2008

Spatial economics of the Louisiana wetland mitigation banking industry

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Recommended Citation
Bourriaque, Ryan Joseph, "Spatial economics of the Louisiana wetland mitigation banking industry" (2008). *LSU Master's Theses*. 1978.
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SPATIAL ECONOMICS OF THE LOUISIANA WETLAND MITIGATION BANKING INDUSTRY

A Thesis

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

In

The Department of Agricultural Economics
and Agribusiness

by
Ryan Joseph Bourriaque
B.A., Louisiana State University, 2005
August 2008

ACKNOWLEDGEMENTS

Many times throughout my life, my family had placed a substantial amount of emphasis on education. Louisiana State University was always a second home to me even as a young child showing livestock through the 4-H program. However, I never anticipated the accomplishments of my seven years here at LSU. First, I would like to thank my supportive family and extended family who stood by me through the years and paid a bill or two. Next, I would like to thank all my Cameron Parish teachers who have impacted me over the years starting in kindergarten and progressing on to my senior year.

When I first moved to Baton Rouge and was looking for a place to help augment my income, Dr. Paul and Mrs. Arlene Coreil stepped in. I have to thank them both for their interest in my success and the many suppers and counseling sessions they have provided over these past seven years in Baton Rouge. It was through Dr. Coreil that I met such wonderful people as the staff of Sea Grant and Mr. Mike Liffman, where I spent most of my time in my undergraduate days. It was through Sea Grant that I was introduced to my major professor, Dr. Rex H. Caffey.

Dr. Caffey deserves much of the credit in me obtaining this Masters degree. Not only did he serve effectively as a major professor, but over the two and a half years spent with him, he has become a friend. At times when it seemed as if things were getting too rough and maybe a little too serious, he would step in, lighten the mood, and provide a helpful piece of advice just to help get through it all. Thanks, Rex.

For those who served on my committee along with Dr. Caffey, I owe you a great deal of thanks as well. Dr. Steve Henning, Dr. John Westra, Mr. Mike Wascom, and Dr. Hamady Diop offered valuable wisdom and assistance in accomplishing this feat. The staff and fellow graduate students of the Agricultural Economics Department were a very tight-knit and caring group, so I offer them a vote of thanks as well.

Several people also helped in the data collection process in this study. Mr. Jim Holcombe (LaDNR), Mr. Karl Morgan (LaDNR), Dr. James Barlow (Corps of Engineers), Mr. Nathan Watts (Corps of Engineers), Mr. Dan Bollich, and Mrs. Jane Niu were instrumental in this study in collecting and manipulating the necessary data involved. In closing a great “Bien Merci” to this extended network of people who in one shape, form, fashion, or the other helped this Cajun boy finish his Masters degree.

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ABSTRACT

Wetland mitigation banking has become prevalent in many states across the US, with the number of banks increasing 780% from 1992 to 2005. Louisiana led the nation in the total number of banks in 2006 with 96. Despite rapid growth associated with this industry, economic data in regards to the market for wetland mitigation bank transactions has been lacking. Mitigation bank transactions were collected (n=165) for the period 1997 through 2006 from the Louisiana Department of Natural Resources and the US Army Corps of Engineers New Orleans District. Data were evaluated for economic, spatial, temporal, and other descriptive characteristics. Average credit price for the period was $6,382, three to seven times lower than prices of wetland mitigation credits in states adjacent to Louisiana. Evidence of bimodal price trends prompted analysis of market segregation. Wetland credit prices ranged from $4,000-$20,000 for coastal mitigation credits and from $3,000-$10,000 for non-coastal mitigation credits.

A modified hedonic regression model was developed using spatial econometric and statistical software. Twenty-three variables were evaluated for their influence as price determinants, with 11 factors chosen in the final model (Adj. $R^2 = .69$). Parallel sub-models were developed for coastal and inland markets with marginal effects estimated for significant and continuous variables. Major drivers of credit price included sales volume, proximity to population centers, time, and rural land values. Competition within a particular market (watershed) had a positive influence on price, an indication that demand is exceeding supply in this infant market. Findings and recommendations from this study could prove beneficial to policy advisors, bank sponsors, as well as prospective investors in the industry.

CHAPTER 1: INTRODUCTION

In 1972 the nation provided the framework for a host of environmental policies by enacting the Federal Water Pollution Control Act. Regulation pertaining to dredging and deposition of fill materials or spoil in navigable waterways was included in Section 404 of this legislation. This regulation would require obtaining a permit for any entity to alter the hydrology of waters connected to waterways of interstate and foreign commerce. Through this Act, wetlands became a protected facet of the environment. In 1988 President George Bush, through the aid of his Domestic Policy Council, called for the nation to accept “no net loss” of wetlands. In 1993 President Clinton continued with this focus and supported the initiative of a market-based approach of providing financial incentives to protect wetlands. These actions led to the development of federal guidance in 1995 on the formation and use of mitigation banking as a policy option for wetland restoration (U.S. Environmental Protection Agency, 2007). In order for any regulatory or market-based actions to work, however, the definition of a wetland would need to be settled.

Wetland Delineation

The Federal Water Pollution Control Act was amended in 1977 to address wastewater and sewerage issues, point sources, and non-point source pollution. These amendments, now known as the Clean Water Act (CWA), also further pressed for a clear definition of what exactly constitutes a wetland.

Wetlands are not only found in coastal areas but can also be found inland, which are known as non-tidal wetlands. Coastal wetlands are naturally located along the Atlantic, Pacific, and Gulf coasts. These areas are extremely important to the nation’s stock of marine life and serve as estuarine habitat for many species. Inland wetlands are most commonly found in riparian floodplains near rivers and streams, in swamps, and in low-lying areas such as bogs or potholes.

Wetlands have a wide array of classification systems. Such systems take different characteristics into consideration when trying to define an area as a wetland. One such classification system is the Cowardin System. This system breaks down a wetland into a hierarchy varying from Marine wetlands to Palustrine wetlands. Marine wetlands are open water areas on the continental shelf and possess a coastline that is subject to wave and tidal activity. Estuarine wetlands are semi-enclosed areas with tidal influence. The ocean tide typical of this wetland type is diluted by the freshwater influence of runoff. Riverine wetlands include all wetlands and deepwater habitats in a channel except those dominated by tree and shrubs, all the while maintaining a salinity of less than .5 parts per 1000. Lacustrine wetlands include wetland and deepwater channels that have greater than 30% coverage and are more than 20 acres in size. Finally, Palustrine wetlands are nontidal wetlands that contain large amounts of shrubbery and trees and are no more than two meters deep at the deepest point in the area (Cowardin, Carter, Golet, & LaRoe, 1979).

Another classification system for wetlands is the British System developed by Reiley and Page. In their system, classifications are mainly based on the source of the water. Reiley and Page also take into consideration the flow path of the water and the amount of storage capability that a particular area can hold. Two of the more common terms associated with this system are Rheophilous and Ombrophilous. An area determined to be a Rheophilous area is one that is influenced by groundwater from areas immediately outside the watershed. Ombrophilous areas are those areas not subject to groundwater and are maintained predominantly by precipitation (Reiley & Page, 1990).

Despite numerous, conflicting classification systems for wetlands, there is only one system that is legally recognized in the United States. The 1987 Corps of Engineers *Delineation Manual* has become the accepted instrument with delineation. The jurisdictional definition agreed to by both the Environmental Protection Agency (EPA) and the Corps of Engineers (Corps) is as follows:

> Those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. (U.S. Army Corps of Engineers, 1987)

Three key criteria come to the forefront when classifying an area as a wetland. These criteria include hydrology, vegetation, and soils. The first criterion is hydrology. The hydrology of an area can be characterized by evidence of how often the area is wet. Wetland vegetation includes those species that can thrive in saturated soils. These plants, known as hydrophytes, easily adapt to saturated conditions and grow and reproduce efficiently. The third criterion is soils. Soils that display wet features or have the appearance of having developed under saturated conditions are relevant. These soils, classified as hydric soils, form under anaerobic conditions. For an area to be legally delineated as a wetland, all three of these criteria must be met. The development of this jurisdictional wetland delineation method opened the door for a regulatory process of mitigating wetland impacts.

Mitigation Sequencing

When it is not possible to avoid or sufficiently minimize wetland impacts, one must apply for a Section 404 permit from the U.S. Army Corps of Engineers as required by the Clean Water Act. The two types of permits granted by the Corps are general permits and individual permits. A general permit can be divided into two categories: nationwide permits and regional permits. These permits are utilized when an impact is minor in scope and does minimal damage. Nationwide permits (NWP) are used extensively in wetlands. The nationwide permit reduces the amount of paperwork that would ordinarily need to be done. Examples of projects typically covered under NWP include building bulkheads, bank stabilizers, and boat launches are all covered under nationwide permits.

Larger impacts require individual permits granted after a thorough and often lengthy process that includes providing very detailed project descriptions. Applications are reviewed by local, state, and federal agencies as well as many special interest groups or businesses in the nearby area of the activity. If the individual permit is granted, it must be placed on public notice so everyone is well aware of the actions taking place and are at liberty to give comments on the project. If there are no objections to the activity, a more in-depth discussion of the project is not needed. In many cases, problems can arise, however, and further review of the permit must be done by other federal agencies.

Both forms of permits take into consideration the effects of the actions taking place on site. If an entity has damaged a wetland in any way, there is sequencing involved for the restoration of the area. First, the entity must try to avoid the impact to the wetlands altogether. Avoidance of the wetland impact could imply project modification, canceling the project, or relocating it where less damage would be done.

Second, if it is not possible to avoid the damage, the entity must try to minimize the overall impact of their actions. Third, if the impact cannot be sufficiently minimized, the entity must mitigate or restore the damage done. This restoration could take place either on site or off site. If the damage cannot be replaced, the entity must then compensate those negatively impacted by their actions.

As Section 404 permitting began to be enforced throughout the late 1980s, a number of problems became evident. Many restoration projects were occurring away from where the actual damage took place and were constructed independent of one another, otherwise known as piecemeal solutions. Additionally, mitigation projects often failed to restore that the functions and values of the wetlands originally impacted. Finally, the availability of “in-lieu fees” meant that compensation could be paid rather than providing mitigation. In this situation, the developer would pay a regulatory agency instead of proposing a particular mitigation project. This payment allowed developers to avoid taking the time to derive a restoration project for the area. However, there was no guarantee the fee collected would actually be used for wetland mitigation. Because of these problems, a more logical answer was needed.

Mitigation Banking

Mitigation banking was a fairly novel idea at the time the Federal Guidance of 1995 was enacted, although it had first surfaced more than a decade earlier. A mitigation bank, as defined by the EPA, is a way to create, restore, enhance, or preserve habitat to compensate for unavoidable wetland impacts (U.S. Environmental Protection Agency, 1995). Mitigation banks provide both environmental and economic advantages. The environmental advantages are relatively simple. The restoration and/or creation of new wetlands will increase the functions and values of an area. Once the area is created, the bank itself is responsible for the well-being of the wetland in perpetuity.

Another environmental advantage that mitigation banking has over other forms of compensation is that a mitigation bank, as a whole, can provide more functions and values than an individual mitigation project isolated from other wetland areas. The economic advantages of mitigation banking are many. First, the banking area provides a relatively easy way for mitigation to be completed. Developers spend minimal time in trying to get their projects started because of the manner in which regulations are no longer their responsibility and now are on the shoulders of the landowner/banker. This "one-stop-shopping" allows for improved efficiency in commercial and residential development. From the banker's perspective, the mitigation bank provides an economic incentive to entrepreneurs, investors, and landowners to engage in wetland restoration in areas where it is most needed.

The 1995 Federal Guidance on Mitigation Banking provides four components that can characterize a mitigation bank: 1) the bank site—the physical acreage restored, established, enhanced, or preserved; 2) the bank instrument—the formal agreement between the bank owners and regulators establishing liability, performance standards, management and monitoring requirements, and the terms of bank credit approval; 3) the Mitigation Bank Review Team (MBRT)—the interagency team that provides regulatory review, approval, and oversight of the bank; and 4) the service area - the geographic area in which permitted impacts can be compensated for at a given bank (U.S. Environmental Protection Agency, 1995).

Each mitigation bank is allocated a number of credits by the MBRT. This allocation is based on the size of the bank and the quality of the restored wetland habitat.

Credits are not always allocated on a simple acre to credit ratio. This ratio, which can be greater or less than 1:1, depends on quantitative and qualitative factors considered during the MBRT review process.

Regulators calculate a trading ratio to adjust for the size of a wetland development impact as well as functional differences between wetlands. The ratio of acres impacted to credits, or “trading ratio” required, sets the terms by which units of impacted wetlands are traded for units of mitigated wetlands. According to Bonds and Pompe (2003), “Proposed Mitigation Credits (PMC) represent the wetland credits produced by the mitigation bank and the Required Mitigation Credits (RMC) represent the credits measuring the value of the impacted wetland. In accordance with the goal of no-net-loss of wetlands, the mitigation equation requires that the portion of the PMC resulting from restoration, creation, or enhancement (as opposed to preservation) must be at least 50% of the RMC” (p. 966). In many cases the trading ratio of credits required to acres impacted is not always 1:1. This is due to the fact the wetland mitigation bank could have alternate functions and values from the impacted acres.

