2015

A Market-Based Approach for Valuing Ecosystem Services on Coastal Properties

Michelle A. Savolainen
Louisiana State University and Agricultural and Mechanical College, msavolainen@agcenter.lsu.edu

A MARKET-BASED APPROACH FOR VALUING ECOSYSTEM SERVICES ON COASTAL PROPERTIES

A Dissertation

Submitted to the Graduate Faculty of the
Louisiana State University and
Agricultural and Mechanical College
in partial fulfillment of the
requirements for the degree of
Doctor of Philosophy

in

The Department of Agricultural Economics and Agribusiness

by
Michelle A. Savolainen
B.B.A., Texas Woman's University, 2007
M.S., Louisiana State University, 2012
August 2015

This dissertation is dedicated to my parents, Kari and Lea, and my boyfriend and best friend, Jorge.

ACKNOWLEDGEMENTS

Thank you to those who made this document possible. I would like to thank my committee members, Drs. Richard F. Kazmierczak, Jr., Rex H. Caffey, Walter R. Keithly, Jr., and J. Andrew Nyman. I am grateful for your advice and support. Thank you to Mrs. Huizhen Niu for patiently answering my GIS questions. I would also like to thank the funders of this project, the Mississippi-Alabama Sea Grant Consortium. Finally, I would like to extend a special thank you to my family and friends whose love and support means everything to me.

TABLE OF CONTENTS

ACKNOWLEDGEMENTS…………………………………………………………………iii

LIST OF TABLES………………………………………………………………………...v

LIST OF FIGURES……………………………………………………………………… vi

LIST OF EQUATIONS…………………………………………………………………vii

ABSTRACT…………………………………………………………………………… viii

CHAPTER 1. INTRODUCTION……………………………………………………... 1
1.1. Objectives……………………………………………………………………… 5
1.2. Overview of Dissertation………………………………………………………6

CHAPTER 2. LITERATURE REVIEW……………………………………………… 7
2.1. Stated Preference Methods Debate…………………………………………….8
2.2. Hedonic Property-Price Approach……………………………………………14
2.3. Comparative and Joint Stated-Revealed Preference Estimation………………23
2.3.1. Joint Estimation Task……………………………………………………….. 26

CHAPTER 3. DATA COLLECTION AND PREPARATION…………………………29
3.1. Data Collection for Variables Included in Analysis………………………….. 29
3.2. Data Collection for Variables Not Included in Analysis……………………... 36

CHAPTER 4. ANALYSIS METHODS AND RESULTS……………………………... 38
4.1. Functional Form……………………………………………………………….38
4.2. Outlier Analysis………………………………………………………………41
4.3. Regression Diagnostics………………………………………………………..43
4.4. Alabama Model………………………………………………………………..54
4.5. Louisiana Model……………………………………………………………… 57

CHAPTER 5. DISCUSSION……………………………………………………………59
5.1. Comparison to Previous Studies………………………………………………61

CHAPTER 6. CONCLUSIONS……………………………………………………... 66
6.1. Revisiting the Objectives…………………………………………………….. 66
6.2. Limitations……………………………………………………………………68
6.3. Future Research……………………………………………………………… 69

REFERENCES………………………………………………………………………….. 70

VITA……………………………………………………………………………………..76

LIST OF TABLES

Table 1.1. Ecosystem service categories and examples…………………………………………. 2

Table 1.2. USFWS wetland classifications and descriptions…………………………………… 3

Table 2.1. Peer-reviewed literature using hedonic price models to estimate effects of wetlands on residential property prices…………………………………………………………...16

Table 2.2. General summary of results from peer-reviewed literature………………………….18

Table 4.1. Names and definitions of explanatory variables... 39

Table 4.2. Correlations for continuous dependent variables in Alabama model........................ 47

Table 4.3. Correlations for continuous dependent variables in Louisiana model....................... 47

Table 4.4. Variance inflation factors for dependent variables in Alabama model 48

Table 4.5. Variance inflation factors for dependent variables in Louisiana model..................... 48

Table 4.6. Correlations for age and size of home in St. Charles Parish, Louisiana, against other continuous dependent variables 52

Table 4.7. Summary statistics for Alabama data (n=7,060) 52

Table 4.8. Summary statistics for Louisiana data (n=5,751) 53

Table 4.9. Comparison of median single-family home values by source................................... 53

Table 4.10. Alabama log-linear model estimates.. 55

Table 4.11. Louisiana log-linear model estimates 58

Table 5.1. Imputed estimates (in USD) from previous peer-reviewed wetland valuation literature……………………………………………………………………………... 64

Table 5.2. Estimates (in USD) from current study……………………………………………... 64

LIST OF FIGURES

Figure 3.1. Parcel map for properties surrounding Tulane University in New Orleans, Louisiana…… 30

Figure 3.2. Elevation of New Orleans, Louisiana…… 33

Figure 3.3. Road network and property centroids in New Orleans, Louisiana…… 35

Figure 3.4. Freshwater ponds in New Orleans, Louisiana…… 36

Figure 4.1. Plot of leverage and normalized squared residual values for Alabama data 42

Figure 4.2. Plot of leverage and normalized squared residual values for Louisiana data........... 43

Figure 4.3. Map of Alabama study area and number of observations by county 44

Figure 4.4. Map of Louisiana study area and number of observations by parish........................ 45

Figure 4.5. Plot of residuals against predicted values of REALPRICE for Alabama model 45

Figure 4.6. Plot of residuals against predicted values of REALPRICE for Louisiana model 46

Figure 4.7. Histograms of residual frequency for Alabama model.. 50

Figure 4.8. Histograms of residual frequency for Louisiana model 50

Figure 4.9. Normal quantile plot for Alabama model residuals 51

Figure 4.10. Normal quantile plot for Louisiana model residuals 51

LIST OF EQUATIONS

Equation 2.1. Hedonic price function……………………………………………………….. 14

Equation 2.2. Budget constraint for hedonic function……………………………………….. 14

Equation 2.3. First order conditions for hedonic function…………………………………… 15

Equation 4.1. Box-Cox transformation…………………………………………………………40

Equation 4.2. Special forms nested in Box-Cox transformation……………………………….. 40

Equation 4.3. Log-linear hedonic model specification………………………………………… 40

Equation 4.4. Dummy variable coefficient calculation in log-linear model...…………………..41

Equation 4.5. Standard error correction factor………………………………………………… 44

ABSTRACT

As part of ongoing efforts to assess ecosystem services provided by wetlands, this research focuses on estimating the private monetary value of wetland services to residential property owners in Louisiana and Alabama using a hedonic price model. Understanding that tradeoffs must be made with limited resources, valuing ecosystem services is important for policy and decision making purposes, such as determining how much public and private financial resources should be put towards wetland maintenance and restoration. Data on property transactions, wetland coverage, and built infrastructure were collected for the analysis. Based on theory and results from a Box-Cox model, the log-linear functional form was the best fit for the data. Marginal implicit prices of services from wetland ecosystems were estimated using proximity variables. Most wetland proximity variables were statistically significant and indicative of preferences for different wetland types. Based on coefficient estimates, freshwater ponds were the only preferred wetland ecosystems to live in closer proximity to in Louisiana, while freshwater emergent wetlands were the only preferred wetland ecosystems in Alabama. Homeowners preferred living further from rivers in both Louisiana and Alabama. Results are consistent with the wetland service valuation literature from across the United States which used the property-price hedonic approach.

CHAPTER 1. INTRODUCTION

Over half of wetlands in the contiguous United States disappeared over the last 200 years, primarily due to agriculture and development (U.S. Environmental Protection Agency 2001; U.S. Geological Survey 2014). Wetlands are areas that are inundated by water for all or part of the year. Though previously considered wasteland, there is a growing understanding and discussion of the benefits generated by wetlands. These ecosystems provide habitat for fish, birds, and other wildlife, process and reduce pollution, reduce storm surge and prevent flooding, support the maintenance of groundwater supplies, and provide recreational and commercial opportunities for fishermen and hunters (U.S. Environmental Protection Agency 2015a). The benefits derived by humans from ecosystem functions are known as ecosystem services.

Woodward and Wui (2001) differentiate between habitat functions versus habitat services and benefits provided to humans. While examples of functions include flood control and storm surge protection, the related service and benefit to humans is the avoided damage from flooding and severe storms. Ecosystem functions and services do not necessarily map one-to-one with one another (Costanza et al. 1997). Rather, one ecosystem function can be a result of one or more services, and vice versa. Costanza et al. (1997) define ecosystem services as "…the flows of materials, energy, and information from natural capital stocks which combine with manufactured and human capital services to produce human welfare." Freeman (1993) defined the economic value of a natural resource as being equal to the benefits of the resource derived by humans. As an extension of this definition, Woodward and Wui (2001) assume that a wetland's value is a function of the habitat's ecological factors and associated socioeconomic variables.

Natural and manmade disasters, such as hurricanes and the Deepwater Horizon/BP oil spill, "…refocused attention on the value of [Gulf of Mexico] coastal wetlands and the services they provide" (Engle 2011). In response to the oil spill in the Gulf of Mexico, the National Research

Council (2012) investigated methods to value ecosystem services, and in the process outlined four primary categories of wetland services: supporting, regulating, provisioning, and cultural. Table 1.1 lists these categories and provides examples of services for each.

Table 1.1. Ecosystem service categories and examples

Supporting	Regulating	Provisioning	Cultural
Nutrient balance	Hazard moderation	Food	Aesthetics
Hydrological balance	Pollutant attenuation	Raw materials	Recreational opportunities
Biological interactions	Air & water quality	Medicinal resources	Science & education
Soil & sediment balance	Climate balance	Ornamental resources	Spiritual & historic

Source: Adapted from National Research Council (2012)

Due to wetland loss and the growing recognition of lost services, wetland restoration became a considerable topic of research and discussion in academic and policy circles. Major questions included how much public and private money should be spent to restore wetlands and what methods should be utilized to restore wetlands. Although wetlands are located in every state in the nation, these questions are particularly critical in the U.S. Gulf Coast where over 50% of wetlands vanished between 1780 and 1980 and continue to disappear at a rate six times greater than that for wetlands on the U.S. Atlantic coast (Shaneyfelt 2012). Areas around the Barataria-Terrebonne National Estuary in Louisiana and the Mobile Bay in Alabama house some of the most fragile wetlands of the Gulf Coast (U.S. Geological Survey 2014).

Wetlands differ by factors such as salinity of water and the presence and type of vegetation. The U.S. Fish and Wildlife Service (USFWS) classifies wetlands into seven categories: estuarine and marine deepwater, estuarine and marine wetland, freshwater emergent wetland, freshwater forested/shrub wetland, freshwater pond, lake, and riverine. Table 1.2 presents the wetland classifications and descriptions (USFWS 2015).

Table 1.2. USFWS wetland classifications and descriptions

Wetland type	General description
Estuarine and marine deepwater	Open water estuary, bay, sound, open ocean
Estuarine and marine wetland	Vegetated and non-vegetated brackish and saltwater marsh, shrubs, beach, bar, shoal or flat
Freshwater emergent wetland	Herbaceous march, fen, swale and wet meadow
Freshwater forested and shrub wetland	Forested swamp or wetland shrub bog or wetland
Freshwater pond	Pond
Lakes	Lake or reservoir basin
Riverine	River or stream channel

Source: Adapted from USFWS (2015)

While the need to estimate a monetary value for environmental characteristics is widely acknowledged (Hanemann 1994), the most direct way to do so, through a market exchange, is often unavailable. Ecosystem services are rarely exchanged directly in traditional markets because many ecosystems and their respective services are public goods (i.e., non-excludable and non-rivalrous) or common-pool resources (i.e., non-excludable and rivalrous). The common characteristic between these two types of resources is that they are non-excludable, meaning that it is infeasible or impossible to exclude any individual from its use. The lack of market prices and the inability to control access to the resource results in a market externality such that the resource is not allocated efficiently and the ecosystem service benefit is not realized within a transparent market context (Richmond, Kaufmann, and Myneni 2007). Without knowing these values, we are unable to completely account for impacts to the environment and to societal welfare with respect to government policies and actions, as well as natural and manmade disasters (e.g., Exxon-Valdez oil spill).

Some wetland services, such as fish caught by means of commercial fishing, have a direct monetary value since these physical goods can be purchased and sold in a market. However, the majority of wetland services, such as flood mitigation and scenic views, cannot be traded on the market and are considered nonmarket services. Stated and revealed preference approaches can be used to value nonmarket goods. Nonmarket valuation techniques include revealed preference methods such as hedonic analysis and stated preference methods such as contingent valuation. Unlike methods that consider only use values, contingent valuation accounts for use and non-use, or passive-use values, as individuals may value a good if they do not physically use it. Assigning value to passive-use is one of the fundamental characteristics of this type of stated preference analysis.

Costanza et al. (1997) argue that it is not important to analyze the total economic value of a natural resource with respect to human welfare since it would be infinite in value, but rather, advocate for examining the marginal values to human welfare as a natural resource or service changes in quality or quantity. Costanza et al. (1997) also address the debate regarding the valuation of nonmarket goods and services. The paper notes that it is clear that economic valuation of market and nonmarket goods and services (e.g., ecosystem services) needs to be conducted since nonmarket goods are not captured within traditional commercial markets (i.e., market failure) and are often not given enough emphasis in policy frameworks. The authors observe that individuals determine the value of marketed and nonmarket goods and services on a regular basis since every choice involves tradeoffs, even when faced with the classic question regarding the value of a human life. "When we set construction standards for highways, bridges, and the like, we value human life (acknowledged or not) because spending more money on construction would save lives…as long as we are forced to make choices, we are going through the process of valuation" (Costanza et al. 1997).

Tradeoffs must be made because there are finite amounts of resources. It is important to value ecosystem services in order to have an idea of how much public and private financial resources should be put towards wetland maintenance and restoration (Woodward and Wui 2001). Also, monetary ecosystem service values help state and federal natural resource managers in identifying and prioritizing wetland projects (Engle 2011), often through Benefit-Cost Analysis (Caffey, Wang, and Petrolia 2014; Haab et al. 2013; Natural Resources Conservation Service 2009). Impacts to ecosystem services due to a change in government regulation and actions, as well as manmade and natural disasters, cannot be fully accounted for without monetary wetland service values.

1.1. Objectives

The purpose of this dissertation is to estimate, using a hedonic model, the monetary value of ecosystem services provided by different types of wetlands as defined by the USFWS to single-family residential property owners in Louisiana and Alabama. Specific objectives of this market value study include:

1. Conduct a literature review to examine previous wetland service valuation studies using the hedonic price model;
2. Assess the possibilities for comparative and joint stated and revealed preference value estimation and provide a general framework for this type of study using hedonic analysis;
3. Gather property transactions data, as well as, parcel boundary, wetland, and feature maps;

4. Evaluate which functional form is most appropriate for estimating the hedonic price function using theory and the Box-Cox transformation model; and,
5. Estimate monetary value of services from wetland ecosystems for residential property owners near Mobile Bay, Alabama, and Barataria-Terrebonne Estuary, Louisiana, using the hedonic price model.

1.2. Overview of Dissertation

This first chapter describes the background, motivation, and objectives of the dissertation. Chapter 2 fulfills Objective 1 through a presentation of the literature review of wetland service valuation studies conducted using hedonic analysis. Objective 2 is also addressed in Chapter 2 through an assessment of compatible stated and revealed preference estimation methods for hedonic analysis. Objective 3 is completed in Chapter 3 which describes the data collection procedure. Objectives 4 and 5 are fulfilled in Chapter 4 by assessing functional form and estimating a hedonic price function to quantify the private benefits to single-family home property owners in Louisiana and Alabama generated by wetland services. Chapter 5 discusses results from the hedonic analysis. Chapter 6 concludes.

CHAPTER 2. LITERATURE REVIEW

The economic literature contains many valuation studies that measure the economic benefits of wetlands. Although the estimates vary, they suggest that the benefits are positive (Woodward and Wui 2001). Missing from the literature, however, is a consensus on the size of the benefits. Without this information, policymakers cannot determine, from an economic perspective, the optimal investments in wetland restoration projects. Woodward and Wui (2001) call for more research to address this problem in light of growing concern for wetland systems. Understanding that tradeoffs must be made with limited resources, it is important to value ecosystem services and allow for useful information for policy and decision making purposes.

In some policy circles, stated and revealed preference valuation approaches are regarded as substitutes. In other words, whether a valuation uses one method or the other depends on data and resource availability, but not on the desired quality of the estimated results. In fact, however, the two methods should instead be considered complements (Whitehead, Haab, and Huang 2011; Whitehead et al. 2008). Revealed preference methods estimate the *ex-post* value of goods by using market data that records the actual purchasing decisions and tradeoffs made by individuals. Examples of this approach include actual market prices, productivity indices, hedonic price estimates, and estimates derived from travel cost methods. Stated preference approaches measure the *ex-ante* monetary value of goods through survey methods in which individuals express their choices or willingness-to-pay in a hypothetical market scenario. Examples of the methods used in this approach include contingent valuation and contingent choice. Historically, these techniques were primarily used when revealed preference data were not available, suggesting that economists prefer revealed preference valuation, perhaps because of the hypothetical (and other) biases that are endemic to stated preference estimates. However, stated preference methods are commonly used in marketing, health economics, and environmental economics where there is a need to estimate the demand for new products, medical treatments, and nonmarket goods, respectively (Whitehead et al. 2008).

Hedonic analysis is a revealed preference method which estimates private benefits to homeowners that are captured within the purchase price of a property and does not include benefits that accrue to the public (Netusil 2005). These private benefits can include wetland services such as recreational opportunities, flood mitigation, and aesthetic views. Woodward and Wui (2001) suggest that hedonic analysis captures "amenity values provided by proximity to the environment." Often credited to Rosen (1974), hedonic analysis is frequently used in real estate and ecosystem service valuation literature, as well as in Consumer Price Index calculations to adjust for quality (Hausman 2003). The model assumes that the price of a market good decomposes statistically into the characteristics and services it provides to the buyer (Freeman 1993). More specifically, with the hedonic property price approach the price of a property is a function of structural, neighborhood, and environmental amenity (e.g., wetland) characteristics. The following review of the literature begins with a summary of the arguments for and against stated preference methods, then leads into discussion of revealed preferences. The primary focus of the discussion is Rosen's (1974) theory of the hedonic price function and peer-reviewed publications that use the hedonic price model to estimate the impacts of the presence or proximity of wetlands on residential property values. The chapter concludes with an overview of comparative and joint stated and revealed preference methods estimation using hedonic analysis.

2.1. Stated Preference Methods Debate

Revealed preference methods only capture use values, while stated preference techniques estimate both use and non-use values. The fact that stated preference methods potentially capture all value also leads to the major source of criticism of using it to value natural resources, especially in a litigation context. Non-use values are the benefits that individuals perceive they derive from a resource even though they may never actually use or visit the resource (e.g., an individual assigns some value to Australia's Great Barrier Reef even though they may never visit the site). The debate regarding the inclusion of non-use values in natural resource damage assessments first became prominent in Exxon Valdez oil spill litigation (Whitehead et al. 2008; Haab et al. 2013).

