*Sample Weights*

It was mentioned earlier that our sample is older, whiter, more male, more educated, and wealthier than the population of interest. To mitigate this problem to some extent, a probability weight was used to make the sample more representative of the population. Using the income variable from the sample and population income data available through the 2006-2008 American Community Survey (USCB, 2010) probability weights were generated that were used to weight the likelihood function. The weights were generated by taking the probability of the sample that fell within a range of incomes and equivalent probabilities for the population and then calculating a weight that made the probabilities for the income ranges equal across the sample and population. The probability weights that were used are shown in Table 13.

Table 13

Probability Weights

| Income | Population | Sample | Weight |
|---|---|---|---|
| Less than $14,999 | 17.90% | 8.33% | 2.14886 |
| $15,000 - $24,999 | 12.70% | 10.20% | 1.245098 |
| $25,000 - $34,999 | 11.60% | 10.03% | 1.15653 |
| $35,000 - $49,999 | 14.30% | 14.80% | 0.966216 |
| $50,000 - $74,999 | 17.20% | 18.20% | 0.945055 |
| $75,000 - $99,999 | 10.80% | 14.12% | 0.764873 |
| $100,000 - $149,999 | 9.90% | 15.65% | 0.632588 |
| $150,000 - more | 5.40% | 8.67% | 0.622837 |

Table 14 shows the same demographics values for the sample and the population that were covered in Table 2, as well as the weighted sample values for those demographics. The sample's household size, being over 65 years of age, and education level of high school become less representative of the population when calculated using the sample weight. However gender, race, income, associates or bachelor's degree, and graduate or professional degree all become more representative of the population. This indicates that while the sample weight is not perfect, it does cause the sample to become more representative of the population.

Table 14

Comparison of Sample, Weighted Sample, and Population Demographics Proportions (N = 511)

| | | Sample | Weighted Sample | Population* |
|---|---|---|---|---|
| Household size | | 2.51 | 2.46 | 2.63 |
| Age: 65 or over | | 23.87% | 25.50% | 12.60% |
| Education | H.S. diploma | 41.49% | 46.46% | 35.30% |
| | Associates or Bachelor's degree | 37.18% | 32.87% | 18.40% |
| | Graduate or Professional degree | 18.20% | 15.34% | 6.70% |
| Income | | $75,293 | $60,429 | $58,911 |
| Gender | Males | 60.47% | 55.68% | 49.30% |
| Race | White | 81.02% | 76.13% | 64.30% |

*Population data from ACS 06-08 estimates

*Hypothesis Testing*

The following section discusses statistical tests that were conducted. The tests and the estimation of the multinomial logit were performed in Stata 10.0 (2007). Since this is a multinomial logit there are three sets of coefficients that are obtained. In this thesis the three sets are short run vs. no action, long run vs. no action, and long vs. short run.

Test of Sub-Sample Model Equivalence

Tests of structural differences were performed if it was hypothesized that there may be structural difference between sub-samples. Willingness to pay vs. willingness to accept, confidence in government, and a latitude variable that split respondents between coastal and non-coastal were variables that were believed to be potential source of structural difference. These hypotheses were tested by splitting the sample according to each of the sub-samples noted above, estimating the model separately for each sub-sample, and performing an adjusted Wald test (equivalent to a Chow test) to determine if there were statistically significant differences between the parameters estimated for each of these sub-samples. Table 15 presents the probability associated with these tests. This multinomial model has two tests: one for the parameters in the short run equations, and the other for the parameters in the long run equation. The tests of parameter equivalence were rejected for all of the tests except the test of low latitude and high latitude for the long run parameters. Individual parameters were then tested for significant difference across sub-samples using the adjusted Wald test. This narrowed down the number of structural differences across the sub-samples to specific parameters.

Table 15

Adjusted Wald Test Results for Sample Splits

| Sample Splits | Prob. > F |
|---|---|
| $H_o$: Confidence in government SR = No confidence in government SR | 0.11 |
| $H_o$: Confidence in government LR = No confidence in government LR | 0.10 |
| $H_o$: Low latitude SR = High latitude SR | 0.75 |
| $H_o$: Low latitude LR = High latitude LR | 0.00* |
| $H_o$: WTP SR = WTA SR | 0.08 |
| $H_o$: WTP LR = WTA LR | 0.08 |

Null hypothesis that split samples are not different
*Significant at p = 0.05

One way to handle these statistical differences of parameters across split samples is the use of interaction variables. One of the pitfalls of including many interactions terms is multicollinearity. Additionally, some interaction terms can have no theoretical interpretation. A small number of interaction terms were tested to determine if they were significant in the model.

Table 16 presents the interaction terms and the p values associated with each. All of the interaction variables in Table 16 were omitted because of lack of significance. Two other interaction terms were considered. An interaction action between no belief in climate change and no confidence in government was tested in the model. This interaction terms was omitted from the model because for the long run equation no standard errors could be obtained. It is believed this is due to mulicollinearity caused by a high correlation between this interaction term and the no belief in climate change variable (correlation = 0.7213). The other interaction term between no belief in climate change and protection from climate change perceived benefits was considered. After the creation of this variable it was found that all the observations became 0, indicating that the two were mutually exclusive and there was no interaction between the two. Though an interaction term was not implemented into the model to account for the lack of parameter equivalence for low latitude long run equation and the high latitude long run equation, the affect that low latitude has across the equations is estimated in the model through the latitude variable.

Table 16

Interaction Term Significance

| | Interaction Terms | P> \|z\| |
|---|---|---|
| Short run vs. No Action: | PreKnowledge*Government | 0.13 |
| | Latitude*Income-Bid | 0.20 |
| | Latitude*HurrFreqHI | 0.18 |
| | WTP*Income-Bid | 0.69 |
| | Government*Income-Bid | 0.89 |
| Long Run vs. No Action: | PreKnowledge*Government | 0.29 |
| | Latitude*Income-Bid | 0.18 |
| | Latitude*HurrFreqHI | 0.16 |
| | WTP*Income-Bid | 0.52 |
| | Government*Income-Bid | 0.43 |

Test of Parameter Equivalence

The model was also tested to determine if there was statistical differences in the parameters across the short run and long run equations. This was performed using adjusted Wald tests. The results of the adjusted Wald tests are shown in Table 17. The test results show that only the parameters for age, climate change benefit, question order dummy, and willingness to pay dummy were significant, indicating statistical difference across the two equations. Linear constraints were then placed on the model that forced the parameters of all other variables to be equal across the short run and long run regression equations.

