

**Estimating Private Wetland Values in Coastal Louisiana for Use
in Restoration Activities**

**Final Report
To
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A. INTRODUCTION

Louisiana's coastal wetlands, one of the world's largest deltaic systems, were built by the deltaic processes of the Mississippi River. Louisiana's wetlands are bordered on the east by Mississippi, on the west by Texas, and on the south by the Gulf of Mexico. These wetlands, which total about 3.6 million acres, represent a significant natural and economic resource to Louisiana and the nation. Louisiana's coastal wetlands account for about 30% of the U.S. total and are termed "America's Wetlands." It is in these wetlands that 95% of all marine species in the Gulf of Mexico spend a portion of their life cycles. Louisiana's coastal wetlands contain an extraordinary diversity of habitats that range from narrow natural levee and beach ridges to expanses of forested swamps and freshwater, brackish and saltwater marshes. Unlike in most states, where coastal wetlands represent a relatively narrow transition boundary between solid land and water, wetlands in Louisiana are vast, often extending for many miles. Despite the numerous services provided, approximately 1,900 sq. miles of Louisiana's coastal wetlands have been lost since the 1930s and, on average, 24 sq. miles of wetlands were lost every year during the decade of the 1990s.¹

The majority of Louisiana coastal wetlands (approximately 75%) are privately owned. Why, one might ask, are Louisiana's privately owned wetlands disappearing at such a rapid rate if they are so valuable? Framed in a somewhat different manner, the question can be asked: Why don't private landowners invest more in wetland maintenance/rehabilitation activities if the value of their property is gradually (or rapidly) depreciating as a result of coastal erosion? The answer to these questions is straightforward: almost all of the values (i.e., benefits) that are derived from coastal wetlands accrue to the public rather than the individual landowners. Because of this market failure, there is little incentive for landowners to invest in a manner consistent with societal goals and, hence, a potential role for government intervention in the form of stimulating investment.

Private investment at levels less than those that would be established at prevailing social values is not unique to coastal wetlands. An analogous scenario is evident in the case of privately owned forestry property (and other natural resource based properties). Recognizing this to be the case, "[c]ost-share subsidies are commonly used to promote public forestry objectives on land that is beyond public control (Romm et al., 1987)." These subsidies can take any number of forms including: (a) lump-sum allocations tied to technical assistance, (b) the reduction in taxes, or/and (c) the transfer of public rights or usufruct to private parties. "In all cases, monetary benefits,

¹ A discussion of natural factors and human factors contributing to Louisiana's coastal wetland losses is given by Reed and Wilson (2004).

actual and potential, are transferred to those who own or control land in exchange for their investment in some publicly desired forestry regime (Romm et al., 1987)."²

Knowledge of the factors that influence wetland demand can help to establish those economic incentives that might be potentially useful in encouraging landowners to make the capital investments needed to maintain/restore individual wetland tracts. To examine these factors, goals and objectives of this research project are briefly outlined in the next section of the report. Then, a review of some of the relevant hedonic literature is reviewed. Then, attention is turned to discussion of data collection and transformation procedures. After this discussion, the analysis and results are presented. Examination of possible economic incentives and conclusions are presented in the last section of the report.

B. GOALS AND OBJECTIVES

Generally speaking, this study attempts to provide an economic understanding of property value in the coastal wetlands private market in order to devise and implement cost efficient economic incentive mechanisms for private landowners. More specifically, this study has the following three objectives.

1. To identify the underlying characteristics affecting the price per acre or values of coastal wetland properties in coastal Louisiana;
2. Based upon completion of the first objective, is to determine the marginal implicit prices associated with wetland characteristics and other variables that influence coastal wetland prices;
3. The final objective is to assess whether incentive programs that could be offered to landowners need to be tailored to specific wetland characteristics.

Based on data from coastal Louisiana, this project uses the Geographic Information Systems (GIS), statistical tools and the hedonic method to estimate the hedonic price function. This research uses 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 modeling research that examines the value of wetlands, wetlands are considered components of properties in this study rather than the more extensively studied influence of wetland proximities on neighborhood residential housing prices. 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

² As other examples, the Conservation Reserve Program (CRP) and Wetlands Reserve Program (WRP) use annual subsidies (rental payments) to retire environmentally sensitive cropland from production (Ribaudo and Caswell, 1999). The subsidies used in these two programs tend to be blunt instruments, however, in the sense that flexibility in the type of subsidy offered is minimal.

with wetlands within these properties, and whether different types of wetlands and other characteristics are associated with increases or decreases in property prices.

C. LITERATURE REVIEW

Rosen (1974) is credited with providing the theoretical foundation upon which hedonic analysis is applied. Since its publication, Rosen's theoretical framework has been the standard of reference for almost all work in the field of hedonic estimation. As noted by King and Sinden (1988), the "hedonic approach to market analysis uses the relationships between the prices and characteristics of a good to explain differences in the price of a good." In the first stage of Rosen's two stage technique, price of the traded good, denoted P , is specified as a function of that goods characteristics (denoted z_i) and possibly other factors (denoted x_i) and can be written as

$$P(z) = P(z_1, z_2, \dots, z_n : x_i)$$

The hedonic function emerges from the interaction of buyers and sellers of that good. Specifically, each buyer in the market is assumed to possess a bid function for a specific characteristic, say z_1 , given optimal amounts of other characteristics (z_2^*, \dots, z_n^*), the other factors x_i , and one would expect, income (I). Likewise, each potential seller is assumed to possess and offer function which illustrates how much that person would be willing to accept for varying amounts of the characteristic z_1 given optimal amounts of other characteristics (z_2^*, \dots, z_n^*), the other factors x_i , and profit π . The locus of tangency between the buyers' bid function and the sellers' offer function yields the hedonic price function.

Since Rosen's theoretical construct, the hedonic price model has been employed in a wide range of subject matters including valuation of the differentiated factors of production associated with land. As noted by Xu et al. (1993), land has a number of features that make valuation challenging. These features include heterogeneity, spatial fixity and the durability of land parcels. With respect to heterogeneity, Xu et al. (1993) state that "[h]eterogeneity within the hedonic context refers to variation in the characteristic levels associated with land parcels..." With respect to spatial fixity, since land cannot be moved, trading tends to be limited to "buyers and sellers within a region." This implies that one must consider that there may be various submarkets and account for this when conducting hedonic modeling.³ Finally, as noted by Xu et al. (1993), "[t]he durability of the land parcel results in land values being formed within the context of a long-run planning horizon." For land used in profit generating activities therefore, one must consider (a) the productive component of the land, (b) the consumptive component of the land, and (c) the speculative component.

