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An economic analysis of private market wetland values in southwestern coastal Louisiana

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AN ECONOMIC ANALYSIS OF PRIVATE MARKET WETLAND VALUES IN SOUTHWESTERN COASTAL LOUISIANA

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ABSTRACT

Coastal Louisiana wetlands contain more than 30% of the U.S. coastal wetlands, but its wetland loss accounts for about 90% of the continental states. Although the effects of coastal wetlands preservation and restoration never stop since the enactment of CWPPRA in 1990, these regulation projects benefit only a small fraction of the degraded Louisiana coastal wetlands because of the limited budget. The general objective of this study is to provide an understanding of the economic factors which establish property values in coastal wetlands private market in order to devise and implement cost efficient economic incentive mechanisms for private landowners and then address the wetlands loss of coastal southwestern Louisiana.

The research collects 59 useful private property samples from Southwest Louisiana and covered the 1990-2002 period. Four wetland types (fresh marsh, intermediate marsh, brackish and saline marsh), open water, property size, a discrete variable indicating whether a property is separated into two or more parcels, and distance variables (i.e., distance from the nearest coast and road) were the factors affecting property values. With the help of GIS data and tools, hedonic functions are established. Results indicate that open water percentage and percentages of all wetland types have negative effects on property prices. Furthermore, wetland types have different marginal implicit prices. Intermediate marsh has the largest effect on property values, followed by the brackish and saline marsh, and open water in descending order. All three types of wetlands are statistically significant at the level of above 99%; however, fresh marsh percentage is statistically insignificant even at the level of 85%, and has little coefficient effect on property price when considered in relation to the base (i.e., other category).

CHAPTER 1 INTRODUCTION

1.1 Problem Statement

Historically, wetlands were not viewed as valuable or appreciated resources. Wetlands were often regarded as "wastelands" and breeding grounds for insects, pests and disease, and were considered unhealthy, dismal places that were impediments to development and progress (Vileisis, 1997). Wetlands were not useful because they were too wet to culture for farming, and too shallow for swimming and fishing. Ditching and draining wetlands were encouraged, and wetlands were often converted to other land uses.

Around the middle of the 20th century, attitudes towards wetlands began to change, thanks in large part to the increased understanding of the ecological role played by wetlands. Specifically, increasing recognition was given to the fact that wetlands provide a variety of valuable ecosystem services. These services include, but are not limited to, flood control, erosion control, removal of sediment and toxicants, removal or transformation of nutrients, groundwater recharge or discharge, natural area buffers, shoreline anchoring, and the provision of habitat for a variety of species (e.g., fish and wildlife). Wetlands are also valued for recreational, educational and aesthetic reasons and sometimes directly contribute to commercial purposes (e.g., shell fishing).

Despite a growing recognition of the contribution of wetlands to the welfare of society and government policies directed towards protecting wetlands, losses of wetlands continue to be significant. According to a survey performed by the U.S. Fish and Wildlife Service, the 48 contiguous states had approximately 221 million acres of wetlands in 1780. Since then, wetlands have declined significantly and only an estimated

104 million acres, or 47% of the original wetlands, currently remain in a "functional" form. Wetland losses in some states are as high as 80 to 90 percent (Mitsch and Gosselink, 1993). During the decade ending in 1990, wetland loss of the U.S was estimated to be 58,500 acres annually (Dahl, 2000), or more than one-half million acres.

Coastal Louisiana wetlands are termed "America's Wetlands" not only for their 30% contribution to total U.S. coastal marsh (Dahl, 2000) but also because of the environmental and socioeconomic services provided. Louisiana coastal wetlands provide storm protection for ports that carry nearly 500 million tons of waterborne commerce annually, which accounts for 21% of all the U.S. waterborne commerce. Four of the top ten largest U.S. ports are located in Louisiana (USACE, 2002). Louisiana's commercial seafood landings, which exceed one billion pounds annually with a dockside value of $343 million, account for approximately 30% of the total catch by weight in the lower 48 states (USDOC, 2002). Other commercial natural resource based activities directly tied to the wetlands include fur harvests generating revenues of about $2 million annually (LDWF, 2004) and alligator harvests of about $30 million (LDWF, 2003). Coastal Louisiana wetlands also provide the basis for much of the annual recreational fishing expenditures, estimated to range from $703 million (USDI, 2003) to $1.2 billion (Gentner et al., 2001), hunting-related expenditures estimated to equal $446 million annually, and wildlife-watching expenditures of approximately $168 million annually (USDI, 2003). Also, Louisiana's coastal wetlands provide habitat for over 5 million migratory waterfowl (LDWF, 2000).

However, the loss of Louisiana's coastal wetlands has become, according to some individuals, one of the more pressing environmental problems facing the country today.

Nationally, Louisiana currently experiences about 90 percent of the total coastal marsh loss in the continental United States (Dahl, 2000). The U.S. Geological Survey (USGS) and the U.S. Army Corps of Engineers reported that Louisiana lost 1,900 square miles from 1932 to 2000, roughly an area the size of the state of Delaware. During the last 50 years, land loss rates have exceeded 40 square miles per year. The U. S. Army Corps of Engineers estimates that the present rate of coastal land loss is 25 square miles a year -- that is the equivalent of approximately one football field lost every 38 minutes. The U. S. Fish and Wildlife Service places the figure even higher at about 34 square miles a year, based on measuring the loss in coastal land area between 1978 and 1990. With current restoration efforts taken into account, it is estimated that the state will lose an additional 500 square miles wetlands over the next 50 years (Barras et al., 2003).

Associated with the loss of wetlands is the loss of the various functions and values provided by the wetlands. In 2000, over two million residents, or almost one-half of Louisiana's population, lived in the coastal parishes (U.S. Census Bureau, 2002). Without restoration, they may be forced to move or adjust accordingly (e.g., building ever larger and more expensive hurricane walls). It is estimated that just the public use value of this wetland loss will be more than $37 billion by 2050, not including the immeasurable culture and heritage values (LDNR, 1998).

As the social and economic values associated with well functioning coastal wetlands became increasingly recognized, the efforts to preserve and restore them became more apparent. In 1990 the Coastal Wetlands Planning, Protection and Restoration Act (CWPPRA) was passed by the U.S. Congress, and the funding associated with this Act has become the primary mechanism for addressing Louisiana's coastal wetland loss.

Since the enactment of CWPPRA, the act has authorized 107 large-scale and public federal and state restoration projects at a cost of more than $400 million. However, annual CWPPRA expenditures of $30 to $40 million is, according to some estimates, providing only less than 10% of the funding necessary to adequately address the multitude of issues associated with wetland diminution and loss throughout coastal Louisiana. Yet when asked to support a 30-year $14 billion plan for restoring Louisiana's disappearing wetlands/coastline, the Bush administration, in August 2004, instead requested a short-term amount that committed only $1.9 billion dollars over 10 years (Schliefstein, 2004).

The costs of wetland preservation and restoration are high compared with the limited budget of wetland planning projects. Because of the comparatively small budget relative to overall needs, the CWPPRA projects benefit only a small fraction of the degraded Louisiana coastal wetlands. In fact, as previously stated, if recent loss rates continue, even counting the current restoration efforts (including the CWPPRA efforts), coastal Louisiana will still lose more than 630,000 additional acres of coastal marshes, swamps, and islands by 2050 (LDNR, 1998). In short, because of the high costs associated with the current restoration system, which relies highly on engineering projects, CWPPRA cannot be expected to effectively address the wetland loss crisis of coastal Louisiana. Given the limited budget, therefore, it is logical to seek more innovative, cost effective alternative restoration opportunities.

Approximately 80 percent of all coastal Louisiana wetlands are privately owned. As such, it is only natural to ask the question: What incentives can be provided to private landowners to protect/restore their wetland assets? One might also ask: Why should incentives be provided to private property owners?

The answer to this second question is relatively straight forward. Specifically, wetlands provide a multitude of services to society not captured by the private landowners. The gap between public benefits and private benefits leads to underinvestment by individuals in the maintenance and/or restoration activities.

Because privately owned wetlands provide significant positive social and economic contributions, it is reasonable to devise and evaluate alternatives to engage private coastal landowners in addressing wetland loss issues, particularly on individual tracts owned and maintained by these private investors. However, little or no direct restoration funding is available to private interests.

Because of the economic reality of diminishing surface and sub-surface incomes, increasing regulatory constraints, and current tax structure which fails to adequately delineate the use value of coastal property, owner-initiated alternatives are very limited in coastal Louisiana. For example, a coastal Louisiana survey indicated that most coastal landowners earned little or no income: 38% reported no surface revenues from coastal wetland properties while an additional 34% reported incomes of less than $10 per acre (Coreil, 1995).

The federal government protects wetlands through regulations, such as Section 404 of the Clean Water Act and "Swamp buster" provisions of the Food Security Act, economic incentives (tax deductions for selling or donating wetlands to a qualified organization), and acquisitions (i.e., establishing national wildlife refuges). For private landowners, both regulatory and economic incentives may be considered as the alternatives; however, research has found that properties would sell at a discount due to the possibility of being subject to federal wetlands regulation (Guttery, et al, 2000; Guttery, et al, 2004), which indicates that regulatory alternatives might have somewhat negative effects on wetland protection. So the economic incentives would be considered to be a cost efficient mechanism to the coastal Louisiana wetland loss.

Economic incentives, such as direct subsidies and tax credits, could potentially encourage private landowners of coastal Louisiana to preserve and restore wetlands. It is better for policy makers to understand economic factors which affect wetland restoration of coastal Louisiana. Such an understanding of the economic structure of private wetlands is a difficult task, because wetlands, as a natural resource, generate public and private goods, which are difficult to be directly valued through market transaction prices, and many of the services provided by wetlands are not traded in a market.

In this study we use the hedonic property price model to capture the private valuation of coastal Louisiana wetlands by studying the effects of wetland characteristics on the price of property. Unlike most hedonic land research, wetlands are components of properties instead of proximities or neighbors of properties in this study. The characteristics of wetlands, like acreage, location, wetland type, determine whether the wetland outputs are amenities or disamenities to the property owners. This study asks whether property prices have a negative relationship with wetlands within these properties, and whether different types of wetlands and other characteristics are associated with increases or decreases in property prices.

1.2 Objectives

Generally this study attempts to provide an understanding of the economic factors which establish property prices in the coastal wetlands private market in order to devise and implement cost efficient economic incentive mechanisms for private landowners and then address the wetlands loss of coastal southwestern Louisiana.