Table 17

Adjusted Wald Tests for the Null Hypotheses that Each of the Parameters is Equal Across Short Run and Long Run Equations

| Parameter Tests | Prob. > $chi^2$ |
|---|---|
| $H_o$: Income-Bid SR =Income-Bid LR | 0.25 |
| $H_o$: Gender SR = Gender LR | 0.09 |
| $H_o$: Race SR = Race LR | 0.75 |
| $H_o$: Age SR = Age LR | 0.00* |
| $H_o$: Household SR = Household LR | 0.81 |
| $H_o$: Education SR = Education LR | 0.81 |
| $H_o$: Latitude SR = Latitude LR | 0.31 |
| $H_o$: StormBenefit SR = StormBenefit LR | 0.37 |
| $H_o$: EnvironmentBenefit SR = EnvironmentBenefit LR | 0.31 |
| $H_o$: CCBenefit SR = CCBenefit LR | 0.02* |
| $H_o$: CCperception SR = CCperception LR | 0.46 |
| $H_o$: PreKnowledge SR = PreKnowledge LR | 0.56 |
| $H_o$: Government SR = Government LR | 0.07 |
| $H_o$: Influence SR = Influence LR | 0.44 |
| $H_o$: RiskPref SR = RiskPref LR | 0.51 |
| $H_o$: HurrFreqHI SR = HurrFreqHI LR | 0.63 |
| $H_o$: LongRunFirst SR = LongRunFirst LR | 0.00* |
| $H_o$: WTP SR = WTP LR | 0.04* |

*Significant at p = 0.05

Test of Independence of Irrelevant Alternatives

The model was also tested to determine if the assumption of independence of irrelevant alternatives (IIA) was valid. Independence of irrelevant alternatives means that an individual's decision between two choices is not affected if a third (irrelevant) choice is introduced. The common test for this is the Hausman test, but because the likelihood function contained probability weights, a generalized Hausman was necessary, which in this case is an adjusted Wald test. Table 18 shows the IIA hypotheses tests that were performed. The adjusted Wald test indicated that the assumption holds for both short run and long run equations, because the tests failed to reject the null hypotheses that the unrestricted and restricted models are equal.

Table 18

Adjusted Wald Tests for the Hypotheses of Independence of Irrelevant Alternatives

| Null Hypotheses | Prob. > F |
|---|---|
| Ho: Unrestricted Model Short Run Equation Parameters = Restricted Short Run Equation Parameters | 0.07 |
| Ho: Unrestricted Model Long Run Equation Parameters = Restricted Long Run Equation Parameters | 0.75 |

*Significant at p = 0.05

# CHAPTER VI

# RESULTS

The results from the multinomial logit model discussed in the previous chapter are presented in this chapter. The marginal effects, relative risk ratios, and predicted probabilities are covered here. This chapter also contains the willingness to pay and willingness to accept estimates.

### *Coefficients, Standard Deviations, and Significance Levels*

Table 19 presents the estimated parameter coefficients, standard deviations, and significance levels for the multinomial logit model specified earlier, as well as measures of the model's fit. For convenience, also reported are the parameter coefficients of the model with short run as the base to allow for ease of interpretation of short run vs. long run. The parameter coefficients, standard deviations, and significance levels provided allow for the comparison of the short run proposal vs. no action, the long run proposal vs. no action, and the long run proposal vs. the short run proposal.

The decision to choose the short run proposal compared to no action is influenced by the bounded income-bid, race, age, storm protection primary benefit, protection of environment benefit, protection from climate change benefit, having previous knowledge of restoration efforts, no confidence in government, and the treatment for willingness to pay.

Table 19

Estimated Coefficients, Standard Errors, and Significance Levels for the Multinomial Logit Model

| | Short Run (Base No Action) | | | Long Run (Base No Action) | | | Long Run (Base Short Run) | | |
|---|---|---|---|---|---|---|---|---|---|
| Variables | Coef | | SE | Coef | | SE | Coef | | SE |
| Income-Bid[1] | 0.33 | *** | 0.10 | 0.33 | *** | 0.10 | | | |
| Gender[1] | 0.05 | | 0.32 | 0.05 | | 0.32 | | | |
| Race[1] | 0.76 | ** | 0.34 | 0.76 | ** | 0.34 | | | |
| Age | 0.02 | * | 0.01 | -0.03 | * | 0.02 | -0.05 | *** | 0.01 |
| Household[1] | 0.10 | | 0.13 | 0.10 | | 0.13 | | | |
| Education[1] | -0.06 | | 0.20 | -0.06 | | 0.20 | | | |
| Latitude[1] | 0.09 | | 0.17 | 0.09 | | 0.17 | | | |
| StormBenefit[1] | 2.33 | *** | 0.32 | 2.33 | *** | 0.32 | | | |
| EnvironmentBenefit[1] | 2.80 | *** | 0.53 | 2.80 | *** | 0.53 | | | |
| CCBenefit | 1.26 | * | 0.67 | 2.46 | *** | 0.79 | 1.20 | ** | 0.60 |
| CCperception[1] | -0.06 | | 0.37 | -0.06 | | 0.37 | | | |
| PreKnowledge[1] | 0.69 | ** | 0.33 | 0.69 | ** | 0.33 | | | |
| Government[1] | -1.06 | *** | 0.32 | -1.06 | *** | 0.32 | | | |
| Influence[1] | 0.11 | | 0.41 | 0.11 | | 0.41 | | | |
| RiskPref[1] | 0.23 | | 0.34 | 0.23 | | 0.34 | | | |
| HurrFreqHI[1] | 0.00 | | 0.36 | 0.00 | | 0.36 | | | |
| LongRunFirst | 0.00 | | 0.29 | -2.68 | *** | 0.72 | -2.68 | *** | 0.69 |
| WTP | -1.56 | *** | 0.31 | -0.84 | * | 0.50 | 0.72 | * | 0.42 |
| Constant | -5.87 | | 5.65 | -5.62 | | 5.68 | 0.26 | | 0.75 |

Observations = 511
Log Pseudoliklihood = -282.80
Wald chi2(22) = 138.51
Prob > chi2 = 0.00
Pseudo R2 = 0.28

***, **, * Significant at p = 0.01, 0.05 and 0.10, respectively
1. Constrained to be equal across Short Run and Long Run Equations

The decision to choose the long run proposal compared to no action is influenced by the bounded income-bid, race, age, storm protection primary benefit, protection of environment benefit, protection from climate change benefit, having previous knowledge of restoration efforts, no confidence in government, question order and the treatment for willingness to pay. Age, protection from climate change benefits, question order, and the willingness to pay treatment were the variables that influenced the decision between the long run proposal and the short run proposal.

*Marginal Effects*

Table 20 presents the marginal effects for the variables in the model evaluated at variable means. Also, the marginal effects for the binary variables are a discrete change from the base. Respondents that were white were 8.61 percent more likely to choose the short run proposal. As the respondent's age increases by a year the probability of choosing the short run proposal increases by 0.38 percent. Those respondents that stated that protection from storms was their primary benefit of concern were 29.13 percent more likely to choose the short run proposal. The probability of choosing the short run proposal increases by a probability of 22.94 percent if respondents stated that protection of the environment was the benefit that they were primarily concerned about when making there decision. Having prior knowledge of restoration efforts underway made respondents 7.81 percent more likely to choose the short run proposal. Respondents that were presented with the long run proposal first were 8.79 percent more likely to choose the short run proposal. Yet, respondents that had no confidence in government were 11.52 percent less likely to choose the short run proposal. Also, if the respondents received the willingness to pay payment mechanism the probability of choosing short run decreases by 20.49 percent.