There are differing characteristics that arise in certain mitigation banks. The Corps distinguishes the different types of banks according to the relationship of the sponsor and the client. Single use banks provide compensation for a particular client. A common example is state highway departments compensating for large-volume losses associated with road construction activities. Public commercial banks, often formed by government or non-profit organizations, compensate for wetland losses involving a large, contiguous site. Private commercial or entrepreneurial banks are sponsored by private owners who develop the mitigation bank in order to derive a profit (Zinn, 1997).

The numerous advantages of mitigation banking are outlined in the EPA Federal Guidance on Mitigation Banks (U.S. Environmental Protection Agency, 1995). These businesses offer specific advantages:

- Provide greater flexibility to applicants needing to comply with mitigation requirements;
- May be more advantageous for maintaining the integrity of the aquatic ecosystem by consolidating compensatory mitigation into a single, large parcel or contiguous parcels when ecologically appropriate;
- Consolidates financial resources and planning and scientific expertise not practicable to many project-specific compensatory mitigation proposals;
- Increases the potential for establishment and long- term management of successful mitigation that maximizes opportunities for contributing to biodiversity and/or watershed function;
- May reduce permit processing times and provide more cost-effective compensatory mitigation opportunities for projects that qualify;
- Compensatory mitigation is typically implemented and functioning in advance of project impacts, thereby reducing temporal losses of aquatic functions and uncertainty over whether the mitigation will be successful in offsetting project impacts;
- Consolidation of compensatory mitigation within a mitigation bank increases the efficiency of limited agency resources in the review and compliance monitoring of mitigation projects, and thus improves the

reliability of efforts to restore, create or enhance wetlands for mitigation purposes; and

- The existence of mitigation banks can contribute towards attainment of the goal for no overall net loss of the Nation’s wetlands by providing opportunities to compensate for authorized impacts when mitigation might not otherwise be appropriate or practicable.

According to the EPA fact sheet on mitigation, there were only 46 approved banks in 1992 in the U.S., and most of them were run by state governments or large companies who would use the credits themselves. By the end of 2001, there were approximately 219 approved wetland mitigation banks nationwide, more than 130 of which were entrepreneurial banks, and 22 of which had sold out of credits. This represented a 376% increase in the number of banks over 10 years, nearly all of which occurred following the release of the 1995 Banking Guidance. And an additional 95 banks were under review with approval pending as of December 2001 (Environmental Law Institute, 2001).

More recent reports indicate that by 2006, there were 405 approved mitigation banks throughout the United States (Environmental Law Institute, 2006). This number represented an 85% increase from the total number in 2001, and a 780% increase from 1992 (see Figure 1.1). The respective Corps districts have also reported there are currently 169 banks for which approval is pending. Clearly, there has been a significant increase nationwide, but is Louisiana a major representation of the total number of mitigation banks?

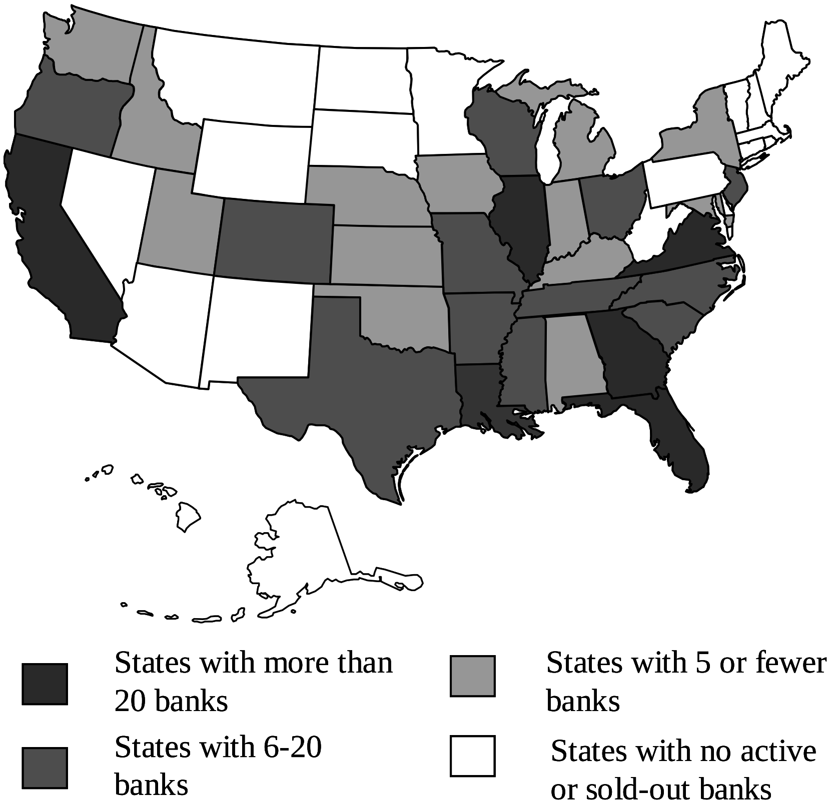

Figure 1.1 US Mitigation Banks in 2006 (Environmental Law Institute, 2006)

Louisiana Situation

In the wake of Hurricanes Katrina and Rita, Louisiana has placed an increased emphasis on the preservation and conservation of wetlands. One possible way to meet this goal is through mitigation banking. Indeed, Louisiana ranks first in the nation in the total number of credited mitigation banks with 96[1] (Environmental Law Institute, 2006). There is, however, a lack of readily available information that characterizes the mitigation banking industry in Louisiana. Mitigation banking policies in Louisiana call for offsetting impacts of the affected habitat type and preferably in the same watershed. Unfortunately at times, mitigation banks sell credits to individuals in a different watershed not to mention a completely different habitat type.

Aside from the aforementioned discrepancies with the purchasing of credits, there is also little information available to prospective bankers on how credit prices are affected by temporal and spatial factors. A spatial economic analysis of the state's mitigation banks could help identify how a certain price is derived, while providing additional information on the market for mitigation credits in regards to time and location.

Problem Statement

Mitigation banking has become a rapidly expanding sector in the past decade. A more in-depth look at the industry in Louisiana would be extremely beneficial. There is a lack of economic knowledge currently in Louisiana regarding this industry. An examination of the economic and spatial characteristics of this industry could bring light

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[1] According to the Environmental Law Institute (2006), Louisiana leads the nation with 96 wetland mitigation banks, 42 of which are currently active, 25 that are pending MBRT approval, and 29 that have sold out of credits.

to the subject and serve as an aid in many policy decisions regarding wetland management and preservation.

Objectives

The overall goal with this study is to examine and subsequently characterize the market for mitigation banking credits in Louisiana. The study will focus on three specific objectives:

1. Collect credit transaction data from state and federal institutions
2. Examine the functional relationship between credit prices and spatial variables
3. Characterize the spatial and economic factors that affect the wetland mitigation industry and make observations that could be of use to prospective investors.

Methods

In order to accomplish the objectives above, data pertaining to the price of credits, the location of the impacts, the date of the transaction, and the entity that affected the wetland will be needed. Information from wetland banking credit transactions within the Louisiana Coastal Zone will be collected from the Louisiana Department of Natural Resources (LaDNR). Transaction data from outside the Louisiana coastal zone will be collected from the United States Army Corps of Engineers (USACE).

Included in this work will be a spatial representation of each mitigation bank through the use of Geographic Information Systems (GIS). A database of this information is available through LDWF. Polygon files for each mitigation bank will be formed and the spatial data will be analyzed in order to determine the correlation related to cities in the area, the landscape, the area’s hydrology, and other variables. The recorded data from both LDNR and the USACE in addition to the GIS component will be converted into an objective model in which an optimal location for potential mitigation banks can be determined.

Expected Results

Up to this point, mitigation banking appears to be the answer to many of our wetland loss problems. This is not a perfect science, however, and there are some critics of mitigation banking whose reasoning is not difficult to understand. Many questions arise when people begin speaking about mitigation banking. Some aspects of mitigation banking are rather confusing and are essentially in the hands of nature. A wetland can be restored completely through construction and still not work as a functioning wetland for one reason or another. Moreover, maintaining a wetland over an extended period of time can prove costly. It is a risk assuming that someone or some entity will maintain a wetland for over 50 years, not to mention a lifetime.

This project could help the mitigation banking industry in Louisiana by providing a framework for further policy and economic decisions dealing with this industry in the future. With an increased focus on the conservation and preservation of wetlands, mitigation banks could be an important aid in maintaining valuable ecosystems that provide benefits to the state of Louisiana and the nation. With the improvement of the mitigation banking industry, there is also a probability of improving many coastal industries on a greater level. Examples of pertinent questions that this research will address include the following: how has the market for credit prices changed over time in Louisiana?; how does Louisiana’s industry compare to other U.S. markets for wetland mitigation credits?; and , what are the most important physical and economic characteristics for siting a perspective mitigation bank?

CHAPTER 2: LITERATURE REVIEW

Wetland mitigation banking derives from a fusion of greater emphasis on coastal wetland loss and a market-based approach to solving environmental problems. This chapter will provide a summary on the evolution of natural resource valuation techniques and how they serve as a guide to valuing wetlands.

Natural Resource Valuation: Non-Market Techniques

As the importance of natural resource management and education has grown over the past few decades, increased emphasis has been placed on natural resource valuation. Various methods have been developed to try and place a dollar value on non-market, resources; however, these techniques can be complex and controversial. Many natural resources are not traded in an open market due to circumstances concerning the uncertainty of property rights, or for the simple fact that these resources are public goods (e.g., clean air) and are not easily isolated. The problem associated with the status of public goods is due to the reality that if this good is made readily available to one person, others can benefit from its use as well (Markandya, Harou, Bellu, & Cistulli, 2002).

Such problems often cause public goods to be undervalued. When trying to establish the value of an environmental good, the use and non-use values should be taken into consideration. Use values are those values derived from the actual utilization of the resource to produce a benefit of that resource. For example, when fish from a lake are caught for the purpose of providing a meal, the lake is providing a use value. The lake does provide other values known as non-use values. However, non-use values are not as clearly defined as use values. In the previous example, there was a direct use of the lake through catching fish. The lake could also be aesthetically pleasing to those who live in the area and could increase the ecological biodiversity. This indirect use of the lake can sometimes be overlooked in trying to estimate its overall value.

One valuation technique for addressing the issue of indirect value in public goods is the contingent valuation method (CVM). This method typically involves direct surveys to gauge how much the general public or a subset of a population is willing to pay (WTP) to provide for the protection or restoration of a public good. Conversely, the method also elicits a willingness to accept (WTA) compensation or payment for partial or complete loss of a public good. The advantage of CVM is that the resulting monetary values can be used to guide policy or be incorporated into a benefit-cost analysis to determine the feasibility of various courses of action. The disadvantage is that contingent valuation is often based on a set of hypothetical conditions, and the resulting monetary values might not be truly representative of what would exist in a viable market. Another disadvantage of this method is that strategic bias is often present in the manner in which the survey is offered or completed (Mitchell & Carson, 1989).

Another form of alternative, non-market valuation is the Travel Cost Method. The Travel Cost Method (TCM) is widely used as a way to value recreational sites (Ward & Loomis, 1986). The data gathered in using the TCM is inclusive of the monies spent in traveling to and from a particular destination. This monetary value takes into consideration the opportunity cost of the time required to travel to this location. The sum of the travel costs can be used to determine a demand curve for the recreational area. A number of problems can arise when using the TCM. One such hurdle pertains to the ranking of characteristics between similar sites (Smith, 1989). While it might be evident that a particular destination was chosen over another, it is not always clear what characteristics had a greater influence on the decision.

One valuation method that does focus on many aspects affecting the decision to visit or invest in a particular resource is the Hedonic Pricing Method (HPM). The HPM estimates the dollar value placed on environmental amenities located near particular properties. The HPM takes into consideration many different characteristics of the area such as the presence of open space, wetlands, and availability of major roads in the area. The HPM has a major advantage in that it estimates values on consumer's actual choices. Different variables can be added to a model to measure the effect each variable has on the final monetary value. A major disadvantage of the HPM is the relatively large amount of descriptive data necessary to have a decent model. The HPM's relevance to this study is that it can relate environmental goods with market goods and can be modified to take these aspects into account.

There are many different types of valuation techniques providing a means for understanding a resource's non-market value. These examples of non-market valuation methods above, however, do not estimate the value of goods traded in a market. A more in-depth look at how these marketable assets, such as wetland mitigation credits, is needed.

Natural Resource Valuation: Market-Based Techniques

Environmental issues and problems with resource management have led many policy analysts to turn to markets in trying to alleviate some of the challenges (Hahn, 2000). Creating incentives for those participants in a market can be beneficial to buyers and sellers. In recent years, markets have been used more extensively with a notable success (Woodward, 2005). Environmental markets are now used in the delegation of emission fees and tradable permits, as well as management problems with fisheries resources. If this trend is becoming more widely accepted, what exactly makes it work?

Market-based approaches are often viewed as an improvement over non-market techniques in dealing with economic issues. The concern over property rights in non-market valuation is less of an issue in a well-functioning market with well-defined property rights. As Hahn (2000) states, accountability mechanisms are pertinent when dealing with a market. The policy analysis is inclusive of a broad list of instruments to aid in determining the costs and benefits of such actions. This assessment is intended to reach goals set by decision makers while simultaneously improving overall well-being. Relying on market interactions can be helpful to policy makers.