Specifically, this study has the following four objectives:

(1) To identify the factors affecting the price per acre or value of coastal wetland properties in coastal southwestern Louisiana and to assess whether property ownership is related to a specific set of economic and wetland characteristics.

(2) To identify those wetland characteristics which influence private market property values, where wetlands are the component of studied properties, not just nearby properties.

(3) To differentiate the effects of wetland types on private market property values.

(4) To estimate implicit prices associated with underlying wetland characteristics.

Based on data from southwestern Louisiana, this thesis uses the Geographic Information System (GIS), statistical tools and the hedonic method to estimate the hedonic price function and implicit prices, which will help make policies to preserve wetlands, and estimate the value of wetland amenities and disamenities of Coastal Louisiana wetlands in the future.

CHAPTER 2 REVIEW OF LITERATURE

2.1 Hedonic Property Price Model

Hedonic techniques have attracted the interest of economists as a means of measuring values of non-market goods. By studying the market transactions of differentiated products such as automobiles and houses, implied values and corresponding demand schedules can be estimated for underlying characteristics such as automobile safety features, two-car garages, and air quality of residential neighborhoods.

The basic premise of the hedonic method is that the price of a marketed good is related to its characteristics, or the services it provides. For example, the price of a car reflects the characteristics of that car -- transportation, comfort, style, luxury, fuel economy, etc. Therefore, we can value the individual characteristics of a car or other goods by looking at how the price people are willing to pay for its changes when the characteristics change.

2.1.1 Theoretical Framework

Although the hedonic model concept can be traced back to Court (1939), it was not until 1974 that Rosen developed a theoretical model for differentiated consumer products that now serves as the basis for empirical estimates of marginal prices of product characteristics. According to Rosen, in housing markets, equilibrium prices are determined such that buyers and sellers are perfectly matched. Property values are influenced by home characteristics, economic conditions, and nearby amenities (or disamenities). Rosen defined hedonic prices as “the implicit prices of attributes” and stated that they “are revealed to economic agents from observed prices of differentiated products and the specific amounts of characteristics associated with them." Prices of these characteristics are implicit because there is no direct market for them. Since its publication, Rosen's theoretical model and its two-stage estimation procedure have been the standard for almost all hedonic empirical estimates.

Suppose that some good is composed of Z, n attribute bundle of characteristics provided by this good. The price of the good will generally depend on the quantities of the various attributes of which it is composed; therefore this price can be expressed as:

$$P(Z) = P(Z_1, Z_2, \dots , Z_n) \qquad (2.1)$$

An implicit market is in equilibrium when the marginal bid price of Z_i equals the marginal offer price of Z_i for all i in z at the equilibrium, and these two marginal values equal to $P_i(Z)$, where:

$$P_i (Z) = \partial P/\partial Z_i \qquad (2.2)$$

To estimate the structural parameter of the two marginal values, Rosen suggested a two-stage procedure. First an ordinary "hedonic" market equation, P(Z), is estimated through regressing observed differentiated products' prices on all their characteristics using the best fitting functional form. In the second step, the derivatives of the equation estimated in the first step, evaluated at each individual observation's level of characteristics Z, are used in the estimation of a system of supply and demand equations:

$$P_i(Z) = F_i(Z, Y_1) \quad \text{(demand)} \qquad (2.3)$$

$$P_i(Z) = G_i(Z, Y_2) \quad \text{(supply)} \qquad (2.4)$$

Where Y_1 and Y_2 are exogenous variables affecting household demand and firm supply.

Procedures to estimate demand schedules of underlying characteristics were outlined in Palmquist (1984). Brown and Rosen (1982) questioned whether we could identify marginal bid price function using simple linear functions as a derivative of bid function. Scotchmer (1985, 1986) proved that it was not possible to distinguish the bid price function from the hedonic price function even in the case of the homogeneous consumer. Palmquist (1989) further extended Rosen's theoretical model to consider land as a differentiated factor of production. Freeman (1993) provided a useful summary of the theoretical aspects of the hedonic property price models.

2.1.2 Empirical Estimation of Hedonic Property Model

The hedonic price model has been widely used since its establishment while most empirical applications considered only the first step of Rosen's two-stage procedure. A number of recent studies have used the hedonic methods to examine the relationship between environmental characteristics and differentiated consumer goods, especially farmland, rural land, property, etc.

The literature contains a large number of studies that examine the relationship between land or property values and the environmental changing characteristics using the hedonic models. Miranowski and Hammes (1984) found that three measures of topsoil quality (topsoil depth, potential erosivity, and pH) had the expected signs and were statistically significant. Both studies from Ervin and Mill (1985) and Gardner and Barrows (1985) concluded that land values were not predictably related to actual or potential erosion. Palmquist and Danielson (1989) found that land values were significantly affected by both potential erosivity and drainage requirements. Kohlhase (1991) concluded that people would pay to live farther from toxic waste sites. Palmquist (1992) found that property values were reduced by noise from nearby highways. Reichert (1997) found that property value within 6,750 feet of the landfill decreased significantly and the reduction in value was directly related to the proximity to the landfill during the peak publicity period. Boisvert et al (1997) found that the value of agricultural land could be related directly to productivity, location, and environmental vulnerability in the lower Susquehanna River Basin.

In many cases, environmental degradation, a type of environmental change, can directly impact property values. For example, Palmquist, Roka, and Vurina (1997) found that proximity to hog farming operations reduced property values.

On the other hand, the hedonic method is most often used to value environmental amenities that affect the price of residential properties. In other words, by observing how much is paid for houses with different characteristics, it should be possible to estimate how the individual characteristics of a property influence its overall price. Hedonic techniques attempt to disaggregate the price of properties into sets of values for their various quality characteristics. The hedonic approach aims at explaining the specific contribution of each attribute of a property using multiple regression analysis (MRA) (Can, 1990; Can, 1993; Dubin, 1998). This method, applied to the property market, makes it possible to estimate the sales price on the basis of a bundle of attributes which are specific to each property. From a conceptual point of view, land and property prices are a combination of externality effects and location rents (Can, 1993; Dubin, 1998; Hickman, et al. 1984; Shefer, 1986; Strange, 1992; Yinger, et al. 1987).

Although research has shown that the hedonic technique can be successfully employed to estimate the impact that a change in environmental quality will have on the prices of properties in a market, there is some debate regarding appropriate model specification including the 'proper' dependent variable, explanatory variables to be included in the analysis, multicollinearity, functional form and spatial dependence of the approach applications (Bateman, et al. 2001).

2.2 Wetland Valuation

2.2.1 Theoretical Framework

Estimating the value of wetlands in monetary terms goes back at least as far as 1926 when Percy Viosca, Jr. estimated that the value of fishing, trapping and collecting activities from wetlands in Louisiana was worth $20 million annually (Vileisis, 1997). A landmark early valuation study by economists was by Hammack and Brown (1974). Hammack and Brown focused on wetlands as waterfowl habitat and estimated the value that wetlands provided in terms of hunting with a contingent valuation method (CVM).

Responding to the fact that the value of wetland functions, or products and services, is often not known and therefore not included in decisions regarding wetland use and conservation, there are now a number of studies attempting to value the partial or total economic value of wetlands. Brander et al. (2004) collected 190 wetland valuation studies, and found that a diverse range of valuation methods had been applied to value wetlands, they are:

(1) Contingent Valuation Method (CVM): it is the only method capable of estimating non-use values, and by directly asking respondents to state their willingness to

pay (WTP) or willingness to accept (WTA) for real or hypothetical changes of environmental quality or quantity it provides estimates of the technically precise welfare measures of compensating and equivalent surplus.

(2) Hedonic Pricing and Travel Cost Methods: these revealed preference methods estimate the Marshallian consumer surplus, which approximates, and is bounded by, the compensating variation (CV) and equivalent variation (EV) welfare measures.

(3) Production Function: it estimates changes in consumer and producer surplus resulting from quantity or quality changes in an environmental good that is used an input in a production process.

(4) Net Factor Income (NFI): it also estimates changes in producer surplus by subtracting the costs of other inputs in production form total revenue, and ascribes the remaining surplus as the value of the environmental input.

(5) Replacement Cost: it places values on ecosystem services by estimating the cost of replacing them, and it is based on the assumption that if individuals incur costs to replace ecosystem functions, then the lost services must be worth at least what people are willing to pay to replace them.

(6) Opportunity Cost: it takes the value of the next best alternative use of the resources used to provide the ecosystem function being values.

(7) Market Prices: it assigns value equal to the total market revenue of goods or services.

Brander et al. (2004) found from the collected 190 wetland valuation studies that CVM produced the highest estimates of wetland values, followed by the replacement cost method and hedonic pricing, and the lowest value estimates were produced by the opportunity cost and production function methods. However, Woodward and Wui (2001) concluded from 39 wetland valuation studies that relative to the hedonic pricing or replacement cost methods, and using the CVM tended to yield a lower estimated value of wetlands while there was no statistically significant difference between the CVM and the travel cost or NFI methods.

2.2.2 Empirical Estimates of Wetlands Using Hedonic Method

Heimlich et al. (1998), Kazmierczak (2001), Woodward and Wui (2001), Boyer and Polasky (2004), Brander et al. (2004) reviewed empirical valuation studies of wetlands including non-hedonic studies.

In urban areas, four studies have applied the hedonic method to estimate the value of wetlands to nearby property owners (Doss and Taff 1996; Lupi et al. 1991; Mahan et al. 2000; Earnhart 2001). All studies found a positive impact from wetlands on property values. Doss and Taff (1996) found that the more negative the value of the distance to wetland proximity, the more proximity to that wetland type was valued, and the implicit prices for proximity to open-water and scrub-shrub wetlands were relatively higher than those for emergent-vegetation and forested wetlands. Lupi et al. (1991) found that changes in wetland acreage were relatively more valuable in areas where wetland acreage was low than where wetland acreage was high. Mahan et al (2000) concluded that wetlands influenced property values differently than other amenities, and that increasing the size of the nearest wetland to a residence by one acre increased the residence's value by $24, similarly, reducing the distance to the nearest wetland by 1,000 feet increased the value by $436, and that home values were not influenced by wetland type. Earnhart

(2001) combined a hedonic analysis with conjoint analysis to study the value of wetlands in Fairfield, Connecticut, and this study found that restored wetlands generated large positive increases in nearby property values while disturbed wetlands generated decreased in property values.