Stated preference methods are important, especially in cost-benefit analysis and other policy analyses that require empirical estimates of value (Haab et al. 2013). The most prominent debate in the economic literature against stated preference techniques is against contingent valuation. Though this stated preference approach was first proposed by Ciriacy-Wantrup (1947), the method did not come under scrutiny until after its major role in litigation for the Exxon Valdez oil spill.

There were two primary milestones for greater acceptance of contingent valuation. First, Mitchell and Carson (1989) published a book on contingent valuation that linked economic theory, survey development methods, measurement issues, and the Exxon Valdez oil spill. Second, in the aftermath of the Exxon Valdez oil spill, the NOAA Panel on Contingent Valuation (Arrow et al. 1993) concluded that a well-designed and executed contingent valuation study could provide a legitimate means of valuation in damage assessment. In response to this "conditional endorsement," (Haab et al. 2013) a consortium of primarily Exxon-funded researchers published critical articles of contingent valuation putting into question the method's accuracy and validity.

Surveys in general are not foolproof (Ciriacy-Wantrup 1947). These instruments must be designed and executed with expertise. Every aspect of the survey must be considered including sampling method, questionnaire structure and development, creation of valuation scenario, and data analysis. In the aftermath of the Exxon Valdez oil spill, the NOAA Panel of Contingent Valuation provided recommendations for conducting reliable surveys (Arrow et al. 1993).

Recommendations included pre-testing and use of focus groups, in-person interviews (though this may not be feasible based on the budget for conducting surveys), portraying a specific and realistic situation to the respondent for valuation, closed-ended questions posed as if voting in referendum, portraying a specific, realistic payment vehicle, reminding the respondent of substitutes and their budget constraint (i.e., respondent's income), allowing for "don't know" responses, debriefing after the interview, and using the median instead of the mean in data analyses.

Diamond and Hausman (1994) and Milgrom (1993) are major critics of stated preference methods and, in particular, contingent valuation. Primary critiques of surveys in general include problems with response effects. This is a problem with all surveys, not just contingent valuation. Minor changes in wording or order can cause substantial changes in responses. Respondents can become impatient, disinterested, and fatigued.

Another criticism is that the survey process creates the values such that respondents simply create values during an interview or survey. This critique implies that respondents do not have any real value for the good in question. This potential problem, however, can be examined in the debriefing after the interview. Diamond and Hausman (1994) concluded that the answers people give are not based in reality. Hanemann (1994), however, stated, "If a subject responds thoughtfully to a question about voting to raise taxes for a public good, by what criterion is that not a valid preference?"

Another criticism of surveys is that members of the general public are not properly trained for valuing the environment. Hanemann (1994) argued that if you're eliciting people's preferences as if voting in a referendum, then this implies that prior experience or training is irrelevant. People do not necessarily have special training prior to voting in a political election. It is not a prerequisite to be an informed voter prior to voting in an election; therefore, it is not economists' place to say who has standing and whose values should count.

Diamond and Hausman (1994) presented other critiques. First, they argued that survey responses cannot be verified, and therefore, are not useful. Hanemann (1994), on the other hand, argued that surveys (and results) can be replicated to see the consistency of answers and make sure that the instrument is working. Also, results can be compared with estimates from other sources or predictions can be compared with actual behavior if possible. They also claimed that the income elasticity of willingness-to-pay is lower than if true preferences were measured. Hanemann (1994) said that there is no basis for this claim. With an evaluation of the contingent valuation literature, results fall within the ranges of demand for state and local government services, as well as charitable giving by individuals. Diamond and Hausman (1994) concluded that no value is better than some value estimated using the flawed contingent valuation methods. Instead, they recommended that expert opinion should be preferred to imperfect contingent valuation results. While experts may be appropriate for assessing what to measure, assessing worth is different. Hanemann (1994) stated that "…a well-designed contingent valuation survey is one way of consulting the relevant experts – the public itself."

Economists in general argue against stated preference estimation because it "violates habitual commitment of the profession to revealed preference" (Hanemann 1994). Revealed preference methods, however, are more difficult to apply to public goods than private goods. Also, revealed and stated preference methods do not have to be mutually exclusive. A researcher can observe behavior while still asking about their intentions and motives for the behavior. Hanemann (1994) advocated that additional collected information should be welcomed.

Hausman (2012) had three primary critiques of contingent valuation: hypothetical bias, a difference in the willingness-to-pay and willingness-to-accept values, and a lack of scope effects. With respect to his first critique, Hausman (2012) says that contingent valuation suffers from hypothetical bias where what people say is different from what they do. This is not just a problem in contingent valuation, however, as this is a potential problem with all surveys. Surveys are used in environmental valuation, marketing, and public polling. Some form of a testable hypothesis that stated preference responses are equal to responses to analogous questions when money or some real outcome is at stake is assumed in all of these studies. If the hypothesis is not accepted, then the method is considered faulty or invalid. Marketers use surveys to assess demand for new products, while pollsters assess expected voting behavior to predict election results and understand voter preferences. Haab et al. (2013) present two examples from the environmental economics literature where stated preference estimates of expected demand accurately predicted future conditions. Grijalva et al. (2002) provided an example of this using rock climbing trip behavior, while Whitehead (2005) accurately predicted hurricane evacuation behavior. Haab et al. (2013) present methods of mitigating or elimination hypothetical bias. The first is the "cheap talk" survey design where respondents are provided with additional instructions to treat the presented hypothetical scenario as if an actual monetary transaction were taking place. Second, is the solemn oath method, where respondents are asked to follow some variations of a solemn oath prior to being interviewed (e.g., as in the courtroom prior to testifying, "I promise to tell the truth, the whole truth, and nothing but the truth…"). A third method to mitigate hypothetical bias is scenario adjustment where the researcher takes into account the level of certainty respondents have that they would make the same decision if the choice they were making was real. There is currently no conclusion in the contingent valuation literature as to which is the best approach.

Hausman's (2012) second critique was that willingness-to-accept is greater than willingness-to-pay in contingent valuation studies. To the critics, the differences in these values imply a violation of basic economic theory, therefore rendering the contingent valuation method invalid. Hausman (2012) stated that the willingness-to-pay and willingness-to-accept should be equal. McConnell and Horowitz (2003) concluded that the difference between these two values is too great to be consistent with neoclassical preferences. Haab et al. (2013) suggested that the difference in willingness-to-pay and willingness-to-accept can be explained in a neoclassical framework or extensions to this framework using behavioral economics. McConnell and Horowitz (2003) conclude that the gap does not automatically render the contingent valuation method invalid, but rather, the reasons for the difference should be further examined. Hanemann (1991) presented a neoclassical explanation for the gap using income and substitution effects. Shogren et al. (1994) found that their results support Hanemann's (1991) results. Knetsch (2010) argued that the difference is not inadequacy in the contingent valuation method, but rather that people simply value losses greater than gains. Also, the use of willingness-to-pay or willingness-to-accept depends on the initial assignment of property rights.

Finally, Hausman's third critique was that contingent valuation suffers from a lack of scope effects. Scope effect is the conception that the willingness-to-pay is the same whether an individual is valuing one, two, or ten goods (e.g., lakes). Hausman (2012) argued that contingent valuation studies fail the Diamond-Hausman adding up test, though it was unknown what the magnitude of the scope effects should be. Haab et al. (2013) criticized the adding up test by stating that it imposes a "specific structure on the preference function that may not be appropriate."

As a replacement for contingent valuation, Hausman (2012) advocated the use of experts to evaluate public policy and projects, including establishing non-use values. Decision-makers, however, are generally interested in the opinion and behavior of the general public. Experts are unable to claim to know the preferences of a population without first conducting a survey of their own or some form of informal observation about the public's willingness to make certain tradeoffs (Haab et al. 2013).

2.2. Hedonic Property-Price Approach

Following Rosen (1974), assume that an individual's utility with respect to a specific property is a function of structural, neighborhood, and ecosystem attributes, as well as a composite commodity signifying all goods other than the property. If preferences are weakly separable between housing attributes and other goods, then it is possible to identify the demand for housing characteristics as being independent from prices of other goods (Mahan, Polasky, and Adams 2000). In hedonic analysis, it is further assumed that the housing market is in equilibrium and that individuals optimize their selection based on prices of alternative housing options.

With these assumptions, the purchase price of a property can be described as a hedonic function of its structural, neighborhood, and ecosystem characteristics:

$$P_h = P_h(S, N, Q) \tag{2.1}$$

where P_h is the purchase price of housing option h, S is a vector of structural attributes, N is a vector of neighborhood attributes, and Q is a vector of ecosystem characteristics. Each individual maximizes utility subject to a budget constraint:

$$M - P_h - X = 0 \tag{2.2}$$

where M is income, P_h is price of the selected housing option, and X is the numeraire good. Taking first order conditions of the utility maximization problem provides the optimal level of the j^{th} ecosystem characteristic, q_j:

$$\frac{\partial u/\partial q_j}{\partial u/\partial X} = \frac{\partial P_h}{\partial q_j} \tag{2.3}$$

In other words, the additional utility to an individual of ecosystem characteristic q_j is reflected in the price of the property. The left-hand-side of Equation 2.3 is the marginal rate of substitution of the ecosystem characteristic for the numeraire (i.e., marginal willingness-to-pay for the ecosystem characteristic) (Freeman 1993; Mahan, Polasky, and Adams 2000). The right-hand-side is the partial derivative of the hedonic price function with respect to the ecosystem characteristic, which is the marginal implicit price of the ecosystem characteristic.

Over the past 20 years, 10 peer-reviewed studies used the hedonic price model to estimate the effects of wetlands on urban and rural residential property prices. Geographic study areas included Oregon, Minnesota, North Carolina, Maryland, Washington, D.C., and Australia. Surprisingly, four of these studies used the same property transactions dataset for single-family homes purchased between June 1992 and May 1994 in Portland, OR. Though not the primary focus of this literature review, a handful of peer-reviewed studies estimate the effects of wetlands on rural and agricultural land values as well (Johnston et al. 2001; Reynolds and Regalado 2002; Shultz and Taff 2004; Mashour et al. 2005). Table 2.1 lists the peer-reviewed studies that used a hedonic approach to estimate the effects of wetlands on single-family home prices using residential property transactions.

Table 2.1. Peer-reviewed literature using hedonic price models to estimate effects of wetlands on residential property prices

Author(s) and year published	Geographic location	Property transaction dates	Functional form
Bin (2005)	Portland, OR (urban)	June 1992 – May 1994	Semiparametric
Bin and Polasky (2005)	Carteret County, NC (rural)	January 2000 – September 2004	Log-linear
Doss and Taff (1996)	Ramsey County, MN (urban)	1990 (tax assessed market values)	Quadratic
Earnhart (2001)	Fairfield, CT (urban)	January 1994 – August 1996	Discrete-choice/ multinomial logit
Hardie et al. (2007)	5 counties in Washington, D.C./Baltimore, MD (urban)	1992 – 2000	Box-Cox
Mahan et al. (2000)	Portland, OR (urban)	June 1992 – May 1994	Log-linear
Martins-Filho and Bin (2005)	Portland, OR (urban)	June 1992 – May 1994	Nonparametric
Netusil (2005)	Portland, OR (urban)	1999 – 2001	Log-linear, log-log
Tapsuwan et al. (2009)	Perth, Western Australia (urban)	July 2005 – June 2006	Log-linear
Wu et al. (2004)	Portland, OR (urban)	June 1992 – May 1994	General equilibrium, log-log

Table 2.2 presents a general overview of results from the hedonic wetland service valuation studies.

Doss and Taff (1996) analyzed the effects on residential property prices in Ramsey County, MN, with respect to the proximity to four types of wetlands: open water, emergent vegetation, forested, and scrub-shrub wetlands. Though actual property transaction prices more accurately reflect equilibrium prices than tax assessed values (Doss and Taff 1996; Mahan, Polasky, and Adams 2000; Tapsuwan et al. 2009), Doss and Taff used tax assessed values for 1990 since transaction prices "simply were not available." The coefficients of the estimated quadratic hedonic model suggested a preference for living close to scrub-shrub, emergent, and open water wetlands. In other words, property price decreased as the distance from these wetland types increased. Results for the coefficient on forested wetland indicated that as the distance between a property and forested wetland increased the value of the property tended to increase.

Mahan, Polasky, and Adams (2000) examined the effects of proximity to wetlands on residential property prices in Portland, OR. Two log-linear hedonic models were estimated to capture effects of wetland proximity regardless of type and to estimate effects by type of wetland. Each model estimated the effects of four types of wetlands: open water, emergent vegetation, forested, and scrub-shrub, which were the same wetland types studied in Doss and Taff (1996). The first estimated model assumed that property values are a function of proximity and size of nearest wetland. The specification included structural and neighborhood attributes, size and distance to nearest wetland regardless of type, and dummy variables indicating the type of nearest wetland. Results suggest that property price tends to increase as the size of the nearest wetland increases and distance to nearest wetland decreases. The dummy variables for type of wetland were not statistically significant. So while there was a general preference for properties to be located near wetlands, the type of wetland did not influence preferences.

The second estimated model assumed that a property's proximity to different types of wetlands affects property values. Along with structural and neighborhood characteristics, this specification included the size of the nearest wetland and distance to nearest wetland of each type. Similar to the first model, results suggested that property price increased as the size of the nearest wetland increased (not accounting for wetland type). With respect to proximity, property price increased as the distance increased to emergent vegetation and scrub-shrub wetlands, which indicates that people would be willing to pay more to live further from these wetland types.

Table 2.2. General summary of results from peer-reviewed literature

		General		Wetland types		
Preferences	Location	Proximity	Size	Emergent vegetation	Forest	Scrub-shrub
Bin (2005)	Portland, OR	N/A	Smaller	-	-	Further
Bin and Polasky (2005)	Carteret County, NC	Further	Smaller	-	-	Further
Doss and Taff (1996)	Ramsey County, MN	N/A	N/A	Closer	Further	Closer
Earnhart (2001)	Fairfield, CT	Closer	N/A	N/A	N/A	N/A
Mahan et al. (2000)	Portland, OR	Closer	Larger	-	-	Further
Martins-Filho and Bin (2005)	Portland, OR	Closer	N/A	N/A	N/A	N/A
Netusil (2005)	Portland, OR	Closer	N/A	N/A	N/A	N/A
Tapsuwan et al. (2009)	Perth, Western Australia	Closer	N/A	N/A	N/A	N/A
Wu et al. (2004)	Portland, OR	Closer	N/A	N/A	N/A	N/A

Note: "N/A" indicates variable not included in study; " – " indicates not statistically sig. variable; green shaded cells (i.e., "closer" or "larger") indicate preference for closer proximity or larger wetland; red shaded cells (i.e., "further" or "smaller") indicate preference for further proximity or smaller wetland

Earnhart (2001) used revealed and stated preference data to examine household preferences for residential properties located near natural amenities in Fairfield, CT. Revealed and stated preference data were estimated separately and jointly. Focusing only on the revealed preference data, a discrete-choice hedonic analysis was used to estimate preferences for natural water amenities and restored marsh. Results indicated that households preferred properties located near restored marsh over disturbed marsh, as well as properties located near rivers and streams.

Wu, Adams, and Plantinga (2004) used an equilibrium model to analyze the effects of environmental amenities on house prices in Portland, OR. Their simultaneous system of equations used a log-log specification for residential properties sold between June 1992 and May 1994. The housing price function estimated the demand side of the market for housing and included a variable measuring the distance to the nearest wetland in feet. The estimated coefficient on this variable was negative and statistically significant, indicating that as the distance between a property and wetland increases, the price of the property decreases. Based on these results, households appear to prefer living close to wetlands.

Netusil (2005) investigated the effect of environmental zoning and amenities on house prices in Portland, OR. A log-log hedonic model included dummy variables for four "areas" that indicated whether a wetland was present on a property (Area A), located within 200 feet (Area B), located between 200 feet and 0.25 miles (Area C), or located between 0.25 and 0.50 miles from the property (Area D). The coefficients were not statistically significant for Areas A and B. The coefficients for Areas C and D, however, were negative and statistically significant (-0.015 and -0.039, respectively). This result indicates that wetlands located between 200 feet and 0.50 miles from properties had a negative impact on purchase price. Overall results imply that there is a preference for living closer to wetlands because increased distance between properties and wetlands negatively impacted home values. Wetland proximity was estimated to have no impact on home values within 200 feet, and property prices further from the wetland were negatively impacted.

Bin and Polasky (2005) estimated the effect of different wetland types on rural residential property prices in Carteret County, NC, between January 2000 and September 2004. The authors estimated three separate log-linear hedonic price functions. The first model included a variable indicating the percent of land that is covered by wetlands within 0.25 miles of a property. The coefficient on this variable was negative and statistically significant (-0.004). The reported marginal effect was -$561.91 at the sample mean. This value can be interpreted to mean that as wetland coverage increases by 1% within 0.25 miles of a property, the purchase price decreases by $561.91 (at the sample mean).

The second Bin and Polasky model estimated the effects of the distance to the nearest wetland in feet and the size of the nearest wetland in acres on purchase price. The coefficient for proximity was statistically significant (0.021) and indicated that as the distance to the nearest wetland increased, the purchase price also increased. For proximity variables, a positive (negative) coefficient indicates that people have a preference to live further from (closer to) the wetland. The marginal effect was $4.30 at the sample mean, meaning that as distance to the nearest wetland increases by 1 foot, the property price increases by $4.30. The coefficient on wetland size was negative and statistically significant (-0.006) indicating that as the size of the nearest wetland increases, the purchase price of a property decreases. The reported marginal effect was -$17.10.

Estimates from the third model captured effects on property price with respect to different types of wetlands by using interaction terms between distance to nearest wetland and a dummy variable indicating wetland type, as well as between size of nearest wetland and a dummy variable indicating wetland type. The four examined wetland types were coastal emergent, inland emergent, scrub-shrub, and forested. In general, results indicated that the type of wetland was not a significant factor affecting property prices, except for the size of the nearest scrub-shrub wetland. The coefficient was statistically significant (0.022) and had a marginal effect of $9.97. As the size of the nearest scrub-shrub wetland increased, property prices tended to increase as well.

Hardie, Lichtenberg, and Nickerson (2007) studied the effects of zoning regulations and open space on land prices in the Washington, D.C./Baltimore, MD, metropolitan area. The authors used a hedonic Box-Cox model and included a variable for the percent of subdivision land coverd by wetlands. The coefficient on this variable was not statistically significant indicating that wetland coverage in a subdivision did not affect land prices.

Tapsuwan et al. (2009) used a hedonic price model to estimate the effects of wetland proximity on the purchase price of urban properties in Perth, Western Australia. Three variables were specified in the log-linear model to capture wetland proximity: distance between a property and nearest wetland, inverse distance between a property and nearest wetland, and the number of wetlands near a property. The inverse distance variable allows for a property price to decrease at a faster rate when examining shorter distances between a property and wetland, while allowing for a less rapid decrease in property price for properties further away from the nearest wetland. For example, consider properties near a coastline. Beachfront properties will have a greater purchase premium than those located behind these properties due to the direct ocean view, while the other properties may have a partially blocked view. The difference in price between the beachfront properties and the properties with a partially blocked view will be larger than the difference for properties a mile away. The estimated coefficient on the distance between a property and nearest wetland was not statistically significant; however, the coefficients on the inverse distance and number of wetlands near a property were positive and statistically significant at the 1% and 10% levels, respectively. The positive and significant coefficient on the inverse distance variable suggests that as the distance between a property and wetland decreased, the purchase price increased. The coefficient on the number of wetlands near a property indicated that a greater number of wetlands near a property increased the purchase price.