These revealed preferences are essential in establishing a willingness to pay in regards to environmental amenities. From the willingness to pay data, more reliable supply and demand curves can be derived. There are manners in which to deal with varying attributes in questionable situations. A random utility model is one such application. Random utility models (RUM) are models that take into account different characteristics when trying to value amenities. A RUM can also be combined with certain non-market valuation methods (i.e., the Travel Cost Method). The valuation of recreational areas and wetland restoration are two examples of situations when this method is more reliable (National Oceanic and Atmospheric Administration, 2008). An established way of valuing wetland restoration using random utility models with both market and non-market valuation methods is known as wetland mitigation banking.

Wetland Mitigation Banking

Wetland conservation and restoration is one area of environmental concern that has received much attention in recent years. The foundation for wetland policy decisions was laid in 1972 when the Clean Water Act (CWA) was passed. Section 404 of the CWA called for the issuance of permits to dredge and fill wetland areas only after public hearings were held. Wetland policy began taking form in 1989 when President George Bush provided initiatives for a “no-net loss” of wetlands. The Corps and the EPA signed a Memorandum of Agreement (MOA) in 1990 to set forth the goals of having no net loss of the nation’s wetlands functions and values. President Clinton reaffirmed this decision in 1993 when he called for an interim goal of no overall loss of the nation’s wetlands. Through these legislative acts, permitting for many standard development projects was required.

Before a developer could continue with a project, Corps sequencing has to be followed. The sequencing guidelines of CWA section 404(b)1 include 1) avoiding the impacts, 2) minimizing the adverse effects the impact would have on wetlands, and 3) compensating for the impacts. Traditionally, the compensation for impacts was the restoration, creation, enhancement, or preservation of wetlands on site. Compensation of this nature led to a more ecologically isolated, postage-stamp style of mitigation (Salzman & Ruhl, 2005). Complicating matters even more, the compensation efforts of developers were often poorly monitored. This failure of wetland policy led to the alteration of wetland regulation.

The Federal Guidance for Mitigation Banking provided several arguments for wetland mitigation banking as a replacement for compensatory mitigation. The Guidance suggests that the establishment of a mitigation bank can “bring together financial resources, planning, and scientific expertise not practicable for many project-specific compensatory mitigation proposals.” In streamlining the process, the overall transaction costs of obtaining a permit could be lessened along with the total cost of the project. The consolidation of piecemeal mitigation efforts into larger mitigation banks also allowed for more efficient monitoring by regulatory agencies.

Figure 2.1 illustrates the interaction of regulatory agencies, developers, and mitigation bank sponsors for a credit transaction with a 2:1 trading ratio. As evident in the figure above, the Corps’ role is prevalent in many aspects of the wetland mitigation banking industry. From the initial meetings with the mitigation banking review team (MBRT), the bank sponsor is collaborating with many state and federal agencies as well as local resource planning agencies. The MBRT serves as the guiding hand in establishing a bank by overseeing the formulation of a Memorandum of Agreement or Understanding (MOA/MOU). The document should include detailed descriptions of various characteristics of the particular mitigation bank including: the bank’s goals and objectives, the size of the bank, the type of wetland present in the bank, financial assurances the sponsor has undertaken, performance standards for the bank over time, and the provisions for long-term management and maintenance (U.S. Environmental Protection Agency, 1995). As a general rule, the MBRT process has been more likely to approve mitigation banks that propose to create or restore wetlands, versus those that would enhance or preserve wetlands. This inclination is based in the “no net loss” basis of U.S. wetland policy (including Section 404 sequencing and mitigation banking) which states wetland losses should be offset on a one-to-one basis. In some cases when a large future development is planned, the permit applicant will be granted permission for a mitigation bank. Banks developed for a single purpose, for large developments

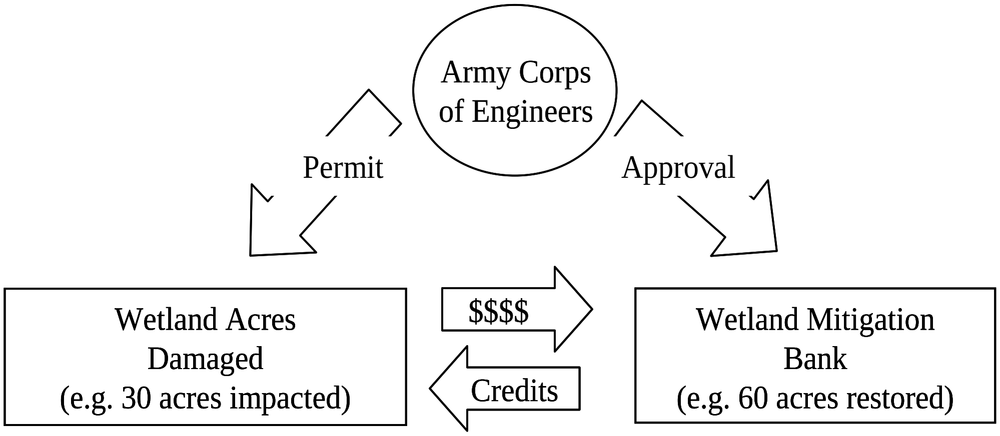

Figure 2.1 Wetland Mitigation Banking in Practice (Salzman & Ruhl, 2005)

(e.g., highway built by state department of transportation), are labeled as single-use mitigation banks. In single-use banks, the sponsor also serves as the main client. However, most wetland impacts result from much smaller developments. Prior to the establishment of a mitigation banking industry, these small impacts were off set by in-lieu fee programs.

In-lieu fees allowed developments to take place providing the developer made a pre-specified payment to third party with Corps approval, many times a governmental agency or restoration organization. Like mitigation banking, in-lieu fees allow the developer to transfer the responsibility of wetland restoration to a third party (Shabman & Scodari, 2004). Some fee-based programs have been criticized for not guaranteeing that fees collected will be used for wetland restoration. An additional criticism is that in-lieu fees often accrue for several years before any restoration activity is begun. Finally, mitigation bankers argue that in-lieu fees create a government-funded alternative that can serve to dilute the market for credits in a given area. The effect of these shortfalls has led to a reduction in the use of in-lieu fees in recent years.

In the transference of mitigation obligations from developers to bankers, the banker takes on all legal and financial responsibility of the wetland impact. Banks of this nature are referred to as commercial, or entrepreneurial, mitigation banks. Since 1995, developers who impacted wetlands could turn to a bank sponsor to deal with their mitigation requirements. This action is achieved in the selling of “wetland credits” to developers. As is the agreement in the purchasing contract, the bank sponsor will provide mitigation for the developer and guarantee the protection of the wetland credit in perpetuity. In order to make a profit and provide this service over an elongated period of time, the sponsor must be conscious of the importance of setting the credit price. Credit prices are complex and include the costs to buy and improve land, the application and review costs involved in obtaining bank approval, and the long-term costs of monitoring and maintenance obligations.

The time element in gaining approval to market mitigation credits varies widely. Some states allow the partial selling of credits once the development of a bank is initiated, whereas others only allow a staged release of credits to be sold as the bank achieves its environmental goals. Many bank sponsors struggle to operate economically under the latter policy. In such cases, greater risks are involved in trying to establish a mitigation bank and then establishing the correct prices for credits. The sponsor will have forgone investment in other interests in order to provide assurances to the development of a sound wetland system. Figure 2.2 illustrates the relationship of the economic and ecological aspects of credit approval and release for sell (Brumbaugh 1995). In short, there is a trade-off between ecological and economic risks that depends on when a new bank is allowed to sell credits. If the bank is allowed to market credits immediately following approval, there is less economic risk and more ecological risk. Conversely, delaying the sale of credits will increase economic risks and reduce ecological risks.

There is also great uncertainty in trying to determine the future demand for credits in a given area. The location of the bank could have a great impact on the price of the credit and the ability to market credits. In most cases, the watershed in which the impacts take place should also be the watershed in which the credit is purchased. Therefore, the market focus shifts to the individual watershed on the part of the bank sponsor. Likewise, the determination of the final credit price could be affected by the number of mitigation banks in a particular service area.

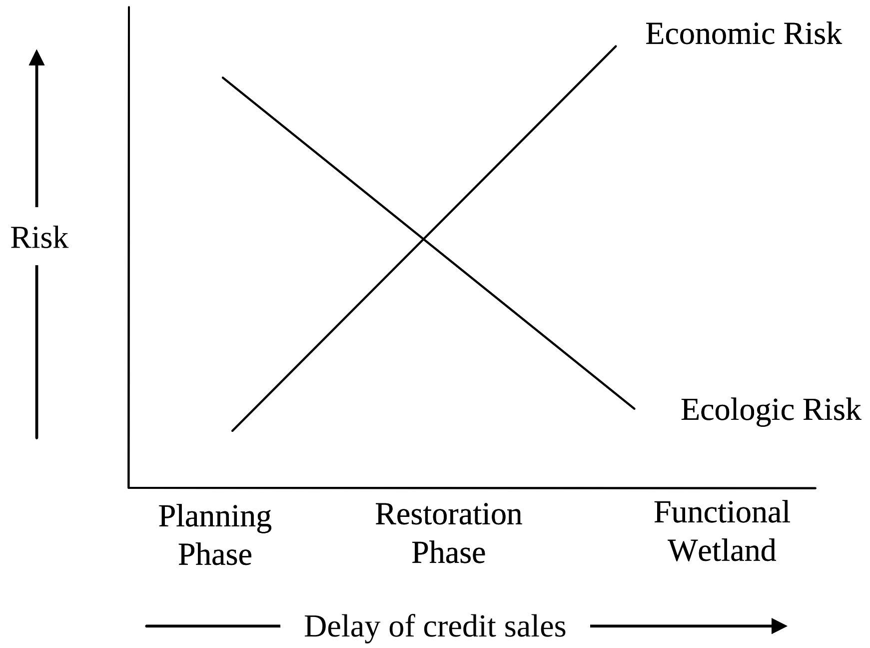

Figure 2.2 Timing of Credit Approval and Apportionment of Risk: A Hypothetical Tradeoff
(Adapted from Brumbaugh, 1995)

The service area is an important issue for a mitigation bank. According to the *Federal Guidance for the Establishment, Use and Operation of Mitigation Banks* (U.S. Army Corps of Engineers, 1995), the service area of a mitigation bank is the designated area (e.g., watershed, county) wherein a bank can reasonably be expected to provide appropriate compensation for impacts to wetlands and/or other aquatic resources. In other words, the credit(s) purchased should provide similar ecological functions as the wetlands impacted if these are both in the same service area.

The purchasing of credits that has changed the way wetland restoration is viewed. Wetland credit sales have now transformed the goal of the no-net loss of wetlands into an incentive-based, market-based approach to an environmental problem - *but is this method effective?* As previously mentioned, the primary advantage of wetland mitigation banking over previous policy instruments is that it provides a consolidated effort that enables more efficient wetland restoration (Gardner, 1996). Another important aspect of wetland mitigation banking is that the restoration effort is often initiated prior to the issuing of the permit enabling impacts. This results in a temporary surplus of wetland acres prior to the selling of the approved credits (Gardner, 1996). Mitigation banks can provide a more time-efficient and economical manner for developers to receive their permits. A developer can spend more work on the actual development project rather than devising a restoration project about which the developer may know little or nothing. According to Brown and Lant (1999), mitigation banking is a useful tool that has great potential when it is included in land-use and watershed planning.

Mitigation banking can also prosper due to an increased awareness of the importance of the nation’s coastal areas. A contingent valuation study performed by Bauer, Cyr, and Swallow (2004) gauged Rhode Island residents’ willingness to pay for mitigated wetland acres. The survey was given to citizens living throughout the state and involved choosing one of three scenarios for mitigating the impacts to a specific area. The alternative restorations actions would be either a) no action at a cost of $0; b) 64 acres of salt marsh to be preserved at $25/acre/year, or c) 135 acres to be restored at $35/acre/year. The average value assessed in the study was $196,000/acre of salt-water marsh to either be preserved or restored. A restoration project of 42 acres of salt-water marsh performed by the Rhode Island state government had a total cost of $3.3 million. However, with the estimates presented earlier, $8.23 million would have been paid by the public.

Several publications have indicated the recent increase in the use of mitigation banks. As of September 2005, there were 405 active banks in the United States, which includes banks that were selling credits and those that were sold out of credits. The 2005 level of mitigation banks represented a 184% increase in the number of active banks from 2001-2005 and an increase of 476% from 1992-2001.

Although mitigation banking appears be the best solution to a wetland loss problem, this may not always be the case. Problems can arise in trying to determine the true value of the wetlands themselves. In the case of purchasing credits, it seems the developer simply wants to get permitted by the Corps in the least expensive manner. Whereas in credit selling, the bank sponsor is worried about the Corps' approval and the eventual selling of credits to hopefully gain a profit. Neither the buyer nor seller in this case is worried about the quality of credit being purchased or sold as long as the outcome is favorable for them (Salzman & Ruhl, 2005). Sale of credits is driven primarily by the need for income and regulatory compliance, and there is little market-based incentive related to the quality aspects of wetland functions and values.