The vast majority of wetlands valuation studies were done for wetlands in rural areas, and hedonic studies of the value of wetlands in rural areas showed a more mixed response. Reynolds and Regalado (1998) found that forested and emergent wetlands in Florida, which accounted for 94% of the wetlands in the study, had negative effects on rural land values. However, scrub-shrub and shallow pond wetlands had a positive effect on land values. Shultz and Taff (2003) found that farmland prices in North Dakota with wetlands were lower by $209 per acre than those without wetlands, almost half of the average local cropland values from 1995-2002. Bin and Polasky (2004) found that proximity to inland wetlands lowered property values, and proximity to coastal wetlands, which also meant proximity to Pamlico Sound, increased property values.

Although people may prefer to reside near wetlands, as is generally found to be the case with water (i.e., properties on lakes are valued higher than properties not located on lakes), no studies to our knowledge have examined the value of wetland properties as it is related to characteristics of the wetland properties. Specifically, most studies examine the influence of wetlands proximity on nearby residential tracts (i.e., wetlands are merely one characteristic that determines residential prices) or the influence of wetlands as a single component of other land masses (e.g., the impacts of wetlands on agricultural land prices). This study attempts to directly examine the relationship between rural wetland values and wetland characteristics associated with each property (e.g., types of wetlands and associated amount of open water).

CHAPTER 3   STUDY AREA, DATA AND VARIABLES

3.1 Study Area

The focus of this study includes two Parishes, Cameron and Calcasieu, which are located in southwest of Louisiana and north of the Gulf of Mexico (Figure 3.1).

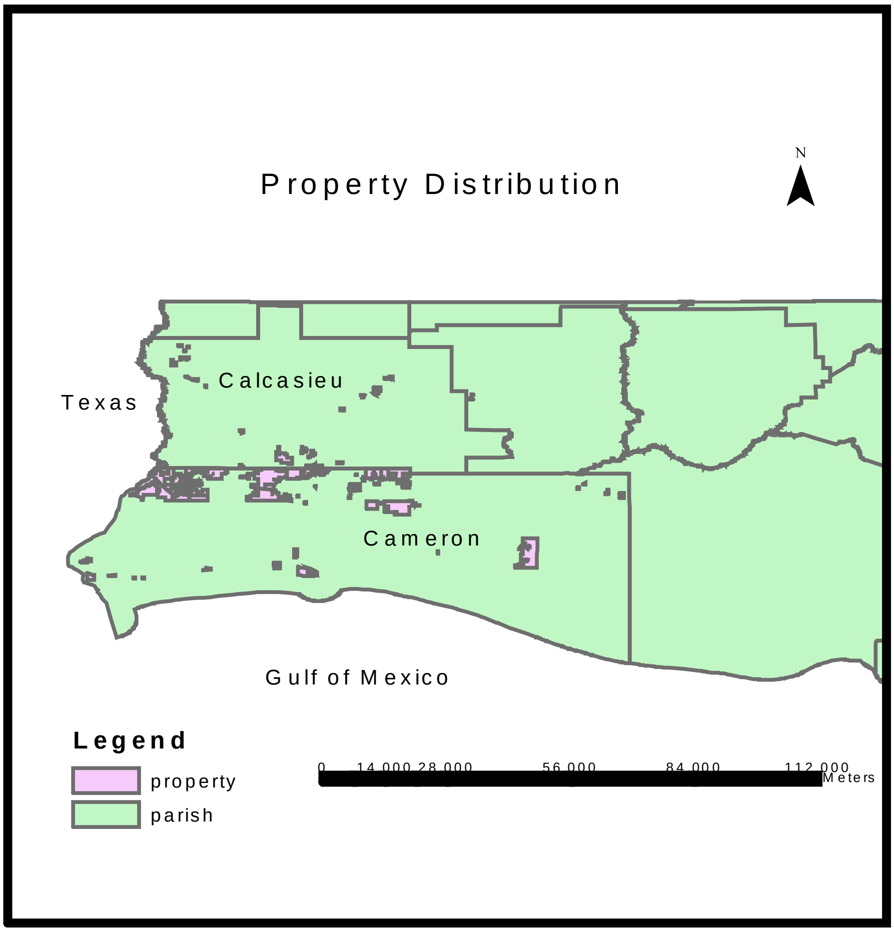

Figure 3.1 Property Distribution

Cameron Parish is the largest parish in the southwest Louisiana. The parish has a total area of 1,932 square miles, 1,313 square miles of which is land and the remaining 619 square miles constitutes water. In percentage terms, 32.0% of the Parish is considered water. Approximately 75% of the parish's acreage is wetlands. As of the 2000 census, there are 9,991 people, 3,592 households, and 2,704 families residing in the parish. The population density is eight per square miles. There are 5,336 housing units at an average density of four per square miles. Primary commodities in the parish are rice, cattle and calves, beef cows, soybeans, and hay-alfalfa.

The reported land area of Calcasieu Parish is 1,071 square miles and its population density is 157 per square mile. Primary commodities in the parish are rice, beef cattle, soybeans, sugarcane, crawfish, and sorghum.

These two parishes belong to the Calcasieu / Sabine Basin. The Basin contains about 312,500 acres of coastal wetlands, consisting of 32,800 acres of fresh marsh, 112,000 acres of intermediate marsh, 158,200 of brackish marsh, and 9,500 acres of saline marsh. A total of 122,000 acres have been lost since 1932, or about 28 percent of the marsh that existed in 1932.

Calcasieu and Sabine lakes are the major water bodies within the Basin. Freshwater inflow to the Basin occurs primarily through these lakes via the Calcasieu and Sabine rivers. Marshes within the Basin historically drained into these two large lakes. This process was altered by the construction of channels to enhance navigation and mineral extraction activities. Navigation channels now dominate the hydrology of the Basin.

The water circulation patterns allow for higher salinity water to enter the interior marshes (saltwater intrusion). The Basin soils, which are 87 percent organic and support lower salinity marsh vegetation, are infiltrated by the more saline waters. This leads to increased stress and loss of the plant communities, and eventually erosion and sediment transport out of the inner marsh areas.

Wetland loss within the Basin is largely the result of extensive hydrologic alterations to wetland building and maintenance processes, although many factors account for this loss. For instance, Penland (2003) found that up to 36 percent had been attributed to dredging for oil and gas exploration and recovery statewide.[1] Recent observations regarding marsh recovery indicate that in some areas, reducing salinities may protect and restore wetlands.

3.2 Data

Hedonic modeling of wetland properties requires a database of property transactions. For purposes of this study, transactions were limited to relatively large tracts of properties (i.e., those in excess of approximately 50 acres). Transactions were also limited to those occurring during the 1990 through 2002 period for two primary reasons. First, while information on transactions occurring prior to 1990 is available, transfers prior to this period were infrequent. Second, the probability of significant structural shifts, not included in the estimation process, increases in conjunction with the timeframe used in the analysis. As such, inclusion of property transfers prior to 1990 was deemed 'unwise.'

Relevant information pertaining to property transfers during the period 1990-2002 was taken from conveyance deeds collected from the courthouses in Cameron and Calcasieu Parishes. These conveyance records provide information on each transaction

[1] There appears to be no information regarding specific causes for wetland loss in the Calcasieu/Sabine Basin. Wetland loss in Southwest Louisiana is significantly less than in the eastern coastal region.

including, but not limited to: (1) acreage included in the transaction, (2) the boundary of property included in the transaction, (3) the price associated with the property being transferred, (4) the transaction date, (5) the number of parcels included in the transaction[2], and (6) the relevant names and addresses of both sellers and buyers.

The relevant transfer data were collected and then entered into an ArcGIS system, which displays every collected property as an area or polygon instead of one point on maps. Merging these property areas with the U.S. Geological Survey (USGS) 1978, 1988 and 2001 wetland databases permitted the estimation of wetland characteristics associated with each individual property, such as open water acreage, brackish marsh acreage, fresh marsh acreage, intermediate marsh acreage, and saline marsh acreage. In addition, merger of the databases allowed for estimation of changes from land to open water (or vice versa) associated with each individual property during the 1978-2001 period.[3]

Finally, combining the transfer data into the relevant Louisiana GIS geographic maps also produces the requisite accessibility characteristics data associated every individual property that can be used in the hedonic regression analysis. Such information includes distance of each property to the nearest primary local road, distance of each property to the coastline, and distance of each property to the nearest city, town or village which has a population in excess of 1,500.

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[2] In many instances more than one parcel was sold under a given transaction.

[3] As discussed in greater detail in a subsequent section, losses of land to open water (or vice versa) during the 1978-2001 period were insignificant (if any) for all considered properties. While wetland loss in the western coastal portion of the state is known to be less than along the eastern portion, the finding of no significant wetland loss was still somewhat unexpected. This unexpected finding is somewhat disturbing in that it may indicate some self-selection bias associated with properties being transferred. Specifically, it may indicate that properties of lower quality (i.e., those with a large land loss rate) are not being transferred due to a lack of interest among potential buyers. As indicated in Figure 3.1, most, but by no means all, of the transfers in Cameron Parish are in the northwest where one might hypothesize a lower rate of wetland loss. Closer examination suggests that a large portion of 'central" Louisiana is part of the Sabine Wildlife Refuge while land along the coast is generally owned by a relatively few "large" landowners.

Overall, a total of 70 individual property transactions meeting the conditions previously stated (i.e., size and date) were identified during the collection process. Of these 70 transactions, a total of 60 had the information needed for analysis. The other 10 transactions were not included in the coastal zone and, hence, were not represented in the USGS database. One additional property was deleted from the analysis because it was considered to be an 'outlier.'[4] Among the 59 transactions used in the analysis, 56, or 95%, are from Cameron Parish.

Of the 59 properties used in the analysis, 47 represented the transfer of a single piece of property. The remaining 12 represented the transfer of two or more pieces of property; often not contiguous in nature. While one might consider deletion of those transfers representing noncontiguous properties, such action was not taken in the current study due to the relatively small sample size.[5]

3.3 Variables

Variables selected for inclusion in the hedonic model are presented in Table 3.1. The hedonic model seeks to estimate the "true price" – that dollar value agreed upon by willing buyers and sellers, each with full information and no coercion- based upon property (and other) characteristics. In theory, only "arms length" transactions should be included in the analysis. Insufficient information existed to determine whether each of the 59 observations included in the analysis represented an 'arms length' transfer but a

[4] The per acre price of this property was significantly higher than any of the others included in the analysis (approximately twice that of the next highest property). A review of the conveyance deed associated with this outlier indicated that the buyer was The Lake Charles Harbor and Terminal District. It is likely that the District needed this property for expansion and hence the seller likely had leverage on the buyer.