Results from the papers discussed above are mixed. The differing results, however, are not surprising given that the studies use different functional forms and assess value for wetlands in different geographic locations. Though the majority of studies that estimate the effect of wetlands on residential property prices with a hedonic price function used parametric methods, a semiparametric or nonparametric model is another approach. These types of models are attractive in hedonic analysis because there is little *a priori* economic theoretical guidance to assist with functional form selection. Bin (2005) used a semiparametric hedonic model to estimate the effects of wetland proximity to residential properties in Portland, OR, purchased between June 1992 and May 1994. The evidence of nonlinearity in the variables is consistent with the general understanding that the hedonic price function is typically nonlinear (Freeman 1993). Results suggest that, in general, open water wetlands are preferred to emergent vegetation, forested, and scrub-shrub wetlands. Open water wetlands tended to show an overall positive impact on residential property prices, emergent vegetation wetlands had a negative impact, and the forested and scrub-shrub wetlands showed an insignificant effect. The results are consistent with the Doss and Taff (1996) study that used a fully parametric hedonic model.

Martins-Filho and Bin (2005) estimated the effects of wetland proximity on residential property prices in Portland, OR, using an additive nonparametric hedonic model. Wetland types were not differentiated in this study. Results of a linear parametric model and additive nonparametric model were presented. The authors noted that the parametric model produced similar results and findings for wetland values as that of the nonparametric model. Distance of a property to the nearest wetland is included in the model. The results indicate that as this distance increases, property values tend to decrease. This finding is true for distances between 0 and 2 kilometers. Wetland proximity does not have a significant impact on property values beyond a distance of 2 kilometers.

2.3. Comparative and Joint Stated-Revealed Preference Estimation

Revealed preference methods are not without their own criticisms. The reliance on historical data is a weakness of revealed preference methods and is often not available in cases where new products or policies are under consideration (Whitehead et al. 2008). Since stated preference methods are flexible and can capture this type of data, it is intuitive that combining data from these two types of sources helps overcome limitations.

The extent of available market data is also a limitation of revealed preference methods. Chapter 3, for example, uses historical housing market data for wetland service estimation which includes sales prices and property characteristics for single-family homes sold in 2010-2013. The dataset, therefore, does not contain information on houses not sold during this period which could present sample selection bias. It remains unknown whether the preferences for households that did not sell their homes during the time period are any different than for those that sold their house. Also, certain property characteristics such as house age and size were not available for parishes in Louisiana due to data limitations. Stated preference data could remedy this unavailability of data. The data enrichment paradigm (Louviere 2000) combines stated and revealed preference methods to enhance estimation by minimizing overall weaknesses. The idea of combining these two types of data first evolved in the fields of marketing and transportation and later spilled over into environmental economics (Whitehead et al. 2008).

The use of revealed and stated preference data benefits comparative and joint analysis studies. Comparison studies estimate revealed and stated preference data individually and then compare the estimates from the two methods to assess convergent validity (Whitehead et al. 2008). These types of studies typically use the same sample of individuals in both sets of data. For joint estimation, the focus here is on pooled data studies where data are stacked and errors are assumed to be independent and identically distributed. Stated and revealed data can be stacked when both datasets include similar dependent and explanatory variables. In other words, the structure of the analysis methods must be compatible for combining data.

Not all revealed preference methods can be combined or easily combined with stated preference approaches. Earnhart (2001) is the only study in the nonmarket valuation literature that utilizes hedonic analysis to jointly estimate marginal attribute values with stated preference methods. McConnell (2011) states that hedonic analysis is not often used in joint stated-revealed preference estimation "with good reason." Hedonic analysis relies on market equilibrium, and this type of structure is not appropriate with stated preferences for joint estimation.

Hedonic analysis can be performed through hedonic price functions and discrete-choice hedonic analysis. A hedonic price function, like that used in Chapter 3, has price as a function of housing and ecosystem attributes. For these functions, McConnell (2011) suggests a comparison study where the hedonic marginal price of an attribute is compared to the estimated stated preference marginal value for convergent validity.

Discrete-choice hedonic analysis assumes that households choose from a selection of discrete housing options (dependent variable) and that these different housing options are a function of the price, property characteristics, and environmental attributes, as well as socioeconomic characteristics of the households. Based on available sources of revealed preference data for the housing market, socioeconomic characteristics can typically only be obtained through surveys. As an alternative to a side-by-side estimates comparison study, Earnhart (2001) uses a joint estimation approach by combining a discrete-choice hedonic model and conjoint analysis in which data from these stated and revealed preference methods are estimated simultaneously. Choice-based conjoint analysis is a stated preference method in which an individual chooses one of several hypothetical options based on varying prices and attributes for each possible selection (as opposed to rank-ordered where respondents are presented with a set of hypothetical housing options and asked to rank all locations based on varying attributes, which is not an appropriate application for the housing market (Freeman 1991)). Though this combination of methods can be used in joint analysis, estimation will be difficult at best since an equilibrium model will be required (McConnell 2011). This type of approach also “imposes considerable structure (implicit in the discrete choice modeling itself) on the nature of household preferences” (Sheppard 1999).

The discrete-choice methods are based on the same structure and can be analyzed using a multinomial logit model where the dependent variable is a discrete variable that takes on greater than two values. The dependent variable contains the feasible set of housing options from which people make their housing selection in either a real market (revealed preference) or hypothetical market in a survey (stated preference). As part of the explanatory variables, Earnhart (2001) primarily uses dummy variables to indicate whether properties are adjacent to environmental amenities and does not include distances to these amenities. “Incorporating distance into the discrete-choice framework would substantially expand the analysis…because distance would need to be interacted with each type of amenity” (Earnhart 2001).

2.3.1. Joint Estimation Task

If joint estimation were undertaken for a wetland services study using hedonic analysis, the best option would be to model the analysis after Earnhart (2001). In this example, discrete-choice hedonic analysis and choice-based conjoint analysis are employed. Earnhart (2001) recommends first estimating the revealed and stated preference data separately and then jointly. The discrete-choice hedonic analysis implies that the selected housing option is a function of price and property, neighborhood, and environmental attributes (McFadden 1978). The revealed preference data used in the estimation would be collected using the same methods as those described in Chapter 3. Under this model, the data will be separated into smaller housing markets (e.g., counties). The dependent variable is a discrete variable consisting of all feasible housing options available at the time of purchase which is called the feasible or choice set. Earnhart (2001) suggests limiting the feasible set for "tractability." Following Milon, Scrogin, and Weishampel (2007), choice sets for each property sold are defined as the purchased property, as well as 249 properties that were sold within a three-month timeframe of the selected property. For example, if a property was purchased in February, then 249 randomly selected properties that were sold in January, February, and March of that same year are part of the feasible set. The multinomial logit model is used to estimate the revealed preference data, where the probability that a particular house is purchased given the choice set is a function of price, property attributes, and wetland proximity. The wetland proximity variables should be transformed into categorical variables by range of distance.

For the choice-based conjoint analysis, a subset of the homebuyers collected as part of the revealed preference data will be surveyed to obtain stated preference data. The survey will collect data based on similar variables that are included in the revealed preference estimation. In addition to these variables, socioeconomic data will be collected particularly to control for differences in population groups such that the models assumes independence of irrelevant alternatives (Earnhart 2001; Quigley 1985; Ben-Akiva and Lerman 1985). Specific attributes and the number of levels for each must be considered carefully as to not make the model too extensive and unmanageable. Each choice set presented to survey-takers will include three housing options. One selection is the house that they purchased describing that property's characteristics, while the other two will include varying levels of attributes for properties that were not purchased. An orthogonal main effects survey design will be implemented using software such as Sawtooth or Ngene. This methodology diminishes the burden on respondents by reducing the number of choice sets that must be evaluated in each survey. Focus groups will be consulted on the survey design and appropriate number of choice sets to evaluate. The multinomial logit model is the most appropriate approach to estimating this type of stated preference data.

If most coefficients are statistically significant in the revealed and stated preference models, then it is worthwhile to go forth with joint estimation (Milon, Scrogin, and Weishampel 2007). Once stated and revealed data are combined, the data can be estimated in a conditional logit model (Adamowicz, Louviere, and Williams 1994) and assume that observations are independent (Adamowicz et al. 1997). The hypothesis of equal parameters should be tested with a likelihood ratio test. Failure to reject the hypothesis indicates that the two data types have "similar preference structures" (Earnhart 2001).

Comparing and jointly estimating stated and revealed preference data benefits estimation by minimizing weaknesses. Estimates can be compared for convergent validity. Surveys are also able to capture types of information that otherwise do not exist in revealed preference data sources. Hypothetical and omitted variable biases, which are primary criticisms of stated and revealed preference models, respectively, can also be diminished. Stated and revealed preference methodologies should be utilized as complementary tools in comparative and joint estimation studies due to the possible improvements in nonmarket value estimation. Given the benefits, future research will include comparative and joint estimation of stated and revealed preference models.

CHAPTER 3. DATA COLLECTION AND PREPARATION

Mobile Bay Estuary in Alabama and Barataria-Terrebonne Estuary in Louisiana were chosen as the study areas because these areas house some of the most fragile wetlands in the U.S. (U.S. Geological Survey 2014) and monetary values for private benefits to residential property owners have not yet been estimated. To capture private benefits of coastal wetlands in the Mobile Bay Estuary Program and Barataria-Terrebonne Estuary Program, only residential properties located in counties and parishes in the National Coastal Zone Management Program along these estuaries were considered for inclusion in the study. In Alabama, these counties include Mobile and Baldwin. In Louisiana, the parishes included Assumption, St. James, Terrebonne, St. John the Baptist, St. Charles, Jefferson, Orleans, Plaquemines, Lafourche. To estimate wetland service values using hedonic analysis, data must be collected through property maps, sales transactions data, and feature maps. Maps and property sales data were only available for Mobile, Baldwin, St. Charles, Jefferson, and Orleans; therefore, these counties and parishes were included in analysis.

3.1. Data Collection for Variables Included in Analysis

Parcel maps allow for property-specific spatial data collection and were purchased from CoreLogic[1] and ReportAllUSA[2] in the shapefile (.shp) format. Figure 3.1 presents an example parcel map for properties surrounding Tulane University in New Orleans, Louisiana. Green-shaded areas indicate the properties included in analysis. The geographic information systems software ArcMap 10.2.2 (ESRI 2014) was used to determine property-specific attributes such as crime rate, elevation, and proximity to wetlands. Embedded within these shapefiles is information

[1] CoreLogic (purchased September 2014): http://www.corelogic.com/
[2] ReportAllUSA (purchased September 2014): http://reportallusa.com/

regarding property location (geographic coordinates of property boundary), physical address, and property identification number (assigned by the county/parish tax assessor).

Figure 3.1. Parcel map for properties surrounding Tulane University in New Orleans, Louisiana

Property sales transaction data were purchased from DataQuick[3] (now part of CoreLogic). Two primary data sources were available: recorder and assessor data. Recorder data provides information about property sales transactions (e.g., purchase price, date of sale, arms-length transaction indicator), while assessor data provides property characteristics data (e.g., age of home, size of home and property, number of stories, number of units on property, tax assessor property identification number). The recorder and assessor data files were received as large text files (.txt) with each file being over 10 GB.

The statistical software package Stata/MP 13.1 (StataCorp 2013) was used to analyze data. The text files were imported into Stata using dictionary files (.dct). Dictionary files are typically user-written code that provide Stata with a set of instructions for importing fixed-width text files. These instructions include what text file to read into Stata, the variable format (e.g., string or

[3] DataQuick / CoreLogic (purchased February 2014): http://www.corelogic.com/landing-pages/dataquick.aspx

numeric), variable name, and number of values in each variable (width) to import. Once the recorder and assessor datasets were imported as Stata data files (.dta), then the two datasets were merged using the DataQuick internal property identification number. Separate datasets were then created for each county/parish included in the study area. These datasets will be referred to as "sales transaction datasets" or "sales data" in the remainder of this document. The purchase price, age of home at the time of purchase, size of the home and lot, and date of sale (indicating whether the home was purchased during the summer or not) are obtained from these sales transactions datasets.

In order to transfer property-specific spatial data from ArcMap to Stata, the data must be linked. ArcMap uses feature identification numbers (FIDs) to identify properties (i.e., features) in the shapefile. These FIDs link the data between ArcMap and Stata and allow for the transfer of spatial data between the software. In order to link the data, a list of FIDs, tax assessor property identification numbers, and addresses from shapefiles are exported as text files (.txt) and then imported into Stata as data files (.dta). This imported dataset is then merged with the sales transaction dataset by tax assessor property identification number. The variable that will be used to perform the merge must be exactly the same in each dataset. Therefore, the tax assessor property identification numbers were changed to the same case (i.e., transformed into all captial letters) and all punctuation was removed. Merges were successfully performed using the tax assessor property identification numbers for all counties and parishes except Orleans. For Orleans Parish, properties in each dataset were matched by physical address instead. With the successful merges, the FID acts as the identifying link between properties in ArcMap and Stata.

Crime rate data were acquired through Applied Geographic Solutions, Inc.[4] and FBI Uniform Crime Report databases, which provides a comparable national crime rate index by zip code. The national base level is 100. A value higher than this, such as 150, indicates that an area has an overall crime rate 50% greater than the national average. Crime rates were assigned to properties in Stata based on the zip code of the property location.

Spatial data can be collected using feature maps in ArcMap. Once these shapefiles are overlaid with the property boundary maps, property-specific data can be collected such as elevation and proximity to the central business district, nearest park, coastline, and different types of wetlands. For distances to be calculated correctly, all shapefiles must use the same geographic coordinate system. All shapefiles were projected into WGS 1984 UTM Zone 15N.

Elevation maps obtained through the U.S. Geological Survey (USGS) National Elevation Dataset[5] provide the elevation of properties in feet above and below sea level at the property centroid. The shapefiles downloaded from the USGS website are raster data where aerial imagery is transformed into a grid such that each cell of the grid represents elevation at that location. Figure 3.2 provides an example of how the raster data appear in ArcMap for New Orleans, Louisiana. As indicated by the key in the bottom-right corner of the figure, darker areas indicate lower elevations closer to -13.45 feet (below sea level), while lighter areas indicate relatively higher elevations closer to 25.33 feet (above sea level). The blue dots represent the centroid of properties included in the analysis.

The central business district was determined to be Mobile in Alabama and New Orleans in Louisiana. In ArcMap, the shortest driving distance between each property and the nearest central

[4] Applied Geographic Solutions, Inc. crime rate comparison map through ArcGIS Online (downloaded March 2014): http://www.arcgis.com/home/item.html?id=8125e8f4244a47d986f4cd840824eef3
[5] USGS National Elevation Dataset (downloaded March 2014): http://ned.usgs.gov/

business district was calculated using the Network Analyst Tools in the ArcToolbox. A TIGER/Line shapefile that maps the roads in each county/parish was downloaded from the U.S. Census Bureau website. Each shapefile was then used to build a network dataset in ArcCatalog 10.2.2, a data management system for ArcMap. Network datasets allow for the calculation of the shortest distance between two features along the road network. Each property and central business district had to be added to the network dataset using the "Add Locations" feature in the Network Analyst Tools. The "Make OD Cost Matrix Layer" tool was used to calculate the shortest driving distance between each property and the nearest central business district. Figure 3.3 presents an example of how the road network appears in New Orleans. In this figure, yellow lines indicate roads, blue dots represent centroids for properties included in analysis, and the single red dot indicates the location of the central business district.

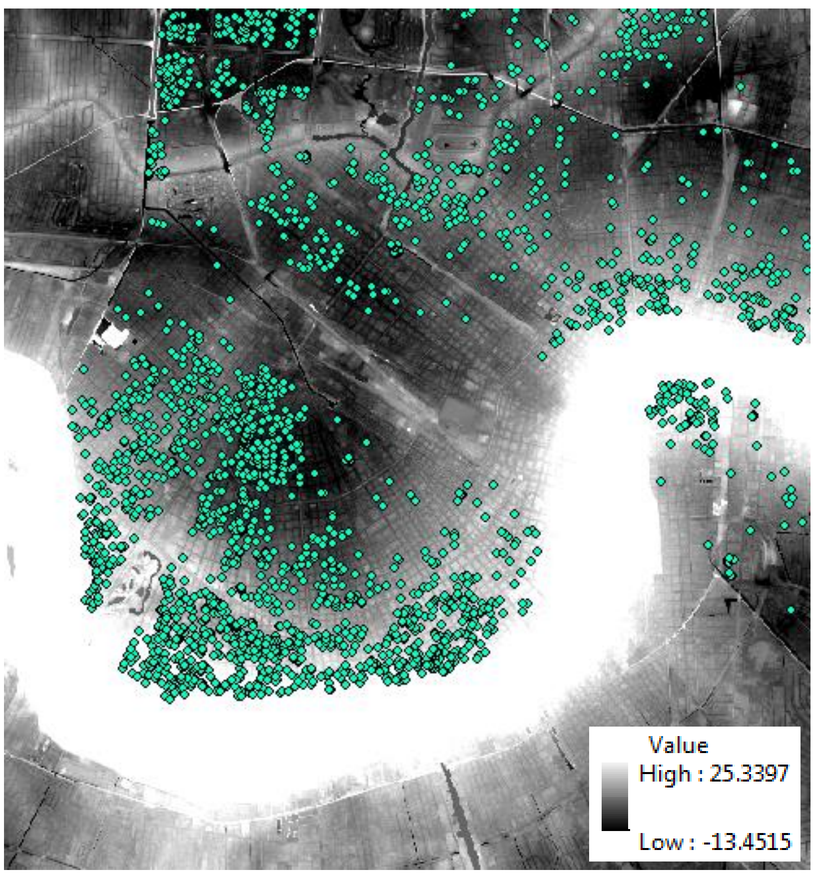

Figure 3.2. Elevation of New Orleans, Louisiana

Proximity to nearest park was determined using the USA Parks layer[6] downloaded from ArcGIS Online. The layer uses data from the National Park Service to provide the name and location of local, state, and national parks in Alabama and Louisiana. The "Generate Near Table" proximity tool calculates the shortest distance between two features and saves this information for every property as a table in a text file. In this case, this tool was used to calculate the distance in miles between the centroid of a property and the edge of the nearest park regardless of type. The nearest park did not have to be located in the same county/parish as the examined property. Once this information was saved in a text file, the data were imported into Stata and merged with the appropriate county/parish sales transaction dataset. The same process was followed for proximity variables for distance to the nearest point along the coastline. U.S. Census Bureau TIGER/Line[7] shapefiles mapping the coastline in Alabama and Louisiana allowed for the calculation of the distance of each property to the coastline.