Table 20

Average Marginal Effects Shown as Percentage Changes

| Variables | Short Run | Long Run | No Action |
|---|---|---|---|
| Income-Bid* | 0.0009% | 0.0001% | -.0010% |
| Gender[1] | 0.55 | 0.06 | -0.61 |
| Race[1] | 8.61 | 0.96 | -9.56 |
| Age[1] | 0.38 | -0.23 | -0.15 |
| Household | 1.07 | 0.12 | -1.19 |
| Education | -0.58 | -0.07 | 0.65 |
| Latitude | 0.94 | 0.10 | -1.04 |
| StormBenefit[1] | 29.13 | 2.91 | -32.04 |
| EnvironmentBenefit[1] | 22.94 | 2.40 | -25.35 |
| CCBenefit[1] | 2.30 | 11.39 | -13.69 |
| CCperception[1] | -0.65 | -0.07 | 0.72 |
| PreKnowledge[1] | 7.81 | 0.87 | -8.68 |
| Government[1] | -11.52 | -1.30 | 12.82 |
| Influence[1] | 1.17 | 0.13 | -1.30 |
| RiskPref[1] | 2.39 | 0.27 | -2.65 |
| HurrFreqHI[1] | -0.04 | 0.00 | 0.04 |
| LongRunFirst[1] | 8.79 | -11.35 | 2.56 |
| WTP[1] | -20.49 | 2.24 | 18.25 |

*For a $1,000 change in income

1: dy/dx for the binary variables is a discrete change from the base

As the respondents age increase by a year the probability of them choosing the long run proposal decreases by .23 percent. Respondents were 2.91 percent more likely to choose the long run proposal when their primary benefit of concern was protection from storms. Respondents were 2.4 percent more likely to choose the long run proposal when their primary benefit was protection of the environment. If protection from the effects of climate change was the respondent's primary benefit of concern the probability of the respondent choosing the long run proposal increase by 11.39 percent. If the respondent was presented with the long run proposal first then their probability of choosing the long run proposal decreases by 11.35 percent.

As the respondents age increases by a year the probability of the respondent choosing no action decreases by .15 percent. The probability of choosing no action also decreases by 32.04 percent when protection from storm was primary concern when making their choice. The probability of choosing no action decreases by 25.35 percent when protection of the environment is their primary benefit. The probability also decreases by 13.69 percent if protection from the effects climate change was their primary benefit. The probability of choosing no action increases by 12.82 percent if the respondent has no confidence in government. The probability of choosing no action also increases by 18.25 percent if the respondent received the willingness to pay payment mechanism.

*Relative Risk Ratios*

Table 21 presents the relative risk ratios or odds ratios associated with these parameter coefficients. The ratios are presented as percentage difference from the base option in the decision. The relative risk ratios represent the relative increase or decrease in the probability of observing the selected option relative to the base option. The mathematical equation for the calculation of the relative risk ratios is $RRR = \Pr\left(\frac{Y \mid x^1}{Y \mid x^2}\right)$.

Relative risk ratios are presented for all the variables in the model, but the ratios that correspond to variables that are significant are shown in bold.

Starting with variables that were shown to be significant for the decision between the short run proposal vs. no action, it was observed that individuals are 0.82 percent more likely to choose short run over no action for every $1,000 increase in income. Respondents that are white are 114 percent more likely to choose the short run proposal over no action being taken. As age increases by a year the probability of the respondent choosing the short run proposal over no action increases by 1.78 percent. If respondents stated that protection from storms was the primary benefit in mind when making the decision they were 932 percent more likely to choice short run over no action. Respondents that said protection of the environment was their primary benefit of concern then they were 1549 percent more likely to choose short run over no action. Respondents that stated protection against sea-level rise due to climate change as primary benefit of concern were 254 percent more likely to choose short run over no action. If the respondent answered that they had previous knowledge of restoration efforts taking place in coastal Louisiana they are 100 percent more likely to choose the short run proposal over no action. Respondents that had no confidence in the government to accomplish wetland loss prevention were 65 percent less likely to choose the short run proposal over the no action. Also, if respondents were given the payment mechanism of willingness to pay rather than the willingness to accept mechanism the probability of choosing short run over no action decreases by 79 percent.

Table 21

Relative Risk Ratios (interpreted as a percentage change from the base; base category is listed second)

| Variables | Short Run vs. No action | Long Run vs. No Action | Long Run vs. Short Run |
|---|---|---|---|
| Income-Bid | **0.82%*** | **0.82%*** | |
| Gender | 5.38% | 5.38% | |
| Race | **114.17%** | **114.17%** | |
| Age | **1.78%** | **-2.79%** | **-4.49%** |
| Household | 10.67% | 10.67% | |
| Education | -5.40% | -5.40% | |
| Latitude | 9.31% | 9.31% | |
| StormBenefit | **931.95%** | **931.95%** | |
| EnvironmentBenefit | **1548.57%** | **1548.57%** | |
| CCBenefit | **253.71%** | **1075.83%** | **232.43%** |
| CCperception | -5.92% | -5.92% | |
| PreKnowledge | **99.67%** | **99.67%** | |
| Government | **-65.20%** | **-65.20%** | |
| Influence | 11.85% | 11.85% | |
| RiskPref | 25.24% | 25.24% | |
| HurrFreqHI | -0.34% | -0.34% | |
| LongRunFirst | -0.02% | **-93.17%** | **-93.17%** |
| WTP | **-78.93%** | **-56.64%** | **105.77%** |

Ratios for significant are shown in bold

* For a $1,000 change in income

The bounded income-bid, race, storm protection primary benefit, protection of environment benefit, previous knowledge of restoration efforts, and confidence in government variables are the significant relative risk ratios that have the same effect in the decision of the long run proposal over no action as in the decision of the short run proposal over no action. When age increases by a year the probability of the respondent choosing the long run proposal over no action decreases by 2.79 percent. If respondents stated that protection from climate change was the primary benefit of concern they were 1076 percent more likely to choose the long run proposal over no action. If the long run proposal was presented first the respondent was 93 percent less likely to choose the long run proposal over no action. If respondents were given the payment mechanism of willingness to pay rather than the willingness to accept mechanism the probability of choosing long over no action decreases by 57 percent.