³ This would generally imply estimating separate models for each of the different submarkets or controlling for the influences on implicit prices associated with differences in the submarkets via appropriate restrictions in the hedonic model (e.g., using appropriate discrete variables).

The estimation of implicit prices associated with differentiated agricultural land was the initial focus of much of the earlier research in the area. In one of the initial studies of agricultural land prices, Miranowski and Hammes (1984) tested the hypothesis that buyers properly discounted land prices to "...reflect foregone soil productivity caused by soil erosion and ...the potential erosivity of the land or the costs necessary to prevent future productivity declines due to erosion." Based on individual Iowa farm transactions covering the 1974-79 period, the authors found that differences in farm prices are related to soil characteristics (measured by average topsoil depth) though the authors could not conclude that the discount given to soil erosion accurately reflected the loss in productive capacity. Ervin and Mill (1985) argued, however, that some erosion types (sheet and rill) are gradual and that it is unreasonable to expect buyer, much less the sellers, to correctly identify subtle erosion rates. As such, the authors hypothesized that only moderate or highly erodible farmlands would exhibit appropriately discounted sales prices. Using 1976-78 sales transactions from Page County, Iowa, the authors found that discounting of farmland values did not relate well to the group of variables used in their analysis to measure past and future erosion damages. Based on 1979-80 farm-and-forest land sales in North Carolina, Palmquist and Danielson (1989), like previous researchers, also analyzed land values in relation potential erosivity. Based on the hypothesis that poorly drained lands are not conducive to crop productivity, Palmquist and Danielson (1989) also considered drainage requirements. The econometric analysis suggested that both potential erosivity and drainage requirement influenced land value in the manner suggested by economic theory. Building upon the earlier hedonic price analyses applied to agricultural land sales, researchers have examined the influence of other "relevant" variables as determinants of farmland prices. Two of the most relevant factors are land irrigation needs (Faux and Perry, 1999) and environmental aesthetics associated with the property (Bastian et al., 2002).

While much of the earlier research assessing differentiated land values focused on agricultural properties, increased attention has more recently been given to assessing differentiated land values associated with unimproved forestland. In general, the studies on forestland parallel those of agricultural lands in terms of the types of variables included in the analysis with the exception that erosion is of little concern. Turner et al. (1991), for example, consider the "sales of unimproved, predominately forested parcels" in an analysis of forestland values in Vermont. Included in their analysis are variables related to the physical characteristics of the property (e.g., property size, topography, and percentage of property in open land), locational characteristics of associated with the property (employed in an attempt to control for the influence of local population on the market), taxes, and date of sale. In general, estimated parameters were of the expected sign and statistically significant. In arguably the most detail forestland study to date, Snyder et al. (2007) argue "that a parcel's amenity attributes, more than timber harvesting value and potential, would be important indicators of forestland price" based on the hypothesis that purchasers of forestland consider timberland production as only a secondary reason for owning the property. Like the study by Turner et al. (1991), Snyder et al. (2007) include in their hedonic analysis a number of variables describing the property (e.g., size of parcel, percentage of parcel covered by different pine types, timber growing stock volume, and a set of binary variables indicating the presence of lake

frontage, river frontage, and whether the parcel is adjacent to public land). Like Turner et al. (1991), Snyder et al. (2007) also consider the influence of local population and transaction date. Unlike most previous land studies (in either forestry or agriculture), however, the authors also included a binary variable in the model to indicate whether the sale was financed via ‘contract for deed.’⁴ In general, the authors concluded that the two most important determinants of forestland price were presence of lakefront and presence of riverfront. Variables indicating land development pressure were also found to significantly influence forestland price. Unexpectedly, the growing stock volume, an indicator of revenues that might be forthcoming from the property, was found to not statistically influence land value.

While there have been no published hedonic studies that directly value wetland characteristics associated with properties that are primarily wetlands in nature, there are a limited number of studies that consider wetlands that are a portion of the larger property. For example, Reynolds and Regalado (2002) examined the influence of wetlands, along with other physical and economic factors, on rural land prices. Based on transactions involving 212 sales of rural properties in Southwest Florida over the 1988-93 period, the authors regressed the sales price of land per acre on a suite of land use variables, a suite of capital improvement variables (e.g., presence of an irrigation well), location variables, size of tract, and wetland variables. Two alternative models were considered. In the first model, the per acre sales price was considered in relation to the total number of wetland acres on the property.⁵ In the second model, wetlands were disaggregated into six categories (Riverine, Lacustrine, and Palustrine with the latter category accounting for 99% of all wetlands and hence being disaggregated into scrub-shrub wetlands, forested wetlands, unconsolidated bottom wetlands, and emergent wetlands). With respect to the first model, the authors found that aggregate wetlands had a significant negative effect on rural land values with a 10% increase in wetland acreage resulting in a 0.206 decrease in rural land value. With respect to the second model, the coefficients associated with most wetland types were found to statistically significant and, when significant, were negative (i.e., exerted a negative influence rural land price). Exceptions were Lacustrine wetland systems and scrub-shrub wetlands which were found to not statistically influence rural land prices.⁶

⁴ As noted by the authors, the contract for deed is a method of financing whereby the seller acts as the bank. Given the higher price equivalency associated with contract for deed, the authors hypothesized a positive influence of this variable on price.

⁵ The authors report that 187 of the 212 properties in the study contained wetlands and these wetlands comprised 17% of all land area in the study.

⁶ While of little relevance to the current study, it should also be mentioned that there have been several studies that evaluated the influence of wetlands on residential property values. Many of these studies are summarized by Boyer and Polasky (2004).

D. Data Collection and Transformation

This study is based on primary data collected and transformed in order to make it meaningful for analysis. Doing so required the following steps. First, wetland property transactions were collected from the relevant courthouses. Second, the boundaries associated with each property were mapped using the Geographic Information Systems. Third, the maps associated with each property were merged with other data sets (e.g., the U.S. Geological Survey wetland database) in order to generate relevant property characteristics (e.g., acres of different types of wetlands). The completion of these three steps provided the relevant information (i.e., data) needed to estimate the regression analyses associated with the hedonic pricing model. The procedure of data collecting and processing is shown in Figure 1.