[5] As discussed in the next section, a discrete variable indicating whether more than one parcel was included in the transfer was employed in the analysis in an attempt to adjust for differences in prices (value) that might be forthcoming as a result of more than one tract being transferred in a given transaction, *ceteris paribus*.

cursory examination of the transactions did not explicitly indicate any 'less than arms length' transactions.[6] Hence, no observations were deleted due to concerns regarding transactions that may have been coerced or otherwise not accurately representing willing buyers and sellers.

Table 3.1 Symbols and Descriptive Statistics for Hedonic Model Variables

Symbol	Variable	Mean	Minimum	Maximum	Std. Dev
PRICE	Price adjusted with CPI at 2000 ($)	367915.87	15365.20	2700957.5	596841
LPRICE	Natural log of PRICE	11.88	9.64	14.81	1.35
PACRE	Price per acre ($)	410.22	121.78	1352.33	292.27
LPACRE	Natural log of price per acre	5.79	4.80	7.21	0.67
ACRES	Size of property (acres)	1242.90	39.64	10925.49	2046
LACRES	Natural log of property size	6.09	3.68	9.30	1.48
COPENW	Open water percentage of size (%)	23.34	0	89.26	23.28
CFRESH	Fresh Marsh percentage of size (%)	8.91	0	86.70	21.86
CINTER	Intermediate percentage of size (%)	24.81	0	97.54	31.99
CBS	Brackish and Saline percentage (%)	21.67	0	96.34	34.67
COTHER	Other acreage percentage (%)	21.27	0	99.66	35.00
DROAD	Distance to the nearest road(miles)	3.27	0.02	11.70	3.50
DCOAST	Distance to the nearest coastline(miles)	18.76	4.15	29.24	6.89
DUMSECT	Whether there are separated sections	0.20	0	1	0.41

[6] For example, no property transactions occurred between individuals, groups of individuals, corporations with the same last names or addresses.

Price associated with the transaction (PRICE) and price per acre (PACRE) are the dependent (endogenous) variables in this study[7]. As indicated, the average value (PRICE) among the 59 properties used in the analysis equaled $368 thousand which translates to $410 when evaluated on a per acre basis (PACRE).[8] There was, as indicated, considerable variation in the per acre price with prices ranging from a low of $122 to a high of $1,352.

For each property sale there is a set of associated explanatory (exogenous) variables that are used to explain the sales price of the property (either in total or on a per acre basis). These independent variables consist of a set of structural variables (ACRES/LACRES, DUMSECT), neighborhood variables (DCOAST, DROAD), and wetland characteristic variables (COPENW, CFRESH, CINTER, CBS, and COTHER) linked to each property in the data set.

As indicated by the information contained in Table 3.1, the average transaction included 1,243 acres with the largest transaction exceeding ten-thousand acres. Wetland characteristics, as indicted, are expressed on a percentage basis, calculated as follows:

$$\text{COPENW} = (\text{open water acreage} / \text{ACRES}) * 100 \tag{3.1}$$

$$\text{CFRESH} = (\text{fresh marsh acreage} / \text{ACRES}) * 100 \tag{3.2}$$

$$\text{CINTER} = (\text{intermediate marsh acreage} / \text{ACRES}) * 100 \tag{3.3}$$

$$\text{CBS} = (\text{brackish and saline marsh acreage} / \text{ACRES}) * 100 \tag{3.4}$$

$$\text{COTHER} = (\text{other acreage}/\text{ACRES}) * 100 \tag{3.5}$$

[7] For purposes of this study, all prices have been adjusted for inflation based on the 2000 Consumer Price Index as calculated by the U.S. Department of Commerce.

[8] Values and associated per acre prices for all properties used in the analysis have been adjusted for the effects of inflation using the 2000 U.S. Consumer Price Index as a base.

In total, open water and intermediate marsh each accounted for about one quarter of the total acreage that was transferred during the period of analysis. Brackish and saline marsh accounted for an additional 21% of the total acreage.[9] Fresh marsh represented about 9% of the transferred acreage. These four categories represent about 80% of the total acreage included in the 59 used in the analysis. The remaining acreage (approximately 20%), defined as COTHER, primarily represents land not designated as wetlands.[10] The average distance of transferred properties to the coast (DCOAST) equaled about 19 miles while the average distance to the nearest road (DROAD) was approximately three miles.

All independent variables (exogenous) variables, with the exception of the variable noted as DUMSECT are continuous in nature. The variable DUMSECT is discrete in nature and is equal to 0 when a given transaction represents only one contiguous parcel being transferred and equal to 1 if a transfer includes two or more parcels that are not contiguous. As noted, 47 of the 59 usable transactions included a single parcel being transferred. These 47 transactions included parcels averaging 1,011 acres in size. Transactions including non-adjacent properties averaged 2,152 acres, or about twice of those involving only a single property transfer.

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[9] Brackish marsh and saline marsh are separated in the USGS database of wetland characteristics. Less than three percent of the acreage transferred in the study constituted saline marsh based upon USGS information. Hence, brackish marshes and saline marshes were combined to create a single marsh designation in the current study.

[10] As discussed in greater detail in a subsequent section, this COTHER category was not included as a variable in the regression analysis. Inclusion would have resulted in a singular matrix since the summation of the five categories would equal 100% and would, therefore, be perfectly correlated with the intercept term. As such, the COTHER category can be considered as the base category with which to compare the other four wetland characteristic categories. As an alternative to this process, the intercept term could, in theory, be deleted from the analysis.

In general, there is little *a priori* information regarding the expected signs associated with each of the parameters to be estimated in a hedonic wetland model of this nature. Certainly, one would anticipate that PRICE is positively related to ACRES while PACRE is negatively related to ACRES. Given the fact that the OTHER category represents the more 'firm' property that can be used in a multitude of financial endeavors, one would anticipate that the expected signs of the parameters associated with wetland characteristics (COPENW, CFRESH, CINTER, and CBS) would be negative given the base characteristic (i.e., OTHER). With less assurance, one might hypothesize that COPENW is a less favorable characteristic than any of the marsh types included in the analysis, suggesting a larger negative estimated coefficient. Finally, one might anticipate that PACRE is negatively related to the distance from the nearest road (DROAD) while positively related to the distance from the coastline (DCOAST), *ceteris paribus*. The hypothesized negative relationship between distance from a road and PACRE reflects the expected increased costs (opportunity costs) associated with transversing water rather than road to reach the property while the hypothesized positive relationship between distance from the coast (DCOAST) and per acre price (PACRE) reflects potentially higher elevation. However, the expected association of these last two variables to PACRE is somewhat tenuous given the nature of wetland usage.[11]

[11] Specifically, the primary use of much of the wetlands in Southwest Louisiana likely relate to hunting activities. Even if relatively close to a road, properties may have little demand from hunters of larger towns.

CHAPTER 4 METHODOLOGY

The study collects the coastal property transaction data, enters them into Geographic Information Systems (GIS) compatible with the U.S. Geology Survey wetland database, outputs data necessary for econometric analysis, and then applies ordinary least squares regression to estimate a "best" fit hedonic function. Finally a hedonic property model is set up and implicit marginal price can be calculated through this hedonic equation. Therefore, this study applied two main methods: the specification of the hedonic model and statistical analysis.

4.1 Hedonic Model

Assume that $\boldsymbol{S}$ denotes a vector of structural characteristics (such as property acreage and distance from the coast), that $\boldsymbol{E}$ represents a vector of environmental characteristics (such as acres of open water and/or marshes), and that $\boldsymbol{A}$ represents a vector of accessibility characteristics (such as distance to the nearest road). In this study neighborhood characteristics are not considered. Then the price of any property, $\boldsymbol{P}$, can be described as a function of structural, accessibility, and environmental characteristics:

$$\boldsymbol{P} = P(\boldsymbol{S}, \boldsymbol{A}, \boldsymbol{E}) \tag{4.1}$$

Equation (4.1) is referred to as the hedonic price function.

The hedonic price function in equation (4.1) is the reduced form equation representing the results from the interaction of supply and demand forces. The choice of function form has been important in the specification of hedonic models (Cropper et al. 1988; Halvorsen et al. 1981). This refers to the mathematical transformation that is assumed to best describe the relationship between each explanatory (exogenous) variable and the dependent (endogenous) variable[12]. The issue arises because economic theory gives little guidance in relation to the proper functional relationship between property attributes and property prices. Smith and Huang (1995) found that the functional form could significantly influence the estimated implicit price.

Graves et al. (1988) concluded from a comprehensive investigation of this issue that a flexible functional form known as the Box-Cox transformation (Box and Cox, 1964) provided the best specification for their hedonic models. Wooldridge (1992) introduced some flexible functional forms as alternatives to the Box-Cox regression model and suggested that some of the more flexible functional forms, not permitted under the alternative Box-Cox specification, yielded superior results. Other hedonic price studies have shown a growing interest in nonparametric/semi-parametric regressions as an estimation method because these methods require only weak assumptions on the functional form and directly estimate the association between the variables of interest (Pace, 1988; Iwata et al. 2000; Clapp et al. 2002; Martins-Filho and Bin, 2003). Most of these alternative specifications, however, are considered under the construct of relatively large data sets. The limited data set used for the current analysis limits the testing of alternative specifications, such as that of nonparametric/semi-parametric regression.

For this study, only the first stage model of Rosen's (1974) two-stage hedonic pricing model and the marginal implicit prices of the characteristics are estimated.

[12] The term "best describes" is based primarily on economic considerations rather than statistical considerations. In general, however, one would generally assume that a "well specified" model from an economic standpoint would tend to lessen statistical-based violations.

4.1.1 First Stage Hedonic Model

Following the approach used by Danielson (1984) and Kennedy et al. (1995), a transcendental function was specified for the coastal Louisiana properties in this study:

$$\Pr ice = \beta_0\, Z_1^{\beta_1} \exp[\sum_{i=1}^{m} \alpha_i X_i + \sum_{j=1}^{n} \gamma_j D_j] + \varepsilon \qquad (4.2)$$

where Price is the dollar value (or dollar value per acre if expressed on a per acre basis) of the property, Z_1 is the size of property expressed in acres, m is the number of additional continuous variables (X_i), n is the number of discrete (dummy) variables (D_j), and ε is a random disturbance term. Taking the natural logarithm of both sides of equation (4.2) yields:

$$\ln \Pr ice = \ln \beta_0 + \beta_1 \ln Z_1 + \sum_{i=1}^{m} \alpha_i X_i + \sum_{j=1}^{n} \gamma_j D_j + \varepsilon \qquad (4.3)$$

Estimation of the hedonic model used in the current analysis is based on the transformation of the transcendental model as specified in equation (4.3).

