Economic Analysis of Habitat Conservation Banking in the United States

by

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ABSTRACT

The Endangered Species Act (ESA) is probably the most powerful environmental law ever enacted in the United States and is often portrayed as one of the most extreme forms of government intervention. Private landowners often avoid management activities that can potentially attract endangered species into their land and probably take actions to eliminate endangered species habitats. Several landowner incentive programs have been implemented by the U.S. Fish and Wildlife Service to encourage landowner to manage their land in ways that provide ecosystem services to promote the recovery of listed species.

Habitat conservation banking offers financial incentives to landowners in exchange for managing land in a way that provides habitat for endangered species. This feature of the market-based approach is generating specific price signals for entrepreneurs to get involved in solving environmental issues. The United States pioneered habitat conservation banking program and is recognized as a leader in implementing biodiversity offsets as a means to conserve endangered species. Few studies have evaluated the performance of habitat conservation banking market. However, most of those studies were conducted a decade ago, except recent survey by Department of Interior (DOI).

In the first chapter, we fill the gap by quantifying the number of total banks, conservation credit supply, sales, and analyze the trends and the characteristics of conservation banks. As of December 2015, we find 137 conservation banks conserving some 153,000 acres of land. Nearly, 519,540 conservation credits were generated from 137 banks. Based on 2,134 transactions record, some 71,365 credits were sold in last 21 years. About 66% of conservation credits were sold by private companies, and credit price ranges between $1,502 and $205,055 per credit. This chapter concludes that habitat conservation banking has become a business-based habitat planning system and that large urban areas tend to have the highest demand for conservation credits, and organizations in these urban areas are willing to pay the highest prices per credit.

The second chapter presents an econometric analysis of factors influencing demand and supply of the conservation credit. The results show that demand and supply coefficient estimates are statistically significant with expected signs and are inelastic to price, suggesting that conservation credit price changes are not likely to lead to significant changes in the quantity of credit demand. Inverse price and quantity relation show the actual distribution of price in the market. Furthermore, the results suggest that the marginal production of conservation credit is likely to increase over time with more land area allocated for conservation bank and likely to decrease with increased in land value.

The third chapter uses hedonics to explores the relationship between credit prices and the characteristics of credits. This approach allows an implicit price to be estimated for each covariate. Private bank ownership, species types, the number of listed endangered species, and time factors were significant predictors of credit price. These results should be useful for landowners, bankers, and investors interested in enhancing the marketability of their land and understanding the effect of management actions.

Chapter four assesses the habitat conservation banking project investment by examining the costs structure, revenue, and profitability of several conservation banks. We calculated the net present value of selected numbers of conservation bank located in California at the discount rates of 8%. Results show that the all eight selected conservation banks' NPV appears to be positive. Our findings suggest that the investment in habitat conservation banking is not only profitable but also yield high returns. Those landowners who may have been discouraged because of lack of knowledge and data and from the fear that presence of endangered species habitat in their land would result in a regulatory compliance can be reassured from our finding that habitat conservation banking can be a perspective market for financial incentives.

Finally, we conclude that habitat conservation banking is dynamic and has a monopolistic market structure or imperfect competition in certain areas. An advance econometric model that incorporates either the dynamic or oligopolistic aspects of the habitat conservation banking market, or both, seems to be a more promising prospect for future research.

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Banking Annual conference participates who provided me with valuable information on the habitat conservation banking market.

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CHAPTER I

GENERAL INTRODUCTION

1.1 Habitat conservation banking in the United States

The Endangered Species Act (ESA) 1973 represents an example of the uncertainty of social benefits with private costs (Smith and Shogren 2001). About 80% of listed endangered species have some sorts of habitat on private land (Brown and Shogren 1998; Innes, Polasky, and Tschirhart 1998) and landowners are concerned about the large private costs of complying with the ESA (Smith and Shogren 2001). Restricting the private property rights to protect an endangered species has been controversial with many private landowners. Since the list of threatened and endangered species continues to expand- from 114 in 1973 to over 1,523 in 2014, and as many as thousands of additional species waiting to be added to this list (Smith and Shogren 2001), the private cost of protecting these species is likely to increase. Hence, to protect endangered species and provide financial incentives for private landowners, policy makers and natural scientists have identified incentives based program such as habitat conservation banking.

Habitat conservation banking, a market-based policy instrument, is increasingly being identified as one potential policy approach for the conservation of endangered species on private land. Furthermore, it offers financial opportunities to landowners in exchange for managing land in a way that provides habitat for endangered and threatened wildlife species. The U.S Fish and Wildlife Service (USFWS) defines a conservation bank as "a permanently protected land that contains natural resource values, which are conserved and permanently managed for species that are endangered, threatened, candidates for listing as endangered or threatened, or are otherwise species -at-risk."