Collecting Conveyance Transaction Deeds

The study collected relevant information pertaining to property transfers from conveyance deeds available at the respective courthouses. These conveyance records provided information on each transaction including, but not limited to: (a) the boundary of property included in the

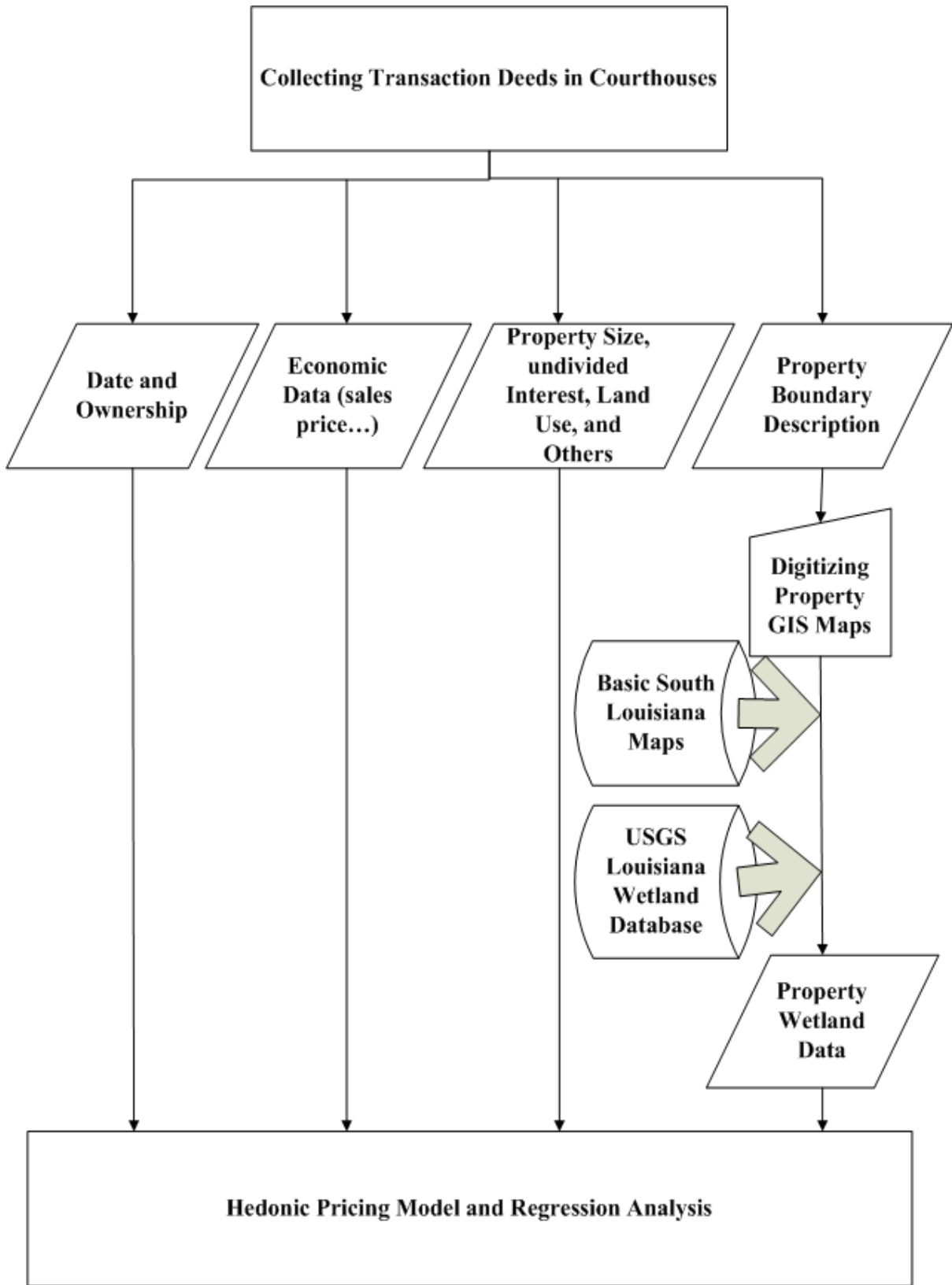


Figure 1 Data Collecting and Processing Procedure

transaction⁷, (b) acreage included in the transaction⁸, (c) proportion of interest in property that is being sold⁹, (d) the number of parcels included in the transaction¹⁰, (e) the price associated with the property being transferred, and (f) the transaction date, and (g) the relevant names and addresses of both sellers and buyers. Data collected from these deeds of particular interest to this study included: the property boundaries, sales price information, features associated with the transfer (e.g., acres and proportion of interest in property that was being transferred), and transaction date (Figure 1).¹¹

Thousands of property conveyance deeds are recorded in the courthouses of the three parishes of southwest Louisiana.¹² Correspondingly, the transactions collected in the study comply with some criteria or rules. First, sales of relatively small wetland properties (generally, less than about 40 acres) were excluded from the analysis. Second, transactions with vague description of property boundaries were eliminated since digitizing these properties proved to be exceeding cumbersome¹³. Other transferred properties were not considered for inclusion in the analysis because of exceptionally low (or high) specified sale prices.¹⁴ Finally, transactions used in the analysis were limited to those occurring during the 1990 through 2006 period. There were two primary reasons for limiting the analysis to these years. First, while information on transactions occurring prior to 1990 was 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.’

⁷ Descriptions of some property boundaries in their conveyance deeds are hard to follow the drawing and digitizing, and they cannot be used in this research.

⁸ The acreage information on many of the conveyance deeds was considered “unofficial” and did, in some instances, differ from that estimated after mapping the property boundaries.

⁹ Sometimes a property seller sold the buyer a share of a property which is shared with others and undivided. If a buyer purchases a whole property, the undivided interest for the buyer is 100%, or 1; if he or she purchases half of an undivided property, the undivided interest is 50%, or 0.5.

¹⁰ In many instances more than one parcel was sold under a given transaction.

¹¹ Determination of whether the transaction was “arms length” was often made at the initial stage of the process (i.e., when collecting the deeds from the respective courthouses).