4.1.2 Implicit Marginal Prices of Characteristics

The implicit marginal price of each characteristic is an estimate of change in dollar value or per acre property price brought about by a one-unit change in that characteristic. For all continuous variables in equation (4.2), the partial derivatives, which are the marginal prices, are given by the following:

$$\begin{aligned} \partial \Pr ice_t / \partial Z_{1,t} &= IZ_{1,t} = (\beta_1 / Z_{1,t}) * \Pr ice_t \\ \partial \Pr ice_t / \partial X_i &= IX_{i,t} = \alpha_i * \Pr ice_t \end{aligned} \qquad (4.4)$$

Where t, the subscript, implies that there are implicit prices associated with each transaction. If the mean value of each variable is substituted into the equation (4.4), the implicit marginal price at the mean price and mean level of the characteristics over all observations will be estimated (Kennedy, 1995). This study estimates the implicit marginal price under such a scenario.

The derivative for discrete (dummy) variables is given in semi logarithmic equations using the variance of the dummy variable (Kennedy, 1981);

$$ID_j = (\exp[c_j - 1/2 * V(c_j)] - 1) * mean\_price \tag{4.5}$$

Where ID_j is the implicit price of the dummy variable, c_j is its estimated coefficient, $V(c_j)$ is the variance of the c_j, and mean_price is the mean price per acre over all of the observations used in the model. Using the variance of the estimated coefficient can lead to a reduction in bias in the estimate when $V(c_j)$ is substantial.

4.2 Statistical Considerations

This study applies least square multiple regression for the purpose of deriving relevant parameter estimates. Whether multiple linear regression is adequate for estimation purposes depends upon a limited set of assumptions regarding the variables used in the analysis as well as the structure of the resultant error term. When these assumptions are not met, the results may be misleading, resulting in a Type I or Type II error, or overestimation or underestimation of significance or effect sizes. As Osborne et al (2001) observed, however, few articles reported having tested the assumptions (i.e., employing the needed statistical tests) generally considered a prerequisite for drawing meaningful conclusions.

With data collected, the first task, as noted by Osborne (2001), is not that of estimating the regression model but, rather, to evaluate the underlying assumptions. All multivariate techniques have underlying assumptions, both statistical and conceptual, that substantially impact their ability to represent multivariate relationships. Several assumptions of multiple regressions are "robust" to violation (e.g., normal distribution of errors). Therefore, we will focus on the assumptions of multiple regression that are not robust to violation and that researchers can deal with if violated.

4.2.1 Assumptions

1) Linearity Assumption

The dependent variable y is a linear function of the independent variables x's, plus a random disturbance ε:

$$y = b_0 + \sum_{i=1}^{n} b_i x_i + \varepsilon \tag{4.6}$$

Standard multiple regression can only accurately estimate the relationship between dependent and independent variables if the relationships are linear in nature. Because there are many instances in which nonlinear relationships occur, it is essential to examine analyses for nonlinearity. If the relationship between independent variables and the dependent variable is not linear, the results of the regression analysis will likely underestimate (overestimate) the true relationship. This underestimation carries two risks: increased chance of a Type II error for that independent variable, and, in the case of multiple regression, an increased risk of Type I errors (overestimation) for other independent variables that share variance with that independent variable.

Some researchers suggest three primary methods for detecting nonlinearity. The first method is to use theory or previous research to inform current analyses. However, because many prior researchers have probably overlooked the possibility of nonlinear relationships, this method is not foolproof.[13] A preferable method of detection is to examine residual plots (plots of the standardized residuals as a function of standardized predicted values, readily available in most statistical software packages). The third method of detecting curvilinearity is to routinely run regression analyses that incorporate curvilinear components (squared and cubic terms) or use the nonlinear regression option available in many statistical packages. However, use of this method is to some extent dependent upon the amount of data one has available for analysis. Specifically, larger data sets more naturally lend themselves to the inclusion of additional variables (e.g., squared and cubic terms) in the estimation procedure.[14] It is important that the nonlinear aspects of the relationship be accounted for in order to best assess the relationship between variables.

2) Mean Independence Assumption

The most important assumption we make about the random disturbance ε is that its mean or average value does not depend on the x's (i.e., the exogenous variables). More specifically, we assume that the mean of ε is always 0 to derive unbiased parameter estimates. This assumption simply implies that the exogenous variables are unrelated to the random disturbance ε. While there are ways of dealing with violations of the mean

[13] Furthermore, little guidance may be available in relatively new areas of empirical research where few/any previous studies exist (such as hedonic modeling of large wetland tracts). Certainly, the amount of information available to the researcher is positively related in some manner to the amount and quality of previous research conducted on problems of a similar nature.

[14] The relatively small data set used in the current analysis limits specification of some of the more 'general' nonlinear functional forms, such as the quadratic model; particularly if interaction terms are included in the specification.

independence assumption, they invariably require additional data, additional assumptions, and more complex methods of analysis.

The mean independence assumption and the linearity assumption, in conjunction, guarantee that the least squares estimates of coefficients are unbiased estimates.

3) Homoscedasticity Assumption

Homoscedasticity implies that the variance of errors is the same across all levels of each exogenous variable. Stated somewhat differently, homoscedasticity dictates that the variance of random disturbance ε cannot depend on the level of the exogenous variables, and it has always the same value (i.e., predicted value equal to zero). When the variance of errors differs at different values of the exogenous variable, heteroscedasticity is indicated. Slight heteroscedasticity has little effect on significance tests; however, when heteroscedasticity is marked, it can lead to serious distortion of findings and seriously weaken the analysis, thus increasing the possibility of a Type I error. For example, since the standard errors associated with the estimated parameters are likely to be influenced by the presence of heteroscedasticity, presence thereof may lead to the unwarranted rejection (acceptance) of significance of the estimated parameter.

Unlike the assumption of mean independence, the homoscedasticity assumption can be checked readily with data. For example, this assumption can be checked by visual examination of a plot of the standardized residuals (the errors) by the regression standardized predicted value. Most modern statistical packages include this as an option.

Ideally, residuals are randomly scattered around 0 (the horizontal line) when plotted against a specified exogenous variable, providing a relatively even distribution. Heteroscedasticity is indicated when the residuals are not evenly scattered around the line. There are many forms heteroscedasticity can take, such as a bow-tie or fan shape. When the plot of residuals appears to deviate substantially from normal, more formal tests for heteroscedasticity should be performed. Possible tests for this are the Goldfeld-Quandt test when the error term either decreases or increases consistently as the value of the dependent variable increases as shown in the fan-shaped plot, or the Glejser tests for heteroscedasticity when the error term has small variances at central observations and larger variance at the extremes of the observations as in the bow tie-shaped plot. In cases where skewness is present in the independent variables, variable transformations can reduce the heteroscedasticity chances.

4) Uncorrelated Assumption

The value of disturbance term ε for any individual in the sample is uncorrelated with the value of ε for any other individual. The general consequences of correlated disturbances are identical to those for heteroscedasticity. Although the coefficients remain unbiased, they will be inefficient – the least squares method is no longer optimal. More seriously, the estimated standard errors will be biased. Although possible, there are not many convenient ways to diagnose correlated disturbances by examination of the data.

With the three above assumptions (Linearity, Mean Independence, and Homoscedasticity) and this uncorrelated assumption, the least squares coefficient estimates are BLUE (best linear unbiased estimation). This implies that the coefficients are unbiased and efficient.

5) Normality Assumption

Many people naively believe that all the variables in a regression equation must be normally distributed. This belief is incorrect. Only the disturbance term ε is required to be normally distributed.[15] Non-normally distributed ε (highly skewed or kurtosis, or residuals with substantial outliers) can distort relationships and significance tests. There are several pieces of information that are useful to the researcher in testing this assumption: visual inspection of data plots, skew, kurtosis, and P-P plots give researchers information about normality, and Kolmogorov-Smirnov tests provide inferential statistics on normality.

Combined with the above assumptions, the normality assumption implies that a t table can be used validly to calculate p values and confidence intervals.

6) Multicollinearity Assumption

Independence of the exogenous variables to each other is not a requirement for OLS regression. If all exogenous variables are independent, one has an orthogonal matrix of exogenous variables. While orthogonality of the exogenous variables is 'preferable' for the purposes of regression, analysis based on economic data rarely lends itself to such conditions. In the extreme (when one exogenous variable is perfectly correlated with another or subset of exogenous variables), multicollinearity will result in a singular matrix; hence precluding estimation. Problems with multicollinearity can also be manifested in less than 'extreme' cases, however. Specifically, as correlation among the exogenous variables increases, the ability to separate the influence of one variable over another on the endogenous variable is lessened. This generally results in less precision

[15] Having said this, extreme non-normality of the endogenous variable can result in non-normality of the error term. In such cases, OLS may not be appropriate for analysis but other generalized least square (GLS) techniques can be used.

associated with the estimated parameters and increasing standard errors associated with the estimates. Parameter estimates, however, remain unbiased even when multicollinearity is large.

While the presence of correlation among exogenous variables is probably the 'norm' rather than the exception when conducting economic based regression analysis, reducing the influence can be problematic. Increasing the number of observations, while often mitigating multicollinearity problems, is often impractical in applied research.[16] In other instances, variables can be transformed and/or combined to mitigate the effects of multicollinearity.

4.2.2 Assumption Testing

For purposes of this study, efforts are primarily focused on testing for homoscedasticity, normality, and multicollinearity. These tests are conducted using SAS statistical programming. For purposes of testing for homoscedasticity, the White's test is conducted (see Greene, 2003 for a description of this test). If the probability of White's test is greater than 0.05, the null hypothesis of homoscedasticity cannot be rejected. The Shapiro-Wilk statistic (see Hair et al., 1998 for a description of this test) is often employed for normality test of sample size of 2,000 or less. If the probability of the statistic is less than 0.05, the null hypothesis of normal distribution of random disturbance is rejected. The Tolerance or Variance Inflation Factor (VIF) is a generally accepted practice for testing for multicollinearity. This test, however, is somewhat

[16] In the current study, for example, all relevant properties (i.e., those in excess of approximately 50 acres) that were sold in the coastal areas of Cameron and Calcasieu Parishes between 1990 and approximately 2002 were included in the analysis. Hence, increasing the sample size would require inclusion of properties before 1990. However, such inclusion could result in additional statistical issues if structural change, not accounted for in the model specification, were occurring. Obviously, structural change becomes more likely as the timeframe for analysis is expanded.

imprecise and there is no ‘critical’ value for which one could conclude with any certainty that multicollinearity is a ‘significant’ problem. Many researchers suggest that, as a general ‘rule of thumb,’ multicollinearity becomes a ‘significant’ issue (i.e., one that would ‘trigger’ reconsideration of the model specification) when the VIF is greater than 2.5 (see, for example, Allison, 1999). Other researchers, however, have suggested that multicollinearity is not a ‘significant’ problem until VIF is greater than 10.