Furthermore, given the Corps support for mitigation banking as an acceptable form of compensation, enforcement of the avoidance-minimization section of the 404(b)1 guidelines may be lessened (Bean & Dwyer, 2000). In studies followed by Turner, Redmond, and Zedler (2001), ecological equivalency of mitigation banks to the functions lost were accomplished by only 21% of the mitigation sites. Conservationists argue that when a particular wetland is impacted, those functions and values can be diminished in nearby ecosystems as well. Consequently, a new mitigation site constructed away from the impact may not serve the best purpose (Kusler, 1992). Brown and Lant (1999) assert that many approved banks, once they have sold out, will be converted to other uses. These points have been the basis for improvement of the restoration methods used in mitigation banking.

One suggestion made by Hallwood (2007) is to focus more on the contract design and execution of the mitigation bank. The author argues that bank sponsors will cut as many corners as possible in order to lower overall costs, but at the same time keep the mitigation bank's appearance as flourishing. He advocates more careful inspection by the agencies of the finished work. A novel idea taken from North Carolina is known as a credit resale program. The program is one part of the North Carolina Ecosystem Enhancement Program (NCEEP). The credit resale program involves a bidding process amongst bank sponsors that focuses on the quality and price of the credit. When a credit is certified by the state agency, demand uncertainty for that particular bank is eliminated. Scodari and Shabman (2005) contend that this program allows mitigation banking to benefit from the openly competitive environment, but they do not view this as an alternative to the current wetland permitting process. The interaction of many policy instruments merges in the wetland mitigation banking industry, but how does the wetland mitigation banking system utilize economic theory?

Economics of Wetland Mitigation Banking

Wetlands provide a wide range of services to an area or ecosystem. From flood protection to enhancing water quality to providing barriers to oil and natural gas pipelines, wetland areas are linked to nearly every aspect of our lives. In trying to value these wetlands, problems arise. How probable is it that an agency will not undervalue these areas? Turner, Van Den Bergh, Barendregt, and Maltby (1997) developed an ecology-economics interface illustrating the relationship between the environment and the economy. It is clear to see that many uses and values of wetlands can be lost in the plethora of possibilities when calculating values. The total economic value of a wetland system can be estimated to a certain degree, but it is unclear as to how accurate the estimate will be. The aforementioned dilemma with valuing wetlands also presents itself in trying to set the price of a mitigation credit.

A bank sponsor will need a great deal of information and foresight in trying to effectively set a credit price. As Saeed and Fukuda (2003) state, credit prices can be tied to costs, government regulated, left up to market forces, or be based on a combination of all three. They further claim "market pricing of credits might be the easiest and the most effective way to assure reliable functioning of the mitigation banking system that should support growth of built environment to a sustainable level while the functionality of physical environment is preserved" (pp. 2, 14). Although wetland banking seems to be a more efficient way to deal with the mitigation requirement, there are numerous constraints affecting their use.

One problem with the current credit trading system pertains to spatial characteristics. Credit location has become a tense regulatory issue with many agencies. In compliance with the 1995 federal guidance, agencies have tried to limit the purchase of credits only from those banks located in the same watershed where the impacts occurred. The trouble with this constraint is that in some instances, little or no banks/credits are present/available in the watershed. Additionally, the bank sponsor, knowing the lack of competition in his watershed, may engage in monopolistic pricing behavior. Conversely, a watershed in which there is high demand for credits will eventually attract additional banks, which could mitigate monopolistic pricing—depending on the availability of credits at any given time. Another issue deals with the size of the particular watershed. If the watershed is fairly small, there may be no suitable land in the area to develop into a mitigation bank which in turn increases the demand for land with wetland functions and values (Shabman & Scodari, 2004).

Other spatial characteristics in addition to competition that can play an important role in the formation and financial well-being of a mitigation bank include 1) population levels (i.e., demand) in a given watershed, 2) the availability and value of rural land, 3) the type of habitat present, 4) size of the transaction (i.e., potential economies of scale), and 5) and location of the bank and impact.

Conceptual and Theoretical Framework

Modeling economic characteristics from a spatial perspective has become a more prevalent occurrence in recent years. Researchers have benefited from progression in technology that allow for more thorough interpretation of spatial data. Geographic information systems (GIS) are one such advancement. Anselin (1998) states that GIS is a database that efficiently combines value (attribute) information on the objects of interest with locational and topographical information. Burrough (1986) refers to GIS as a "powerful set of tools for collecting, storing, retrieving at will, transforming, and displaying spatial data from the real world for a particular set of purposes." Studies have been performed using GIS to analyze spatial data. Geoghegan, Wainger, and Bockstael (1997), Pace, Barry, and Sirmans (1998), and Bastian, McLeod, Germino, Reiners, and Blasko (2001) all employed GIS components to evaluate environmental and real estate amenities from a spatial standpoint.

The approach taken by these researchers consisted of using a hedonic approach to measure the relationships causing differences in prices of goods. Rosen (1974) developed a two-step technique to estimate influential characteristics involving a hedonic price equation:

$$P = f(Z_i)$$

Where: P= price of a good and Z_i= characteristics of a good.

Beal (2007) utilized hedonic price functions in trying to gauge Florida residents' view of the impact nearby wetland mitigation banks have on property values. In some cases, the mitigation bank was viewed as a negative externality. The author documented a direct correlation between property values and rural proximity. She found that the closeness of mitigation banks to urban areas raised their overall property values (i.e., residents viewed this as a positive externality). It was also hypothesized that the more rural areas viewed mitigation banks as a negative externality—possibly due to the large number of wetlands already in the area or for the potential for restriction on commercial development. Hill (2006) provides a review of wetland loss mitigation. The author advocates the incorporation of spatial data of wetland impacts. Such information would be beneficial to prospective bankers and as a descriptive tool for wetland regulators.

Wetland valuation is clearly not a simplistic economic or environmental matter. However, market and non-market techniques can be effectively used for dealing with wetland loss. Mitigation banking is one approach proven to be a popular solution among public and private interests. This study utilizes a hedonic price framework to clarify which economic and spatial variables are most significant in affecting the pricing mitigation credits in Louisiana.

CHAPTER 3: DATA AND METHODS

In order to bring the outlined goals and objectives to fruition, a thorough data collection process is needed. Permitted projects throughout the state of Louisiana are filed with the Department of Natural Resources (LaDNR) as well as the US Army Corps of Engineers (USACE). Each of these files was examined for transaction data (i.e., total number of credits purchased and price per credit) between the mitigation area and the permitee. Along with transaction data, information was recorded on the type of habitat impacted, spatial coordinates for the location of the impact, the entity that applied for the permit, and the date the credit was purchased.

The LaDNR Coastal Management Division (CMD) provided access to their database on all permit files requiring mitigation. A spreadsheet-based subset of mitigation permits was cross-referenced and used to expedite the search for mitigation transaction data. Access to a CMD computer was provided and all permits that required mitigation were reviewed. Data were recorded in a Microsoft Excel (2003) spreadsheet according to the permit number.

Because the permits at LaDNR included only those impacts in the Louisiana coastal zone (LCZ), a more balanced sampling approach was needed. The USACE maintains all permit files containing information from wetland mitigation banks located outside of the LCZ. For Louisiana, this information is housed at the New Orleans District Office (NOD) of the Corps. A total of 13 site visits were conducted for the purpose of data collection at the NOD office during August and September 2007. The database of mitigation permits contained over 3,400 permit numbers that required mitigation from 1995-2006. Files were organized according to bank name. Permit files were separated for each bank and six to ten files for each bank were randomly selected, each varying over time. The goal was to have transactions for each bank showing price data of the early stages of the bank and progressing through to the latter stages of bank operations. In order to view these files to obtain the necessary information, contact was made with USACE NOD Technical Support Division for access to microfilm files. Files were recorded according to permit number. In order to view the files, the corresponding cartridge and file number were needed. A Microsoft Access file containing this information was made available and was downloaded to a laptop computer. During the initial site visit, a database file containing 150 mitigation files, each coded separately, was provided. This subset of files greatly expedited data collection.

Over the next two weeks, data were pulled and recorded on each bank throughout the NOD. After each site visit, data were organized into a Microsoft Excel spreadsheet according to permit, cartridge, and file number. As with the LaDNR data, information was recorded on the date of the transaction, the number of credits purchased, the amount paid for the credit(s), the habitat type affected, the latitude and longitude of the impact's location, and the parish in which the development took place. A master list was created from both the Corps and LaDNR. Data were imported into ArcView (ver. 3.2) to provide spatial assessments and for the creation of additional spatial variables. A Louisiana parish shapefile layer was incorporated with the geocoded transaction data (see Figure 3.1). In addition, a shapefile of Louisiana-specific mitigation banks was added (see Figure 3.2) in which a centroid point was identified for the purpose of references each mitigation bank's location. Finally, an additional shapefile was added to illustrate the Hydrologic Unit Code (HUC) used by the USCAE NOD for Louisiana (U.S. Geological Survey, 2008) (see Figure 3.3).

Annual parish population estimates at the time of the transaction were also incorporated. These data were obtained from a U.S. Census database that included actual census data as well as interpolative estimates from non-census years during the period 1996-2007 (U.S. Dept. of Health and Human Services, 2007). Another variable added to the database was the average value of rural land in the parish impacted for 1996-2003 (see Table 3.1).

These data were derived from a hedonic study of rural land values in Louisiana (Soto, 2004). In a similar fashion, this study develops a spatial-economic model of those attributes that affect the value (price) of an acre/credit purchased from a wetland mitigation bank. Table 3.2 describes 23 independent variables with their definition and expected sign according to economic theory. The dependent variable—price—is generated from the transaction data. Although as previously stated, the ratio of mitigation credits required to acres purchased is not always equal; the data obtained on credit transactions from permit files were expressed in acres. Only a small number of files contained detailed information on credit calculations and credit requirements. Thus, for reporting the results of this study, credits prices and acre prices will be used interchangeably, assuming an average 1:1 trading ratio.

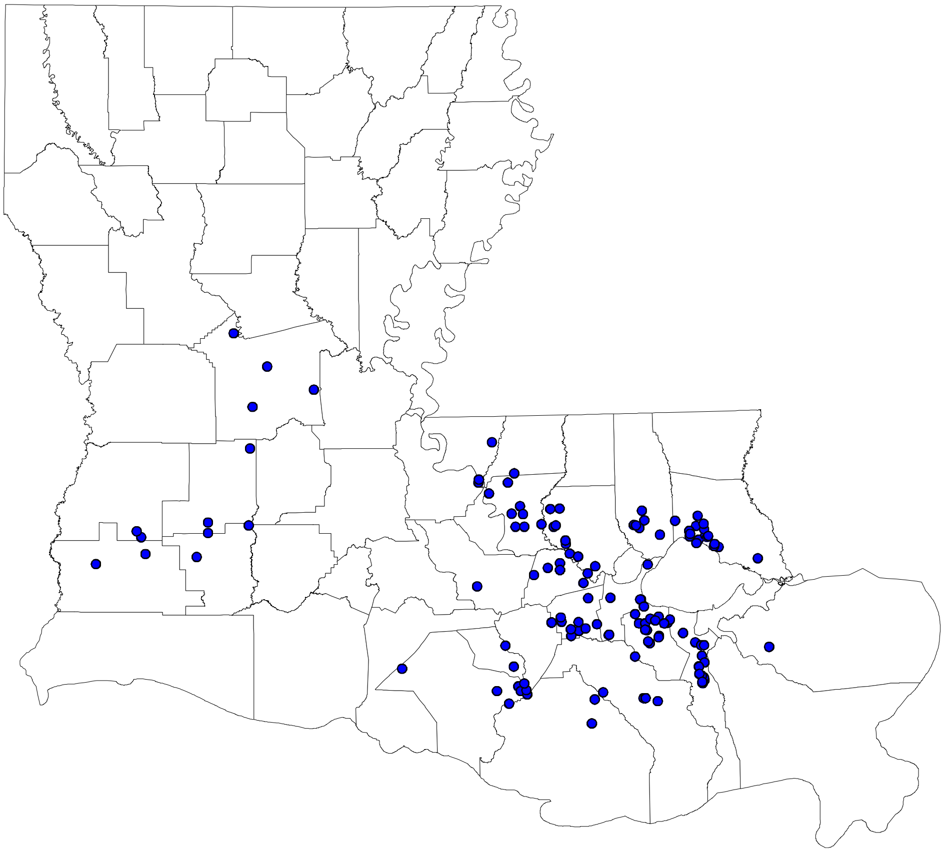

Figure 3.1 Spatial distribution of wetland mitigation banking credit transactions, 1996-2006 (*n*=164)