¹² The number of wetland properties that were transferred was, however, relatively limited. In an effort to facilitate research, we focused on those wards where wetland acreage was known to be large. To some extent, these wards were selected based on tax assessment records as well as with help from personnel in each of the tax assessor’s offices.

¹³ For example, boundaries for some properties were specified in terms of boundaries of other properties. Hence, to determine the boundaries for the property of interest (i.e., that property that was sold), boundaries of several properties would need to be digitized. In other instances, boundaries were specified in terms of some physical object (e.g., pipeline or canal) for which information was not readily available.

¹⁴ Low prices likely reflect attempts to evade paying capital gain taxes on property sales or transfers that were not at “arms length” (even though the buyer and seller had different names). There were relatively few property transfers with abnormally high prices.

Overall, a total of 219 individual property transactions meeting the conditions previously stated (i.e., size and date) were identified during the collection process. However, only 157 of these transactions were usable in hedonic analyses; 114 for the analysis of the Southwest parishes (Cameron, Calcasieu, and Vermillion) and 43 for the analysis of the Southeast parishes.¹⁵ Reasons for excluding the remaining properties included: (a) many partially or completely fell outside the coastal zone, (b) the stated price per acre did not fall within the established bounds¹⁶ (c) a relatively limited number of transactions also indicated “other goods” in the purchase price (e.g., \$30,000 plus other goods and services)¹⁷ and (d) the boundary descriptions for many of the properties were not conducive to GIS mapping.¹⁸ In general, establishing the property boundaries was a much larger problem with the Southeast properties than the Southwest properties which, to some extent, explains the relatively limited number of transactions available for the Southeast wetland price analysis vis-à-vis the Southwest hedonic analysis.

Digitizing Property Maps

The relevant property transfers were collected and then entered into a GIS system with the ArcGIS system. The time-consuming step converted the text boundary descriptions of the studied properties, with or without manual paper maps, into digital GIS maps.

Acquiring Wetland and Distance Data of Properties

Another data source used in the current analysis is the wetland database developed and maintained by the United States Geological Survey (USGS), National Wetland Institute¹⁹. This database is a high resolution source providing relevant wetland features including types of marsh by area, open water by area, historical wetland loss by area, and projected loss during 2000-2050. Projected wetland loss is provided on the basis of three categories (four categories if “no loss” is included): nominal, moderate, and extreme.²⁰ The projected wetland loss along Louisiana’s coast during the period 2000-2050 is illustrated in Figure 2.

¹⁵ As discussed in greater detail below, two separate analyses were conducted: one for the Southwest parishes and one for Southeast parishes.

¹⁶ For purposes of analysis, we considered payments of less than \$100 per acre or in excess of \$5,000 per acre to be unrepresentative. Specifically, while payments in excess of \$5,000 per acre were noted for a few transactions, payments of this level likely indicate some amount of coercion.

¹⁷ While it is believed that such nomenclature may be included automatically on some transactions (i.e., no other goods were considered),

¹⁸ For example, the boundaries for some properties were specified in terms of man-made structures (e.g., pipes) and information associated with these man-made structures and little information was provided on these man-made structures. Hence, they could not be accurately mapped.

¹⁹ The U.S.G.S. databases give relevant wetland information for four years: 1956, 1978, 1988, and 2000.

²⁰ A detailed discussion of the estimation procedure used to calculate projected wetland loss is found in Barras et al. (2003).

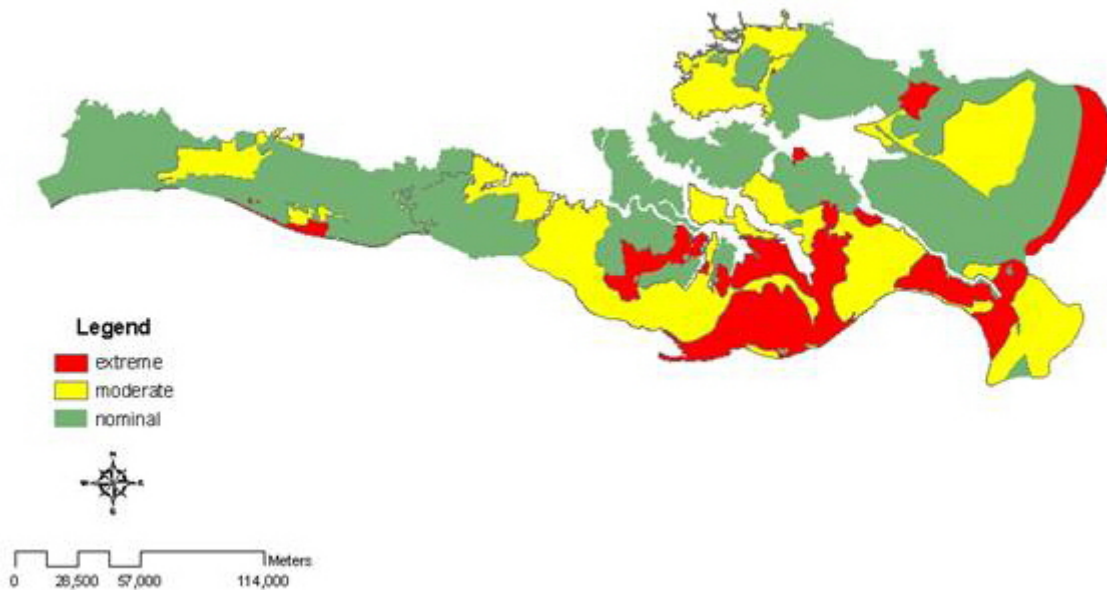


Figure 2. Projected LCA Wetland Loss for 2000-2050

Merging Data Sets

Finally, combining the digitized property information into the relevant Louisiana GIS basic maps (road, land and water, coast, city and town, population, stream, and lake, etc.) produces the requisite accessibility characteristics data associated every individual property²¹. 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 1,500.²²

²¹ For a noncontiguous property (with two or more separated parcels), the nearest distance of each parcel to primary roads, coastline, or cities/towns are calculated, and the shortest is chosen as the nearest distance of the property to primary roads, coastline, or cities/towns.

²² While distance to the nearest town or city was estimated, it was not used in the analysis since it was not expected to significantly influence property prices.

E. VARIABLE IDENTIFICATION AND SUMMARY DATA

(a) Variable Identification and Definition for Southwest Analysis

In general, the variables considered for hedonic modeling of coastal wetland properties represent the attributes of coastal wetlands in Louisiana. A description of variables used in the Southwest Louisiana (i.e., Cameron, Calcasieu, and Vermilion Parishes) analysis is presented in Table 1 while some summary statistics are presented in Table 2.