Wetland ecosystem maps were obtained through the U.S. Fish and Wildlife Service (USFWS) National Wetlands Inventory[8]. The following seven types of wetlands are classified by the USFWS as: 1) estuarine and marine deepwater, 2) estuarine and marine wetland, 3) freshwater emergent wetland, 4) freshwater forested/shrub wetland, 5) freshwater pond, 6) lake, and 7) riverine. Primary differences between these wetlands include the salinity of the water (i.e., freshwater, brackish, and saltwater), depth of water, and vegetation. Once the shapefiles were downloaded for Alabama and Louisiana, all wetland types were included in one shapefile. In order to calculate the distance to the nearest wetland by type, individual shapefiles were created for each

---

[6] USA Parks map through ArcGIS Online (downloaded March 2014): http://www.arcgis.com/home/item.html?id=578968f975774d3fab79fe56c8c90941

[7] U.S. Census Bureau 2014 TIGER/Line files (downloaded September 2014): https://www.census.gov/geo/maps-data/data/tiger-line.html

[8] USFWS National Wetlands Inventory wetlands maps by state (downloaded March 2014): http://www.fws.gov/wetlands/Data/State-Downloads.html

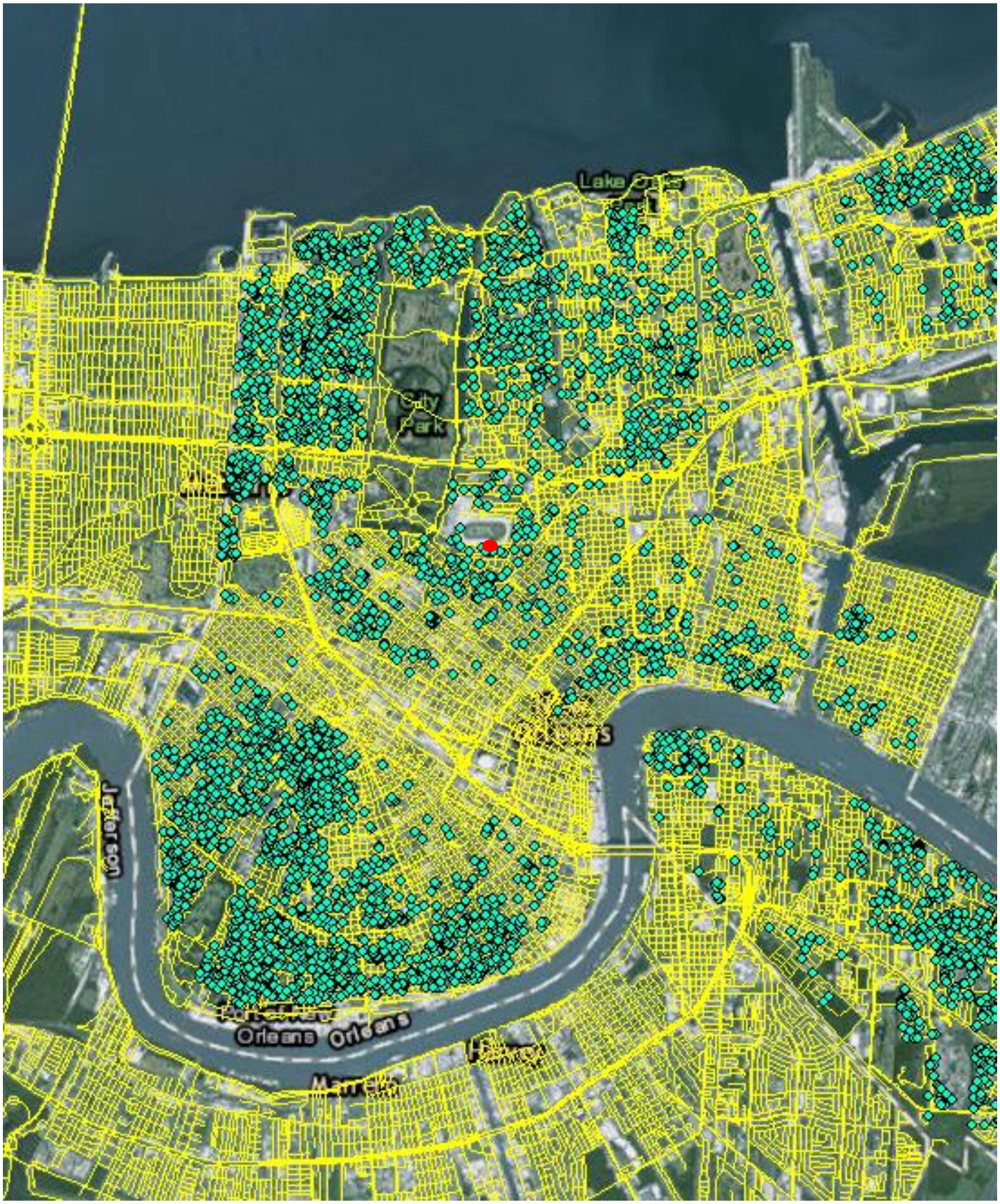

Figure 3.3. Road network and property centroids in New Orleans, Louisiana

wetland type. The "Generate Near Table" proximity tool was then used to calculate the shortest distance between each property and each type of wetland. The nearest wetland did not have to be located in the same county/parish as the examined property. Once this information was saved in a text file, the data were imported into Stata and merged with the appropriate county or parish sales transaction dataset. This process was completed for each wetland type. Figure 3.4 presents an example wetland map of freshwater ponds in New Orleans. Red-shaded areas indicate the presence of a freshwater pond ecosystem.

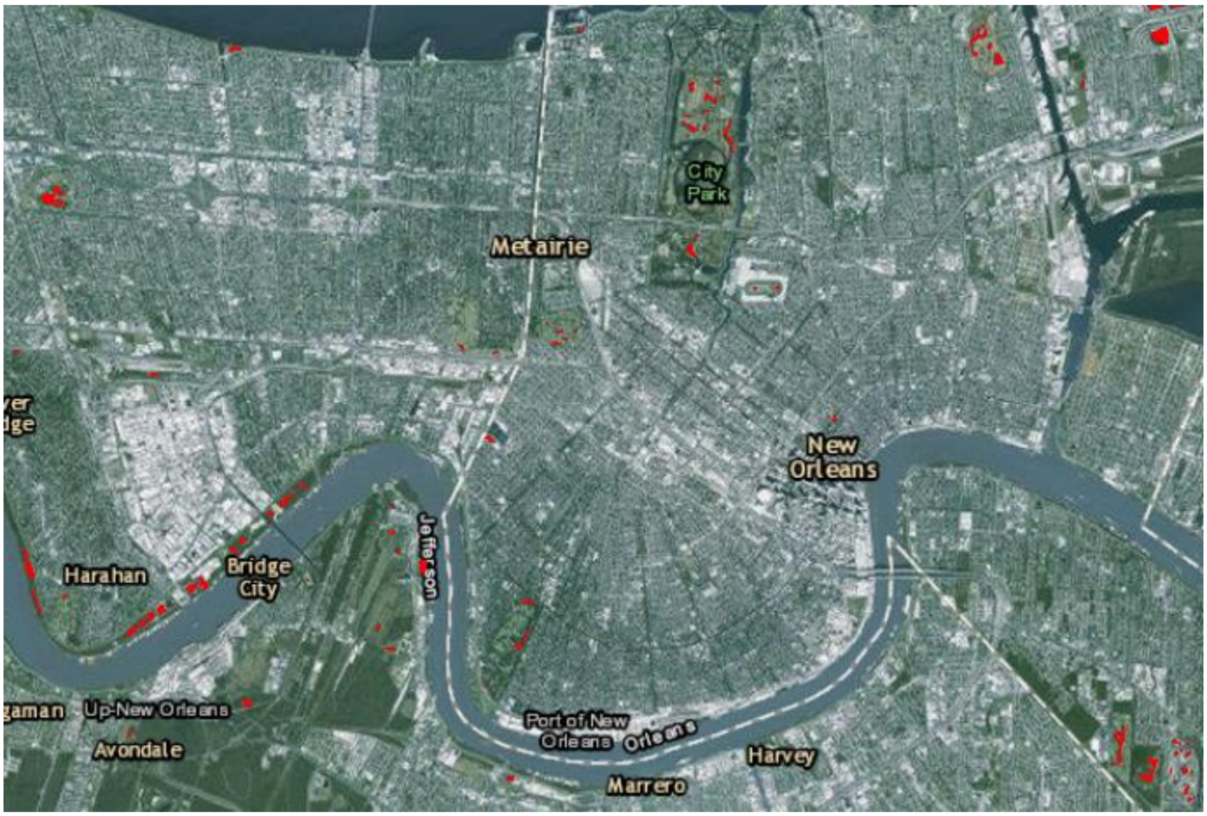

Figure 3.4. Freshwater ponds in New Orleans, Louisiana

3.2. Data Collection for Variables Not Included in Analysis

Data on school quality was considered for inclusion in the Alabama and Louisiana models but could not be incorporated into analysis because of data limitations. The school district quality index was obtained through Zillow[9] and GreatSchools.org. This index rates district quality on a 1 to 10 scale, incorporating attributes such as student/teacher ratios and schools' test results. School districts in Louisiana are based on parishes. Three out of four of the parish school districts received

[9] Zillow school ratings map (data viewed in March 2014): http://www.zillow.com/jefferson-parish-la/schools/

a score of 8, while one received a rating of 5. Using the data in this form creates a simple dummy variable that, if used in a model, would only capture differences in purchase prices by parish and would not accurately capture effects of school quality. The same was true for Alabama school districts which are primarily based on counties. Therefore, the school quality index was not used.

Federal Emergency Management Agency (FEMA)[10] flood zones were also considered for inclusion. Flood zone classifications categorize different levels of flood risk for properties (FEMA 2014). In Louisiana, for example, properties classified into Zone A are considered to be in an area with an elevated risk for flooding. These areas are considered Special Flood Hazard Area (SFHA), which FEMA (2014) defines as, "…the area that will be inundated by the flood event having a 1-percent chance of being equaled or exceeded in any given year" (i.e., 100-year flood). Maps have not yet been digitized into shapefile format for Louisiana and Alabama. The best available information is in PDF format which does not allow for direct collection of property-specific data. Due to this limitation, FEMA flood zone classifications were not included in the analysis for either state's study area.

[10] FEMA Flood Map Service Center (data viewed in September 2014): https://msc.fema.gov/portal

CHAPTER 4. ANALYSIS METHODS AND RESULTS

This chapter presents the methods used to estimate the monetary value of wetland services that can be captured using the hedonic price model for residential property owners near Mobile Bay, Alabama, and Barataria-Terrebonne Estuary, Louisiana. General analysis methods are presented first, followed by estimation results for Alabama and Louisiana.

4.1. Functional Form

The ordinary least squares approach was used to estimate the parameters of a linear regression model. Variables were selected for inclusion in the model based on previous hedonic studies and available data. Since property transactions data are available for 2010 to 2013, purchase prices were adjusted to base year 2013 using the Consumer Price Index: Housing for the U.S. published by the Organisation for Economic Co-operation and Development (OECD) and Federal Reserve Bank of St. Louis (FRED Economic Data). Table 4.1 lists the names and descriptions of explanatory variables included in the Alabama and Louisiana model specifications. The table also includes the hypothesized signs on estimated coefficients which are based on previous hedonic studies in the wetland service valuation and real estate literature.

Functional form is a primary concern in hedonic analysis. Some of the most popular forms used in the hedonic price literature are linear, quadratic, log-linear, and Box-Cox (Freeman 1993; Palmquist 2005; Graves et al. 1988). Linear and quadratic specifications are appropriate when assuming that there exists a continuous supply of products (Sopranzetti 2010; Taylor 2008). This continuum of products, however, is not necessarily available in a housing market where houses are not easily restocked once sold; therefore, the log-linear specification is more appropriate in the case of discontinuity in product supply (Sopranzetti 2010). The Box-Cox transformation model (Box and Cox 1964) is also suggested as it is a flexible functional form where the transformation parameter estimate is not imposed on the model; however, the primary disadvantage is that the coefficients have no direct economic interpretation.

Table 4.1. Names and definitions of explanatory variables

Name	Description	Hypothesized Sign
<u>Property and Neighborhood Attributes</u>		
AGE	Age of building (years); Alabama model only	-
BLDG	Size of building (square feet); Alabama model only	+
LAND	Size of property (1,000 square feet)	+
SUMMER	1 if sold during summer months, 0 otherwise	+
CRIME	Crime rate index	-
CBD	Distance to central business district (miles)	- *
PARK	Distance to nearest park (miles)	- *
MARINA	Distance to nearest publicly accessible marina or boat ramp (miles)	- *
ELEVATION	Property elevation at centroid (feet)	+
COAST	Distance to coastline (miles)	- (AL) / + (LA)*
<u>Wetland Characteristics</u>		
EMW	Distance to nearest estuarine and marine wetland (miles)	Unknown
FEW	Distance to nearest freshwater emergent wetland (miles)	Unknown
FFSW	Distance to nearest freshwater forested/shrub wetland (miles)	Unknown
POND	Distance to nearest freshwater pond	Unknown
LAKE	Distance to nearest lake (miles)	Unknown
RIVER	Distance to nearest river (miles)	Unknown

**A positive sign on proximity variables can be interpreted such that as the distance between the property and amenity increases (decreases), the purchase price increases (decreases).*

A popular use of the Box-Cox transformation model is to test three special cases nested within the transformation as the functional form of best fit for the data: linear, log-linear, and multiplicative inverse functional forms (Atkinson 1985; Arguea and Hsiao 1993; Davidson and MacKinnon 1993). The Box-Cox transformation is defined by:

$$y^{(\lambda)} = \frac{y^{\lambda}-1}{\lambda}, \tag{4.1}$$

where y is the dependent variable and λ is the transformation parameter. The value of λ determines the special forms:

$$y^{(\lambda)} = \begin{cases} y-1\,, if\ \lambda = 1 \\ \ln(y)\,, if\ \lambda = 0 \\ 1-\frac{1}{y}\,, if\ \lambda = -1 \end{cases} \tag{4.2}$$

The three special cases are linear (λ = 1), logarithmic (λ = 0), and multiplicative inverse (λ = -1). Estimating the Box-Cox model produces a value which helps determine which of these special forms is the most appropriate by examining minimum differences. For example, if the estimated parameter value is λ = 0.99, then the linear form is the best fit for the data out of the three special cases. Based on the likely discontinuity of product supply in the housing market and results of the Box-Cox model test (discussed in Sections 4.4 and 4.5), the log-linear functional form was estimated. The log-linear hedonic model is specified as:

$$\ln(P_i) = \beta_0 + \sum_{j=1}^{J}\beta_j S_{ij} + \sum_{k=1}^{K}\beta_k N_{ik} + \sum_{m=1}^{M}\beta_m W_{im} + \varepsilon_i \tag{4.3}$$

where $\ln(P_i)$ is the natural log of the real purchase price in 2013 dollars for property i, S_{ij} is the j^{th} structural characteristic of property i, N_{ik} is the k^{th} neighborhood characteristic of property i, W_{im} is the m^{th} wetland characteristic for property i, and ε_i is the error term for property i.

Dummy variables are interpreted differently in a log-linear model than in a linear model (Halvorsen and Palmquist 1980). The impact of a zero-one dummy variable on the dependent variable is:

$$p = e^{\beta} - 1 \tag{4.4}$$

where p is the proportional impact of the dummy variable on the dependent variable and β is the estimated coefficient of the dummy variable.

4.2. Outlier Analysis

Properties were removed from analysis if: (1) a match could not be made between sales data and parcel boundary maps using property identification numbers or addresses; (2) observations were for properties other than single-family residences (e.g., condominiums); (3) transactions were flagged as a distress sale (e.g., foreclosure); (4) property was vacant land (i.e., no structure on lot at the time of purchase); (5) not an arms-length transfer; and, (6) observations were missing for variables in model. Despite accounting for these factors, the minimum purchase price for several observations was unusually low. For example, the purchase price for a 2,500 square foot home in Orleans Parish, Louisiana, was listed as $3,500, which is not realistic.

After a review of property listings in the study areas on Zillow, Trulia, and Realtor.com, it was determined that $30,000 was a realistic minimum purchase price in an arms-length transfer for properties with a single-family home (e.g., instead of a slab only or undeveloped land). Therefore, observations with a purchase price less than $30,000 were removed from analysis (n=330 in Alabama; n=654 in Louisiana). The Cook's D statistic was then used to assess outliers with large model influence based on large residual values and leverage. Observations with a Cook's D statistic greater than 4/*n* should be considered for removal from analysis, where *n* is number of observations (Swanson and Tyam 2012). Figures 4.1 and 4.2 show the leverage and normalized squared residuals for Alabama and Louisiana, respectively. Observations to the right of the red vertical line have large residuals, while those above the red horizontal line have large leverage. Observations above and/or to the right of these red lines were removed from analysis where Cook's D was greater than 4/7,578 ≈ 0.0005 in Alabama (n=226) and greater than 4/6,040 ≈ 0.0006 in Louisiana (n=289). The resulting number of observations used in each state's model is shown in Figures 4.3 and 4.4 by county and parish, respectively. The colored markers in these figures represent the centroids of properties included in the analysis. The analysis uses 5,751 properties in Louisiana and 7,060 in Alabama for single-family homes purchased between 2010 and 2013.