CHAPTER 5 RESULTS AND ANALYSIS

From the collected data and the wetlands database, we have the necessary information to accomplish the objectives set forth in Chapter 1. To do so, we first examine the variables and data used in the analysis.. Because a linear regression model may not be appropriate for this research, some, if not all variables, must be transformed. After some protesting, equation (4.2) was selected as the "preferred" model specification to fit for the hedonic model of Southwest Louisiana private wetland property values. For the convenience of estimation, equation (4.3) serves as the basis for estimation purposes. Finally the hedonic price functions are acquired according to the equation (4.2) and (4.3). From these hedonic price functions, we have information about how the wetlands affect property price, whether the wetland types have different effects on property price or not, and marginal implicit prices of all factors of these models, etc. This information and study results will help to establish an economic instrument for the southwestern Louisiana's coastal wetland restoration and protection.

5.1 Hedonic Price Functions

Based on equations (4.2) and (4.3), the hedonic price functions can be analyzed using the SAS statistics software package. This study uses a multivariate regression analysis to estimate two models. The first model is on a per acre basis with price per acre (PACRE) expressed in natural log being the endogenous variable. The exogenous variables, as provided in Table 3.1, include the size of the property (ACRES), percent of the property comprised of open water (COPENW), percent of the property comprised of fresh marsh (CFRESH), percent of the property comprised of intermediate marsh

(CINTER), percent of the property comprised of brackish and saline marsh (CBS), the distance to the coastline in miles (DCOAST), the distance to the nearest road (DROAD), and whether the property transaction includes separated sections (DUMSECT). The second model examines the value or total price (value) of transaction (PRICE) based upon the same set of exogenous variables. Given the identical set of exogenous variables, one would expect similar results, with some notable exceptions as discussed below.

1) Assumption Testing

Based on the discussion presented in Chapter 4, a set of assumptions should be tested to provide some “validity’ to the estimated parameters as well as to the associated standard errors. If these assumptions are not satisfied or if there exist some assumption violations, some model modifications are in order.

The White’s test p-values are the same for both models and equal to 0.3186, which is greater than 0.05. This suggests that there are 3,186 chances to fail to reject the residual homoscedasticity null hypothesis from total 10,000 events. Therefore the null hypothesis of residual homoscedasticity of both models fails to be rejected.

Also, the Shapiro-Wilk test p-values of both models are the same and equal to 0.3936, which is greater than 0.05 critical value. This would indicate that there are 3,936 chances of the total 10,000 events to fail to reject the normal distribution null hypothesis of the disturbance residual term. Therefore, the null hypotheses of residual normally distributions of both models fail to be rejected.

As previously indicated, both models include several variables representing wetland characteristics. These variables include the percentage of total acreage of each individual transaction comprised of open water (COPENW), the percentage of each property which is designated as fresh marsh (CFRESH), the percentage of each property being designated as intermediate marsh (CINTER), and the percentage of each property being designated as brackish and saline marsh (CBS). These four designations plus COTHER[17] total to 100, or:

$$COPENW + CFRESH + CINTER + CBS + COTHER = 100 \tag{5.1}$$

Given, the interrelationship between this set of exogenous variables, one might anticipate problems with multicollinearity. Strictly speaking, exogenous variables in this set are not likely to be independent of one another. For example, a high level of COPENW for one property dictates low levels of other wetland characteristic variables. Conversely, a low value of COPENW would indicate higher levels for at least one other wetland characteristic variable.

Given this to be the case, special attention should be given to the issue of multicollinearity. Based on discussion in the previous chapter, the VIF method can be used to test the multicollinearity assumption. Here we apply this stricter test VIF value of 2.5 though, as previously noted, there is no strict criteria for selection of a critical value. The results associated with the VIF analysis are presented in tables 5.1 and 5.2. As indicated, no VIF value is greater than 2.5. This suggests that multicollinearity does not appear to be a serious concern with respect to either model specification.

In summary, it appears as though the two model specifications meet the requirements of residual homoscedasticity, residual normality, and multicollinearity

[17] As previously noted, the COTHER property designation was not included in the regression analysis to avoid a singular matrix and, hence, inability to generate meaningful estimates.

assumptions. As such, no model remedies or adjustments (such as a respecification) appear warranted.

2) Hedonic Price Function Results

The results of the hedonic price models are presented in Tables 5.1 and 5.2. The regression process of the first model uses natural log of price per acre as the dependent variable (the results shown as Table 5.1). The regression process of the second model uses the natural log of price (i.e., the total sales price) as the dependent variable (the results shown as Table 5.2).

With respect to the first model (using price per acre as the dependent variable), results suggest that all marsh types (expressed in percentage terms of total acreage) as well as open water have negative or zero effects on property prices (table 5.1) when compared to the base category, COTHER. Of these variables, open water percentage, intermediate marsh percentage, and brackish and saline marsh percentage are highly statistically significant. The negative parameter estimates associated with the different marsh types (CINTER, and CBS) as well as that for open water (COPENW) are expected, given the base of hard land (COTHER).   The insignificant parameter estimate associated with fresh marsh (CFRESH) suggests that this wetland characteristic is valued at approximately the same level as COTHER. Somewhat unexpectedly, the results also suggest that the characteristics associated with both intermediate and brackish and saline marshes (CINTER and CBS) are valued less than open water (COPENW).   Whether this is the result of model misspecification or reflects the actual situation warrants additional investigation.[18]

The dummy variable DUMSECT is statistically significant at the level of 10% with the negative coefficient value of -0.2463. This suggests that the price per acre among transactions involving multi non-adjacent properties is less than the price per acre for single properties, *ceteris paribus*. This may reflect the desirability for single, larger tract pieces of property.

Table 5.1 Hedonic Price Function with Dependent Variable of LPACRE

Variables	*Coefficients*	*Standard Error*	*t Stat*	*Pr>|t|*	*VIF*
Intercept	6.7953	0.3811	17.83	<0.0001	0
LACRES	-0.0363	0.0482	-0.75	0.4550	1.6763
COPENW	-0.0088	0.0028	-3.13	0.0029	1. 4108
CFRESH	-0.0011	0.0033	-0.33	0.7455	1.6961
CINTER	-0.0143	0.0026	-5.60	<0.0001	2.1951
CBS	-0.0098	0.0024	-4.01	0.0002	2.3497
DROAD	-0.0134	0.0219	-0.61	0.5438	1.9188
DCOAST	0.0050	0.0109	0.46	0.6511	1.8595
DUMSECT	-0.2463	0.1462	-1.68	0.0983	1.1540

R^2:0.6588
Adjusted R^2: 0.6042
F value: 12.07

[18] As a first step in the investigation, distance of each property from the coast was included as an exogenous variable in a subsequent model run. Inclusion of this variable did not significantly change results and the results, including this additional variable, are not presented.

Supporting this argument, price per acre (LPACRE), as indicated in Table 5.1, was not found to be significantly influenced by the size of the transaction, as measured in total acreage (LACRES). In previous studies of farm prices, price per acre is often found to be significantly negatively influenced by the size of the property being sold; at least after a given size is attained. This analysis suggests that the price per acre of wetland properties, at least in Southwest Louisiana, is not negatively related to the size of the property.[19]

The two distance variables, distance to the nearest city (DCITY) and distance to the nearest road (DROAD) were found to be statistically insignificant in explaining variation in wetland, per acre prices. As previously noted, a finding of this nature is not unexpected given the primary uses of wetlands and likely participants.

From the model, different wetland types have different coefficient effects on property per acre price. In this study, intermediate marsh has the greatest coefficient effect on property value with the coefficient of -0.01434, followed by brackish and saline marsh, open water. Fresh marsh has no or little coefficient effect on property value. All these are shown on the following Figure 5.1.

[19] As one would expect, the estimated coefficient associated with acreage in Table 5.1 (i.e., price per acre) is simply equal to one minus the estimated coefficient associated with acreage in Table 5.2 (i.e., total sales price of the property). This simply reflects the fact that normalization was based on acreage.

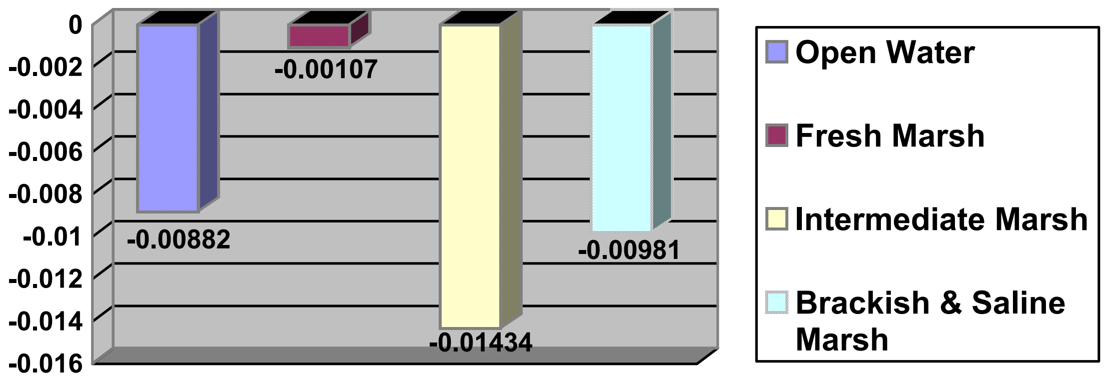

Figure 5.1 the Effect Chart of Wetland Types on Property

With respect to the second model (using the variable value or total price of property as the dependent variable), the results of hedonic price function are presented on Table 5.2. This model uses natural log of property price as the dependent variable, with others held as in the first hedonic function. Except the variable LACRES, all coefficients and statistical values are the same as the price per acre function. The biggest difference is that LACRES is statistically significant and positive related to the dependent variable. Overall, the estimated coefficient associated with LACRES is not statistically different from one at the 95% level of confidence, suggesting no discounting associated with the transfer of larger property tracts, *ceteris paribus*.

5.2 Marginal Implicit Prices of Characteristics

Marginal implicit prices are used to observe the magnitude and direction of influence of various model factors on price per acre or price through examination of the implicit prices at the mean values of the property price and the quantity of the characteristic. A positive marginal implicit price indicates that an increase in that characteristic, or variable, results in an increase in the price per acre or price, holding other factors constant. A negative marginal implicit price, resulting from a negative model coefficient, has a depressing effect on per acre price or price.