The variables that had an effect on the decision between the long run proposal over the short run proposal were age, protection from climate benefit, question order, and payment mechanism. As age increases by a year, the respondents are 4.49 percent less likely to choose the long run proposal over the short run proposal. If respondents stated that protection from climate change was the primary benefit of concern they were 232 percent more likely to choose the long run proposal over the short run proposal. Respondents that were presented with the long run proposal first were 93 percent less likely to choose the long run proposal over the short run proposal. Respondents were 106 percent more likely to choose the long run proposal over the short run proposal if the payment mechanism received was willingness to pay.

*Predicted Probabilities*

Table 22 shows the probabilities of choosing the short run proposal, long run proposal, and no action that were predicted using the model and the percentage of actual responses for each of the three proposals. There is little difference between the predicted probabilities and actual responses given on the survey.

Table 22

Predicted Probabilities of Proposal Preference
Compared to Actual Responses

| | Short Run | Long Run | No Action |
|---|---|---|---|
| Predicted Probabilities | 71.99% | 6.85% | 21.16% |
| Actual Responses | 72.41% | 6.65% | 20.94% |

The predicted probabilities of the choice variable were obtained for each of the options within each variable in the model, while holding all other variables constant. Table 23 represents these probabilities. These two tables show the probabilities of choosing one of the three proposals given a certain characteristic. Comparing the predictive probabilities of the options within a variable provides insight into how certain characteristics affect an individual's preference between the three proposals.

For instance, respondents that were white had substantially larger probabilities of choosing the short run proposal and smaller probability of choosing no action than did those individuals that were nonwhite. These probabilities show that as age increases the probability of choosing short run increases and the probability of choosing long run decreases.

Respondents that stated that they had no prior knowledge of restoration efforts taking place in Louisiana had a 44.20 percent predicted probability of choosing the short run proposal, but this probability increased to 55.06 percent for individuals that did have previous knowledge of restoration efforts. Also, individuals that had no prior knowledge were predicted to choose no action 52.19 percent of the time, while the probability of choosing no action decreased to 40.32 for those respondents that had prior knowledge.

Table 23

Predicted Probabilities of Proposal Preference

| Variables | | Short Run | Long Run | No Action |
|---|---|---|---|---|
| Gender: | Male | 72.21% | 6.88% | 20.91% |
| | Female | 71.69% | 6.82% | 21.49% |
| Race: | White | 73.75% | 7.03% | 19.21% |
| | Nonwhite | 65.45% | 6.09% | 28.46% |
| Age: | 30 | 61.92% | 13.78% | 24.30% |
| | 40 | 66.95% | 9.99% | 23.07% |
| | 50 | 71.32% | 7.04% | 21.64% |
| | 60 | 75.06% | 4.84% | 20.10% |
| | 70 | 78.22% | 3.27% | 18.51% |
| | 80 | 80.90% | 2.18% | 16.92% |
| Household size: | 1 | 70.32% | 6.64% | 23.04% |
| | 2 | 71.36% | 6.76% | 21.87% |
| | 3 | 72.37% | 6.88% | 20.75% |
| | 4 | 73.35% | 6.99% | 19.66% |
| | 5 and up | 74.30% | 7.10% | 18.60% |
| Education: | 1. High school or below | 72.36% | 6.90% | 20.74% |
| | 2. Associates or bachelors | 71.81% | 6.84% | 21.36% |
| | 3. Beyond a bachelors | 71.25% | 6.77% | 21.98% |
| Latitude: | 29 degree | 70.43% | 6.69% | 22.88% |
| | 30 degree | 71.35% | 6.79% | 21.86% |
| | 31 degree | 72.24% | 6.89% | 20.87% |
| | 32 degree | 73.10% | 6.99% | 19.91% |
| | 33 degree | 73.94% | 7.08% | 18.98% |

Table 23 (Continued)

| | Variables | Short Run | Long Run | No Action |
|---|---|---|---|---|
| StormBenefit: | Storm important benefit | 81.33% | 7.83% | 10.84% |
| | Otherwise | 53.45% | 4.93% | 41.62% |
| EnvironmentBenefit: | Environment important benefit | 83.13% | 8.05% | 8.82% |
| | Otherwise | 46.67% | 4.30% | 49.03% |
| ClimateChange-Benefit: | Climate change important benefit | 63.55% | 15.58 % | 20.87% |
| | Otherwise | 52.73% | 4.40% | 42.87% |
| Climate Change: | No Belief | 51.95% | 4.32% | 43.73% |
| | Believe | 52.89% | 4.41% | 42.70% |
| Prior Knowledge: | Prior knowledge | 55.06% | 4.62% | 40.32% |
| | No Prior Knowledge | 44.20% | 3.61% | 52.19% |
| Government: | No Confidence | 43.97% | 3.60% | 52.44% |
| | Confidence | 60.55% | 5.15% | 34.30% |
| Influence: | Believe responses matter | 61.90% | 5.28% | 32.82% |
| | Do not believe responses matter | 60.22% | 5.12% | 34.66% |
| Risk Preference: | No gamble | 61.57% | 5.28% | 33.15% |
| | Gamble | 58.15% | 4.95% | 36.90% |
| HurrHiFreq: | Believe in high hurricane frequencies | 60.53% | 5.15% | 34.31% |
| | Otherwise | 60.58% | 5.16% | 34.26% |
| Question order: | Long Run First | 63.53% | 0.75% | 35.72% |
| | Short Run First | 57.57% | 9.59% | 32.84% |
| WTP: | WTP | 46.46% | 5.70% | 47.83% |
| | WTA | 73.67% | 4.70% | 21.64% |

Respondents that claimed to have no confidence in government had 43.97 percent probability of choosing the short run proposal, but those that had confidence in government had a higher probability of 60.55 percent of choosing the short run proposal. The probability of choosing no action for those that had no confidence in government was 52.44 percent, while the probability of choosing no action decreases to 34.30 for those that had confidence in government. Also, respondents that received the willingness to accept payment mechanism were much more likely to choose the short run proposal compared to those that received the willingness to pay payment mechanism. Those respondents that did receive the willingness to pay payment mechanism had a 47.83 percent probability of choosing no action, while those that received the willingness to accept payment mechanism had a 21.64 percent probability of choosing no action.

*Welfare Estimates*

Parametric Estimates

Median willingness to pay and median willingness to accept estimates were calculated using the procedure presented in Haab and McConnell (2002). The mathematical equation for median willingness to pay is $MD(WTP_j) = \frac{\bar{y}_j}{1+\exp(-\bar{\mathbf{x}}_j \boldsymbol{\alpha})}$,

where $\bar{y}$ is the mean income, $\bar{\mathbf{x}}$ is the vector of means, and is $\boldsymbol{\alpha}$ a vector of the parameters divided by the parameter of the income variable. The coefficients and means for the variables in the previously discussed multinomial logit model were used to calculate one set of WTP and WTA estimates. A multinomial probit model was also used to generate another set of coefficients that allowed for a second set of median WTP and

WTA estimates to be calculated. This allowed for a comparison of WTP and WTA estimates generated assuming either the logistic or normal distribution on the error term.