Table 1: Variable description for Southwest Louisiana hedonic analysis.

Variable	Variable description/definition
price	Total property price in current dollars divided by acres (i.e., price per acre in nominal dollars)
Property types:	
openw	Acres of open water on the i-th property divided by total acres of the i-th property
freshm	Acres of fresh marsh on the i-th property divided by total acres of the i-th property
interm	Acres of intermediate marsh on the i-th property divided by total acres of the i-th property;
bracksalm	Acres if brackish and saline marsh on the it-th property divided by total acres of the i-th property
other	Acres of unspecified land type on the i-th property divided by total acres of the i-th property;
Other property characteristics;	
acres	Total acreage of the i-th property as determined by GIS;
number	Total number of land types on property (maximum equal to five);
coast	Distance of property from coast (in meters);
road	Distance of property from nearest paved road (in meters);
dsections	Variable indicating whether more than one property was involved in transaction (equal to 1 if more than one tract);
dnoloss	Discrete variable indicating no projected land loss in area (based on 2000-2050 USGS maps);
dnominal	Discrete variable indicating nominal projected land loss on i-th property (based on 2000-2050 USGS maps);

dmoderate	Discrete variable indicating moderate projected land loss on i-th property (based on 2000-2050 USGS maps);
year	Year in which property was sold;

As the information in Table 1 indicates, five property type designations were used in the analysis of Southwest Louisiana hedonic wetland price analysis: open water, fresh marsh, intermediate marsh, brackish and saline marsh, and “other.”²³ Also included in the analysis was an indicator of the number of property types reported for a given property (with a maximum of five). A percentage of the transfers collected from the respective courthouses included multiple tracts and, as such, a discrete variable was included in the analysis to indicate whether the transfer included multiple tracts. Also, included in the analysis was a measure of the distance of the property to both the coast and to the nearest paved road.²⁴ The USGS has also made projections of wetland loss throughout the coast during the 2000-2050 period with four designations: no loss, nominal loss, moderate loss, and extreme loss. Based on the premise that buyers/sellers will discount property prices where wetland loss may be impact the long-term property productivity, discrete variables were included in the analysis to account for projected wetland loss. These discrete variables include dno loss, dnominal, and dmoderate with dnloss representing the control variable (and, hence, excluded from the model).²⁵

Table 2: Selected statistics for transferred properties included in the Southwest Louisiana hedonic wetland price analysis (114 observations).

Variable	Mean	Std. Deviation	Minimum	Maximum
price	622.37	555.61	111.12	3440.43
Property types:				
openw	0.119	0.212	0	0.874
freshm	0.108	0.253	0	1.00
interm	0.254	0.344	0	0.990
bracksalm	0.136	0.293	0	0.980
other	0.303	0.383	0	1.00
Other property characteristics;				
acres	762.15	1682.35	40.28	11395.48

²³ Saline marsh was combined with brackish marsh because only a very small amount of the total was classified as saline marsh (about 1%). The “other” category represented acreage for which no designation was available in the USGS wetland classification.

²⁴ In instances where multiple tracts were transferred, the centroid of the parcels was used to measure distance.

²⁵ In general, projected extreme wetland loss in Southwest Louisiana is relatively minor (See Figure 2) and none of the property transfers collected for this region of the state were in the projected extreme loss area. Hence, an indicator variable representing extreme loss is not included in the Southwest Louisiana hedonic price model. As discussed in a later section of the paper, however,

number	2.56	0.74	1	5
coast	27926.72	11189.51	5451.50	50655.51
road	3429.22	4979.14	1.00	17333.12
dsections	0.184	0.389	0	1
dno loss			0	1
dnominal	0.746	0.437	0	1
dmoderate	0.044	0.206	0	1
interest	0.963	0.153	0.15	1.00
year	1999.84	3.096	1991	2007

As indicated from the information in Table 2, the average property used in the Southwest Louisiana hedonic model totaled 762 acres with a range from 40 acres to more than 11 thousand acres. Each tract contained, on average, 2.52 property types with a standard deviation of 0.74. Of the five property types designated for the analysis, the “other” category represented almost one-third of the total acreage while intermediated marsh represented one-quarter of the total. Fresh marsh and brackish/saline marsh types each contribute approximately 10% of the total acreage while the remaining 10% of the total was classified as open water. The average sales price for the 114 properties included in the analysis equaled \$622 per acre (unadjusted for inflation) with a corresponding range of \$111 to \$3,440 per acre.²⁶

The information in Table 2 also indicates that, on average, properties were about 28 thousand meters from the coast with the nearest primary road being about 3,400 meters from the property. Almost 20% of the 114 property transfers included multiple tracts. About three-quarters of the 114 properties were expected to experience nominal wetland loss through 2050 while about 4% were projected to experience moderate wetland loss. The remaining 20% were projected to experience no wetland loss.

(b) Variable Identification and Definition for Southeast Analysis

A description of variables used in the Southeast Louisiana) analysis is presented in Table 3 while some summary statistics are presented in Table 4. As indicated, the variables used in the Southeast analysis are identical to those used in the Southwest analysis with the exception that a discrete variable indicating expected extreme wetland loss is also included in the analysis (this variable was not included in the Southwest analysis because no properties exhibited the extreme category)²⁷

²⁶ The hedonic wetland analysis was conducted using the nominal sales price as the dependent variable. Results using the deflated price were very similar and are presented in Appendix A.

²⁷ This is largely verified by the information contained in Figure 2.

A comparison of the information in Table 4 with that in Table 2 suggests that the average per acre sales price among Southeast transactions exceeded that of Southwest transactions by about \$200. The average Southeast transaction was also significantly higher than that in the Southwest (1,076 acres compared to 762 acres). While the percentage of open waters among properties in both regions were approximately equal (16.5 percent among properties in the Southeast compared to 19.9% among properties in the Southwest), the percentage of intermediate marsh was twice as large among Southwest properties as that observed for the Southeast properties (25.4% versus 12.1%). Finally, while about three-quarters of the Southwest properties were expected to experience only nominal loss during the 2000-2050 period, only about one-third of the Southeast properties face the same expected wetland loss. Conversely, almost 40% of the Southeast properties are expected to exhibit moderate or extreme wetland loss compared to less than five percent in the Southwest.