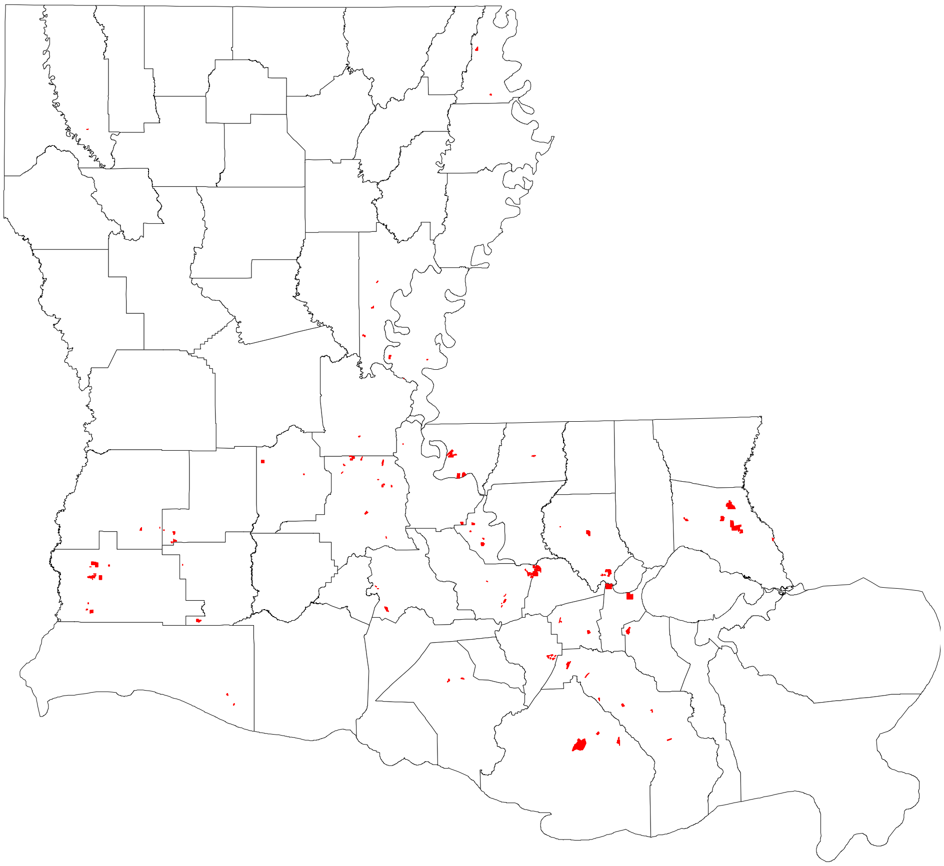

Figure 3.2 **Spatial delineation of wetland mitigation banks in Louisiana, 1996-2006 (*n*=80)**

Figure 3.3 Map of USACE Hydrologic basins in Louisiana

Locational variables are derived from both the permit files and developed from ArcView. Descriptive variables include information on habitat type and bank type. Economic variables pertaining to the size of a transaction (i.e., number of credits sold [TOTAC] or amount of sale/cost [TOTCO]) were assumed to be negative, implying economies of scale. Furthermore, the presence of additional banks within a watershed (COMPT) was assumed to have a negative influence on price.

To facilitate data import into SpaceStat Version 1.9, qualitative data fields were coded into numerical values. Initially, the entity, bank type, and habitat type variables were individually coded by alphabetical order. Entity variables were coded 1) commercial, 2) governmental, or 3) residential. Parishes were coded alphabetically from Allen Parish (#1) to Terrebonne Parish (#22). The mitigation bank type variable was coded 1) enhancement, 2) preservation, or 3) restoration. The mitigation bank habitat type was coded 1) Bottomland Hardwood (BLH), 2) Highland Forested (HF), 3) Pine Forested Savannah (PF/S), and 4) Swamp (SW). The month and year of the transaction was recorded as 1 – 120, beginning with January 1997. The dependent variable (cost per acre), was converted to a natural log to help reduce problems associated with the large variation in this variable. The resulting Log-Linear model form was confirmed as the best fit for the data by the use of a Box Cox Transformation (Appendix A). All dollar values were deflated using the consumer price index in the Southern Region with a base year of 2006 (U.S. Dept. of Labor, 2008).

Table 3.1 Parish Rural Land Values[2] (1993-2002)
Source: Soto(2004)

Parish	**Mean**	**St. Dev**
Allen	1,381	1,112
Ascension	5,676	6,122
Assumption	1,051	403
Calcasieu	5,235	10,620
East Baton Rouge	3,372	4,459
East Feliciana	2,613	1,567
Iberville	1,898	1,068
Jefferson	14,381	*
Jefferson Davis	990	542
Lafourche	2,153	1,563
Livingston	2,279	3,432
Pointe Coupee	1,562	839
Rapides	1,339	1,208
St. Bernard	11,682	*
St. Charles	12,128	*
St. James	975	367
St. John the Baptist	869	641
St. Landry	835	477
St. Martin	1,295	543
St. Mary	1,084	576
St. Tammany	4,985	3,712
Tangipahoa	1,522	796
Terrebonne	1,419	1,913
West Feliciana	3,087	2,539

* Three urban parishes were omitted in the original study (St. Charles, Jefferson, and St. Bernard). In order to estimate rural land values for these parishes, a phone survey of real estate agents in each parish was conducted. Current cost estimates of recent land sales were deflated by a rate of 2.5% per year and a ten-year average was taken.

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[2] Ten year averages were taken from the data provided.

Table 3.2 Model Variables and Definitions

Dependent Variable	Definition
AVGCO	Total cost of acres sold divided by the total number of acres sold
LNAVGCO	Natural log of the average cost variable

Independent Variables	Definition	Expected Sign
IMP_{xy}	Projected spatial coordinate for the impact	N/A
$BANK_{xy}$	Centroid point for mitigation bank	N/A
DATE1	Date of transaction labeled by month of transaction	+
TOTAC	Total number of acres/credits sold	-
TOTCO	Total cost of transaction	-
PARISH	Parish of impact	N/A
COMPT	Number of banks in a particular hydrologic unit	-
HUCNO	USGS Hydrologic Unit Code (HUC) number	N/A
PAPOP	Parish population estimate for year of transaction	+
LANVA	Rural land value estimates for the parish impacted	+
COMMERCIAL	Dummy, clientele type: commercial	+
GOVERNMENT	Dummy, clientele type: governmental	+
RESIDENT	Dummy, clientele type: private/residential	-
ENHANCEM	Dummy, enhancement-based wetland mitigation bank	-
PRESERVA	Dummy, preservation-based wetland mitigation bank	-
RESTORAT	Dummy, restoration-based wetland mitigation bank	+
BLH	Dummy, bank selling bottomland hardwood credits	-
PF_S	Dummy, bank selling pine forested savannah credits	+
SW	Dummy, bank selling swamp credits	+
COASTAL	Dummy, bank located in the Louisiana Coastal Zone	+
D_IMP_URBA	Distance from the impact to nearest urban area (measured in miles). Urban area centroid points were identified through U.S. Census Data.	-
D_BANK_URB	Distance from the mitigation bank to nearest urban area (measured in miles). Urban area centroid points were identified through U.S. Census Data.	-
D_IMP_BANK	Distance from the impact to nearest mitigation bank (measured in miles)	-

CHAPTER 4: RESULTS

This chapter provides detailed information on data pertaining to the wetland mitigation banking industry in Louisiana. Included in this chapter are descriptive statistics, spatial analysis, and regression model output for 145 transactions obtained from state and federal agencies. Data were collected from the United States Army Corps of Engineers New Orleans District (USACE NOD) and the Louisiana Department of Natural Resources (LaDNR). These agencies provided access to databases containing 3,164 wetland mitigation bank transactions.

A total of 189 permit files were sampled from the LaDNR records, 85 of which (45%) contained actual transaction data between the permitee and the bank sponsor. Of the 427 files sampled from the USACE NOD, only 80 (19%) contained actual transaction data. The higher rate of transaction data obtained from LaDNR compared to the Corps is attributed to differences in record keeping and the level of financial detail required by each agency. Permit files were sampled in a manner that provided spatial and temporal spread of Louisiana wetland mitigation bank transactions for 1997-2006. A description of the data is presented below.

Descriptive Statistics

A variety of information was recorded in data collection process. Information relevant to the mitigation bank included bank type, bank location, habitat type, and credit prices over time. Descriptive information on impacts requiring mitigation included the entity purchasing the credits; location of the impact, habitat type; parish of impact; date of transaction; and the price paid for the credit. Figure 4.1 shows the distribution of mitigation bank transactions by bank type.

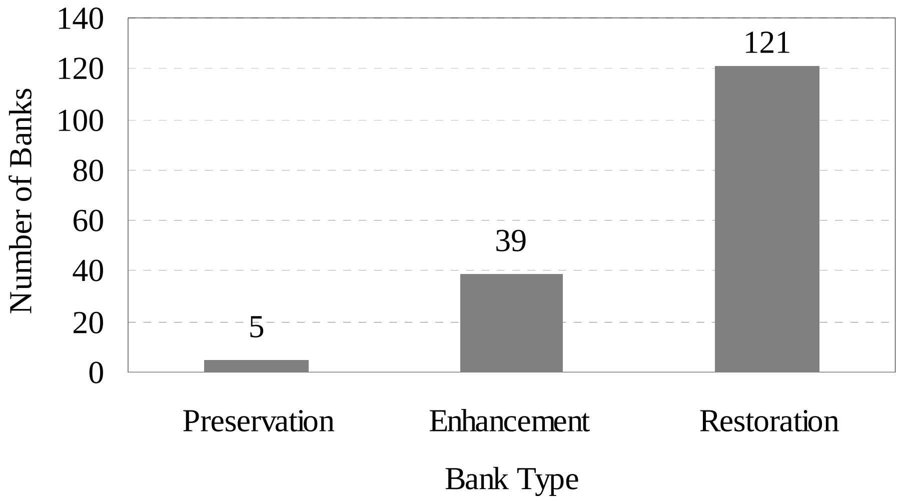

Figure 4.1 Transactions by Mitigation Bank Type (LADNR and USACE NOD data, *n*=165)

As described in Chapter 2, the agencies comprising the MBRT have shown opposition to proposals for enhancement—and preservation-based banks in the past, a trend depicted in this graphic. Accordingly, preservation-based banks accounted for only 3% of all transactions examined in this study. In contrast, restoration banks accounted for 83% of the total number of transactions observed.

Figure 4.2 shows the observations broken down by entity permitted. The highest number of mitigated, permitted projects were in the commercial category (54%). The commercial category involved any type of development with economic profit being the goal. This was inclusive of oil and gas exploration, retail development, waterfront development, and other business opportunities. The residential category (26%) included those projects requiring mitigation due to the impacts of building a single, private residence. The government category (20%) took into consideration all actions undertaken by municipal and state governments. Examples of clientele in this category included parish school boards and the Louisisna Department of Transportation and Development.

As Figure 4.3 indicates, credit purchases from bottomland hardwood (BLH) forest mitigation banks made up 67% of the transaction data sampled. Indeed, impacts to this habitat type are most common as BLH forests are the most prevalent wetland type found throughout the state and are a prominent feature of the Mississippi River and Atchafalaya River alluvial plains. Credit purchases from banks featuring all other habitat types accounted for only one-third of the total transactions. Credit sales from Swamp (SW) mitigation banks were the second largest contingent, accounting for 20% of the transactions sampled. Credits purchased from pine forest savanna (PF/S) wetlands, located primarily in the Florida parishes north of Lake Pontchartrain, accounted for 10%

of the transactions. Finally, credits purchased from highly individualized, rare wetland mitigation banks, such as freshwater marsh banks, accounted for the remaining three% of transactions labeled *Other*.

In the early years of the mitigation banking industry in Louisiana, the majority of the transactions hovered in the range of $3,000 to $5,000 per acre; however, as time increased, credit prices did also. This upward trend is depicted in Figures 4.4 and 4.5. In the most recent years sampled (2004-2006), several transactions were recorded in excess of $20,000 per acre. Nevertheless, a substantial number of transactions in Louisiana during that same period remained at or below the price of $5,000 per acre. This bimodal trend could be indicative of a segregation in the wetland mitigation credit market. In fact, over the ten-year period for which Louisiana credit prices were collected, the average price was only $6,382.

A national database of wetland mitigation transactions for 2000-2005 shows that Louisiana had the second lowest average credit price for the nine states sampled (Katoomba Group, 2008) (see Figure 4.6). Although Louisiana has the highest number of approved mitigation banks in the U.S., the state is consisently at or near the bottom of average credit prices. In fact, credit prices for neighboring states in the northern Gulf of Mexico region are significantly higher than in Louisiana, with the average price being nearly twice as high in Alabama, 3½ times higher in Texas, and nearly 7 times higher in Florida (Katoomba Group, 2008).

Figure 4.7 illustrates the differences between average annual credit prices for coastal and non-coastal mitigation transactions[3] in Louisiana. On average, non-coastal

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[3] As used here, “coastal and non-coastal transactions” is likely equivalent to “coastal and non-coastal banks” due to the requirements for mitigation in like watersheds and habitats. However, the data were of insufficient detail to equate the two.