Confidence intervals were generated using the Krinsky-Robb procedure (1986). The procedure is outlined in Haab and McConnell (2002). The first step of the procedure is to produce a K x K variance-covariance matrix for the estimated parameters of vector $\hat{\boldsymbol{\gamma}}$, represented by $\hat{\mathbf{V}}(\hat{\boldsymbol{\gamma}})$. Then from the variance-covariance matrix sub-matrixes for short run and long run were extracted and independence across the equations had to assumed, because of the constraints on the model. C is the K x K lower diagonal matrix of the square root of the $\hat{\mathbf{V}}(\hat{\boldsymbol{\gamma}})$ so that CC' = $\hat{\mathbf{V}}(\hat{\boldsymbol{\gamma}})$. The C matrix is often referred to as the Cholesky decomposition matrix. It is also necessary to generate a K-dimensional column vector of independent draws from a standard normal density function, represented by $x_k$. Then, using a single K-vector draw from the asymptotic distribution of the parameters $\boldsymbol{\gamma}_d$ is: $\boldsymbol{\gamma}_d = \hat{\boldsymbol{\gamma}} + C' x_k$. This is repeated N, number of random draws, times to produce the simulation of the full distribution of the parameter vector $\hat{\boldsymbol{\gamma}}$ distributed $N(\hat{\boldsymbol{\gamma}}, \hat{\mathbf{V}}(\hat{\boldsymbol{\gamma}}))$ under ideal asymptotic conditions. The WTP estimate is then produced for each N from the asymptotic distribution of the WTP function. In the procedure here N = 50,000, and the procedure was repeated for the two sets of multinomial parameters.

The willingness to pay and willingness to accept estimates here represent the equivalent surplus and the compensating surplus, respectively, mentioned earlier. The willingness to pay estimate here represents the amount of money the respondent is willing to give up (in the form of a tax) to prevent the future wetland loss. Willingness to accept is the amount of money the respondent needs to receive (in the form of a tax return) to accept the loss of the wetlands.

Table 24 shows the WTP and WTA estimates. The WTP and WTA estimates for the multinomial logit and multinomial probit models do not vary greatly, indicating that difference between the assumption of logistic and normal distribution on the error term does not drastically affect the WTP and WTA estimates. The median willingness to pay for the short run proposal is $3,943.45 using the multinomial logit model parameters and $4,324.93 using the multivariate probit model. The willingness to accept estimate for the short run proposal using the multinomial logit model's coefficients is almost 14 times higher than the WTP estimate. The 95 percent confidence interval for the WTP for the short run proposal ranges from $1,493.10 to $33,066.96.

Table 24

Willingness to Pay and Willingness to Accept Estimates

| | | | 95% Confidence Interval | |
|---|---|---|---|---|
| | | Multinomial Logit | Lower Bound | Upper Bound |
| Short Run: | WTP | $3,943.45 | $1,493.10 | $33,066.96 |
| | WTA | $53,855.33 | $13,650.96 | $60,429.85 |
| Long Run: | WTP | $0.78 | $0.00 | $24.22 |
| | WTA | $10.11 | $0.11 | $168.95 |
| | | Multinomial Probit | | |
| Short Run: | WTP | $4,324.93 | $1,626.79 | $38,167.33 |
| | WTA | $54,498.21 | $13,987.70 | $60,429.86 |
| Long Run: | WTP | $1.74 | $0.00 | $30.35 |
| | WTA | $19.13 | $0.69 | $175.29 |

To take a closer look at the WTP for the short run proposal, Figure 7 illustrates the histogram of median willingness to pay values for the 50,000 willingness to pay estimates generated using the Krinsky-Robb procedure. It is apparent that even though the 95 percent confidence interval does yield a high upper bound, the majority of the willingness to pay estimates actually fall between \$0 and \$20,000. Also, the parametric WTP estimate for the short run proposal lies within this range of \$0 to \$20,000.

The reason that the WTP and WTA estimates for the short run proposal were so high and the long run proposal were so low can be attributed to the very high number of votes in favor of the short run proposal in comparison to the low number of votes in favor of the long run proposal. For the WTP for the short run proposal this means that the bids did not allow for an upper bound on WTP to be identified, thus the upper bound imposed by the model, income, becomes binding. \$60,429 is the mean income and thus the upper bound on the distribution in Figure 7.

<u>Turnbull Estimates</u>

The Turnbull method is another way to calculate willingness to pay estimates. This method is also called the lower bound method because it forces the upper bound to be equal to the highest bid. Habb and McConnell (2002) describes the mathematical framework that was laid out for the distribution-free estimator by Turnbull (1976), Cosslett (1982), and Ayer *et al*.(1955). This method was first used in contingent valuation studies by Carson, Hanemann *et al*. (1994) and Haab and McConnell (1997). The Turnbull estimate is calculated as:

$$E_{LB}(WTP) = \sum_{i=0}^{M*} t_i . f_{j+1}^{*} \qquad 35$$

where $t_i$ is the bid, $M^*$ is the total number of bids after pooling bids to achieve a monotonic income density function, and $f_{j+1}^*$ is the probability that the willingness to pay lies between bid $j$ and the next highest bid $j + 1$.