A conservation bank, once established, can generate credits which are considered as the only assets of the bank. Conservation credit is a science-based, consistent, and quantifiable metrics developed to measure ecological functions or services at the bank site and impact sites, and it is based on habitat quality, land conserved, and species involved (USFWS 2016). Credits are often expressed as a measure of area (e.g., an acre), a number of individuals of a particular species, habitat function, and other appropriate metric that can be consistently quantified (USFWS 2016). Once the number of credits has been verified and approved by the Service, they can be sold to the developers who can purchase credits to mitigate for adverse environmental impacts. Credits cannot be re-used, resold, and are not allowed to trade among developers.

Since the inception of habitat conservation banking program in 1995, the number of banks approved has increased to 148 (as of March 2017). Several studies conducted at a different time have reported the increased numbers of conservation banks and area of land conserved (e.g., Fox and Murcia 2005; DOI 2013; and DOI 2016). However, it is unclear how many conservation credits have been generated, transacted, and how many endangered species are involved. The annual trends, demand and supply, and cost-benefit analysis of habitat conservation banking program have not been systematically investigated, both at regional and national levels.

This dissertation research was conducted to analyze the trends of habitat conservation banking market and to identify the supply and demand factors associated with conservation credits. The specific objectives in this dissertation are to; (1) study the trends of habitat conservation banking; (2) analyze the demand and supply characteristics of the conservation credit market using two-stage least square techniques; (3) estimate the implicit prices for characteristics of habitat conservation credits; and (4) estimate the net present value of a selected numbers of conservation banks.

Understanding the features of conservation bank development can firstly be explained by the current trends analysis of habitat conservation banking market. Few scholars have assessed the habitat conservation banking program. Fox & Murcis (2005) have collected the information about the status of habitat conservation banking and evaluated the bankers' perspectives. Even though this research has provided some information about the trends of habitat conservation banking program, most of this status and trends were evaluated over a decade ago. Pawliczek & Sullivan (2011) conducted the online survey of those who were directly and indirectly associated with the species trading programs, and recently, Boisvert (2015) analyzed the institutional framework of habitat conservation banking mechanism. Having limited literature on the market status of habitat conservation banking program, Chapter 2 intends to fill in the gap by quantifying the total banks, conservation credit supply, sales, and by analyzing the trends and the characteristics of conservation banks.

The habitat conservation banking market is an under-investigated ecosystem service markets, and many questions remained unanswered. To evaluate the performance of habitat conservation banking market, Department of Interior (DOI) conducted a two-phase analysis. The first phase was conducted in 2013 which includes a review of relevant literature of habitat conservation banking program and recently in 2016, the second phase of the study was conducted which includes the results from the survey of conservation bank sponsors. These studies, however, focused on the perceptions and the experiences of bank sponsor or owners and intended to identify the issues and challenges in habitat conservation banking market. As of my knowledge, there is no known empirical evidence of the current market condition of habitat conservation banking.

In chapter 3, I attempted to answer the fundamental question: what determines the supply of and the demand for conservation credits? Chapter 3 develops the supply and the demand models for the conservation credit market using transaction data. The demand for credit varies among developers and is affected by the intensity, type, and location of mitigation requirement. Habitat conservation banking is a quantity based market structure induced by the government regulation. Even though the government regulation fixes the quantity, the price of credits can substantially vary across the regions, across endangered species and habitat type, between public and private bank, and other economic factors. Chapter 3 address these research questions.

In Chapter 4, I focus on the relationship causing differences in prices of conservation credits. A Hedonic pricing framework is applied to estimate the marginal changes in various attributes of conservation credit. Rosen (1974) used a two-step technique to estimate important characteristics involving a hedonic price equation. His model assumed that the price of a good is the function of the characteristics of a good and that the buyers and the sellers in a perfectly competitive market will reach a market equilibrium guided by the implicit prices of the good's characteristics. By using hedonic price function, it is possible to determine the implicit price for changes in each attribute (Tylor, 2003).

Chapter 5 is focused on estimating the net present value (NPV) of a select group of habitat conservation banks. Financial analysis of conservation banks is necessary and remains a key topic for ecological and economic decisions. The banks analyzed may not be representative of all banks, thus this analysis cannot be generalized. I addressed the gap by presenting evidence from the actual data reporting costs structures and revenue of conservation banks. The NPV is one of the most important criteria for choosing among investment projects and alternative land use and management decisions (Amacher, Ollikainen, and Koskela 2009; Conrad 2010; Bullard and Straka 2011; Zhang and Pearse 2011). This chapter presents the financial performance of a select group of habitat conservation banks that are currently under operation by calculating the present value cost, present value revenue, net present value, and benefit-cost ratio using different discount rates. Finally, Chapter 6 provides the overall conclusion of this dissertation.

CHAPTER II

TRENDS OF HABITAT CONSERVATION BANKING IN THE UNITED STATES

2.1 Introduction

The Endangered Species Act (ESA) is probably the most powerful environmental law ever enacted in the United States and is often portrayed as one of the most extreme forms of government intervention (Gardner & Jason 1998). It remains controversial because more than 80% or nearly 1,100 species of plants and animals listed as threatened or endangered rely at least partially on habitat on private lands (Wilcove et al. 1996; Gardner & Jason 1998). Private landowners often avoid management activities that can potentially attract endangered species into their land and probably take actions to eliminate endangered species habitats (Lueck & Michael 2003; Zhang 2004).