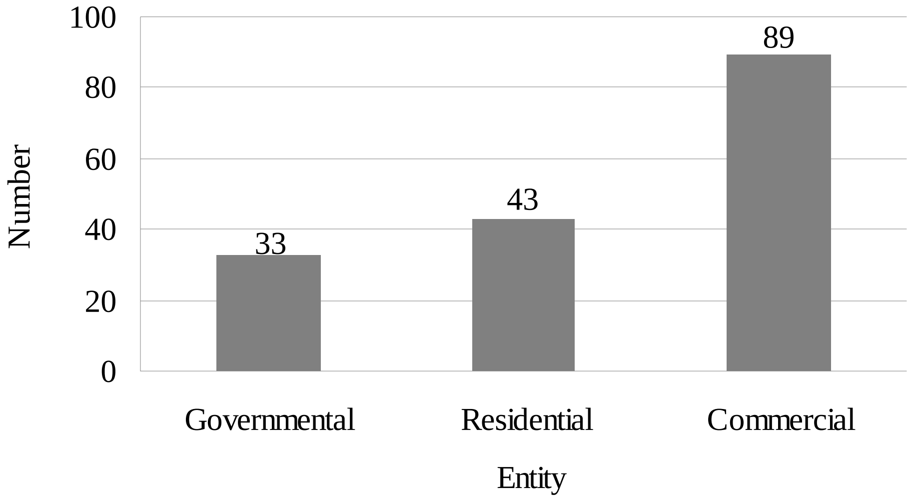

Figure 4.2 Transactions by Entity Permitted (LADNR and USACE NOD data, *n*=165)

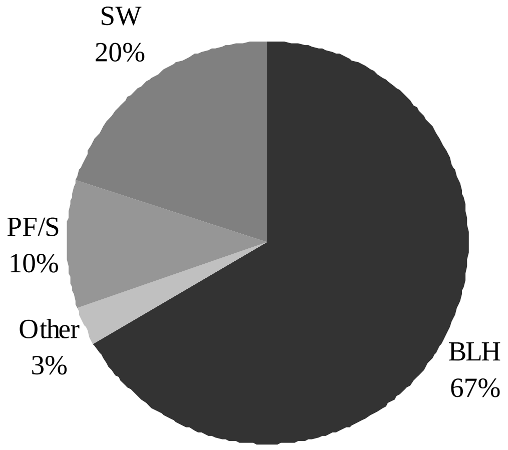

Figure 4.3 **Transactions by Wetland Bank Habitat Type (LADNR and USACE NOD data, *n*=165)**

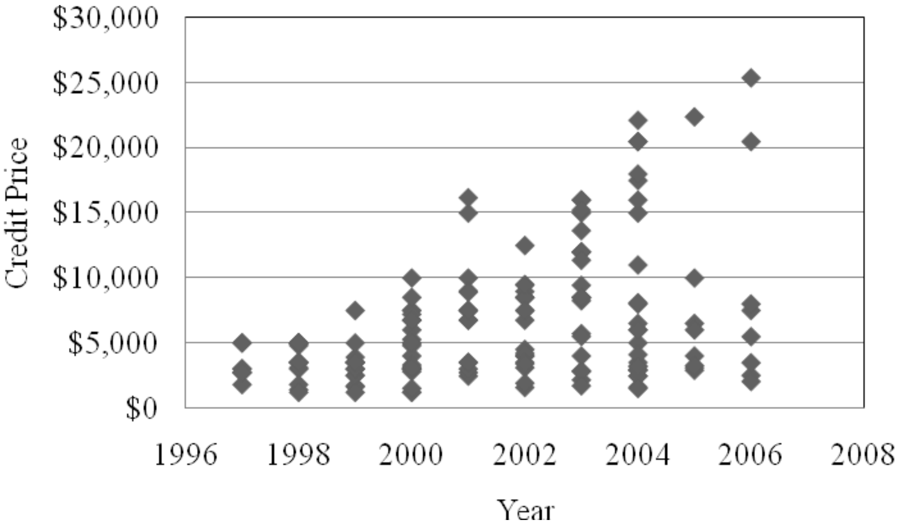

Figure 4.4 Credit Transaction Prices for Louisiana Wetland Mitigation Banks, 1997-2006 (LADNR and USACE NOD data, *n*=165)

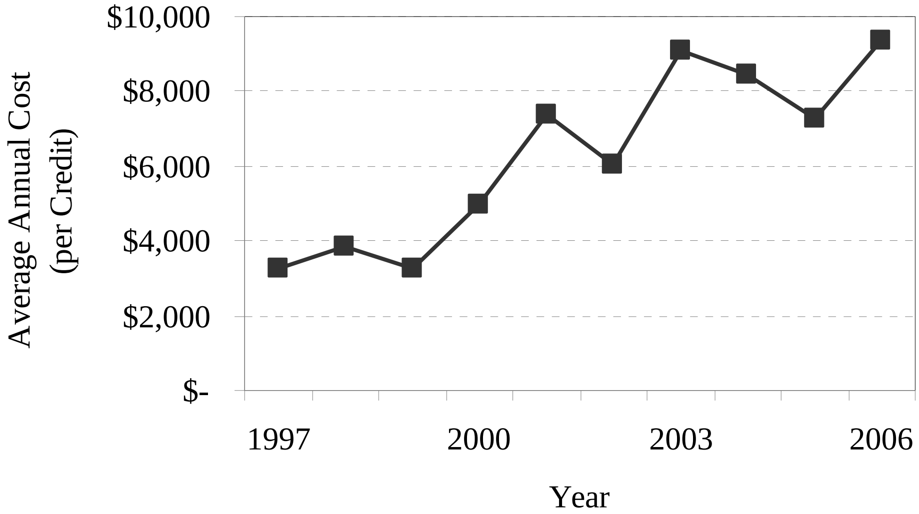

Figure 4.5 Average Annual Credit Transaction Prices for Louisiana Wetland Mitigation Banks, 1997-2006

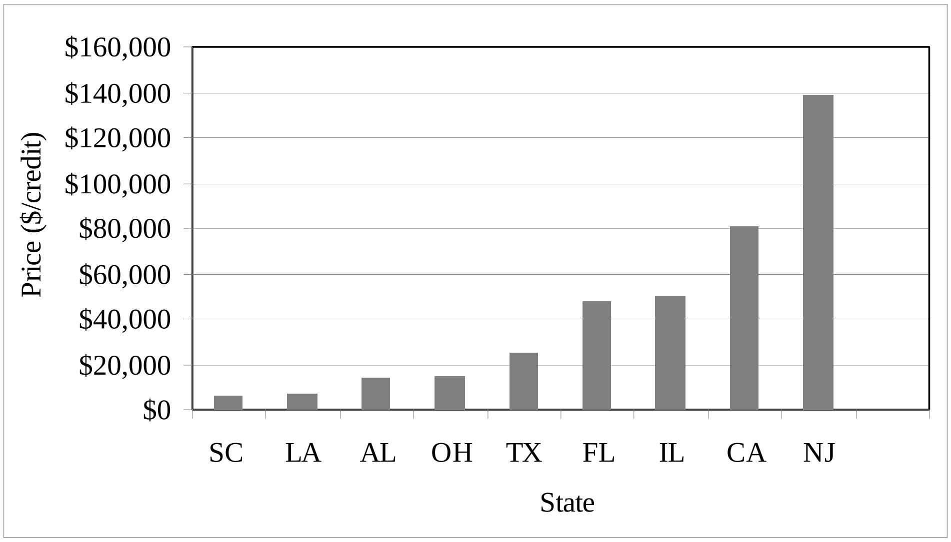

Figure 4.6 **Sample of Wetland Mitigation Credits for Nine U.S. States (Source: Katoomba Group) (*n*=43 transactions, 2000-2005)**

mitigation transactions have maintained an 11% average annual increase in credit prices over time. Coastal mitigation transactions, although remaining somewhat similar to the non-coastal banks at the onset, have increased at a more rapid rate (18% per year). Moreover, non-coastal banks saw a dramatic increase in prices in during 2004-2005, reaching an average price of more than $20,000 per acre. Despite a drop in prices during 2006, transactions from coastal banks remain more than three times higher than non-coastal banks.

Spatial Statistics

GeoDa (Version 0.9.i beta) spatial statistics software was utilized to identify any outliers in the transaction data by using a Moran’s I Box Plot (Appendix A). Given that no outliers were identified as problematic, the data were imported into SpaceStat (Version 1.9) to evaluate the data. Despite solid indications that spatial effects matter, much empirical work that uses spatial data still fails to take its distinctive characteristics into account. SpaceStat is a software program that includes a wide range of embedded techniques for evaluating spatial statistics and spatial econometrics. In order to properly estimate significance of the independent variables, SpaceStat first develops spatial weights matrices matrix for the data. Subsequent tests are then run using different matrices to identify which distance option is the most reliable. After initial tests showed several variables to be insignificant, iterative combinations of variables were evaluated.

A G-test run in SpaceStat and plotted in ArcView showed the data to be spatially autocorrelated. Results indicated that an Ordinary Least Squares Regression (OLS) would be an appropriate model to run. The data were evaluated using an OLS estimation procedure within SpaceStat. The best functional form for the data was determined to be a

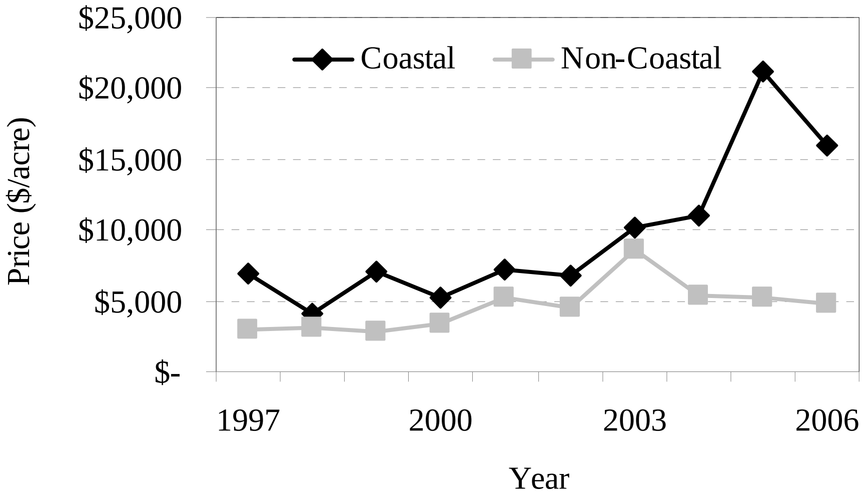

Figure 4.7 **Average Annual credit prices for coastal (*n*=94) and non-coastal (*n*=51) wetland mitigation tranaction in Louisiana (1997-2006)**

log-linear model:

$$\text{Log}(y)=b_1+b_2(X)\ldots+b_n(X)$$

Six independent variables were chosen for the model:

$$\text{LNAVGCO} = f(\text{DATE1, TOTAC, COMPT, RESIDENT, COASTAL, D\_BANK\_URB})$$

Where: LNAVGCO is the natural log of the average cost per acre (credit) for a given transaction; DATE1 is the month and year of the transaction (1-120); TOTAC is the total number of acres in the transaction; COMPT is the number of mitigation banks that existed in a given watershed at the time of the transaction, RESIDENT is a transaction from a residential client; COASTAL is a transaction for impacts in the coastal zone; and D_BANK_URB is the distance from the bank of record to the closest urban area. Results from the estimation are presented in Tables 4.1 and 4.2.

The adjusted R^2 reported in the OLS output (.4012) is fairly low by regression standards but not necessarily low for spatial or hedonic models. Each of the independent variables was statistically significant although the date variable (DATE1) was only marginally significant with a probability of <.10. According to the regression results, the total number of acres sold (TOTAC) has a negative effect on the credit price, as does residential clientele (RESIDENT) and distance from the bank to the urban area (D_BANK_URB). All other independent variables cause an increase in price.

Table 4.1 Ordinary Least Squares Estimation using SpaceStat (version 1.9)

R^2	0.4621	R^2-adj	0.4012		
LIK	-115.154	AIC	244.307	SC	265.144
RSS	41.5618	F-test	17.0777	Prob	4.81364e-014
SIG-SQ	0.301173	(-0.548792)	SIG-SQ(ML)	0.28663	(0.535381)

Table 4.2 Regression Procedure Results using SpaceStat (version 1.9)

Variable	Coefficient	Std. Err	t Value	Pr > |t|
CONSTANT	8.12677	0.183606	44.261916	0.000000
DATE1	0.00311658	0.00187842	1.659145	0.099358
TOTAC	-0.00696479	0.00276208	-2.521574	0.012820
COMPT	0.111923	0.0216142	5.178203	0.000001
RESIDENT	-0.292885	0.101232	-2.893213	0.004433
COASTAL	0.408701	0.098506	4.148994	0.000058
D_BANK_URB	-0.0164705	0.00525857	-3.132133	0.002119

Table 4.3 Regression Diagnostics using SpaceStat (version 1.9)

MULTICOLLINEARITY CONDITION NUMBER			10.76586
TEST ON NORMALITY OF ERRORS			
TEST	DF	VALUE	PROB
Jarque-Bera	2	1.629334	0.442787
DIAGNOSTICS FOR HETEROSKEDASTICITY			
RANDOM COEFFICIENTS			
TEST	DF	VALUE	PROB
Breusch-Pagan test	6	41.07688	0.000000
SPECIFICATION ROBUST TEST			
TEST	DF	VALUE	PROB
White	25	71.34961	0.000002
SPATIAL DEPENDENCE			
FOR WEIGHTS MATRIX IMPD_2 (row-standardized weights)			
TEST	MI/DF	VALUE	PROB
Moran's I (error)	0.35248	0.771971	0.440131
Lagrange Multiplier (error)	1	0.496968	0.480835
Robust LM (error)	1	0.637528	0.424607
Lagrange Multiplier (lag)	1	0.980782	0.322006
Robust LM (lag)	1	1.121342	0.28963
Lagrange Multiplier (SARMA)	2	1.61831	0.445234

The number of mitigation banks in the hydrologic unit (COMPT) and whether the impact was in the coastal zone (COASTAL) had a highly significant, positive effect on credit price. Regression diagnostics (see Table 4.3) indicate that multicollinearity, as indicated by the Jarque-Bera test, was found to be elevated but not significantly high.