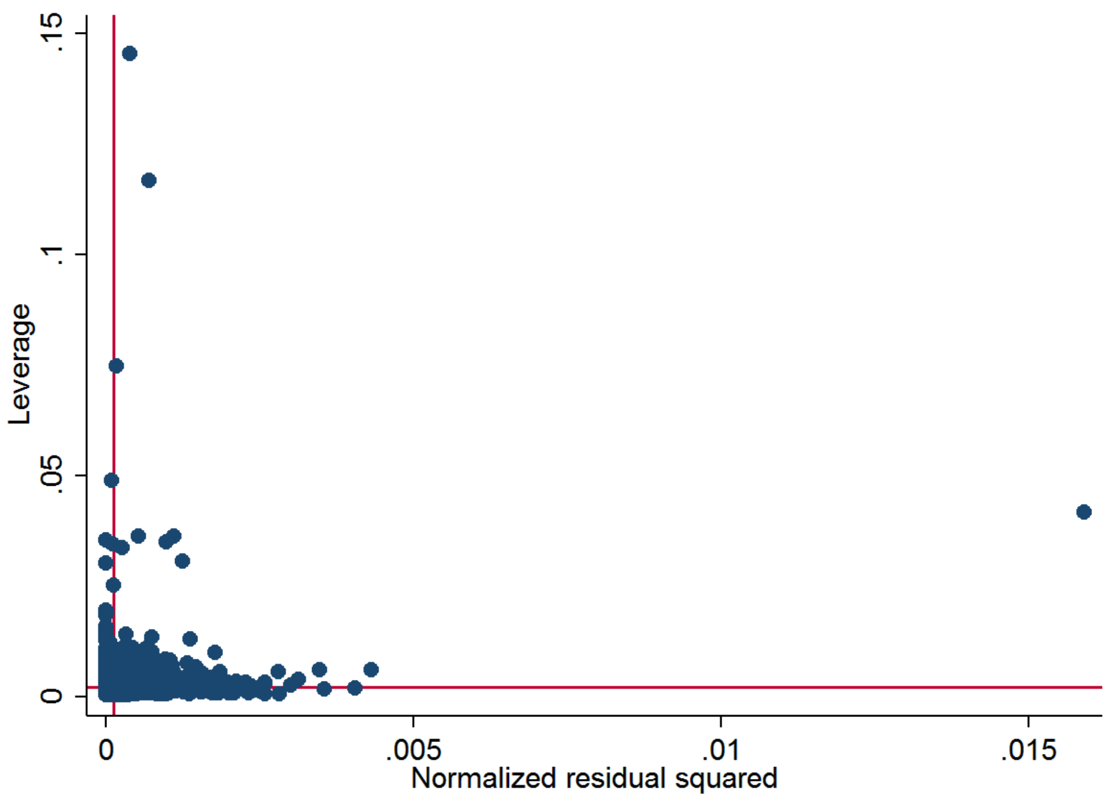

Figure 4.1. Plot of leverage and normalized squared residual values for Alabama data

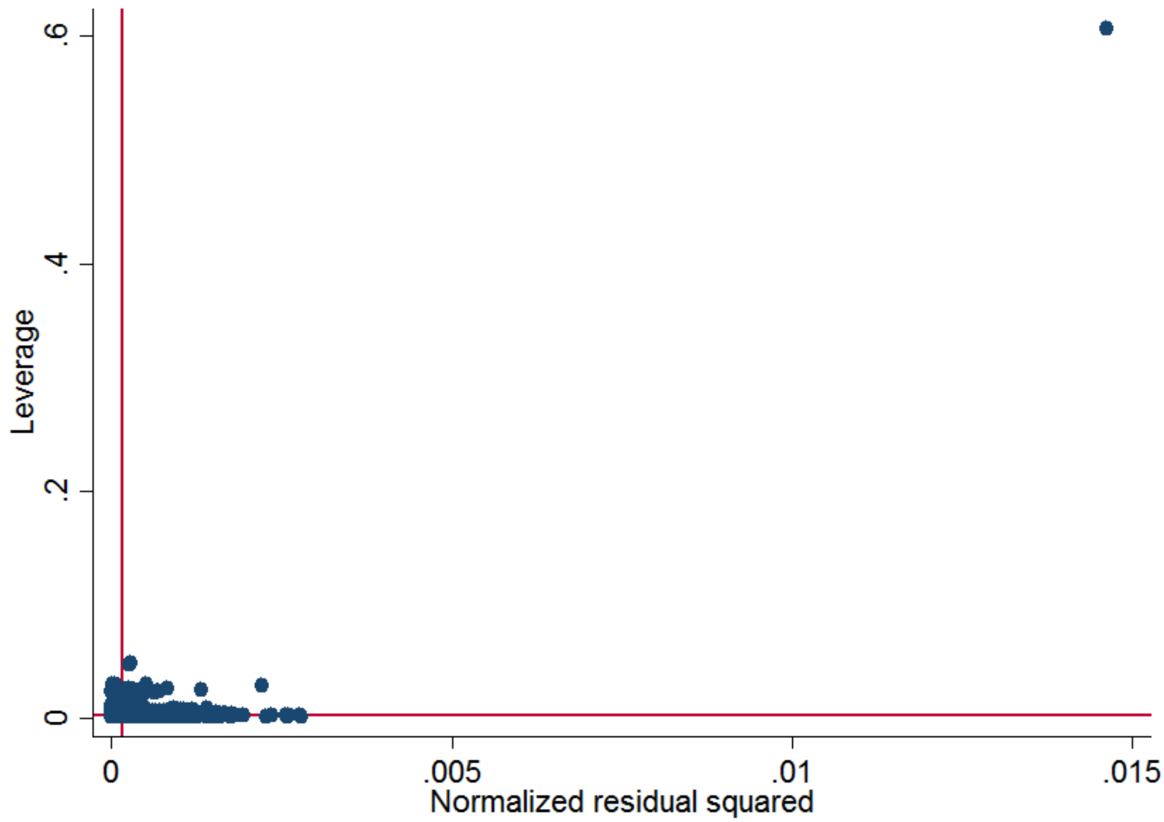

Figure 4.2. Plot of leverage and normalized squared residual values for Louisiana data

4.3. Regression Diagnostics

For the estimates of a linear regression to be valid, the following assumptions must hold: (1) the expected value (i.e., mean) of the residuals is zero; (2) homoskedastic errors; (3) uncorrelated errors; and, (4) normally distributed residuals. The expected value of the errors was checked by estimating the mean value of residuals. This value was zero in both the Alabama and Louisiana models. Homoskedasticity of residuals can be examined through a plot of the residuals against predicted values of REALPRICE or by the Breusch-Pagan test for heteroskedasticity. Residual plots for Alabama and Louisiana are presented in Figures 4.5 and 4.6, respectively. After visual inspection of the plots, evidence of heteroskedasticity is present in both models. Results of the Breusch-Pagan test reject the null hypothesis of constant variance at the 0.01 level, suggesting that the errors are heteroskedastic in both models ($\chi^2(1) = 33.56$ for

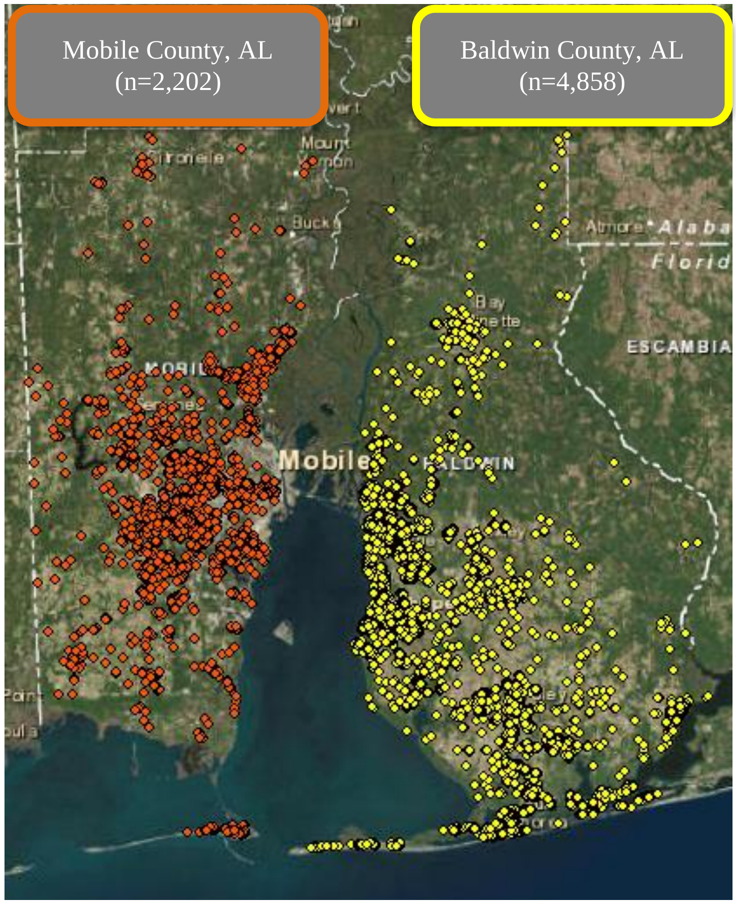

Figure 4.3. Map of Alabama study area and number of observations by county

Alabama; $\chi^2(1) = 6.08$ for Louisiana). With these results, robust standard errors were estimated using the vce(hc3) option in Stata. Suggested by Davidson and MacKinnon (1993), this method adjusts standard errors for bias with the following correction factor:

$$u_j^2/(1 - h_{jj})^2 \tag{4.5}$$

where u_j is the estimated residual of the jth observation and h_{jj} is the element along the main diagonal of the projection matrix (StataCorp 2013).

Uncorrelated errors are achieved when the explanatory variables do not have a large degree of linear association. Pearson correlation coefficients are presented in Tables 4.2 and 4.3 for

Alabama and Louisiana, respectively. The majority of the explanatory variables do not exhibit a large degree of correlation. Variance inflation factors (VIFs) also help to identify variables that

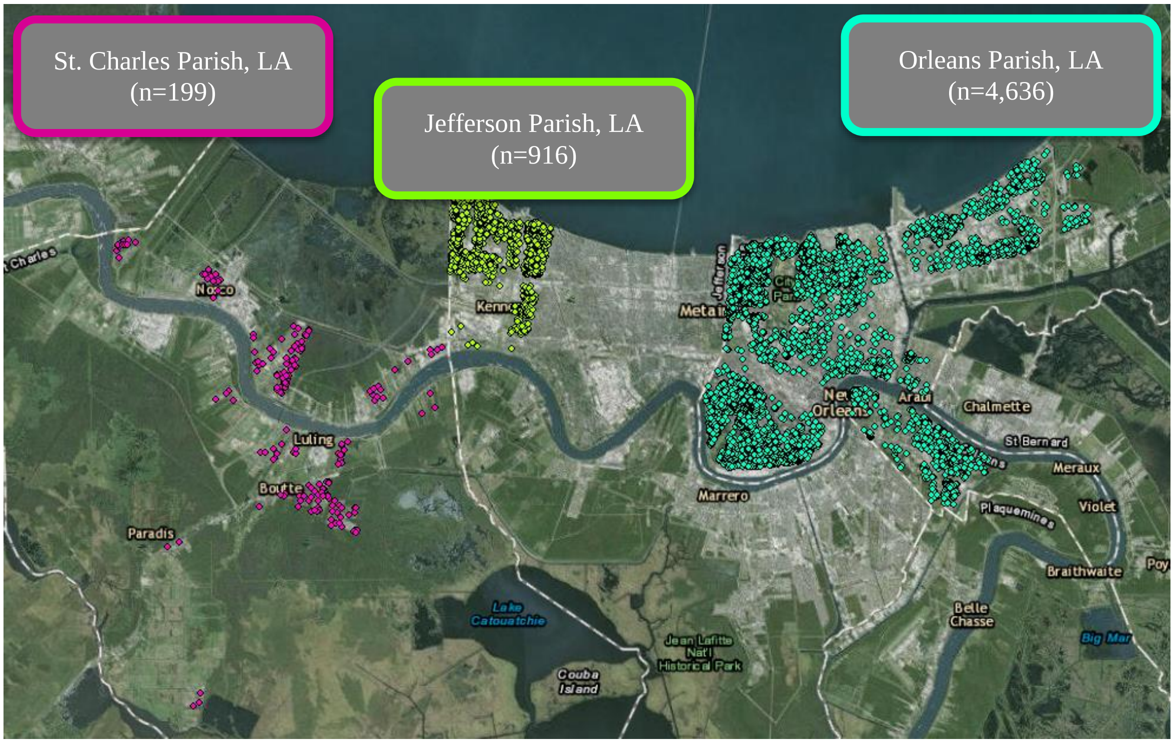

Figure 4.4. Map of Louisiana study area and number of observations by parish

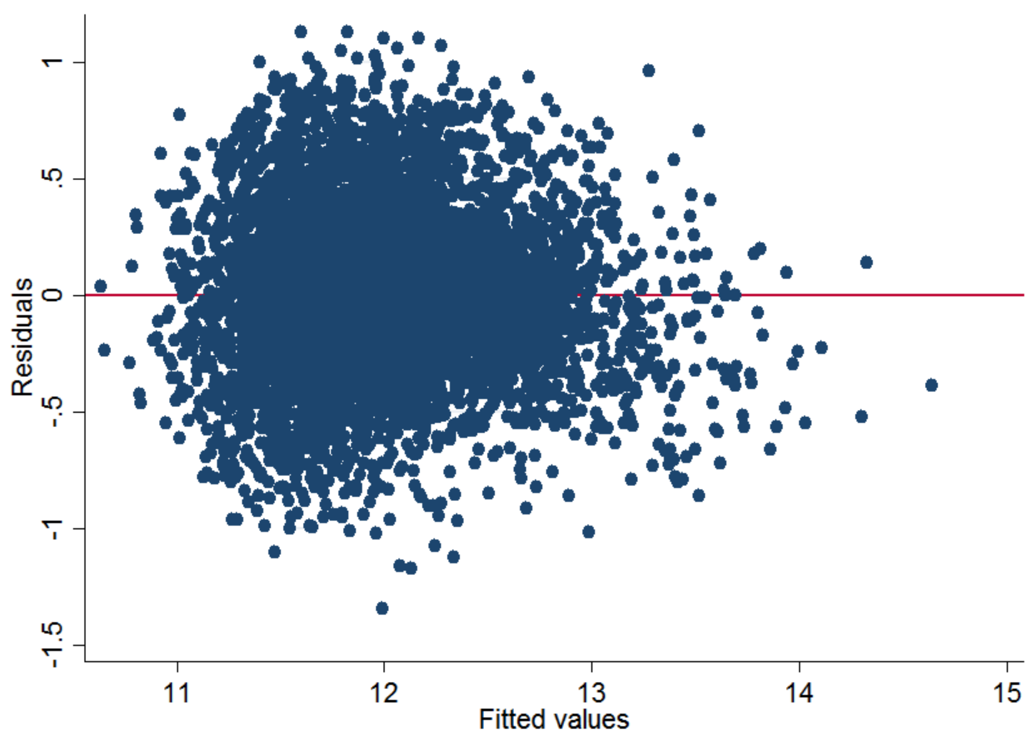

Figure 4.5. Plot of residuals against predicted values of REALPRICE for Alabama model

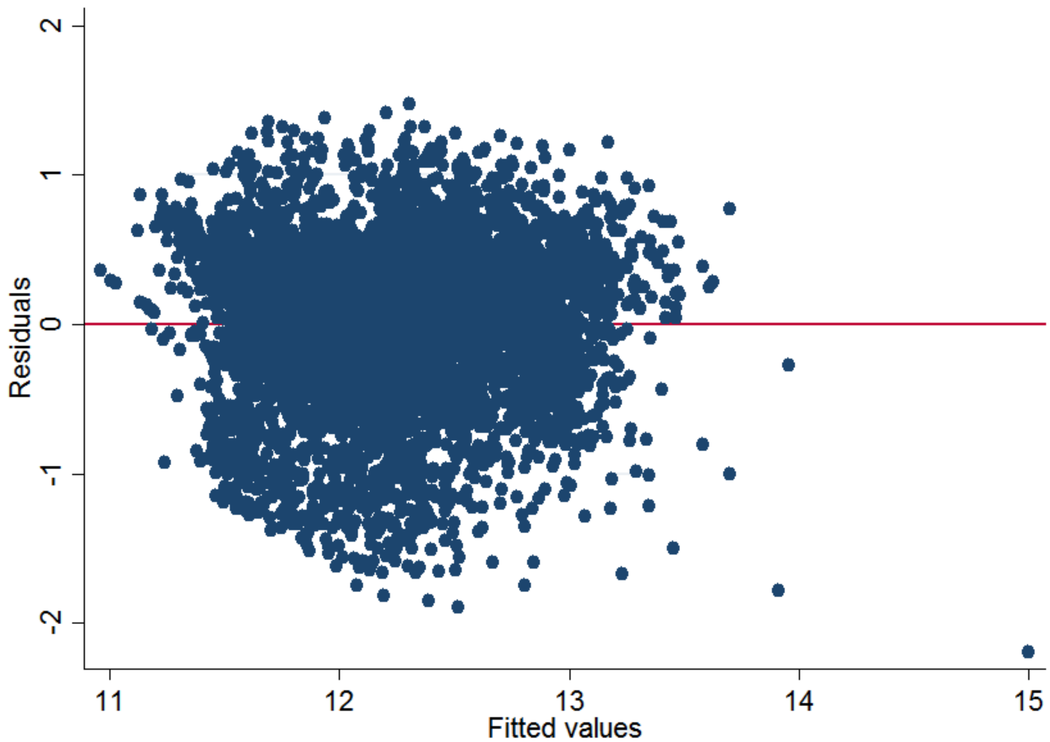

Figure 4.6. Plot of residuals against predicted values of REALPRICE for Louisiana model

are highly correlated and problematic to analysis. A variable with a VIF greater than 10 suggests that it is unnecessarily inflating variance in the model since it is explaining the same type of information as other explanatory variables included in the model. VIFs for explanatory variables in the Alabama and Louisiana models are presented in Tables 4.4 and 4.5, respectively. There was no evidence of correlated errors for any variable.

According to the Gauss-Markov Theorem, the ordinary least squares estimator is the best linear unbiased estimator when assumptions (1), (2), and (3) hold (Greene 2011). Therefore, non-normality of residuals does not bias coefficient estimates of a linear regression. Non-normality has the potential to affect standard errors and p-values; however, Type I error (i.e., probability of rejecting the null hypothesis when it is actually true) is only marginally affected when the normality assumption is not met. The Central Limit Theorem states that asymptotic normality can

Table 4.2. Correlations for continuous dependent variables in Alabama model

	AGE	SQFT	LAND	CBD	PARK	MARI	ELEV	COAST	EMW	FEW	FFSW	POND	LAKE	RIV
AGE	1													
SQFT	-0.285	1												
LAND	0.061	0.088	1											
CBD	-0.264	-0.093	0.035	1										
PARK	-0.071	-0.120	0.199	0.410	1									
MARI	-0.196	0.011	-0.017	0.301	-0.007	1								
ELEV	0.019	0.018	0.069	-0.456	-0.121	0.113	1							
COAST	0.149	-0.184	0.251	-0.023	0.344	-0.030	0.518	1						
EMW	0.026	-0.115	0.215	-0.096	0.172	0.124	0.593	0.824	1					
FEW	0.306	-0.067	-0.100	-0.368	-0.101	-0.128	0.166	0.011	-0.012	1				
FFSW	0.325	-0.063	-0.123	-0.187	-0.137	-0.076	0.045	-0.027	-0.043	0.501	1			
POND	0.344	-0.156	-0.146	-0.274	-0.206	-0.037	-0.002	-0.134	-0.158	0.413	0.461	1		
LAKE	-0.019	-0.096	0.040	0.303	0.189	-0.002	-0.286	-0.137	-0.126	0.052	0.046	-0.004	1	
RIVER	-0.018	-0.120	0.027	0.339	0.166	0.180	-0.039	0.044	-0.002	0.011	0.094	0.058	0.665	1

Table 4.3. Correlations for continuous dependent variables in Louisiana model

	LAND	CBD	PARK	MARINA	ELEV	COAST	EMW	FEW	FFSW	POND	LAKE	RIVER
LAND	1											
CBD	0.257	1										
PARK	0.303	0.431	1									
MARINA	-0.191	-0.335	-0.052	1								
ELEV	-0.197	-0.147	-0.018	0.562	1							
COAST	0.079	0.666	0.223	-0.338	0.072	1						
EMW	-0.297	-0.372	-0.151	0.413	0.513	0.041	1					
FEW	-0.122	-0.322	-0.411	-0.217	0.083	0.011	0.441	1				
FFSW	0.028	-0.280	-0.294	-0.396	-0.261	-0.096	0.235	0.811	1			
POND	-0.256	-0.217	-0.193	0.313	0.348	0.032	0.321	0.254	0.010	1		
LAKE	0.011	0.449	-0.034	-0.078	-0.023	0.594	-0.284	-0.155	-0.406	0.163	1	
RIVER	0.147	0.007	0.380	-0.166	-0.379	-0.454	-0.428	-0.478	-0.244	-0.365	-0.316	1

Table 4.4. Variance inflation factors for dependent variables in Alabama model

Variable	VIF
COAST	4.95
EMW	4.35
ELEVATION	2.64
CBD	2.54
RIVER	2.29
LAKE	2.28
FEW	1.63
PARK	1.61
FFSW	1.58
POND	1.57
AGE	1.51
MARINA	1.42
SQFT	1.22
CRIME	1.19
LAND	1.16
SUMMER	1.00
Mean VIF	*2.06*

Table 4.5. Variance inflation factors for dependent variables in Louisiana model

Variable	VIF
FFSW	9.11
FEW	8.34
COAST	7.33
LAKE	5.37
MARINA	5.1
RIVER	4.06
EMW	3.97
CBD	3.18
ELEVATION	2.81
CRIME	2.32
PARK	2.3
POND	1.47
LAND	1.27
SUMMER	1.01
Mean VIF	*4.12*

be assumed when there is a large number of observations (Greene 2011). With 7,060 observations in the analysis for Alabama and 5,751 observations in Louisiana, asymptotic normality of residuals is assumed. Histograms of residual frequency are presented in Figures 4.7 and 4.8 for Alabama and Louisiana, respectively. A kernel overlay of the normal distribution is shown in the histograms. Normal quantile plots are presented in Figures 4.9 and 4.10, which graph quantiles of model residuals against the quantiles of a normal distribution. The blue 45 degree line represents the quantiles of a normal distribution, while the blue markers indicate the quantiles of the model residuals. Based on residual histograms and quantile plots, the distributions appear approximately normal.