Table 3: Variable description for Southeast Louisiana coastal hedonic analysis.

Variable	Variable description/definition
price	Total property price in current dollars divided by acres (i.e., price per acre in nominal dollars)
Property types:	
openw	Acres of open water on the i-th property divided by total acres of the i-th property
freshm	Acres of fresh marsh on the i-th property divided by total acres of the i-th property
interm	Acres of intermediate marsh on the i-th property divided by total acres of the i-th property;

bracksalm	Acres if brackish and saline marsh on the i-th property divided by total acres of the i-th property
other	Acres of unspecified land type on the i-th property divided by total acres of the i-th property;
Other property characteristics;	
acres	Total acreage of the i-th property as determined by GIS;
number	Total number of land types on property (maximum equal to five);
coast	Distance of property from coast (in meters);
road	Distance of property from nearest paved road (in meters);
dsections	Variable indicating whether more than one property was involved in transaction (equal to 1 if more than one tract);
dno loss	Discrete variable indicating no projected land loss in area (based on 2000-2050 USGS maps);
dnominal	Discrete variable indicating nominal projected land loss on i-th property (based on 2000-2050 USGS maps);
dmoderate	Discrete variable indicating moderate projected land loss on i-th property (based on 2000-2050 USGS maps);
dextreme	Discrete variable indicating extreme projected land loss on the i-th property (based on the 2000-2050 USGS maps);
year	Year in which property was sold;

Table 4: Selected statistics for transferred properties included in the Southeast Louisiana hedonic wetland price analysis.

Variable	Mean	Std. Deviation	Minimum	Maximum
price	837.58	649.06	109.94	3110.94
Property types:				
openw	0.165	0.165	0	0.625
freshm	0.336	0.345	0	0.937
interm	0.121	0.273	0	0.988
bracksalm	0.053	0.165	0	0.691

other	0.325	0.372	0	1.00
Other property characteristics;				
acres	1076.57	3073.04	53.49	19540.42
number	2.51	0.736	1	4
coast	54367.55	17501.79	29057.57	107928.36
road	1811.37	3075.22	1.00	13295.82
dsections	0.186	0.393	0	1
dnloss	0.256	0.402	0	1
dnominal	0.349	0.482	0	1
dmoderate	0.279	0.454	0	1
dextreme	0.116	0.324	0	1
interest	0.902	0.242	0.10	1.00
year	1999.51	2.979	1992	2004

F. MODEL SPECIFICATION

Following Larkin et al. (2005), the following general model was deemed appropriate for the Southwest and Southeast Louisiana wetlands hedonic analyses :

$$\ln(\text{price}_i) = \alpha + \sum_j \beta_k f(X_{ji}) + \sum_k \delta_k Z_{ki} + \sum_l \theta_l D_{li} \quad (1)$$

As specified, equation 1 establishes the natural logarithm of price per acre of wetlands as a function of its characteristics.²⁸ These characteristics can enter the equation as continuous variables, in either nonlinear $f(X_{ji})$ or linear form Z_{ki} , or discrete variables D_{li} . Because the price per acre is hypothesized to decline at a decreasing rate in relation to property size, the variable denoting the size of the property transfer (*acres*) is incorporated nonlinearly. The continuous linear variables property types (openw, freshm, interm, bracksalm, other), the number of land types comprising the property (number), distance from the coast (coast) and primary road (road), percentage of interest

²⁸ One of the major issues associated with estimation of the hedonic model is the appropriate functional form. This is because theory provides no guidance given that the model represents a reduced form of a demand equation and a supply equation. While many researchers employ a Box-Cox transformation to assess the most “appropriate” functional form, Cassel and Mendelsohn (1985) advise against doing so when a large percentage of the exogenous variables can take a value of zero. Given that most of the variables used in the current analysis can take on zero values, the Box-Cox transformation was not considered. The semi-log model has been found to be an appropriate specification of many hedonic land analyses and is thus used the current analysis.

in sale (interest) and the year of transfer (year). Remaining variables are of a discrete nature.

The specific model considered for the Southwest hedonic wetlands model is presented in Equation 2.

$$\ln(\text{price}_i) = \alpha + \beta_1 \ln(\text{acres}_i) + \delta_1(\text{openw}_i) + \delta_2(\text{freshm}_i) + \delta_3(\text{bracksalm}_i) + \delta_4(\text{other}_i) + \delta_5(\text{number}_i) + \delta_6(\text{road}_i) + \delta_7(\text{coast}_i) + \delta_7(\text{interest}) + \delta_8(\text{year}_i) + \theta_1(\text{dsections}_i) + \theta_2(\text{dnominal}_i) + \theta_3(\text{dmoderate}_i) + \epsilon$$

where all variables have been previously defined. ϵ represents the error term which is assumed $iid(0, \sigma)$. The variables *interm_i* and *dno_{loss}* have been deleted to avoid singularity.²⁹

Estimated marginal implicit prices for the nonlinear variables (X_i), continuous linear variables (Z_k) and discrete variables (D_l) can be expressed as follows:

$$\frac{\partial(\text{price})}{\partial X_j} = \left(\frac{\beta_j}{X_j} \right) (\text{price})$$

$$\frac{\partial(\text{price})}{\partial Z_k} = \delta_k(\text{price})$$

$$\frac{\partial(\text{price})}{\partial D_l} = \exp \left[\theta_l - \frac{SE(\theta_l)^2}{2} \right] - 1$$

where $SE(\bullet)$ represents the standard error of the corresponding estimated coefficient. The first two of these equations represent elasticities which yield the change in expected price resulting from a one percent change in the variable of interest (measured at the mean). The last equation measures the expected change in price resulting from a change in any discrete variable included in the analysis.

²⁹ The Southeast hedonic wetland model is identical to that of the Southwest with the exception that it includes one additional variable (dextreme).

G. RESULTS AND DISCUSSION

(a) Results for Southwest Louisiana

Table 5. Estimation Results and Price Effects Associated with Southwest Louisiana Hedonic Model (114 observations)^a.