Table 5.2 Hedonic Price Function with Dependent Variable of LPRICE

Variables	*Coefficients*	*Standard Error*	*t Stat*	*Pr>|t|*	*VIF*
Intercept	6.7953	0.3811	17.83	<0.0001	0
LACRES	0.9637	0.0482	19.98	<0.0001	1.6763
COPENW	-0.0088	0.0028	-3.13	0.0029	1. 4108
CFRESH	-0.0011	0.0033	-0.33	0.7455	1.6961
CINTER	-0.0143	0.0026	-5.60	<0.0001	2.1951
CBS	-0.0098	0.0024	-4.01	0.0002	2.3497
DROAD	-0.0134	0.0219	-0.61	0.5438	1.9188
DCOAST	0.0050	0.0109	0.46	0.6511	1.8595
DUMSECT	-0.2463	0.1462	-1.68	0.0983	1.1540

R^2:0.9167
Adjusted R^2: 0.9034
F value: 68.81

5.2.1 Values of Marginal Implicit Prices

The marginal implicit price results, calculated using equations (4.4) and (4.5), are provided in the Table 5.3. In the first model, using price per acre as the dependent variable, the dummy variable DUMSECT has the largest negative marginal implicit price. Specifically, holding other factors constant, a property, of which all sections are adjacent, increases the per acre value by $108.99 in comparison to transactions involving

Table 5.3 Marginal Implicit Prices as Mean Price by Dependent Variable (Dollars)

Variable	**Model 1**	**Model 2**
ACRES	-0.012	285.263***
COPENW	-3.618***	-3245.018***
CFRESH	-0.439	-393.670
CINTER	-5.883***	-5275.914***
CBS	-4.024***	-3609.255***
DROAD	-5.485	-4919.035
DCOAST	2.043	1832.221
DUMSECT	-108.99*	-97746.71*
* denotes significance at 0.10 level, ** denotes significance at 0.05 level, *** denotes significance at 0.01 level.		

non-adjacent tracts. With respect to intermediate marsh, the marginal implicit price was estimated to equal -5.88. This suggests that a one unit increase in intermediate marsh percentage will reduce the property price, expressed on a per acre basis, by approximately 5.9 dollars. The analysis also suggests that a one percent increase of brackish and saline marsh percentage will decrease the price of the property about $4.02 per acre. Finally, the effect of open water on price should also be considered. One unit increase of open water percentage would decrease the price per acre of property about $3.62. The marginal implicit prices of ACRES and CFRESH are for both intents and purposes equal to zero. So the change of property size and fresh marsh percentage of size would have little or no effects on price per acre of property. The two distance variables have opposite effects on price, A one mile increase of DROAD (distance to the nearest primary road) will decrease per acre property price about $5.88, a one mile increase of DCOAST (distance to the nearest coast) will increase per acre property price about $2.04. However, these two estimates are very insignificant.

In general, the variable DUMSECT has the greatest marginal implicit price, and then intermediate marsh percentage, brackish and saline marsh percentage and open water percentage in descending order, which is the same as the coefficient effect order of the hedonic price functions. Other variables, including fresh marsh percentage, acres, distance to the nearest coast, and distance to the nearest primary road, have zero or almost zero marginal implicit prices, or are very insignificant.

For the second model, using total price or value of property as the dependent variable, the situation is similar to the above model 1. The dummy variable DUMSECT still has the greatest effect on property price. Holding others constant, the value of a property of which all sections are adjacent will be about $97,747 higher than that of a property of which a section or some sections are separated with other sections. With one unit increase of intermediate marsh percentage, the property price will decrease about $5,276. With a one unit increase of brackish and saline marsh percentage, the property price will decrease about $3,609. With one unit increase of open water percentage, the property price will decrease about $3,245. For the fresh marsh percentage, one unit increase will bring into about $394 decrease of property price. Although the distance to the nearest coast also has a positive marginal implicit price value, it, as well as the distance to the nearest primary road, is so insignificant that we may neglect their effects on property price.

But there exist some differences. Unlike the model 1, the size has a positive effect on property price in model 2. An increase of one acre in property size will increase the property price about $285. The variable acre of property has important effect on property price. It is logical: the more size a property has, the more expensive the property is.

5.2.2 Discussion about Marginal Implicit Prices

1) Marginal Implicit Price of Size

When the size of a property changes, the open water percentage, fresh marsh percentage, intermediate marsh percentage, brackish and saline marsh acreage percentages of the total size of a property must change unless these wetlands acreages change proportionally to the change of the total size of the property. If these wetlands change proportionally to the change of the property acreage, these explanatory variables can be held constant when the size of property changes, the equation (4.4) is not wrong to calculate the marginal implicit price of property size. But we can see that these wetlands variables should be related to the size of property. It should be more precise to estimate the effect of property sizes on these wetland variables when we consider the marginal implicit prices of size on price.

Different from equation (4.4), the marginal implicit price equation of size on price becomes:

$$\partial Price_t / \partial Z_{1,t} = IZ_{1,t} = (Price_t / Z_{1,t}) * (\beta_1 - \sum_{i=1}^{m} \alpha_i X_i) \qquad (5.2)$$

For the model 1, the marginal implicit price of size on per acre price increases from -0.012 to 0.230, both are too small. Moreover, the acreage is still insignificant, so we can say the marginal implicit price of size on per acre price does not change much. But for the model 2, the marginal implicit price of size on price increases from about \$285 to \$503 at the 0.01 significance level. A one acre increase of property size will increase the property price about \$503.

2) Marginal Implicit Prices of Wetland Percentages

According to the equation (4.2), we have the model:

$$P = \beta_0 Z^{\beta_1} \exp(\beta_2 OW + \beta_3 FM + \beta_4 IM + \beta_5 BS) \exp(\beta_6 DUMSECT + \beta_7 DCITY + \beta_8 DROAD) \tag{5.3}$$

Where, OW, FM, IM, BS – percentage of open water, intermediate marsh, fresh marsh, brackish and saline marsh of total property acreage, and short name of COPENW, CFRESH, CINTER, CBS, respectively, 0-100.

When we estimate the marginal implicit prices of wetland percentages using the equation (4.4), we assume that the wetland percentages OW, FM, IM, and BS are independent. Then we have:

$$\frac{\partial P}{\partial OW} = \beta_2 P; \ \frac{\partial P}{\partial FM} = \beta_3 P; \ \frac{\partial P}{\partial IM} = \beta_4 P; \ \frac{\partial P}{\partial BS} = \beta_5 P \tag{5.4}$$

The marginal implicit prices of wetland percentages are estimated as the above (5.4) equations, and are shown as the Table 5.3.

However, the aggregation of OW, FM, IM and BS plus others percentage of size must be 100 according to the equation (5.1), especially the others percentages of 28 sample properties equal to zero, it means that OW, FM, IM and BS for almost half the sample properties aggregate to 100. Because the change of OW may affect FM, IM, BS, it might be hard to hold variables FM, IM, and BS all constant when the variable OW changes, the marginal price estimate of OW, $\partial P/\partial OW$, is somewhat complicated. So are the marginal price estimates of FM, IM, and BS. We think OW, FM, IM, and BS are not independent variables although there are no singular matrixes statistically.

Therefore, the marginal price estimate function may be as the following:

$$\frac{\partial P}{\partial OW} = P(\beta_2 + \beta_3 \frac{\partial FM}{\partial OW} + \beta_4 \frac{\partial IM}{\partial OW} + \beta_5 \frac{\partial BS}{\partial OW})$$

$$\frac{\partial P}{\partial FW} = P(\beta_3 + \beta_2 \frac{\partial OW}{\partial FW} + \beta_4 \frac{\partial IM}{\partial FW} + \beta_5 \frac{\partial BS}{\partial FW})$$

$$\frac{\partial P}{\partial IW} = P(\beta_4 + \beta_2 \frac{\partial OW}{\partial IW} + \beta_3 \frac{\partial FM}{\partial IW} + \beta_5 \frac{\partial BS}{\partial IW})$$

$$\frac{\partial P}{\partial BS} = P(\beta_5 + \beta_2 \frac{\partial OW}{\partial BS} + \beta_3 \frac{\partial FM}{\partial BS} + \beta_4 \frac{\partial IM}{\partial BS})$$

(5.5)

We do not know the values of the partial derivatives between types of wetlands, like $\partial OW / \partial FW$, and it is difficult to estimate exactly the marginal implicit prices of wetland percentages, but equation (5.5) tell us some information. When one type of wetland percentage increases, another type of wetland percentage or the combination of types of wetland percentages must decrease, so we expect the partial derivatives should be negative. Because all these coefficients of wetland percentages are negative or zero, the marginal implicit prices of all wetland percentages according to the equation (5.5) would be greater than those according to the equation (4.4). According to the results from the Table 5.3, all marginal implicit prices of wetland percentages are negative, so the absolute values of adjusted marginal implicit prices of all wetland percentages according to the equation (5.5) would be smaller than those in the Table 5.3. Therefore, the effects of wetlands on property value or per acre price would be reduced compared to the Table

5.3. For example, according to the equation (4.4), a one percent increase of open water of its total property acreage would decrease the total price of the property about $3,245; however, when we think the possibility that open water percentage increase might cause the change of other wetland percentages, according to the equation (5.5), the total price decrease amount should less than $3,245 with one percent increase of open water.

CHAPTER 6 SUMMARY AND CONCLUSIONS

It is known that wetlands provide important ecosystem services, outdoor recreational, educational, aesthetic and commercial uses. The value of wetlands has been growingly recognized; however, wetland loss is still significant.

Coastal Louisiana wetlands contain more than 30% of the U.S. coastal wetlands, but the wetland loss of coastal Louisiana is the most severe, and Louisiana currently experiences about 90% of the total coastal wetlands loss in the continental United States. Within the past 50 years, land loss rate has exceeded 40 square miles per year. The present rate of coastal land loss is 25-34 square miles a year. The Louisiana wetland loss is worsening, although steps have been made to prevent and restore the coastal Louisiana wetlands. The enactment of CWPPRA began the efforts of wetland preservation and conservation, and has been the primary mechanism for addressing the wetland loss issue in Louisiana. The annual CWPPRA expenditure of $30 to $40 million is providing only less than 10% of the funding necessary to adequately address the wetland loss in coastal Louisiana. CWPPRA cannot be expected to effectively address the wetland loss crisis of the coastal Louisiana. By 2050 coastal Louisiana will still lose more than 630,000 additional acres of coastal marshes, swamps, and islands. In August, 2004, the Bush administration passed the Water Resource Development Act, which will give $1.9 billion over the next 10 years to repair Louisiana's coasts. However, studies have shown that Louisiana needs a minimum of $14 billion to repair its coastal damages.