Due to data limitations in Louisiana, age and square footage of home were only available for properties in St. Charles Parish. The potential bias on wetland proximity variables is the primary concern with omitting these variables from the model. If age and size of the home are not highly correlated with wetland proximities, then omitting these variables from the model will not bias the coefficient estimates for wetland proximities. Home age and size were checked for correlation against distances to different types of wetlands and are presented in Table 4.6. Correlations were minor, therefore, omitting age and square footage of the home from the model should not cause a substantial bias to the coefficient estimates of the wetland distance variables (Hill, Griffiths, and Lim 2011). Correlations were also checked for age and square footage of home against wetland proximity variables for the Alabama dataset (see Table 4.2). There was no evidence of strong correlation for any of these explanatory variables. Thus, age and square footage of structure were not included in the analysis for Louisiana.

Summary statistics of variables used in the Alabama and Louisiana models are presented in Tables 4.7 and 4.8, respectively. As a check for validity, median purchase prices were compared

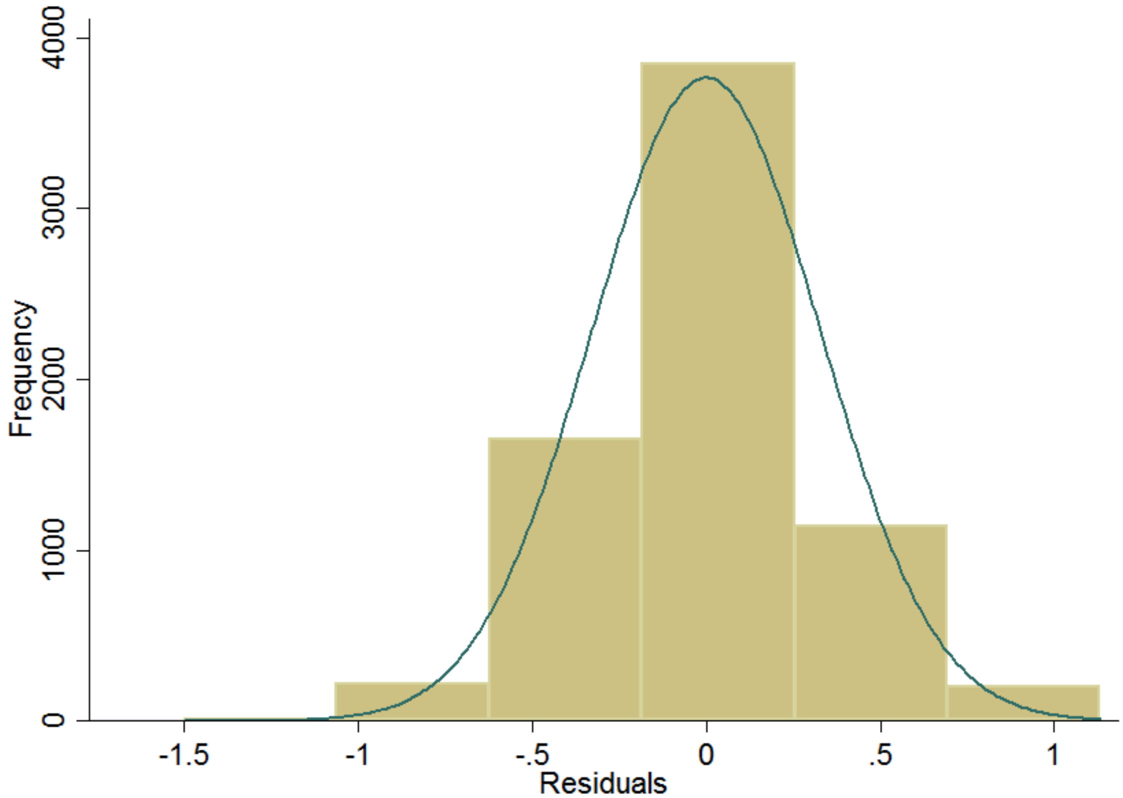

Figure 4.7. Histograms of residual frequency for Alabama model

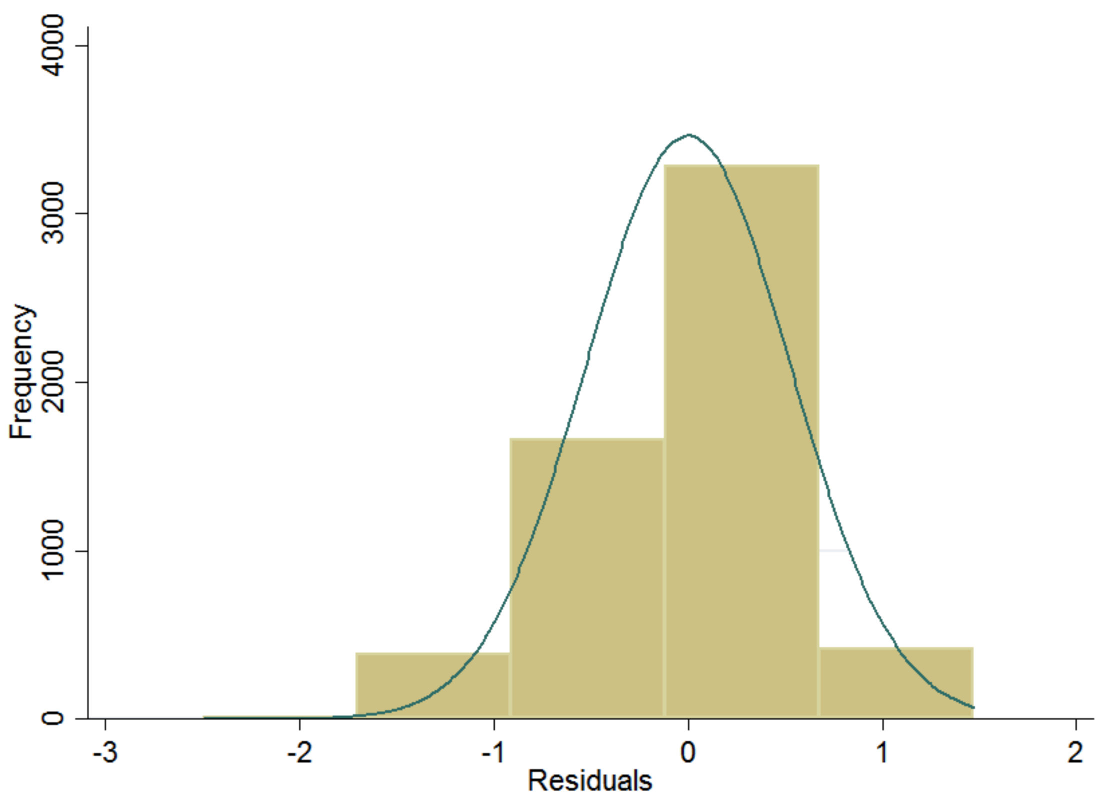

Figure 4.8. Histograms of residual frequency for Louisiana model

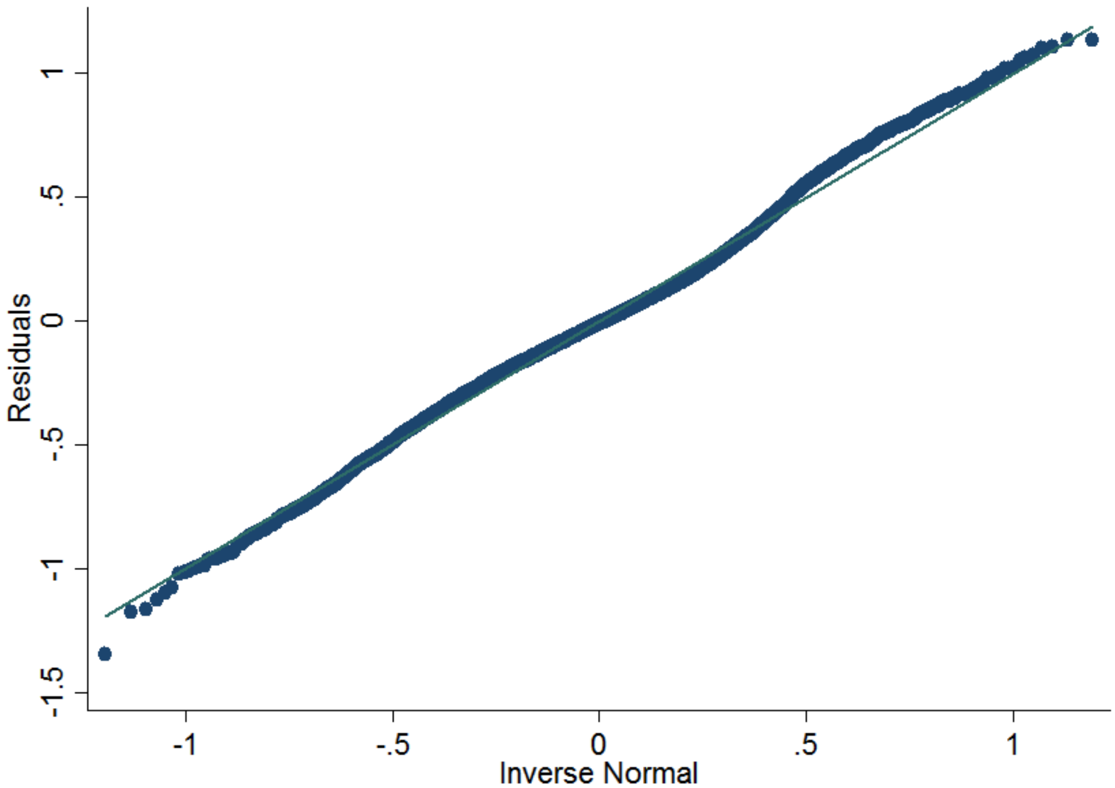

Figure 4.9. Normal quantile plot for Alabama model residuals

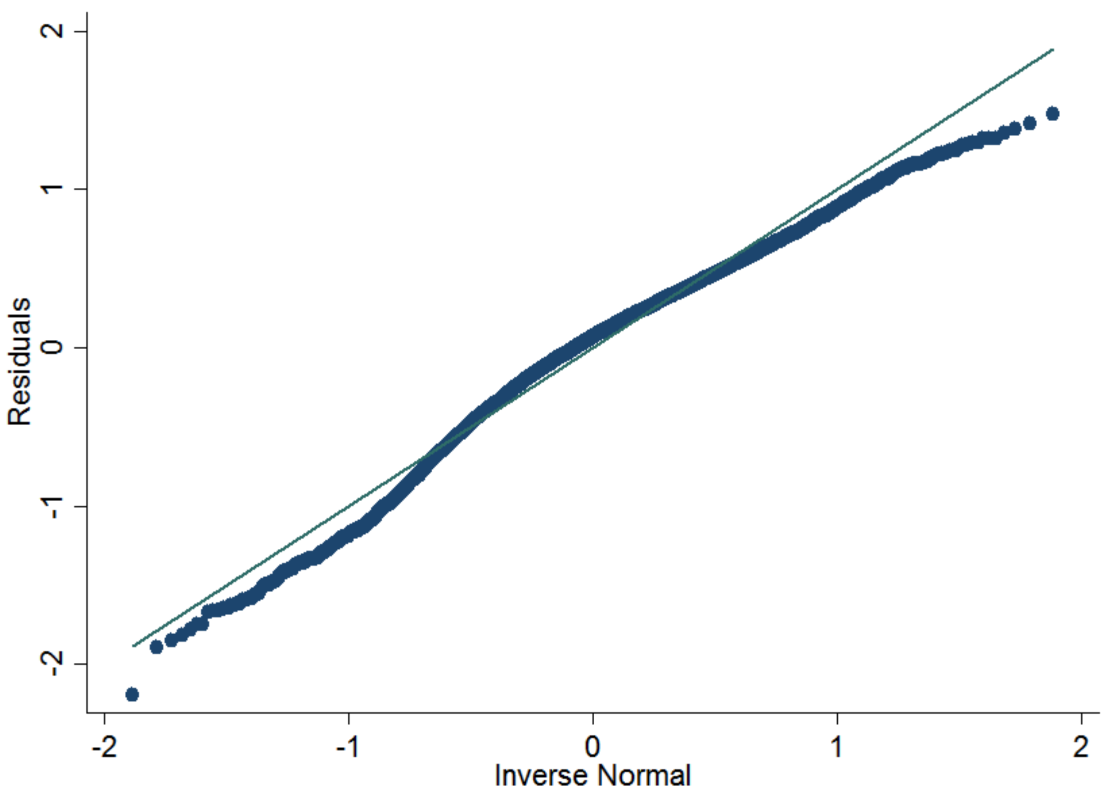

Figure 4.10. Normal quantile plot for Louisiana model residuals

Table 4.6. Correlations for age and size of home in St. Charles Parish, Louisiana, against other continuous dependent variables

	AGE	SQFT
SQFT	-0.301	1.000
LAND	-0.252	0.423
CBD	-0.210	0.015
PARK	-0.259	0.257
MARINA	-0.238	0.408
ELEV	-0.012	-0.143
COAST	-0.165	-0.016
EMW	-0.195	0.026
FEW	-0.056	0.132
FFSW	0.421	-0.198
POND	-0.242	-0.106
LAKE	-0.094	-0.105
RIVER	-0.108	0.328

Table 4.7. Summary statistics for Alabama data (n=7,060)

Variable	Mean	Std. Dev.	Min	Max
Purchase price (2013$)	193,579	129,453	30,000	1,905,869
Age of building (years)	23	19	0	125
Size of building (sqft)	1,974	740	380	6,507
Land (1,000 sqft)	31	70	1	1,612
Sold in summer (dummy)	0.58	0.49	0	1
Crime rate index	117	200	11	1,610
Dist to CBD (miles)	22.43	13.75	0.35	64.80
Dist to nearest park (miles)	5.96	4.74	0.045	26.10
Dist to boat ramps (miles)	12.03	5.16	0.086	37.50
Elevation (feet)	103	67	0	344
Dist to coast (miles)	6.02	4.93	0	38.20
Dist to EMW (miles)	3.36	3.06	0	26.78
Dist to FEW (miles)	0.72	0.58	0	3.72
Dist to FFSW (miles)	0.24	0.24	0	3.61
Dist to pond (miles)	0.38	0.30	0	3.23
Dist to lake (miles)	3.39	2.40	0	18.91
Dist to river (miles)	2.38	2.59	0	20.68

Table 4.8. Summary statistics for Louisiana data (n=5,751)

Variable	Mean	Std. Dev.	Min	Max
Purchase price (2013$)	255,763	190,607	30,000	1,900,000
Land (1,000 sqft)	6.34	2.86	0.40	43.61
Sold in summer (dummy)	0.59	0.49	0	1
Crime rate index	390	95	18	706
Dist to CBD (miles)	6.87	4.74	0.51	31.39
Dist to nearest park (miles)	0.84	0.93	0	12.33
Dist to boat ramps (miles)	4.75	2.56	0.19	11.33
Elevation (feet)	-0.71	4.71	-10.38	12.45
Dist to coast (miles)	15.16	5.75	1.39	36.57
Dist to EMW (miles)	4.36	2.43	0.01	12.98
Dist to FEW (miles)	2.18	1.31	0.01	5.60
Dist to FFSW (miles)	1.47	1.26	0	5.16
Dist to pond (miles)	0.81	0.55	0	2.83
Dist to lake (miles)	2.29	1.90	0	7.60
Dist to river (miles)	1.46	1.79	0	11.14

to outside sources. The U.S. Census Bureau releases estimates for median home values by county/parish based on data from the 2013 American Community Survey (ACS). Table 4.9 presents median single-family home values from the ACS and from the data used in this study. The greatest difference in values is almost $26,000 for Orleans Parish, while the smallest difference is $20 for Jefferson Parish. The estimates are similar in value for each county/parish, and therefore, conclude that the data are representative of the population.

Table 4.9. Comparison of median single-family home values by source

Location	ACS*	Data
Baldwin County, AL	$165,600	$176,758
Mobile County, AL	122,500	125,000
Jefferson Parish, LA	171,100	171,120
Orleans Parish, LA	183,100	209,029
St. Charles Parish, LA	188,200	205,000

**Source: U.S. Census Bureau, 2013 American Community Survey*

4.4. Alabama Model

The Box-Cox model was used to determine which one of the nested functional forms was the best fit for the data. The lambda parameter is 0.09 and statistically significant at the 0.01 level. Lambda is closest to the log-linear parameter specification (λ=0), which produces the greatest log-likelihood function value; therefore, these results indicate that the log-linear model is the best fit. Results from the Box-Cox model are in line with theory, suggesting that this functional form suits real estate data well because houses are generally not easily restocked as a continuum of supply (Sopranzetti 2010).

The estimated log-linear model is statistically significant, where the overall *F*-statistic is significant at the 0.01 level ($F(16, 7043) = 842.78$). The R^2-statistic measures how much variation in *ln(REALPRICE)* is explained by the independent variables in the model. The value of the R^2-statistic is 0.6746, which means that approximately 67% of the variation in *ln(REALPRICE)* is explained by the model.

Results of the log-linear model are presented for Alabama in Table 4.10. The majority of coefficients are statistically significant, and most signs on the coefficients are in line with hypotheses. Noting that the dependent variable is in log form, the β coefficients can be interpreted as a β% change in price for every unit change in the explanatory variable, *ceteris paribus*. The coefficient estimate on AGE can be interpreted such that as the age of the building increases by 1 year, the purchase price decreases by 0.7%, *ceteris paribus*. The marginal effect in dollars was calculated at the mean and median purchase price (as presented in Table 4.7) for a home in Alabama by multiplying the coefficient estimate by the average price and median price, respectively. At the mean, a 1-year increase in the age of a building would be expected to decrease the purchase price by $1,330 (i.e., -0.007 * $193,579 = -$1,330). Similarly, at the median purchase price, the marginal effect of increasing age of the home by 1 year decreases the purchase price by $1,090 (i.e., -0.007 * $158,660 = -$1,090).