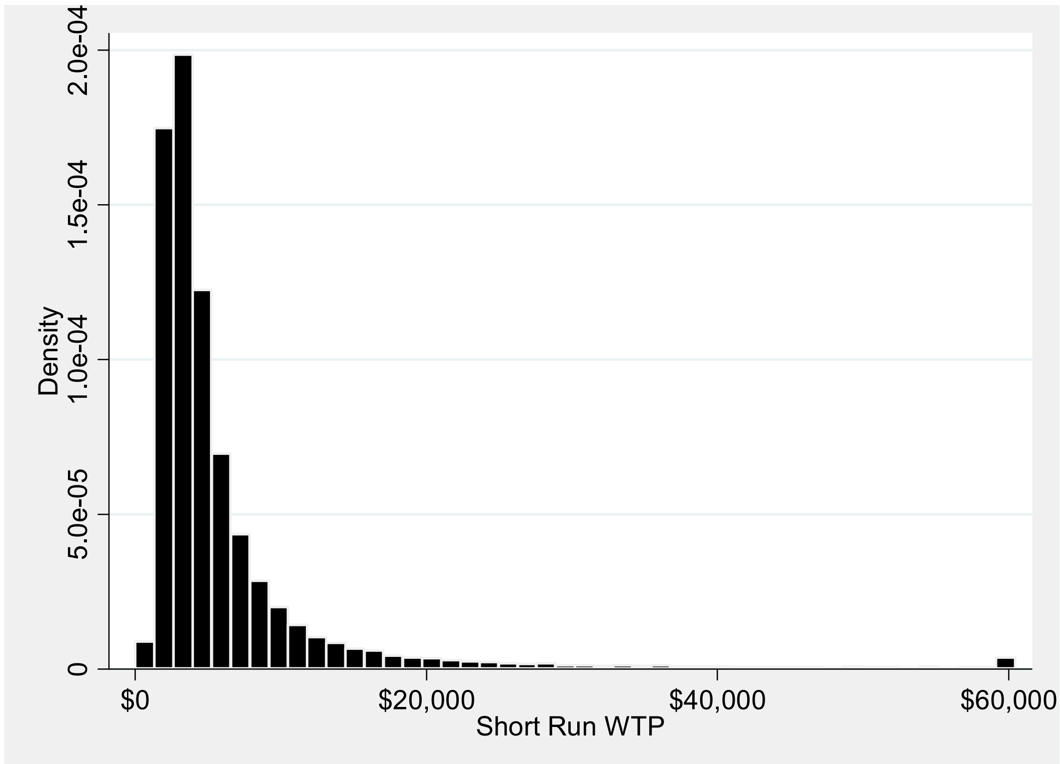


Figure 7 Density of WTP Estimates using Generated Parameters from a Standard Normal Distribution

The variance of the lower bound estimate is

$$V(E_{LB}(WTP)) = \sum_{i=0}^{M*} \frac{F_j^*(1-F_j^*)}{T_j^*}(t_j - t_j - 1)^2 \quad 36$$

$$= \sum_{i=0}^{M*} V(F_j^*)(t_j - t_j - 1)^2 . \quad 37$$

Using the bids and the responses to the trichotomous choice question the Turnbull willingness to pay estimate for the short run proposal was calculated. The Turnbull WTP estimate and its confidence intervals are shown in Table 25. It is evident that the Turnbull WTP estimate for the short run proposal is lower than the parametric estimates. This is to be expected since the Turnbull estimate has an upper bound of the highest bid and the parametric estimates upper bound is mean income. Also, the long run willingness to pay was incalculable due to the low number of observations and a monotonic income density function could not be obtained.

Table 25

Turnbull Distribution Free WTP Estimates
for The Short Run Proposal

| | | 95% Confidence Interval | |
|---|---|---|---|
| | WTP | Lower Bound | Upper Bound |
| Preference | $745.67 | $742.34 | $749.00 |

Net Present Value and Aggregate Estimates

Since the bids that respondents stated they would be willing to pay were incremental installments over a 10 year period it is necessary to generate a net present value for the median willingness to pay and median willingness to accept estimates using different discount rates. The discount rates that were used to calculate the net present values were elicited rates from the sample for illustration purposes. The discount rates used for the net present value estimates were generated using responses to a question on the survey. The respondents were given three questions where they chose between receiving different lump-sum amounts or annual payments over 20 years for a hypothetical lottery price. Responses to these three questions were used to estimate an implied discount rate for each respondent. Table 26 shows the frequency of respondents' discount rates that fell within each of the four ranges.

Table 26

Implied Discount Rate Ranges Obtained From Sample

| | Frequency | Percentage |
|---|---|---|
| Less than 1.89% | 54 | 10.57% |
| Between 1.89% and 10.31% | 146 | 28.57% |
| Between 10.31% and 26.42% | 106 | 20.74% |
| 26.42% or higher | 123 | 24.07% |
| Other | 82 | 16.05% |
| Total | 511 | |

Table 27 shows the net present values for willingness to pay and willingness to accept under each discount rate (midpoints were used for the two intermediate values) plus one additional discount rate (50%).

Table 27

Net Present Values for the Short Run Willingness to Pay and Willingness to Accept Estimates

| | Assumed Discount Rate | | | | |
|---|---|---|---|---|---|
| | 1.89% | 6.10% | 18.37% | 26.42% | 50.00% |
| WTP | $35,627.07 | $28,887.09 | $17,491.65 | $13,494.51 | $7,750.12 |
| WTA | $486,556.17 | $394,508.74 | $238,882.12 | $184,293.44 | $105,842.80 |
| Turnbull | $6,736.73 | $5,462.27 | $3,307.50 | $2,551.68 | $1,465.47 |

Figure 8 illustrates the net present values for the willingness to pay estimates of the short run proposal, the estimated confidence interval, and the Turnbull estimate.

Figure 8 shows that the net present value of the parametric median willingness to pay, the lower bound of willingness to pay, and the Turnbull estimate are all relatively close to one another as the discount rate increases. It can also be seen that the gap between these three measures and the upper bound of willingness to pay decreases as the discount rate increases.

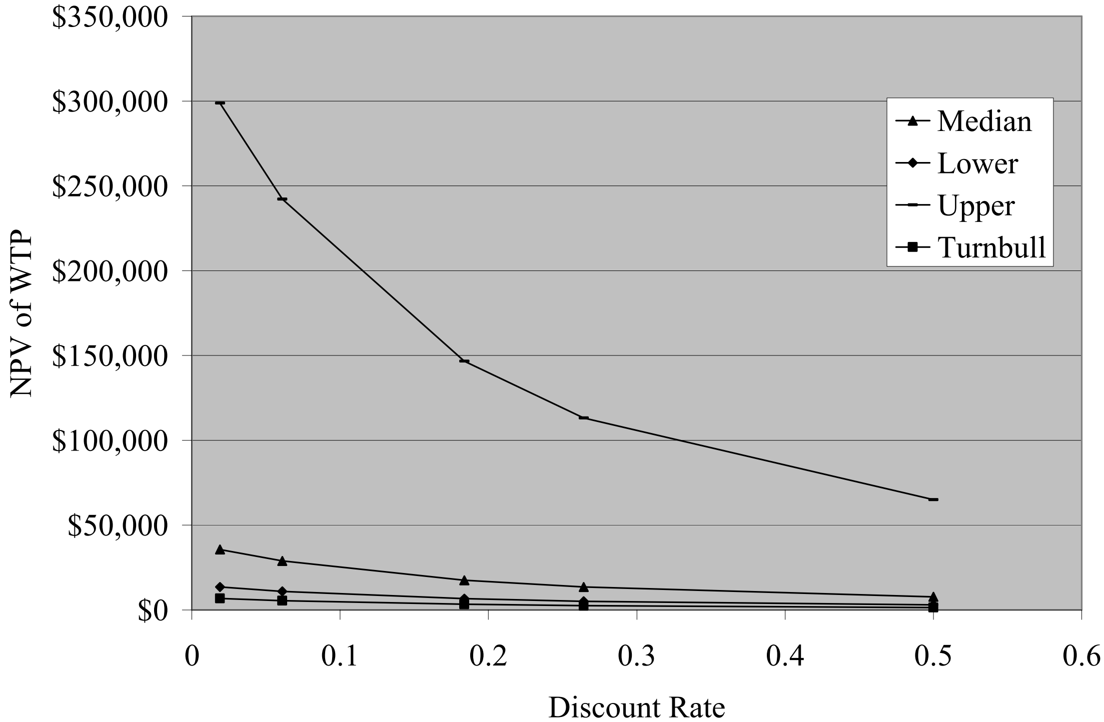


Figure 8   Net Present Value of Willingness to Pay for the Short Run Proposal

Figure 9 illustrates these net present values for the willingness to accept estimates of the short run proposal, the estimated confidence interval, and the Turnbull estimate. Figure 9 shows that the net present value of the median willingness to accept and the upper bound of willingness to pay are relatively close to one another, while not within close proximity to the lower bound and the Turnbull estimate. Also, from both Figure 8 and Figure 9 it is evident that as the discount rate increases difference between the median willingness to pay and accept estimates, their confidence intervals, and the Turnbull estimates decreases.