Therefore, it is logical to seek more effective alternatives for coastal Louisiana wetland preservation and restoration under the limited budget constraint. Because 80% of all coastal Louisiana wetlands are privately owned, owner-initiated alternatives would be crucial to the preservation of the ecosystem and restoration of the coastal Louisiana wetland loss. Current landowner incentive alternatives are very limited. One reason is the lack of information for the incentive mechanism device. Buyers, sellers, planners, policymakers, lawmakers, and others are expected to have an increasing need for information which evaluates private market wetland values.

In order to measure the private market wetland value, this research collected 59 useful private property samples which sold between 1990 and 2002 from southwestern Louisiana. These data were entered into an ArcGIS system, which displays every property as an area or polygon instead of point or line on maps. Combining these data with the Louisiana wetland databases and relative Louisiana GIS maps, we have collected variables for the hedonic models. This study regards price per acre or total value of individual property adjusted by CPI indices as the dependent variable, and uses structural, neighborhood and environmental characteristics linked to each property in the data set as the explanatory variables. Size of property ACRES and the dummy variable DUMSECT, which determines whether individual property has separated sections or not, are the structural variables. Distance to the nearest primary road (DROAD), and distance to the nearest coastline DCOAST are the neighborhood variables. The open water percentage of total property size (COPENW), fresh marsh percentage of total property size (CFRESH), intermediate marsh percentage of total property size (CINTER), and brackish and saline marsh percentage of total property size (CBS) are the environmental variables. All explanatory and dependent variables are continuous except the dummy variable DUMSECT.

Most prior research has found that wetlands increase nearby property values, especially in the urban areas. However, Reynolds and Regalado (1998), and Bin and Polasky (2004) found that wetlands in rural areas may sometimes have a negative effect on the nearby property prices. As for this research, we study the effects of wetlands which are inside the properties on property prices instead of the effects of wetlands on nearby property prices.

Before we estimate the hedonic price functions, we test the assumptions of regression models: residual normality assumption, residual homoscedasticity assumption, and multicollinearity assumption. The transformed model (the equation '4.3') does not violate these assumptions, and no other adjustments and remedies are needed.

This study uses model (4.2) and (4.3), resulting in two hedonic price functions with different dependent variable: one uses per acre price as the dependent variable, the other uses price or value of property as the dependent variable, and is generated to compare to the first function. Both functions use the same independent variables.

The hedonic price function of per acre price dependent variable (model 1) is shown as the following:

$$\begin{aligned} Ln(PACRE) = \underset{(0.381)}{6.795^{***}} - \underset{(0.048)}{0.036} \times \ln(ACRES) - \underset{(0.003)}{0.009^{***}} \times OW - \underset{(0.003)}{0.001} \times FM - \underset{(0.003)}{0.014^{***}} \times IM \\ - \underset{(0.002)}{0.010^{***}} \times BS - \underset{(0.022)}{0.013} \times DROAD + \underset{(0.011)}{0.005} \times DCOAST - \underset{(0.146)}{0.246^{*}} \times DUMSECT \end{aligned}$$

(Here, () stands for the standard error, * denotes significance at 0.10 level, ** denotes significance at 0.05 level, *** denotes significance at 0.01 level.)

(6.1)

In model 1 (shown as equation 6.1), open water percentage and all percentages of all other wetland types have negative effects on property prices. As previous studies, wetlands, including open water, may increase the nearby property prices, but here it shows that they reduce the prices of properties with wetlands and open water inside these properties. Moreover, wetland types have different coefficient effects on property value. Intermediate marsh has the greatest coefficient effect on property values, followed by brackish and saline marsh, and open water in descending order. All of these three types of wetlands are statistically significant at the level of above 99%; however, fresh marsh percentage is statistically insignificant even at the level of 85%, and has little coefficient effect on property price.

The dummy variable DUMSECT is statistically significant at the level of 90% with the greatest negative coefficient effect of all independent variables. Other variables have no evidence to be significant, of which, property size has no clear relation to price per acre.

The hedonic price function using price or value of property as dependent variable (model 2) is shown as the equation (6.2).

$$\begin{aligned} Ln(PACRE) = {} & \underset{(0.381)}{6.795^{***}} - \underset{(0.048)}{0.964} \times \ln(ACRES) - \underset{(0.003)}{0.009^{***}} \times OW - \underset{(0.003)}{0.001} \times FM - \underset{(0.003)}{0.014^{***}} \times IM \\ & - \underset{(0.002)}{0.010^{***}} \times BS - \underset{(0.022)}{0.013} \times DROAD + \underset{(0.011)}{0.005} \times DCOAST - \underset{(0.146)}{0.246^{*}} \times DUMSECT \end{aligned}$$

(Here, () stands for the standard error, * denotes significance at 0.10 level, ** denotes significance at 0.05 level, *** denotes significance at 0.01 level.)

(6.2)

This model 2 uses natural log of property price as the dependent variable, others held as in the first hedonic function. Except for the variable LACRES, all coefficients and statistical values are the same as the price per acre function. The biggest difference is that

LACRES is statistically significant and positively related to the dependent variable. It is very reasonable that property price increases with the increasing of property size, and it is easier to understand that the size of property has positive effect on price.

Marginal implicit prices measure the price change with a one unit change of some independent variable, holding other independent variables constant. They are used to observe the magnitude and direction of influence of various model factors on price per acre or price through examination of the implicit prices at the mean values of the property price and characteristic quantity.

When we calculate the marginal implicit prices, we assume that all independent variables are uncorrelated. This means a change of one independent variable will not necessarily affect any other independent variables. So with a one unit change of one independent variable, we hold all other independent variables constant. We examine all variables at their mean value levels.

In model 1, the dummy variable DUMSECT has the largest negative marginal implicit price. This means that holding others constant, a property of which all sections are adjacent would have $108.99 more per acre than a property of which a section or some sections are separated with other sections. Secondly, the intermediate marsh percentage of size has the marginal implicit price of -$5.88, which indicates that one unit increase of intermediate marsh percentage will reduce the price per acre of property about $5.9. Thirdly, a one percent increase of brackish and saline marsh percentage will decrease the price per acre of the property about $4.02. Finally the effect of open water on price should also be considered. A one unit increase of open water percentage would decrease the price per acre of property about $3.62. The marginal implicit prices of other variables, including ACRES, CFRESH, DCOAST and DROAD, are equal to zero, approximately zero, or very insignificant. Therefore, DUMSECT, intermediate marsh percentage, brackish and saline marsh percentage, and open water percentage have negative marginal implicit prices in descending order, same as the hedonic price function coefficient order.

For model 2, the situation is similar to the model 1. The dummy variable DUMSECT has the greatest effects on property price. Holding others constant, the value of a property of which all sections are adjacent will be about $97,746 higher than that of a property of which a section or some sections are separated with other sections. With a one unit increase of intermediate marsh percentage, the property price will decrease about $5,276. With a one unit increase of brackish and saline marsh percentage, the property price will decrease about $3,609. With a one unit increase of open water percentage, the property price will decrease about $3,245. For the fresh marsh percentage, one unit increase will bring into about $394 decrease of property price.

But there exist some differences. Unlike model 1, size has a positive effect on property price in model 2. An increase of one acre in property size will increase the property price about $285. The variable acre of property has important effect on property price. It is logical: the more size a property has, the more expensive the property is.

However, further research finds that there might be some problems in estimating marginal implicit prices for this study. When we estimate marginal implicit prices, we assume that we can hold all other independent variables constant with one unit change of one independent variable. If the assumption is violated, the marginal implicit price calculation equation (4.4) must be adjusted.

When the size of a property changes, the open water percentage, fresh marsh percentage, intermediate marsh percentage, brackish and saline marsh acreage percentages of the total size of a property must change unless these wetlands acreages change proportionally to the change of the total size of the property. If these wetlands change proportionally to the change of the property acreage, these explanatory variables can be held constant when the size of property changes. The equation (4.4) is not wrong to calculate the marginal implicit price of property size. But we can see that these wetlands variables should be related to the size of property. It would be more precise to estimate the effect of property sizes on these wetland variables when we consider the marginal implicit prices of size on price.

If we consider the impact of size on wetland percentage variables, in model 1 the marginal implicit price of size on per acre price increases from -0.012 to 0.230; for model 2 the marginal implicit price of size on price increases from about $285 to $503. A one acre increase of property size will increase the property price about $503 at the 0.01 significance level.

Because any change of one wetland percentage would cause change of other wetland percentages, the marginal implicit price estimations of wetland percentage should be adjusted to estimate more precise. Although this study cannot estimate exactly the more precise values of marginal implicit prices of wetland percentages, some equations indicate that the absolute values of adjusted marginal implicit prices of all wetland percentages would be smaller than before the adjustment. Therefore, wetland percentages would have less effect on property value or per acre than before adjustment.

CHAPTER 7 LIMITATIONS AND FURTHER RESEARCH

This study focuses on the private coastal wetlands. It attempts to estimate the effects of wetlands and other factors on property which is composed of these wetlands and/or other lands, the different effects of wetland types, and marginal implicit prices of wetlands on property value. These findings and results can be found in little of the literature. However, this study also has some limitations, which need further research.

This research collects about 59 useful samples; however, it is not enough for more precise data analysis. The next step of this research will enlarge the sample size.

Another limitation of the research is its spatial distribution of properties. Of the total 59 samples, 56 properties come from the Cameron Parish, and only 3 properties from the Calcasieu Parish. The research needs to collect more samples from parishes other than Cameron Parish in order to make a complete study of the private market wetland values in Southwestern coastal Louisiana.

The variables are also limited. Some variables are not collected in this research, such as some landowner social economic information.

More transformations of variables and more models, such as semi-parameter and non-parameter models, should be compared and contrasted in order to better define the hedonic price function.

Accurate estimates of marginal prices of property characteristics need to be more precise because some independent variables have questionable correlation relationships, and further research is needed. Also, accurate estimates of marginal implicit prices depend on the accuracy of the specification of the model. The model presented in this study explained only part of the overall property value variability. Moreover, the model shows only the partial value of property characteristics. The whole value of every characteristic of property, such as the value of wetland, is not fully measured. From the view of property, wetland has $X value; from another view, such as flood prevention, the wetland may be valued as additional Y dollars. Therefore, the results are site-specific, the estimates here may not readily address how wetland affect coastal property values in other areas.

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