Table 4.10. Alabama log-linear model estimates

ln(PRICE)	Coef.		Std. Err.	Marginal Effect at Mean Price	Marginal Effect at Median Price
AGE	-0.007	***	0.0003	-$1,330	-$1,090
BLDG	0.0005	***	0.00001	97	80
LAND	0.0006	***	0.0001	107	88
SUMMER	0.0260	***	0.0080	5,027	4,121
CRIME	-0.0002	***	0.00002	-31	-25
CBD	-0.001	**	0.0005	-197	-162
PARK	-0.009	***	0.001	-1,754	-1,437
MARINA	0.005	***	0.001	1,035	849
ELEVATION	0.000	*	0.0001	34	28
COAST	-0.021	***	0.002	-4,110	-3,369
EMW	0.004		0.003		
FEW	-0.077	***	0.008	-14,936	-12,242
FFSW	0.227	***	0.020	43,968	36,037
POND	0.052	***	0.017	9,982	8,182
LAKE	0.001		0.002		
RIVER	0.017	***	0.002	3,384	2,773
Constant	11.202	***	0.026		

**sig at 0.10 **sig at 0.05 ***sig at 0.01*

Building and lot size had a direct relationship with price, where purchase price increases as home and property size increases. Increasing the building size by 1 square foot would be expected to increase purchase price by 0.05% ($97 at the mean; $80 at the median). Because lot size is measured in 1,000s of square feet, increasing the lot size by 1,000 square feet would be expected to increase purchase price by 0.06% ($107 at the mean; $88 at the median). Crime rate and elevation were also statistically significant factors affecting home prices. An increase in the overall crime rate by 1% was estimated to decrease home values by 0.02% (-$31 at the mean; -$25 at the median). Elevation had an opposite relationship where an increase in elevation by 1 foot increases purchase price by 0.02% ($34 at the mean; $28 at the median). Because dummy variables are interpreted differently in a log-linear model than in a linear model, the coefficient on SUMMER can be interpreted such that homes that were purchased during the summer months sold for approximately 2.63% more than those sold at other times during the year (i.e., $e^{0.0260} - 1 = 0.0263$; $5,027 at the mean; $4,121 at the median). For the relatively small coefficient values reported, this adjustment does not lead to proportional changes that are much different than what might be determined from just looking at the estimated coefficient. They are included, however, for accuracy.

The remaining factors in the model are proximity variables. A negative sign on a proximity variable can be interpreted such that the purchase price decreases as the distance between the property and amenity increases (i.e., the closer a property is to an amenity, the higher the price). Therefore, distance variables with an inverse relationship to purchase price (i.e., negative coefficient) indicate that people have a preference to live closer to the amenity. For example, as the distance to the central business district increases by 1 mile, purchase price is estimated to decrease by 0.1% (-$197 at the mean; -$162 at the median). Distance to nearest local, state, or national park was also a significant factor where people prefer living closer to these recreational areas. This same inverse relationship between price and distance is found for distance to the coast, presumably because people value living in closer proximity to the Alabama shoreline. Contrary to expectations, the opposite relationship was found for distance to the nearest boat ramp or marina perhaps indicating a preference for non-motorized natural areas.

Four of the six wetland proximity variables were statistically significant. People preferred living in closer proximity to freshwater emergent wetland. As distance increases by 1 mile to the nearest freshwater emergent wetland, purchase price is estimated to decrease by 7.7% (-$14,936 at the mean; -$12,242 at the median). The opposite result was found for freshwater forested/shrub wetland, freshwater ponds, and rivers. An increase in distance by 1 mile to the nearest freshwater forested/shrub wetland, freshwater pond, or river, was estimated to increase price by 22.7%, 5.2%, and 1.7%, respectively. These results indicate that people prefer to live further from these types of ecosystems. Coefficients on estuarine and marine wetlands and lakes were not statistically significant.

4.5. Louisiana Model

The Box-Cox model was used to determine which one of the three nested functional forms was the best fit for the Louisiana data. The estimated lambda parameter is 0.16 and is statistically significant at the 0.01 level. These results indicate that the log-linear model is the best fit since the lambda parameter is closest to zero. This finding is in line with theory which also suggests that the log-linear functional form suits real estate data well since the real estate market is not continuous in supply (Sopranzetti 2010).

Table 4.11 presents the estimates of the Louisiana log-linear model. Marginal effects are calculated at the mean ($255,763) and median ($197,784) purchase price for a home in Louisiana (as presented in Table 4.8). As a property's lot increases in size by 1,000 square feet, purchase price increases by 6.6% ($16,905 at the mean; $13,072 at the median). Homes sold during the summer had a purchase price that was 3.35% higher than those sold at other times of the year (i.e., $e^{0.033} - 1 = 0.0335$). People value higher elevation such that as elevation at the property centroid increases by 1 foot, purchase price increases by 3.8% ($9,645 at the mean; $7,459 at the median).

Proximity to the central business district was also a significant factor such that a 1-mile increase in distance is estimated to decrease purchase price by 0.4% (-$1,151 at the mean; -$890 at the median). People also preferred living in closer proximity to parks. As the distance increases by 1 mile, purchase price is estimated to decrease by 8.1% (-$20,755 at the mean; -$16,050 at the median). The opposite relationship is true for proximity to the coast, where people prefer to live further from the coastline. A 1-mile increase in distance to the coast increases price by 2.0% ($5,071 at the mean; $3,921 at the median).

Table 4.11. Louisiana log-linear model estimates

ln(PRICE)	Coef.		Std. Err.	Marginal Effect at Mean Price	Marginal Effect at Median Price
LAND	0.066	***	0.004	$16,905	$13,072
SUMMER	0.0333	**	0.014	8,507	6,579
CRIME	0.0003		0.0001		
CBD	-0.004	*	0.002	-1,151	-890
PARK	-0.081	***	0.011	-20,755	-16,050
MARINA	0.014	**	0.006	3,588	2,775
ELEVATION	0.038	***	0.002	9,645	7,459
COAST	0.020	***	0.003	5,071	3,921
EMW	0.150	***	0.006	38,353	29,659
FEW	0.105	***	0.015	26,817	20,738
FFSW	0.009		0.016		
POND	-0.224	***	0.016	-57,313	-44,321
LAKE	0.071	***	0.008	18,224	14,093
RIVER	0.079	***	0.008	20,308	15,704
Constant	10.429	***	0.093		

**sig at 0.10 **sig at 0.05 ***sig at 0.01*

All but one of the coefficients for wetland proximity variables were statistically significant in the Louisiana model. However, freshwater pond was the only wetland type that people preferred living near. Price was estimated to decrease by 22.4% as distance to the nearest pond increased by 1 mile. In the Louisiana context, freshwater ponds consisted of small areas scattered throughout developed urban areas in the St. Charles, Jefferson, and Orleans Parishes. A direct relationship was found for other wetland types such that the purchase price was estimated to increase as a property's distance increased by 1 mile to the nearest estuarine and marine wetland (15.0%), freshwater emergent wetland (10.5%), lake (7.1%), or river (7.9%). These findings suggest that people in Louisiana do not value living near these types of wetlands. Proximity to freshwater forested/shrub wetland was not a significant factor.

CHAPTER 5. DISCUSSION

Ecosystem services from wetlands have characteristics of public goods and common-pool resources such that the benefits generated by wetlands are non-rival (i.e., one person's consumption of benefits does not affect another person's consumption of benefits) and non-excludable (i.e., inability to prevent a person from consuming benefits). Particularly because of the non-excludability characteristic, people do not have an incentive to invest in maintaining or restoring wetlands since they will be able to consumer benefits regardless of their level of investment (i.e., free-rider problem). Therefore, the government often intervenes and takes responsibility for wetland maintenance and restoration project decisions.

Policy and development decisions are often assessed using benefit-cost analysis (Stelk and Christie 2014). Benefit-cost analysis provides a quantitative method of weighing benefits against costs to assess any potential net gains of a proposed policy or action. If the benefits outweigh the costs, then the policy may be a worthwhile undertaking. Benefit-cost analysis can also be used to compare multiple policies or projects to determine which generates the greatest net benefits.

Historically, since the monetary value of wetland services has not been quantified, the benefits of these services and the value of lost services have not been factored into benefit-cost analyses and the policy or project decision-making process. Wetlands were previously considered wasteland since the extent of this ecosystem's benefits and productivity was not fully understood (U.S. Environmental Protection Agency 2012). Because of this lack of understanding of wetland services and nonexistent monetary values of these services, wetlands were damaged and transformed for other uses such as agriculture and development (Stelk and Christie 2014).

Engle (2011) describes the need for quantifiable measures of ecosystem services. Because the protection of different types of wetlands are included in U.S. laws such as the Clean Water Act, the U.S. Environmental Protection Agency and Army Corps of Engineers recognize that a mitigation wetland "…should be located where it is most likely to successfully replace lost functions and services" (73 Fed. Reg. 19688 (2008-04-10)). In order to determine this location, for example, quality data and quantified biophysical and economic measures of ecosystem services are needed. Quantifying ecosystem services aids state and federal natural resource managers in "[prioritizing] wetland restoration and conservation decisions" (Engle 2011).

The Clean Water Act is one of the major federal regulations protecting wetlands. Section 404 requires permitting prior to dredging or filling wetlands for development or other use (U.S. Environmental Protection Agency 2015b). The permitting process considers negative impacts to "recreational, aesthetic and economic values" as part of "significant degradation" to a wetland (U.S. EPA 2010). This regulation requires the consideration of economic benefits from wetlands. However, there is currently no standardized wetland service valuation method.

The National Environmental Policy Act (NEPA) requires any federal policy or project proposals to consider impacts to the "human environment" through an Environmental Assessment (EA) or Environmental Impact Statement (EIA) (42 U.S.C. §§4321-4370h). The EA is a document which initially assesses effects on the environment and determines whether a more detailed EIA is required. To be considered "federal," the proposal may come directly from a federal agency or can be controlled by a federal agency such as through licensing requirements or funding. Section 101 speaks to the motivation of the law where citizens should have "…safe, healthful, productive, and esthetically and culturally pleasing surroundings," indicating protection of more than just the physical natural environment (Farber and Findley 2010). Because of the language used in the law, impacts to the "human environment" includes more than just the physical natural environment. The scope of NEPA includes socioeconomic effects.

The EIA is a document created by the entity proposing the policy or project that details the environmental impacts, as well as any possible alternative actions that could be adopted instead. This detailed document forces environmental impacts to be part of the decision-making process and often includes Benefit-Cost Analysis. For projects involving wetland maintenance, restoration, or development, any proposed action would be considered federal due to the federal permitting requirements under Section 401(b) of the Clean Water Act. Monetary ecosystem service values are crucial for decision-making, Benefit-Cost Analysis, and successful fulfillment of NEPA requirements.

5.1. Comparison to Previous Studies

Results from previous literature are in line with estimates for the Alabama and Louisiana state models. Due to differences in units and methodology, estimates from peer-reviewed literature summarized in Chapter 2 are not directly comparable to estimates from this study. Marginal effects for proximity to wetlands were measured as dollars per mile in this study while previous research used dollars per meter or foot. For example, Doss and Taff (1996) measure the marginal effect at the mean in dollars of moving a home 10 meters closer to a scrub-shrub wetland as -$91.78. This estimate can be interpreted such that if two homes were exactly the same except that one home was 10 meters closer to a scrub-shrub wetland, then the home closer to the wetland would be valued $91.78 more than the home further from the wetland. This value can be roughly translated into a comparable estimate to values from the current study by imputing -$91.78 per 10 meters to a dollars per mile estimate. Since there are 160.934 meters in 1 mile, multiplying -$91.78 by 160.934 roughly gives the value per mile. In this case, a property 1 mile closer to a scrub-shrub wetland, ceteris paribus, increases the home's value by $14,771.

This "rough" calculation was performed for distance-based wetland proximity estimates presented in the previous wetland service valuation literature to translate all marginal effects at the mean for wetland proximity to U.S. dollars per mile. Earnhart (2001) and Hardie, Lichtenberg, and Nickerson (2007) did not use distance-based proximity variables. Instead, these studies only examined properties that were adjacent to wetlands. A distance of zero cannot be translated into a comparable dollars per mile estimate. Table 5.1 presents imputed estimates from 8 of the 10 peer-reviewed studies discussed in Chapter 2. Even with these imputed estimates, only general comparisons can be made since values are for wetlands in different geographic locations (Oregon, Minnesota, North Carolina, and Australia), and the wetland attributes and services vary by location (Interis and Petrolia n.d.). Marginal effects at the mean from these studies are compared.

The wetland categories in the literature are similar to those used in the current study. Previous categories examined include emergent vegetation, forested, scrub-shrub, lakes, and rivers. The lake and river categories provide for a straightforward comparison between studies. Freshwater forested/shrub wetland estimates from the current study were compared to forested and scrub-shrub estimates from previous studies. Previous work did not distinguish between freshwater and estuarine/marine wetlands (i.e., water salinity of wetlands); therefore, salinity was determined based on the geographic study area. For studies conducted in Portland, Oregon (Bin 2005; Mahan, Polasky, and Adams 2000; Martins-Filho and Bin 2005; Netusil 2005; and Wu, Adams, and Plantinga 2004), and Ramsey County, Minnesota (Doss and Taff 1996), emergent vegetation wetlands were considered freshwater emergent vegetation. For studies conducted in Carteret County, North Carolina (Bin and Polasky 2005), and Perth, Western Australia (Tapsuwan et al. 2009), emergent vegetation wetlands were considered marine emergent vegetation. Estimates from this category were compared to estuarine and marine wetlands in the current study.

General comparisons between studies for each type of wetland can be made by examining values in the cells of a column. For example, three previous studies assessed the value of proximity to freshwater emergent vegetation wetlands and found mixed results (see column labeled "Freshwater emerg veg" in Table 5.1). Rough estimates show that while Bin (2005) found that people prefer living further from freshwater emergent vegetation wetlands ($26,453), Doss and Taff (1996) found the opposite result (-$5,171). Mahan, Polasky, and Adams (2000) found that this type of wetland was not a significant factor affecting home prices. Comparing these results to those of the current study in Table 5.2, the estimate from the Alabama state model (-$14,936) implies the same preference as that found in Doss and Taff (1996). On the other hand, the estimate for the Louisiana state model ($26,817) indicates the same preference for proximity to freshwater emergent wetland as found in Bin (2005). In fact, the difference between the two values is only $364.

Studies also had mixed results for lakes. Mahan, Polasky, and Adams (2000) and Wu, Adams, and Plantinga (2004) found a preference for living in closer proximity to lakes. The results for Doss and Taff (1996) align with those for the Louisiana model in the current study. Results indicate a preference to live further from lakes, where the rough estimate for Doss and Taff (1996) is $11,509 and $18,224 for Louisiana. Bin (2005) found lakes to be insignificant in affecting home values, which is the same result found in the Alabama model.

Bin and Polasky (2005) was the only previous study to assess the value for proximity to the nearest marine emergent vegetation wetland. This study found a preference to live further from this type of wetland ($15,998). A similar result was found in the Louisiana for the current study, where the home value increased by $38,353 at the mean as the distance between the home and wetland increased by 1 mile. Martins-Filho and Bin (2005) correctly point out, "Although proximity to wetlands may be perceived as a desirable location characteristic due to enhanced view

Table 5.1. Imputed estimates (in USD) from previous peer-reviewed wetland valuation literature

Author(s) and year published	Geographic location	Wetland (any type)	Marine emerg veg	Freshwater emerg veg	Forested	Scrub-shrub	Lake	River
Bin (2005)	Oregon	N/A	N/A	26,453	57,200	-	-	19,642
Bin and Polasky (2005)	North Carolina	N/A	15,998	N/A	23,232	20,222	N/A	N/A
Doss and Taff (1996)	Minnesota	N/A	N/A	-5,171	7,714	14,771	11,509	N/A
Mahan et al. (2000)	Oregon	N/A	N/A	-	-	720	-2,117	-
Martins-Filho and Bin (2005)	Oregon	16,093	N/A	N/A	N/A	N/A	N/A	N/A
Netusil (2005)	Oregon	-29,549	N/A	N/A	N/A	N/A	N/A	N/A
Tapsuwan et al. (2009)	Australia	-89,389	N/A	N/A	N/A	N/A	N/A	N/A
Wu et al. (2004)	Oregon	-1,416	N/A	N/A	N/A	N/A	-2,169	-

Table 5.2. Estimates (in USD) from current study

Author(s) and year published	Geographic location	Wetland (any type)	Estuarine & marine wetland	Freshwater emergent	Freshwater forested/shrub	Lake	River
Savolainen (2015)	Alabama	N/A	-	-14,936	43,968	-	3,384
Savolainen (2015)	Louisiana	N/A	38,353	26,817	-	18,224	20,308

Note: "N/A" indicates variable not included in study; " – " indicates not statistically sig. variable; green shading indicates preference for closer proximity to wetland; red shading indicates preference for further proximity from wetland quality or increased pollution protection, it can also be undesirable due to development restrictions on nearby properties, bad odor and wildlife annoyances."

The majority of previous studies found that people prefer living further from forested and scrub-shrub wetlands, with the lowest value being $720 and highest being $57,200. In Alabama, people also preferred living further from freshwater forested/shrub wetlands with an estimate of $43,968. Mahan, Polasky, and Adams (2000) found that proximity to forested wetlands was not a significant factor affecting home prices. The same result was found in the Louisiana model.

Mahan, Polasky, and Adams (2000) and Wu, Adams, and Plantinga (2004) found rivers to be insignificant in affecting home values. Results from Bin (2005) indicate that people prefer living further from lakes ($19,642). Similar conclusions were found in Alabama and Louisiana where home values increased by $3,384 and $20,308, respectively, as the proximity to a lake increased by 1 mile.

The studies do not consider freshwater ponds separately. While the majority of the previous literature was published in the mid-2000s and prior, the USFWS did not classify ponds in a separate category until the mid- to late-2000s. In a report to Congress on the status and trends of wetlands in the U.S., the USFWS assessed trends for freshwater ponds in an individual category due to the growth of this type of wetland (Dahl 2011). Just as noted in Chapter 4, ponds were scattered throughout urban developments in Louisiana and were the only type of wetland people preferred living in closer proximity to. Between 2004 and 2009, the area of freshwater ponds increased by 3.2% in the U.S. (Dahl 2011).

CHAPTER 6. CONCLUSIONS

Wetlands provide supporting, regulating, provisioning, and cultural services. These benefits accrue to the environment and economy. More specific examples include pollution processing, floodwaters collection, storm surge reduction which prevents damage, and marine habitat maintenance. Wetlands support the Gulf Coast's $2.8 billion dollar commercial fishery (Gulf Restoration Network n.d.). This dissertation contributes to the ecosystem services literature by estimating the monetary value for wetlands reflected in single-family home values along the U.S. Gulf Coast using a hedonic price approach.

6.1. Revisiting the Objectives

Chapter 1 describes five primary objectives of this dissertation. These objectives are:

1. Conduct a literature review to examine previous wetland service valuation studies using the hedonic price model;
2. Assess the possibilities for comparative and joint stated and revealed preference value estimation and provide a general framework for this type of study using hedonic analysis;
3. Gather property transactions data, as well as, parcel boundary, wetland, and feature maps;
4. Evaluate which functional form is most appropriate for estimating the hedonic price function using theory and the Box-Cox transformation model; and,
5. Estimate monetary value of services from wetland ecosystems for residential property owners near Mobile Bay, Alabama, and Barataria-Terrebonne Estuary, Louisiana, using the hedonic price model.