Heteroskedasticity, as measured by the Breusch-Pagan test, was found to be significant, so a generic Heteroskedasticity error model was run within SpaceStat to adjust values. Several diagnostics were run to determine spatial dependence such as Moran's I, Lagrange Multiplier (error), Robust LM (error), Lagrange Multiplier (lag), Robust LM (lag), and the Lagrange Multiplier (SARMA), but spatial dependence was determined to not be significant.

Regression Model

A parallel examination of the data was developed using a basic regression model in SAS. Initial model runs were conducted using the same suite of independent variables identified through the use of SpaceStat. Statistical results were identical between the two programs. A subsequent step-wise regression procedure produced a model containing the same additional variables. Further iterations in SAS produced a model with 11 independent variables. The equation of estimate is as follows:

LNAVGCO = F(PAPOP; PF_S; RESTORATION; RESIDENT; LANVA;
TOTAC; BLH; COMPT; DATE1; D_BANK_URB; D_IMP_BANK.

Where: PAPOP is the annual population for the parish of impact, PF_S is a dummy variable showing whether the wetland mitigation bank sells Pine/Forested Savanna credits; RESTORATION is a dummy variable showing whether the wetland mitigation bank is a restored wetland area, LANVA is the estimated rural land value for the parish of impact, BLH is a dummy variable showing whether the wetland mitigation bank sells

Bottomland Hardwood credits, and D_IMP_BANK is the distance from the impact to the nearest wetland mitigation bank.

Temporal autocorrelation was found to be neither positive nor negatively correlated, as indicated by the Durbin Watson test. The data were determined to be normally distributed according to test results from the Shapiro-Wilk, Madria Skewness, Mardia Kurtosis, and the Henze-Zirkler T-test. Heteroskedasticity was present in the data set according to the White Test results, thus correcting for heteroskedasticity was necessary. SAS corrects for heteroskedasticity using a weighted regression approach which is also referred to as the weighted least square (WLS). Once these measures were taken to correct for error in the model, a better fit was provided.

As illustrated in Table 4.4, the adjusted R^2 increased to .6948. Furthermore, independent variables of significance at probability of $p < .10$ changed from the earlier model. Independent variables in the overall model now affecting price include the following: parish of impact's population (PAPOP), if wetland mitigation bank is a restored wetland area (RESTORAT), estimated rural land value for the parish of impact (LANVA), total number of acres (credits) purchased (TOTAC), number of wetland mitigation banks in the same hydrologic unit (COMPT), date of the transaction (DATE1), distance from the wetland mitigation bank to the nearest urban area (D_BANK_URB), and distance from the impact to the nearest wetland mitigation bank (D_IMP_BANK). The distance from the mitigation bank to an urban area as well as the distance from the impact to the nearest wetland mitigation bank produced negative effects on price as Table 4.5 indicates.

The parish of impact's population, if wetland mitigation bank is a restored wetland area, the estimated rural land value for the parish of impact, and the number of wetland mitigation banks in the same hydrologic unit all had highly significant, positive effects on the total credit price. In the model estimates provided earlier, total acreage and private residential clients had negative effects on price, but the sign has changed for both of these variables with private residential clients no longer being significant. The total number of acres sold in the transaction and the date of the transaction are marginally significant with both having positive effects on credit price.

In contrast to results from the SpaceStat model, which depicted economies of scale, the TOTAC variable in this model had a positive effect on price. Elasticities were calculated on six continuous, independent variables: parish of impact's population (PAPOP), estimated rural land value for the parish of impact (LANVA), total number of acres (credits) purchased (TOTAC), number of wetland mitigation banks in the same hydrologic unit (COMPT), distance from the wetland mitigation bank to the nearest urban area (D_BANK_URB), and distance from the impact to the nearest wetland mitigation bank (D_IMP_BANK).

The functional form for the elasticity calculation in the Log-linear model is given by

$$B_n(X_i)$$

Where: B_n is the slope of the independent variable and X represents the trend. Any one unit change in X leads to a percent change in Y. results of the elasticity formulas are presented in Table 4.6. Six of the independent variables in the model were significant and continuous, thus allowing the calculation of elasticity. A 1% increase in the total number of acres sold (TOTAC) results in a 1.12% increase in price. In the case of LANVA, a 1% increase resulted in a 0.286% increase in price. Likewise, a 1% increase in COMPT and PAPOP also had a positive effect on credit price, increasing it by 0.275%

Table 4.4 Nonlinear OLS Summary of Residual Errors for Overall SAS Model

Equation	DF Model	DF Error	SSE	MSE	Root MSE	R-Square	Adj R-Sq
lnavgco	11	133	76.2925	0.57363	0.75738	0.71812	0.6948

Table 4.5 Regression Procedure Results for Overall SAS Model

Variable	Approx Estimate	Approx Std. Err	t Value	Pr > |t|
LNAVGCO	3.867243	0.34549	11.19	<.0001
PAPOP	0.000001546	5.968E-07	2.59	0.0107
PF_S	0.335541	0.314921	1.07	0.2886
RESIDENT	0.235328	0.16259	1.45	0.1501
RESTORATION	0.581873	0.290242	2.00	0.0470
LANVA	0.000051	0.000018	2.89	0.0045
TOTAC	0.135800	0.077654	1.75	0.0826
BLH	-0.13740	0.138179	-0.99	0.3218
COMPT	0.063034	0.032298	1.95	0.0531
DATE1	0.005082	0.00301	1.69	0.0937
D_BANK_URB	-0.00002	4.415E-06	-3.40	0.0009
D_IMP_BANK	-0.00003	7.993E-06	-3.82	0.0002

and 0.239%, respectively. In the case of D_BANK_URB, a 1% increase in the total distance from the bank to the nearest urban area resulted in a decrease in the total credit price by 0.61%. Similarly, an increase in the distance from the impact to an urban area led to a 0.60% change in total credit price.

To further review the underlying reasons for the disparity between coastal and non-coastal wetland mitigation credit prices (Fig. 4.7), subsequent models were run using data isolated for each region. A total of 94 transactions were included in the analysis of the coastal wetland mitigation transactions. Again, coastal wetland mitigation credits are those wetland mitigation credits located within the Louisiana Jurisdictional Coastal Zone as designated by the Louisiana Department of Natural Resources. Comparatively, there were 51 transactions in the non-coastal category. The dependent variable for the coastal credit model became LNAVGCOC (the natural log of the average cost of each coastal credit). The dependent variable for the non-coastal model became LNAVGCON (the natural log of the average cost of each non-coastal credit). Independent variables in these subsequent models were the same 11 variables from the overall model. The coastal model resulted in an adjusted R^2 value of 0.4509 (see Table 4.7), which is substantially lower than the same estimate for the overall model (0.6948). This reduction in model fit could be credited to the larger variation in price for wetland mitigation credits in coastal areas. Table 4.8 depicts the regression results for the coastal model. In this model, only 3 of the 11 independent variables had significant impact on the credit price with a probability of <.05: parish of impact's population (PAPOP), number of competing banks in a watershed (COMPT), and time (DATE1). All three variables had a positive effect on credit price.

Table 4.6 Elasticities for Overall SAS Model

Variable	Approx Estimate	Approx Std Err	t Value	Pr > |t|	Label
TOTAC	1.118896	0.6398	1.75	0.0826	a7*8.23931
LANVA	0.28629	0.0992	2.89	0.0045	a6*5631.58
COMPT	0.275609	0.1412	1.95	0.0531	a9*4.37241
PAPOP	0.23949	0.0925	2.59	0.0107	a2*154956.86
D_IMP_BANK	-0.59795	0.1567	-3.82	0.0002	a12*19605.12
D_BANK_URB	-0.61616	0.181	-3.40	0.0009	a11*40996.21

Table 4.7 Nonlinear OLS Summary of Residual Errors for Coastal Model

Equation	DF Model	DF Error	SSE	MSE	Root MSE	R-Square	Adj R-Sq
lnavgcoc	11	82	43.80913	0.534258	0.73093	0.51585	0.4509

Table 4.8 Regression Procedure Results for Coastal Model

Variable	Approx Estimate	Approx Std. Err	t Value	Pr > |t|
LNAVGCOC	3.065328	1.361259	2.25	0.0270
PAPOP	1.822E-6	9.112E-7	2.00	0.0488
PF_S	0.219975	1.186212	0.19	0.8533
RESIDENT	-0.29903	0.209943	-1.42	0.1581
RESTORAT	0.289347	1.196945	0.24	0.8096
LANVA	-0.00002	0.000022	-0.86	0.3925
TOTAC	-0.07758	0.101828	-0.76	0.4483
BLH	0.008647	0.172593	0.05	0.9602
COMPT	0.088068	0.036925	2.39	0.0194
DATE1	0.008828	0.004103	2.15	0.0344
D_BANK_URB	0.000013	8.371E-6	1.60	0.1142
D_IMP_BANK	-5.14E-06	0.000019	-0.27	0.7870

At 0.5875, the adjusted R^2 for the non-coastal model was slightly higher than that of the coastal model (see Table 4.9). Four independent variables had significant impact on the credit price with a probability of <.10 (see Table 4.10). As seen in the overall model, TOTAC has a positive effect on credit prices. However, a negative influence on price was seen by PF_S (whether the wetland mitigation bank sells Pine/Forested Savannah credits), BLH (whether the wetland mitigation bank sells Bottomland Hardwood credits), and D_BANK_URB (the distance from a mitigation bank to an urban area). The non-coastal wetland credit model shows DATE1 (the date of the transaction) to not be significant. This result coincides with Figure 4.7 that illustrates a relatively constant price for non-coastal wetland credits over a ten-year time span.

Elasticities were also calculated for the coastal (see Table 4.11) and non-coastal (see Table 4.12) models as well. Only two variables were significant and continuous in the coastal submodel. In the coastal model, the population of the parish (PAPOP) had the same effect as before, where total credit prices increase 0.28% for every one% increase in population. Likewise, a 1% increase in COMPT resulted in 0.39% increase in price. In the non-coastal submodel, two variables were significant and continuous. A 1% increase in TOTAC increased the total credit price by 1.94%. Just as in the overall model, a 1% increase in the distance from a mitigation bank to an urban area (D_BANK_URB) led to a decrease in total credit price (-0.94%).

Table 4.9 Nonlinear OLS Summary of Residual Errors for Non-coastal Model

Equation	DF Model	DF Error	SSE	MSE	Root MSE	R-Square	Adj R-Sq
lnavgco	11	39	9.54649	0.244782	0.49475	0.67823	0.5875

Table 4.10 Regression Procedure Results for Non-coastal Model

Variable	Approx Estimate	Approx Std. Err	t Value	Pr > |t|
LNAVGCON	4.818009	0.922133	5.22	<.0001
PAPOP	2.414E-7	1.541E-6	0.16	0.8763
PF_S	-1.04125	0.61036	-1.71	0.0960
RESIDENT	-0.38715	0.480579	-0.81	0.4254
RESTORAT	0.125651	0.31173	0.40	0.6891
LANVA	-0.00002	0.000204	-0.10	0.9187
TOTAC	0.23554	0.11205	2.10	0.0421
BLH	-0.807140	0.473565	-1.70	0.0963
COMPT	0.009229	0.067276	0.14	0.8916
DATE1	0.00978	0.006423	1.52	0.1359
D_BANK_URB	-0.00002	7.846E-6	-2.93	0.0056
D_IMP_BANK	-7.86E-06	0.000015	-0.53	0.5996

Table 4.11 Elasticities for Coastal Model

Variable	Approx Estimate	Approx Std Err	t Value	Pr > |t|	Label
PAPOP	0.28236	0.1412	2.00	0.0488	a2*154956.86
COMPT	0.385069	0.1615	2.39	0.0194	a9*4.37241

Table 4.12 Elasticities for Non-coastal Model

Variable	Approx Estimate	Approx Std Err	t Value	Pr > |t|	Label
TOTAC	1.940679	0.9232	2.1	0.0421	a7*8.23931
D_BANK_URB	-0.94314	0.3216	-2.93	0.0056	a11*40996.21

CHAPTER 5: SUMMARY & CONCLUSIONS

Wetland mitigation banking is emerging as an effective means for achieving the goal of “no-net loss” for wetlands. The concept of mitigation banking began taking form in 1988 and resulted in passage of the 1995 Federal Guidance for the wetland mitigation banking industry. This guidance established a market-based approach for mitigating wetland losses. The environmental advantages brought about through the emergence of wetland mitigation banks are evident by the creation, restoration, enhancement, and preservation of wetland areas. Additionally, the industry has provided entrepreneurial opportunities throughout the United States. At the firm level, the industry provides income to bank sponsors and also benefits developers by significantly decreasing the amount of time and money spent on mitigating wetland impacts. These economic advantages are evidenced by the rapid growth of wetland mitigation banks nationwide, expanding nearly 800% over the last decade. Louisiana leads the nation in the number of wetland mitigation banks, with a total of 96 banks currently active, pending, or sold out of credits. Because of the relative youthfulness of the industry, however, many facets remain unexplained. This study examined various characteristics of the industry in an attempt to describe this new market and document the economic and spatial factors affecting the price of wetland mitigation credits in Louisiana.