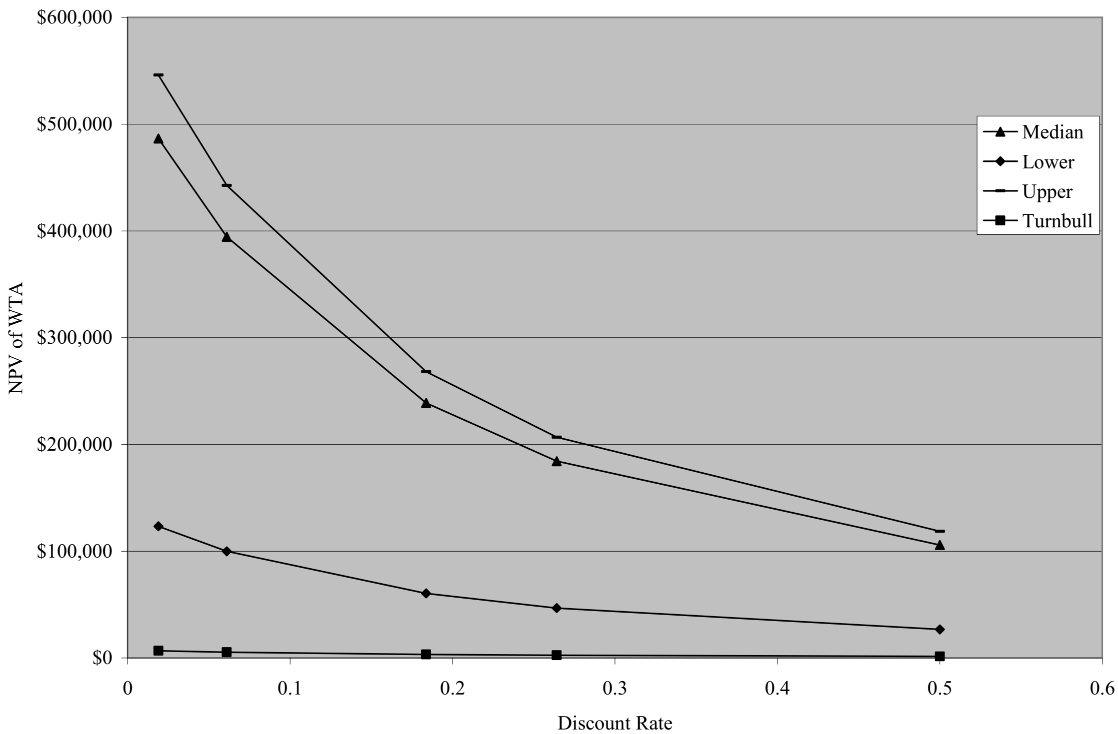


Figure 9 Net Present Value of Willingness to Accept for the Short Run Proposal

Estimates of aggregate willingness to pay and willingness to accept values can be calculated by multiplying net present value WTP and WTA estimates by the number of federal tax returns for the State of Louisiana. The total number of Federal tax returns for Louisiana in 2007 was 2,146,273 (IRS, 2010). Table 28 presents the aggregate willingness to pay, aggregate willingness to accept, and aggregate Turnbull estimate calculated using the 2007 number of Federal income tax returns for Louisiana and the net present value estimates from Table 27. The aggregate Turnbull estimates are the lowest of the three, and the willingness to accept estimates are still the highest.

Table 28

Aggregate Welfare Estimates in Millions of Dollars

| | Assumed Discount Rate | | | | |
|---|---|---|---|---|---|
| | 1.89% | 6.10% | 18.37% | 26.42% | 50.00% |
| WTP NPV | $76,465 | $62,000 | $37,542 | $28,963 | $16,634 |
| WTA NPV | $1,044,282 | $846,723 | $512,706 | $395,544 | $227,168 |
| Turnbull NPV | $14,459 | $11,724 | $7,099 | $5,477 | $3,145 |

A more conservative approach is to assume a $0 WTP/WTA for non-respondents, see Petrolia and Kim (2009). Table 29 shows the calculated aggregate estimates assuming that the individuals that did not return the survey (i.e., non-respondents) had a $0 WTP/WTA for the short run proposal. Table 29 shows that making the assumption of $0 for non-respondents drastically reduces these aggregate estimates.

Table 29

Aggregate Welfare Estimates in Millions of Dollars
Assuming $0 WTP/WTA for Non-Respondents

| | Assumed Discount Rate | | | | |
|---|---|---|---|---|---|
| | 1.89% | 6.10% | 18.37% | 26.42% | 50.00% |
| WTP NPV | $17,358 | $14,074 | $8,522 | $6,575 | $3,776 |
| WTA NPV | $237,052 | $192,206 | $116,384 | $89,788 | $51,567 |
| Turnbull NPV | $3,282 | $2,661 | $1,611 | $1,243 | $713 |

*Summary of Results*

The marginal effects indicate that respondents that were white, protection from storm benefits being primary concern, environment protection benefits primary concern, prior knowledge, being presented with long run first, and/or as age increases were more likely to choose the short run proposal. Having no confidence in government or the willingness to pay payment mechanism decreased the probability of choosing the short run proposal.

The probability of respondents choosing the long run proposal increases if respondents stated protection from storm benefits being primary benefit of concern, environment protection benefits primary concern, or if protection from the effects of climate change was their primary benefit. As age increases or if respondents were presented with the long run proposal first their probability of choosing the long run proposal decreases.

The marginal effects show that as age increases the probability of choosing no action decreases, and the probability of choosing no action decreases if the respondent's primary benefit is protection from the effects of climate change. The probability of the respondents choosing no action increases if respondents had no confidence in government.

Results indicate that the respondents were heavily in favor of the short run proposal as compared to the long run proposal and no action being taken. The results show that respondents that were wealthier, whiter, older, protection from storms primary benefit, protection of the environment primary benefit, protection from the effects of climate change primary benefit, and/or had previous knowledge of restoration efforts taking place in Louisiana were more likely to choose the short run proposal option over no action. Having no confidence in government and receiving the payment mechanism willingness to pay made respondents less likely to choose the short run proposal no action.