Variable	Parameter Estimate	Standard Error	Price Effect
intercept	-104.473*	37.512	NA
Property types:			
openw	0.5354*	0.3175	337.07
freshm	0.8223*	0.2500	515.76
bracksalm	0.0578	0.2149	NS
other	0.8582*	0.2212	537.97
Other property characteristics:			
ln(acres)	-0.2345*	0.0516	-0.191
number	0.1909*	0.0901	108.60
coast	-1.00E-5*	0.546E-5	-0.0060
road	-7.07E-6	0.125E-4	NS
dsections	-0.2643*	0.1507	-0.2879
dnominal	-0.2180	0.1756	-0.1866 ^b
dmoderate	-0.6123*	0.3106	-0.4823
dinterest	0.0734	0.2068	NS
year	0.0557*	0.0187	34.66
<p>* indicates statistical significance at the 10% level. ^a adj R² equals 0.504. ^b though not statistically significant, the price effect associated with nominal projected land loss was estimated due to relevancy of study.</p>			

As indicated from the information provided in Table 3, the model performed relatively well based on the adj-R² and statistical significance of many of the estimated parameters. Given that a large percentage of hedonic models of rural land values suggest heteroscedasticity associated with the parameter estimates, a Breusch-Pagan test was conducted. The Breusch-Pagan test for heteroscedasticity showed no evidence of heteroscedasticity in the model and therefore no correction to the covariance estimator was considered.³⁰

Results indicate that property types do significantly influence property prices. Given that intermediate marsh was the omitted property type category, the price effects should be considered in relation to this omitted category. For example, a one-acre increase in fresh marsh at the expense of intermediate marsh (i.e., a one-acre reduction in intermediate marsh) was found to increase the property price by \$515, *ceteris paribus*. Similarly, a one-acre increase in “other” land at the expense of an acre of intermediate marsh was found to increase the property price by about \$540.³¹ Interestingly, open waters appears to be more valuable than intermediate marsh with a one-acre increase in open water at the expense of intermediate marsh resulting in an expected \$337 in property value, *ceteris paribus*. Finally, no statistically significant difference on the influence on property price was found between intermediate marsh and brackish and saline marsh.

The analysis also indicates that property size significantly influences property value on a per acre basis with a ten-percent increase in acres translating into a 2.3% decrease in per acre value, *ceteris paribus*. The negative relationship between property size and per acre value is consistent with much of the previous literature relating to rural land values.³²

The analysis also indicates that sales price is significantly influenced by the number of land types comprising the property, *ceteris paribus*, and this influence is positive. Specifically, each additional property type (i.e., fresh, intermediate, brackish/saline, open water, other) adds an estimated \$108 to the per acre value of the property. There are at least two possible explanations for the finding. First, increasing the number of property types may contribute to the aesthetics associated with the property. Second, increasing the property types likely enhances activities that could be conducted on the property. For example, the absence of any open waters likely restricts duck hunting quality (as measured by expected take) while a property comprised of only open water is also not conducive to duck hunting. It is the combination of marsh and open water that provides optimal duck hunting conditions. Similarly, increasing the number of marsh types (with open water) likely increases the number of fish species available for harvest.³³

³⁰ The Breusch-Pagan test statistic equaled 11.48 with 8 degrees of freedom. The Pr > Chi Sq equaled 0.1758.

³¹ While it is not known what constitutes this “other” category, the results are suggestive that it is primarily fresh marsh.

³² The literature tends to cite two reasons for the negative relationship between property size and per acre price. The first reason relates to the high cost of subdividing the property into smaller parcels. The second reason is that the potential number of buyers decreases in relation to the size of property being sold, *ceteris paribus*.

³³ To examine whether sale of multiple properties (that would also likely contain more property types) influenced the results, the Southwest analysis was also conducted on those sales that included only a single tract being sold. This analysis resulted in a deletion of 21 properties (i.e., 93 properties included only a single tract). The parameter associated with the variable *number* remained highly statistical significant and equaled 0.299 (see Appendix B for the complete analysis).

After controlling for other factors (e.g., property types), increasing distance from the coast was found to result in lower property values while transfers of multiple properties was also found to negatively influence property value. The variable *year* also significantly influenced value and indicated that the per acre price increased by approximately \$35 per year, *ceteris paribus*. Inflation during the study period (1991-2007) equaled 52%, or about 3.5% annually. This is about two percentage points below the 5.5% increase in wetland sales price when calculated at the mean sales price of \$622 per acre.

Expected wetland loss was also found to influence sales price with moderate loss having a highly significant effect. Specifically, the expected per acre price of properties where wetland loss is expected to be moderate between 2000 and 2050 was found to be statistically significant and about 50% below the base category (no expected loss), holding all other factors constant. Similarly, results indicate that the expected sales price of properties with expected nominal loss is about 20% below the expected sales price of those properties where no wetland loss is expected, *ceteris paribus*. These results are consistent with economic theory that sales prices will be discounted in associated with decreases in the expected future productivity of properties.

(b) Results for Southeast Louisiana

Results associated with the Southeast Louisiana wetlands hedonic analysis are presented in Table 6. Though the adjusted R^2 appears reasonable, the results are implausible. In particular, the price effect associated with a change in the percentage of property that is brackish and/or saline is unrealistically large (i.e., a one acre increase in brackish or saline property at the expense of intermediate would result in about a \$2000 increase).³⁴

On the premise that the implausible results were due, at least in part, to the relatively small sample for Southeast Louisiana, the Southeast properties were combined with the Southwest properties with various interactions and variables (e.g., a discrete variable differentiating the Southwest from the Southeast properties) included in the analysis in an attempt to control for the different markets.³⁵ This procedure yielded 157 observations for analysis. None of the estimated models provided plausible results and hence they are not included in the report. They are, however, available from the author upon request.

The reason for the implausible results associated with the Southeast wetland hedonic analysis likely reflects the dynamic setting of the coast in Southeast Louisiana.

³⁴ There was sufficient information for Southeast properties to separate the brackish acreage from the saline. This analysis was conducted but results remained implausible.

³⁵ Recall that one of the primary reasons for separating the Southwest properties from the Southeast properties reflects the hypothesis that they each represented a separate submarket.

Specifically, wetland classifications become more problematic because the rapid changes along the Southeast coast. This is in contrast to a relatively stable wetland regime in the Southwest portion of the state.

Table 6. Estimation Results and Price Effects Associated with Southeast Louisiana Hedonic Model (43 observations)^a.