Chapter 2 fulfills Objective 1 by presenting a literature review of peer-reviewed publications that use the hedonic price method for ecosystem service valuation of wetlands. Half of the studies were conducted on wetlands in Portland, OR, in which a wetland proximity variable is included in the function to determine property owners' preferences for living near wetlands. Other examined locations include Carteret County, NC, Ramsey County, MN, Fairfield, CT, Washington, D.C./Baltimore, MD area, and Perth, Western Australia. Linear, log-linear, log-log, Box-Cox, and discrete-choice functional parametric forms were used, as well as semiparametric and nonparametric forms. Bin (2005) found that open water wetland, such as freshwater pond, was preferred to emergent vegetation, forested, and scrub-shrub wetlands. Doss and Taff (1996) and Reynolds and Regalado (2002) also found a preference for open water to forested wetlands.

Chapter 2 also provides an assessment for the feasibility of using hedonic analysis for stated and revealed preference data in a comparative or joint estimation approach. Not all estimation methods can be combined or jointly estimated since the approaches must have similar structure. For hedonic price functions, McConnell (2011) suggests a comparison study where the hedonic marginal price of an attribute is compared to the estimated stated preference marginal value (e.g., using conjoint analysis) for convergent validity. If discrete-choice hedonic analysis were used, then the best joint estimation approach would be to follow Earnhart (2001) using conjoint analysis. Both of these estimation methods have similar structure such that the dependent variable is in discrete form, and stated preference surveys have the ability to capture similar and expanded data as the revealed preference data (i.e., property transactions data). The assessment in Chapter 2 fulfills the second objective.

Following Objectives 3, 4, and 5, these studies were expanded to assess marginal implicit prices along the Gulf Coast of different wetland classifications as categorized by the USFWS. With respect to Objective 3, property transactions data and property boundary, feature, and wetland maps were gathered and analyzed in GIS for residential properties near Mobile Bay, Alabama, and Barataria-Terrebonne Estuary, Louisiana. The data collection process was described in Chapter 3. For Objective 4, the Box-Cox transformation model determined that the log-linear functional form was the best fit for the data. Theory also suggests that the log-linear model should be used since houses are not typically available on the market in a continuum (Sopranzetti 2010).

In Alabama, results suggested that people prefer living in closer proximity to freshwater emergent wetlands. The opposite result was found for freshwater forested/shrub wetlands, freshwater ponds, and rivers, while proximity to lakes and estuarine and marine wetlands were not significant factors on purchase price. In Louisiana, freshwater pond was the only wetland type with results indicating that people preferred living near this type of ecosystem. Results suggested that people preferred to live further from estuarine and marine wetlands, freshwater emergent wetlands, lakes, and rivers since purchase price decreased with closer proximity to these wetland types.

6.2. Limitations

Though wetlands provide a wide variety of services, the structure and data used in the hedonic analysis does not allow for estimation of monetary value for all services provided. The hedonic price method estimates private benefits to homeowners that are captured within the purchase price of a property. The marginal prices estimated in Chapter 4 are limited to single-family property owners in St. Charles, Jefferson, and Orleans Parishes in Louisiana, as well as Mobile and Baldwin Counties in Alabama. Since the hedonic price function relies on historic data, like the property transactions data used in this study, the estimates are limited to property owners who purchased homes during the study period (2010-2013). This is a form of self-selection bias that could be minimized using comparative or joint estimation methods using revealed and stated preference data. Stated preference surveys are able to capture types of information that otherwise do not exist in revealed preference data sources.

6.3. Future Research

Further research should be conducted on smaller housing markets, such as on the county or city levels. The primary challenge of estimating hedonic price functions for smaller areas is the availability of data for explanatory variables on a smaller geographic scale. Future research also includes estimating hedonic models for counties in Texas and Florida in order to generate a better understanding of the value of wetland services provided throughout the U.S. Gulf of Mexico. Combining the log-linear model with spatial econometric models may also be beneficial to understanding the relationships between property purchase prices and wetland proximity, as long as coefficient estimates can be translated into values with a clear economic interpretation. The ecosystem service literature would also benefit from conducting comparative and joint estimation of stated and revealed preference data following the conceptual approach described in Chapter 4.

REFERENCES

42 U.S.C. §§4321-4370h.

Adamowicz, W., J. Louviere, and M. Williams. (1994). "Combining revealed and stated preference methods for valuing environmental amenities." *Journal of Environmental Economics and Management* 26(3): 271-292.

Adamowicz, W., J. Swait, P. Boxall, J. Louviere, and M. Williams. (1997). "Perceptions versus objective measures of environmental quality in combined revealed and stated preference models of environmental valuation." *Journal of Environmental Economics and Management* 32(1): 65-84.

Arguea, N.M, and C. Hsiao. (1993). "Econometric issues of estimating hedonic price functions." *Journal of Econometrics* 56 (1993): 243-267.

Arrow, K., R. Solow, P.R. Portney, E.E. Leamer, R. Radner, and H. Schuman. (1993). *Report of the NOAA Panel of Contingent Valuation*. Washington, D.C., 41 p.

Atkinson, A.C. 1985. *Plots, transformations, and regression: an introduction to graphical methods of diagnostic regression analysis*. Oxford: Oxford University Press.

Ben-Akiva, M., and S. Lerman. (1985). *Discrete Choice Analysis: Theory and Application to Travel Demand*. Cambridge, Mass.: MIT Press.

Bin, O. (2005). "A semiparametric hedonic model for valuing wetlands." *Applied Economics Letters* 12: 597-601.

Bin, O., and S. Polasky. (2005). "Evidence on the amenity value of wetlands in a rural setting." *Journal of Agricultural and Applied Economics* 37(3): 589-602.

Box, G.E.P., and D.R. Cox. 1964. An analysis of transformations. *Journal of the Royal Statistical Society,* Series B 26: 211–252.

Caffey, R., H. Wang, and D. Petrolia. (2014). "Trajectory economics: assessing the flow of ecosystem services from coastal restoration." *Ecological Economics* 100: 74-84.

Ciriacy-Wantrup, S.V. (1947). "Capital returns from soil-conservation practices." *Journal of Farm Economics* 29: 1188-1190.

Costanza, R., R. d'Arge, R. de Groot, S. Farber, M. Grasso, B. Hannon, K. Limburg, S. Naeem, R.V. O'Neill, J. Paruelo, R.G. Raskin, P. Sutton, and M. van den Belt. (1997). "The value of the world's ecosystem services and natural capital." *Nature* 387: 253-260.

Dahl, T.E. (2011). Status and trends of wetlands in the conterminous United States 2004 to 2009. U.S. Department of the Interior; Fish and Wildlife Service, Washington, D.C. 108 pp.

Davidson, R., and J.G. MacKinnon. 1993. *Estimation and inference in econometrics*. New York: Oxford University Press.

Diamond, P.A., and J.A. Hausman. 1994. "Contingent Valuation: Is Some Number Better than No Number?" *Journal of Economic Perspectives* 8(4): 45-64.

Doss, C.R., and S.J. Taff. (1996). "The influence of wetland type and wetland proximity on residential property values." *Journal of Agricultural and Resource Economics* 21(1): 120-129.

Earnhart, D. (2001). "Combining revealed and stated preference methods to value environmental amenities at residential locations." *Land Economics* 77(1): 12-29.

Engle, V.D. (2011). "Estimating the provision of ecosystem services by Gulf of Mexico coastal wetlands." *Wetlands* 31: 179-193.

ESRI. (2014). ArcGIS Desktop: Release 10.2.2. Redlands, CA: Environmental Systems Research Institute.

Farber, D. and R. Findley. (2010). *Environmental Law in a Nutshell*. West Academic Publishing: St. Paul, MN.

Federal Emergency Management Agency (FEMA) (2014). "Flood zones." Retrieved on February 2, 2015, from https://www.fema.gov/floodplain-management/flood-zones.

Freeman, A.M. (1991). "Factorial survey methods and willingness to pay for housing characteristics: comment." *Journal of Environmental Economics and Management* 20(1): 92-96.

Freeman, A.M. (1993). *The Measurement of Environmental and Resource Values.* Resources for the Future. Washington, D.C., 516p.

Graves, P., J.C. Murdoch, M.A. Thayer, and D. Waldman. (1988). "The robustness of hedonic price estimation: urban air quality." *Land Economics* 64(3): 220-233.

Greene, W.H. 2011. *Econometric Analysis, 7th Edition*. Upper Saddle River, NJ: Prentice Hall.

Grijalva, T.C., R.P. Berrens, A.K. Bohara, and W.D. Shaw. (2002). "Testing the validity of contingent behavior trip responses." *American Journal of Agricultural Economics* 84(2): 401-414.

Gulf Restoration Network. (n.d.). "Our work: wetland importance." Retrieved on February 26, 2015, from http://healthygulf.org/our-work/wetlands/wetland-importance.

Haab, T.C., Interis, M.G., Petrolia, D.R., and Whitehead, J.C. (2013). From hopeless to curious? Thoughts on Hausman's "dubious to hopeless" critique of contingent valuation. *Applied Economic Perspectives and Policy* 35(4): 593-612.

Halvorsen, R. and R. Palmquist. (1980). "The interpretation of dummy variables in semilogarithmic equations." *American Economic Review* 70: 474–475.

Hanemann, W.M. (1991). "Willingness to pay and willingness to accept: how much can they differ?" *American Economic Review* 81(3): 635-647.

Hanemann, W.M. (1994). Valuing the environment through contingent valuation. *The Journal of Economic Perspectives*, 8(4): 19-43.

Hardie, I., E. Lichtenberg, and C.J.Nickerson. (2007). "Regulation, open space, and the value of land undergoing residential subdivision." *Land Economics* 83(4): 458-474.

Hausman, J. (2003). "Sources of bias and solutions to bias in the consumer price index." *Journal of Economic Perspectives* 17(1): 23-44.

Hausman, J. (2012). "Contingent valuation: from dubious to hopeless." *Journal of Economic Perspectives,* 26(4): 43-56.

Hill, R. Carter, W.E. Griffiths, and G. C. Lim. (2011). *Principles of econometrics*. Wiley, Hoboken, NJ.

Interis, M., and D. Petrolia. (n.d.). "Location, location, habitat." Mississippi State University. Award NA10OAR4170078 to the Mississippi-Alabama SeaGrant Consortium by the NOAA Office of Ocean and Atmospheric Research, U.S. Department of Commerce.

Johnston, R.J., J.J. Opaluch, T.A. Grigalunas, and M.J. Mazzotta. (2001). "Estimating amenity benefits of coastal farmland." *Growth and Change* 32: 305-325.

Knetsch, J. (2010). "Values of gains and losses: reference states and choice of measure." *Environmental and Resource Economics* 46(2): 179-188.

Louviere, J.J., D.A. Hensher, and J.D. Swait. (2000). *Stated Choice Methods: Analysis and Application*. Cambridge: Cambridge University Press.

Mahan, B.L., S. Polasky, R.M. Adams. (2000). "Valuing urban wetlands: a property price approach." *Land Economics* 76(1): 100-113.

Martins-Filho, C., and O. Bin. (2005). "Estimation of hedonic price functions via additive nonparametric regression." *Empirical Economics* 30: 93-114.

Mashour, T., J. Alavalapati, R. Matta, S. Larkin, and D. Carter. (2005). "A hedonic analysis of the effect of natural attributes and deed restrictions on the value of conservation easements." *Forest Policy and Economics* 7: 771-781.

McConnell, K.E. (2011). Joint estimation of stated and revealed welfare measures: the conceptual basis In J.C. Whitehead, T. Haab, and J.-C. Huang (Eds.), *Preference Data for Environmental Valuation: Combining Revealed and Stated Approaches* (pp. 1-9). New York, NY: Routledge.

McConnell, K.E., and J.K. Horowitz. (2003). "Willingness to accept, willingness to pay and the income effect." *Journal of Economic Behavior and Organization* 51(4): 537-545.

McFadden, D. (1978). Modeling the choice of residential location In Anders Karlqvist et al. (Eds.), *Spatial Interaction Theory and Planning Models* (pp. 531-552). Amsterdam: North-Holland.

Milgrom, P. (1993). Is sympathy an economic value? Philosophy, economics, and the contingent valuation method In J.A. Hausman (Ed.), *Contingent Valuation: A Critical Assessment* (pp.417-441). New York: North-Holland.

Milon, J. W., D. Scrogin, J. Weishampel. (2009). A consistent framework for valuation of wetland ecosystem services using discrete choice methods. U.S. Environmental Protection Agency Report RD-8315901-0.

Mitchell, R.C., and R.T. Carson. (1989). *Using Surveys to Value Public Goods: The Contingent Valuation Method*. Washington, D.C.: Resources for the Future.

National Research Council. (2012). *Approaches for Ecosystem Services Valuation for the Gulf of Mexico after the Deepwater Horizon Oil Spill: Interim Report*. Committee on the Effects of the Deepwater Horizon Mississippi Canyon-252 Oil Spill on Ecosystem Services in the Gulf of Mexico, National Academy of Sciences. National Academies Press, Washington, D.C.: 162 p. Online: http://www.nap.edu/catalog.php?record_id=13141.

Natural Resources Conservation Service. (2009). Interim final benefit-cost analysis for the Wetlands Reserve Program (WRP). U.S. Department of Agriculture. 30 pp.

Netusil, N.R. (2005). "The effect of environmental zoning and amenities on property values: Portland, Oregon." *Land Economics* 81(2): 227-246.

Palmquist, R. (2005). Property value models In K.-G. Maler and J.R. Vincent (Eds.), *Handbook of Environmental Economics, Volume 2* (pp. 763-819).

Quigley, J. (1985). "Consumer choice of dwelling, neighborhood, and public services." *Regional Science and Urban Economics* 15: 41-63.

Reynolds, J.E., and A. Regalado. (2002). "The effects of wetlands and other factors on rural land values." *The Appraisal Journal* 70(2): 182-190.

Richmond, A., R.K. Kaufmann, and R.B. Myneni. (2007). "Valuing ecosystem services: a shadow price for net primary production." *Ecological Economics* 64: 454-462.

Rosen, S. (1974). "Hedonic prices and implicit markets: product differentiation in pure competition." *The Journal of Political Economy* 82: 34-55.

Shaneyfelt, R.C. (2012). "Alabama's wetlands." Alabama Department of Environmental Management, Coastal Programs, Mobile Branch. Retrieved on February 25, 2015, from http://www.forestry.state.al.us/Publications/TREASURED_Forest_Magazine/2012%20SpringSummer/Alabama%E2%80%99s%20Wetlands.pdf.

Sheppard, S. (1999). Hedonic analysis of housing markets In P.C. Cheshire and E.S. Bills (Eds.), *Handbook of Regional and Urban Economics: Applied Urban Economics, Volume 3* (pp. 1595-1635). Amsterdam, The Netherlands: Elsevier.

Shogren, J.F., S.Y. Shin, D.J. Hayes, and J.B. Kliebenstein. (1994). “Resolving differences in willingness to pay and willingness to accept.” *American Economic Review* 84(1): 255-270.

Shultz, S.D., and S.J. Taff. (2004). “Implicit prices of wetland easements in areas of production agriculture.” *Land Economics* 80(4): 501-512.

Sopranzetti, B.J. (2010). Hedonic regression analysis in real estate markets: a primer In C.-F. Lee et al. (Eds.), *Handbook of Quantitative Finance and Risk Management* (pp. 1201-1207). New York, NY: Springer Science + Business Media, LLC.

StataCorp. (2013). “Linear regression.” *Stata 13 Base Reference Manual*. College Station, TX: Stata Press.

StataCorp. (2013). Stata/MP 13.1. College Station, TX: StataCorp.

Stelk, M.J., and J. Christie. (2014). Ecosystem service valuation for wetland restoration: what it is, how to do it, and best practice recommendations. Association of State Wetland Managers, Windham, Maine. 74 pp.

Swanson, D.A., and J. Taym. (2012). *Subnational Population Estimates*. Springer Science & Business Media.

Tapsuwan, S., G. Ingram, M. Burton, and D. Brennan. (2009). “Capitalized amenity value of urban wetlands: a hedonic property price approach to urban wetlands in Perth, Western Australia.” *The Australian Journal of Agricultural and Resource Economics* 53: 527-545.

Taylor, L.O. (2008). Theoretical foundations and empirical developments in hedonic modeling In A. Baranzini et al. (Eds.), *Hedonic Methods in Housing Markets: Pricing Environmental Amenities and Segregation* (pp. 15-38). New York, NY: Springer Science + Business Media, LLC.

U.S. Environmental Protection Agency. (2001). “Wetland restoration.” The Wetland Fact Sheet Series. Online: http://water.epa.gov/type/wetlands/outreach/upload/restoration.pdf.

U.S. Environmental Protection Agency. (2010). Part 230 - Section 404(b)(1) guidelines for specification of disposal sites for dredged or fill material. Retrieved on April 17, 2015, from: http://water.epa.gov/lawsregs/rulesregs/cwa/upload/CWA_Section404b1_Guidelines_40CFR230_July2010.pdf.

U.S. Environmental Protection Agency. (2012). America's wetlands. Retrieved on April 18, 2015, from: http://water.epa.gov/type/wetlands/wetlands.cfm.

U.S. Environmental Protection Agency. (2015a). "Water: wetlands." Retrieved on February 23, 2015, from http://water.epa.gov/type/wetlands/.

U.S. Environmental Protection Agency. (2015b). Section 404 permitting. Retrieved on April 17, 2015, from http://water.epa.gov/lawsregs/guidance/cwa/dredgdis/.

U.S. Fish and Wildlife Service (USFWS). (2015). "Wetlands mapper legend categories." Retrieved on February 23, 2015, from http://www.fws.gov/wetlands/data/Mapper-Wetlands-Legend.html.

U.S. Geological Survey. (2014). Louisiana coastal wetlands: a resource at risk. USGS Fact Sheet. Retrieved on February 23, 2015, from http://pubs.usgs.gov/fs/la-wetlands/.

Whitehead, J.C. (2005). "Environmental risk and averting behavior: predictive validity of jointly estimated revealed and stated behavior data." *Environmental and Resource Economics* 32(3): 301-316.

Whitehead, J.C., S.K. Pattanayak, G.L. Van Houtven, and B.R. Gelso. (2008). "Combining revealed and stated preference data to estimate the nonmarket value of ecological services: an assessment of the state of the science." *Journal of Economic Surveys* 22(5): 872-908.

Whitehead, J.C., T.C. Haab, and J.-C. Huang. (2011). Introduction In J.C. Whitehead, T. Haab, and J.-C. Huang (Eds.), *Preference Data for Environmental Valuation: Combining Revealed and Stated Approaches* (pp. 1-9). New York, NY: Routledge.

Woodward, R.T., and Y.-S. Wui. (2001). "The economic value of wetland services: a meta-analysis." *Ecological Economics* 37: 257-270.

Wu, J., R.M. Adams, and A.J. Plantinga. (2004). "Amenities in an urban equilibrium model: residential development in Portland, Oregon." *Land Economics* 80(1): 19-32.

VITA

Michelle Savolainen graduated from Texas Woman's University with a Bachelor of Business Administration in Business Management in 2007. Her interest in natural resource economics led her to the Department of Agricultural Economics and Agribusiness at Louisiana State University to earn a Master of Science in 2012 and become a candidate for the doctoral degree in 2015.