Data for this study were obtained from state (Louisiana Department of Natural Resources) and federal (United States Army Corps of Engineers, New Orleans District) agencies. Each observation was a financial transaction between a permitee and a bank sponsor. Recorded information pertaining to each transaction included spatial coordinates for the wetland impact and the bank, date of transaction, number of acres (credits) sold, total dollar amount of the sale, the parish of impact, the population and rural land values of the parish, the type of habitat mitigated, the hydrologic unit of the impact and bank, type of clientele, and spatial variables measuring the distance from the impact to the bank and to the nearest urban area. A total of 23 independent variables was examined for their influence on credit prices. One hundred sixty-five observations were collected for which financial transaction data were available. These transactions represented credit purchases from a total of 44 mitigation banks or bank sub-areas in Louisiana, with nine of those located in the coastal zone. Coastal transactions accounted for 94 of the total observations and non-coastal transactions accounted for 51.

Descriptive analysis of the data indicates that credits sales from bottomland hardwood (BLH) banks accounted for 67% of the total habitat type of mitigation credits sold. The majority of credits came from restoration-based banks, which accounted for 73% of the transactions. This observation is consistent with the 1995 federal guidance which favors the establishment of restoration banks over less demanding forms of bank development (i.e., enhancement-based or preservation-based). Commercial developers accounted for more that half (54%) of the transactions observed in the study. A bimodal trend in credit prices was observed between coastal and non-coastal transactions. For the 10-year time span studied here (1997-2006), non-coastal credit prices remained relatively flat compared to coastal bank prices. Credits from non-coastal banks ranged from $3,000 to $10,000 per acre, increasing at an average annual rate of 11%. Coastal bank prices ranged from $4,000 to $20,000 and increased by a rate of 18% over the same period. Overall, the average annual price of a wetland mitigation credit has steadily increased over time, averaging just under $10,000 per acre in 2006. Despite the large number of banks in Louisiana, average credit prices in the state remain considerably low for the northern Gulf. Average prices in neighboring states range from 3½ to 7 times higher. Louisiana's low rural land values and/or the abundance of wetland area could be the basis for this difference.

Statistical analyses of the data were conducted using spatial econometric (SpaceStat) and numerical software (SAS). After multiple iterations, a suite of independent variables was identified as significant drivers of wetland mitigation credit price. Results from the two software packages were identical for the same combination of variables. Due to the lack of spatial autocorrelation, all subsequent analyses of the data were conducted by means of regression models developed in SAS. Elasticity calculations were developed for all significant, continuous variables. A stepwise procedure conducted *ex post* confirmed the initial combination of variables. That procedure and additional iterations produced an overall model with a total of 11 independent variables and an adjusted R^2 of .6948. Eight variables were significant determinants of wetland mitigation credit price. These variables were both consistent and inconsistent with their expected sign, as hypothesized by economic theory. As previously mentioned, time was found to be a significant driver of credit prices in all model iterations. Demand for credits—as proxied via parish population—was also found to be a positive driver. A supply-oriented variable—rural land value—also exhibited the expected positive relationship with credit price.

Two economic variables, however, were contrary to conventional economic theory regarding volume and competition. The size of a transaction—as depicted by total credits sold—had a positive effect on credit price. While this outcome does not indicate economies of scale, it could reflect a price segregation in which larger bundles of credits were sold to commercial clients at higher prices. Indeed, commercial clientele on average, purchased 60% more credits per transaction than other clientele and paid 30% more for each credit. Similarly, a variable representing competition by watershed had a counterintuitive effect on overall credit price. Logically, the greater the number of competitors in a market, the less pricing power should be exhibited. However, in this model, an increase in the number of mitigation banks in a watershed resulted in a higher credit price. This could be attributed to the infancy of the wetland mitigation banking industry and the fact that in many markets, demand remains much higher than supply.

Finally, spatial variables produced differing results with respect to their hypothesized influence on price. As predicted, as distance increases from the bank location to an urban area, price decreases. This relationship is confirmed by the influence of similar demand and supply variables on price, most notably population and land value. However, decreases in credit price also appear to occur as distance increases between the impact area and the location of the bank where credits are purchased. This result could be indicative of two constraints: lack of banks in a watershed or a lack of available credits within that watershed. Absent of these constraints, this trend could be indicative of lenient enforcement of the 1995 federal guidance and a potential disincentive to mitigate wetland losses within similar or adjacent habitats. Marginal effects indicated that these spatial variables were among the most influential drivers of credit price. The largest driver of price was transaction size (number of credits sold), which resulted in a 1.12% price increase for every percentage change in volume.

A bimodal trend in credit prices from the descriptive analysis indicated the possibility of separate markets for inland and coastal mitigation banks. To further examine this trend, transaction data were segregated into coastal and non-coastal sub-models for each market. The coastal market, which consists of only 10% (9 banks) of the total wetland mitigation banking market in Louisiana, services more than three quarters of the state's population. The disproportionate demand for credits from these banks creates a situation in which economic factors are the primary drivers of credit price. A submodel for coastal transactions (*n*=94) showed three significant and positive drivers of price: population, competition, and time. Conversely, non-coastal transactions were influenced more heavily by ecological variables related to habitat type. Two discrete variables—sales from bottomland hardwood banks (BLH) and sales from pine forest/savanna banks (PF/S)—both had a significant and negative influence on price. This result is logical in the case of BLH, which represented 67% of all transactions sampled. Indeed, BLH banks are the most prevalent bank type in Louisiana, accounting for 63% of all wetland mitigation credits sold during the last decade. However, the negative influence of PF/S on credit prices from non-coastal banks is less clear. This category of banks constitutes only 10% of the transaction data sampled and only 22% of all wetland mitigation credits sold in the state during the last decade (U.S. Army Corps of Engineers, 2007).

In summary, the research presented above provides a number of interesting findings that could be of value to prospective investors in Louisiana's wetland mitigation banking industry. Some of these findings are consistent with the expected economic relationships between supply and demand, while others are less intuitive. Clearly, the market for coastal banks appears to be the most lucrative; however, the higher risks of conducting business in the coastal zone could be a deterrent for potential investors. Furthermore, state and federal agencies in charge of authorizing mitigation banks have been increasingly hesitant to approve coastal banks due to these very risks. As expected, entrepreneurs would benefit from developing low-priced rural land adjacent to urban areas with high population. Surprisingly, the presence of other banks in a particular watershed does not necessarily infer that price competition will be problematic. Prospective bankers would also be well served by selecting projects for specific clientele. Selling large amounts of credits to commercial entities appears to be the most lucrative marketing strategy.

Limitations

As is the case with many forms of research, certain constraints limited the level of analysis possible within the study. In many cases, information from permit files was incomplete or organized in an inconsistent manner. For example, the permitee is required to provide location of the impact area; however, these data were often listed as street addresses, which required geo-coding into spatial coordinates. More precise coordinates for the impact area would have provided more relevant data (e.g., 20 observations were removed from the data due to insufficient locational information). For instance, if the impact were due to a pipeline, the area listed could stretch through four or five parishes. A center point for impact could not be chosen for this observation due to the variety of habitat impacted as well as the different mitigation bank purchases required for the one permit.

Differing requirements for documenting economic data also proved problematic in researching the permit files. Because it is not the agencies’ position to set or regulate credit prices, most bank sponsors and permitees do not include information on the quantity and value of credit transactions. This limitation is evidenced by the fact that of 616 files reviewed, only 165 (27%) contained sufficient economic data on credit transactions. For those files that did contain economic data, transaction information was often limited to a standard memo from the mitigation bank sponsor detailing the name of the permitee and the number of *acres* purchased. In most cases, wetland mitigation units were reported as acres (not credits) and thus the credit-to-acre ratio (i.e., trading ratio) was unclear. This limitation forced the interchangeable use of the terms *credit* and *acre* throughout the study.

Time limitations played a role in dictating the number of transactions collected. An effort was made to sample permits in a temporal and spatially objective manner. The inconsistent nature of the data recording process, however, made equitable sampling difficult.

In order to estimate the effect of a new mitigation bank's presence in a watershed, a total number of available credits from each bank in that watershed would be necessary. For this reason, the *competition* variable used in this study could not be fully quantified. Due to the large number of transactions and the lack of detailed economic reporting, it is impossible for state agencies to derive a current ledger for wetland mitigation credit sales.

Finally, the degree to which this study satisfies the conceptual requirements of a hedonic model remains in question. Principles brought about by Rosen (1974) suggest a two-step process in which market demand drivers are estimated and first-order conditions, or optimization equations**,** are used in conjunction with marginal prices in order to offset preferences and technology. The models presented here may be best described as simply a spatial-economic depiction of Louisiana's wetland mitigation banking industry.

Additional Research

It should be noted that the original proposal for this thesis called for a survey to characterize the economic, technological, and policy issues of the Louisiana wetland mitigation banking industry. That objective changed with prospect that permit files were indeed public information, and thus actual transaction data could be gathered. The prospect of collecting revealed, versus stated price data, caused the methods of this project to change. Nevertheless, there are numerous issues that a survey effort could address, and future surveying of the industry in Louisiana could prove beneficial to investors and regulators.

Louisiana's credit prices rank very low by regional and national standards. Additional research is needed to determine whether this pricing regime is sufficient, or poses a long-term threat to the economic viability of the industry in this state. One possible area of information that could be generated from an industry survey pertains to the cost structure of different banks and the degree to which future obligations and risk are embedded in the market price of credits.

From a policy standpoint, an inventory of current, available credits in a particular watershed in a given month would be beneficial. Development of such an inventory would allow for a more complete evaluation of the economic effects of competition on credit prices within a particular watershed. For example, current federal guidance—*if followed*—creates a monopoly situation for a single bank in a given watershed. However, examining the degree of monopoly power for a single mitigation bank requires more accurate tracking of available credits.

A map of available wetlands in a watershed coupled with an examination of the wetland loss rates might also yield valuable information related to wetland credit prices.

To some extent, this information is contained in the 20 hydrologic unit codes (HUC) delineated for Louisiana. Use of HUC data was not possible in this study due to a lack of detailed biophysical information that would allow for sufficient aggregation. An aggregated set of HUC data by habitat type would allow for a smaller, more manageable representation of these codes.

Finally, a more in-depth look into the number of mitigation banks in the coastal zone is greatly needed. With only nine banks currently authorized in this region, it is likely that a substantial portion of development impacts is being mitigated off site or not at all (i.e., in lieu of fees). Clearly, there is institutional hesitancy towards approving more coastal mitigation banks, however, the reasons behind this hesitancy are not fully understood. It is logical that agencies would proceed with caution because of the additional environmental risk in coastal areas (e.g., hurricanes, coastal land loss). However, in cases where acceptable lands are available (e.g., less vulnerable, higher elevation), should not such banks be encouraged? In short, would it be more beneficial for developers to purchase credits from a coastal mitigation bank with high risks but similar habitat—or to have them mitigate in non-coastal watersheds? The economic and environmental implications of alternative policies for mitigation banking in this region should be further examined.

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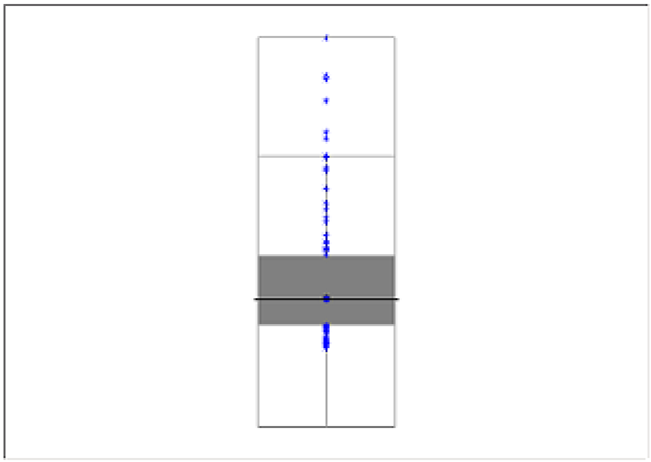
APPENDIX A: FUNCTIONAL FORM DETERMINATION

```
                 The TRANSREG Procedure
               Transformation Information
                  for BoxCox(AVGCO)

               Lambda     R-Square   Log Like
                -3.00       0.15     -996.45
               -2.75       0.15     -947.78
               -2.50       0.16     -900.77
               -2.25       0.16     -855.67
               -2.00       0.17     -812.80
               -1.75       0.17     -772.54
               -1.50       0.18     -735.35
               -1.25       0.19     -701.80
               -1.00       0.21     -672.67
               -0.75       0.23     -649.00
               -0.50       0.25     -632.30
                -0.25      0.27    -624.61 <
                0.00       0.27     -628.56
                0.25       0.27     -646.86
                0.50       0.24     -681.43
                0.75       0.21     -732.51
                1.00       0.17     -798.51
                1.25       0.13     -876.66
                1.50       0.10     -963.95
                1.75       0.08    -1057.80
                2.00       0.07    -1156.25
                2.25       0.06    -1257.97
                2.50       0.05    -1362.06
                2.75       0.04    -1467.91
                3.00       0.04    -1575.14

             < - Best Lambda
             * - Confidence Interval
             + - Convenient Lambda

    TRANSREG Univariate Algorithm Iteration History for BoxCox(AVGCO)

  Iteration    Average    Maximum              Criterion
    Number      Change     Change    R-Square      Change    Note

ƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒ
          1    0.00000    0.00000     0.26583              Converged

  Algorithm converged.
```

APPENDIX B: OUTLIERS IN DATASET (MORAN'S I)



Moran's I BoxPlot (outliers)

VITA

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