Variable	Parameter Estimate	Standard Error	Price Effect
intercept	-276.91*	71.844	NA
Property types:			
openw	-0.693	1.114	NS
freshm	0.955*	0.454	799.88
bracksalm	2.404*	0.854	2013.54
other	1.173*	0.520	537.97
Other property characteristics;			
ln(acres)	-0.167*	0.089	-0.129
number	-0.058	0.169	NS
coast	-8.14E-6*	6.81E-6	-0.0068
road	3.33E-5	3.69E-5	NS
dsections	-0.018	0.295	NS
dnominal	0.561	0.383	NS
dmoderate	0.448	0.335	NS
dextreme	0.5019	0.4646	NS
dinterest	-0.188	0.266	NS
year	0.142*	0.036	
* indicates statistical significance at the 10% level. ^a adj R ² equals 0.521.			

H. INCENTIVES

To begin a consideration of incentive programs that might be offered to wetland owners, it is first instructive to quote Boyer and Polasky (2004). As noted by the authors, “[p]rivate landowners may not see much value in protecting wetlands, even though there may be great social value in doing so. Without proper regulations or incentives in place, even wetlands that have been shown to generate high value for society may be lost.” The authors go on to state that “[i]n the final analysis, understanding the incentives of private landowners and other decision-makers whose decisions affect wetlands, and designing adequate institutions and regulatory schemes, is probably of greater importance for wetland conservation than is accurately measuring values.”

In general, one can argue that some type of subsidy or tax credit to landowners will be required for them to make the capital investments necessary to maintain/restore their respective wetland properties.³⁶ If the Southwest hedonic results accurately depict the factors influencing private values, one obstacle immediately confronting state and federal agencies charged with developing an institutional/incentive framework that encourage maintenance/restoration is the relatively high value placed on open water acreage vis-à-vis intermediate and brackish/saline acreage. This implies that landowners may have little economic incentive to protect intermediate and brackish/saline marsh from erosion.³⁷

If the results are correct and landowners value open water more than intermediate or brackish/saline wetlands, compensation might be required for any state/federal sponsored activity that would convert open water to intermediate or brackish/saline wetlands. This compensation could be in the form of either a direct monetary payment or a reduction in property taxes. Any attempt to reduce property taxes would, of course, face considerable opposition from the local parishes who depend on these property taxes as a source of revenue for parish operations.

Results also suggest that there would be financial benefits to landowners associated with state/federal sponsored activities that would convert open water to fresh marsh. Specifically, the Southwest analysis indicates that that fresh marsh is valued about \$180 per acre more than open water and about \$500 per acre more than intermediate marsh.

The analysis for Southwest Louisiana indicates that variety in terms of wetland types is desired by landowners. With each additional type adding almost \$110 per acre, landowners are likely to be receptive to activities that enhance property types. There are, however, certainly limitations to changes that would be receptive to the landowners.

³⁶ A detailed listing of incentives that may be offered to landowners is presented in Seidemann and Susman (2002).

³⁷ This statement should be conditioned on the property remaining with the landowner. Certainly if the property were to revert to the state due to conversion to open water, there would be some incentive by the landowner to maintain his property. This statement also needs to be tempered by the fact that results suggest that landowners do discount properties in areas where erosion is expected to be moderate between 2000 and 2050. One explanation is that that fresh marsh will be converted to intermediate marsh or brackish/saline marsh rather than open water.

While the results leave many questions unanswered, what appears to emerge from the analysis is that wetland types are valued differently by coastal property owners and an institutional/incentive structure will need to consider this factor if it is to be successful. It appears that incentives will need to be particularly large to encourage landowners to maintain/restore intermediate marshes and brackish/saline marshes. Direct payments for expenditures incurred in maintenance activities would likely yield benefits vis-à-vis a reduction in property taxes for two reasons; both of which are practical in nature. First, property taxes are likely relatively low in relation to the costs that would be incurred to maintain coastal properties at a socially desirable level.³⁸ As such, even a complete elimination of taxes may not be a sufficient incentive. Second, as noted, there is likely to be significant opposition by the local parishes to any reduction in wetland property taxes due to the concomitant reduction in taxes that would be generated.³⁹ As such, direct payment to landowners appears more reasonable.

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³⁸ Property tax rates for marsh properties are discussed in Seidermann and Susman 2002). While they are low relative to maintenance costs, they may be high relative to the benefits (i.e., net revenues) that the private landowner will receive from the property.

³⁹ This opposition, of course, could be overcome if the local coastal parishes were compensated directly for reduction in tax bas associated with reducing wetland property taxes.

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Appendix A. Estimation Results and Price Effects Associated with Southwest Louisiana Hedonic Model (114 observations) Using Deflated Price Per Acre as the Dependent Variable^a.

Variable	Parameter Estimate	Standard Error	
intercept	-54.724*	37.142	
Property types:			
openw	0.5241*	0.3145	
freshm	0.8224*	0.2472	
bracksalm	0.0719	0.2134	
other	0.8610*	0.2185	
Other property characteristics;			
ln(acres)	-0.2252*	0.0517	
number	0.1750*	0.0901	
coast	-0.954E-5*	0.546E-5	
road	-7.77E-6	0.125E-4	
dsections	-0.2347*	0.1511	
dnominal	-0.2016	0.1744	
dmoderate	-0.5971*	0.3080	
dinterest	0.4558	0.3487	
year	0.0306*	0.0186	
<p>* indicates statistical significance at the 10% level. ^a adj R² equals 0.515.</p>			

Appendix B. Estimation Results and Price Effects Associated with Southwest Louisiana Hedonic Model (93 observations) Based Only on Single Tract Transfers^a.

Variable	Parameter Estimate	Standard Error	
intercept	-119.024*	39.659	
Property types:			
openw	0.5195	0.3368	
freshm	0.7379*	0.2631	
bracksalm	0.0241	0.2173	
other	0.8154*	0.2333	
Other property characteristics;			
ln(acres)	-0.2898*	0.5751	
number	0.2990*	0.9761	
coast	-1.20E-5*	0.573E-5	
road	-2.76E-8	1.323E-5	
dsections	omitted	-----	
dnominal	-0.1812	0.1828	
dmoderate	-0.9542*	0.3333	
dinterest	0.4699	0.4427	
year	0.0628*	0.0198	
<p>* indicates statistical significance at the 10% level. ^a adj R² equals 0.600.</p>			