Factors that affected the decision between the long run proposal and no action differed slightly from the previous decision. The factors that made respondents more likely to choose the long run proposal over no action were being wealthier, white, stated protection from storms primary benefit, protection of the environment primary benefit, protection from the effects of climate change primary benefit, and/or having previous knowledge of restoration efforts taking place in Louisiana. Being older, having no confidence in government, being presented with the long run proposal first, and/or receiving the payment mechanism willingness to pay caused respondent's probability of choosing the long run proposal over no action to decrease.

When it came to making the decision between the long run proposal and the short run proposal the variables that made the respondent more likely to choose the short run proposal were being older and being presented with the long run proposal first. The probability of respondents choosing the long run proposal over the short run proposal increased when protection from the effects of climate change primary benefit and/or receiving willingness to pay payment mechanism instead of the willingness to accept.

The willingness to pay and willingness accept estimates indicate that respondents place a far higher value on the short run proposal than on the long run proposal. Also, through the use of confidence intervals on the willingness to pay and willingness to accept estimates for the short run proposal it is apparent that both have fairly wide confidence intervals. Also, Figure 7 illustrates that, though the confidence interval is broad, the majority of willingness to pay estimates taken from the Krinsky-Robb procedure fall between $0 and $20,000.

The Turnbull willingness pay estimate was calculated for the short proposal and was found to be almost $3,000 lower than the parametric willingness to pay calculated for the short run proposal. This is not surprising since the Turnbull estimates is considered to be a lower bound estimate of willingness to pay.

Also, the net present values show the willingness to pay and willingness to accept estimates are affected by the discount rate that is assumed. Figures 8 and 9 illustrate that as the discount rate increases the gap between the willingness to pay and willingness to accept, their confidence intervals, and the Turnbull estimate shrinks.

By calculating the aggregate net present values of willingness to pay, willingness to accept, and Turnbull estimates for the short run proposal the value that the population of Louisiana places on the short run proposal is obtained. Also, by assuming a $0 value for the surveys that were not returned these estimates drastically decrease.

# CHAPTER VII

# CONCLUSIONS

This thesis presents estimates of the value that Louisiana residents place upon the prevention of future wetland loss was obtained. The preference between the three proposal options (short run proposal, long run proposal, and no action) was the main interest in this thesis. It was determined that the short run proposal was extremely preferred to both no action and the long run proposal. Also, no action was preferred to the long run proposal. The average median value was calculated for two types of wetland loss prevention, the short run proposal and the long run proposal. The median annual willingness to pay for the short proposal is \$3,943, with a confidence interval of \$1,493 to \$33,067, using the parameter estimates from the multinomial logit model. The median willingness to pay for the short run proposal exceeded the bid range that was presented in the survey. A Turnbull lower-bound estimate was also generated to provide a more conservative estimate of the value of the short run proposal. Turnbull estimates are considered a lower bound estimate because its upper bound is constrained by the highest bid value. The Turnbull estimate of the short run proposal was \$745.34.

Since the bid was presented as a tax that would be paid incrementally over a ten year, a net present value had to be calculated using these estimates. Then using these net present values and a discount rate calculated from responses of the survey, the aggregate willingness to pay was determined. The net present values of willingness to pay for short run, using the 18.37% discount rate, are $17,492 for the median willingness to pay and $3,308 for the Turnbull estimate. The aggregate values for willingness to pay and Turnbull, using these net present values, are $37.5 billion and $7.1 billion, respectively. Yet, these aggregate values decrease drastically if the assumption is made that all survey non-respondents have a WTP/WTA value of $0 for the proposal. When this assumption is made the aggregate median willingness to pay decreases to $8.5 billion and the Turnbull estimate decreases to $1.6 billion. Depending on what assumption is made for the discount rate and the value of non-respondents, very different willingness to pay estimates for the short run proposal were obtained.

The willingness to accept estimates were extremely high compared to the willingness to pay estimates. The willingness to accept estimates for the short run proposal were almost 15 times greater than the willingness to pay estimates. The willingness to pay estimates being higher than willingness to pay is consistent with the literature and not too surprising, but what was somewhat surprising was the magnitude of the difference being so great.

The willingness to pay and willingness to accept estimates for the long run proposal were extremely small. Neither of the estimates for the value of the long run proposal reached $12. This is dramatically less than the values that were calculated for the short run. This is primarily due to the minimal respondents voting for the long run proposal.

Many of the same factors caused respondents to choose either the short run proposal or the long run proposal over no action. Large increases in income, being white, respondents being concerned about protection from storms, protection of environment, protection against sea-level rise due to climate change, and having prior knowledge of restoration efforts taking place in Coastal Louisiana all increased the probability the respondent of preferring either the short run proposal or the long run proposal over no action. No confidence in government and receiving the willingness to pay payment mechanism were the factors that caused individuals to be less likely to choose either the short run or the long run proposal over no action.

One factor that differed across the two options over no action is age. Older respondents were more likely to support the short run proposal over no action. One interpretation of this is that the long run proposal does not provide benefits until farther into the future and older respondents believed they would not receive the benefits from the long run proposal. Therefore, the older respondents were less likely to support the long run proposal.

One major factor that was driving respondents support for the short run proposal was respondent's primary concern being protection from storms. Also, the majority of respondents had a skewed perception that category 3 hurricanes were going to affect them at least once in 10 years, when actual return period for a category 3 hurricane in Coastal Louisiana is about once every 37.5 years (NHC, 2010). The combination of respondents believing that preventing wetland loss will yield hurricane protection benefits with the high hurricane frequency expectations is driving the support for the short run proposal and its associated willingness to pay estimates.

This study had a few weaknesses. First there was some sample bias due to poor population representativeness. The sample was older, whiter, more male, more educated, and wealthier than the population. Sample weights were placed on the model in an attempt to make the sample more representative of the population. Also, the response rate for the survey was fairly low at 22.7%. Another weakness was that the bids presented in the survey were too low, especially for the willingness to accept questions. This was evident due to the fact that as the bids increased the frequency of “Yes” responses, for some form of wetland loss prevention, did not begin to decrease.

These findings can be of use to policy makers when deciding which types of restoration projects to undertake for the prevention of wetland loss in Louisiana. These findings provide those policy makers with insight into the value that the population Louisiana places on such projects. Policy makers can also determine the reasons why their constituents support or do not support projects such as the ones analyzed in this thesis.

This thesis shows that the population of Louisiana places a high value on the prevention of the loss of their coastal wetlands. It also finds that the residents of Louisiana highly prefer projects that will prevent losses sooner as compared to later. Future research on this topic could determine if the support for these proposals diminishes the farther Hurricanes Katrina and Rita move into the past. This could be done through a similar survey performed farther into the future. This would determine if concern for storm protection diminishes over time and if so, how this change would affect the support for such proposals as the ones in this study.

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