Several landowner incentive programs have been implemented to encourage landowners to manage their land in ways that conserve endangered species. One of these programs is habitat conservation banking. Facilitated by the legal requirements of no taking of endangered species of the ESA, habitat conservation banking offers financial opportunities to landowners who provide additional habitat for endangered species. Habitat conservation banking works as these landowners who provide additional endangered species habitat obtain endangered species conservation credits and sell them to potential buyers who are permitted under the Section 10 of ESA to conduct activities that may harm endangered species habitat and who are required to mitigate the loss of such habitat. The sites that provide additional endangered species habitat is termed a “conservation bank,” and the total conservation value within a conservation bank is quantified as its conservation credits.

The U.S. Fish and Wildlife Service (USFWS) quantifies the habitat's conservation values and approves the conservation credits within a bank, which vary by habitat types or management activities (USFWS 2003). As approved conservation credits from a bank are sold to potential buyers (who are often developers and who are required to offset their endangered species habitat degradation), an exchange of property rights takes place, and a price signal is generated. This is a unique feature of a market-based approach for solving an environmental issue-conservation of endangered species on private lands. The U.S. pioneered habitat conservation banking and is recognized as a leader in implementing biodiversity offsets as a means of conserving endangered species.

Few studies have assessed the habitat conservation banking programs at different levels. Vatn (2015) assessed the theoretical scrutiny of markets in environmental governance, and Boisvert (2015) analyzed the institutional framework of habitat conservation banking mechanism. Zhang (2016) provided insights on the forest-based payment for environmental services. Even though most research has focused on addressing whether the various tools would achieve conservation-development objectives (e.g., Bonnie 1999; Wilcove & Lee 2004; Ferraro et al. 2007; Drechsler & Watzold 2009; Wissel & Watzold 2010), little has been done to analyze the development and characteristics of habitat conservation banking program.

This study fills in the gap by quantifying the total banks, conservation credit supply, sales, and by analyzing the trends and the characteristics of conservation banks. The next section provides some background and the theoretical framework of market-based policy instrument, followed by research methods, data source, and trends of conservation bank development. The final section concludes with some discussion.

2.2 Background

2.2.1 Literature Review

In 1995, U.S. Fish and Wildlife Service released first policy defining species credit trading in California (Wheeler & Strock 1995). The first conservation bank was established in Carlsbad Highlands on the California coast North of San Diego in 1995 by Bank of America, federal, and state environmental regulators (Lawrence 2001). This was seen as a breakthrough model using a market-based mechanism to support conservation of endangered species (Lawrence 2001). By 2002, California had about 30 conservation banks (Fox & Murcia 2005). In 2003, the USFWS adopted the habitat conservation banking approach and released the federal guideline for the establishment, use, and operation of conservation banks.[1]

Habitat conservation banks can be established on publicly or privately owned lands (USFWS 2003). Suitable area for the establishment of such a bank is determined by the topographic features, habitat quality, compatibility of existing and future land use activities surrounding a bank and species available in the area. A conservation bank could be large enough to maintain a viable endangered species population within its boundaries or be situated in a strategic location that would add to an already established conserved area (USFWS 2003). Habitat conservation banking requires regional habitat conservation planning, and the ecological units must be small enough to include similar habitat and big enough to encompass a functioning market.

[1] USFWS guidelines provide the detailed description on conservation bank establishment, use, and operation.

Credits of a conservation bank can be generated using different assessment methods. A credit is a unit representing the ecological functions and/or services at a bank site and are often expressed as a measure of surface area (e.g., an acre), number of individuals or mating pairs of a particular species, habitat function (e.g., habitat suitability index), or other appropriate metric that can be consistently quantified (USFWS 2016). Some scholars questioned the effective measure of biodiversity values gained and lost (e.g., Santos et al. 2015) and called for an exchange unit (Wissel & Watzold 2010). Others (e.g., Bonnie 1999) pointed out that, including habitat quality, functions, and connectivity would increase the complexity of credit assessment.

Bonnie (1999) studied several endangered species programs and policies including Habitat Conservation Plan, Safe Harbor program, and species mitigation banking. He suggested that endangered species mitigation banking has the potential to resolve the conflict between endangered species habitat and private land management. He argued that landowners might be able to satisfy the ESA requirement far more inexpensively than under a habitat conservation plan by reducing time and transaction costs.

Wilcove & Lee (2004) examined three incentive-based programs, including Safe Harbor program, Environmental Defense Fund’s landowner conservation assistance program, and habitat conservation banking program. They concluded that landowners are willing to assist endangered species if it does not carry the risk of additional regulatory burdens and that the lack of knowledge on technical information and financial support had prevented landowners from participating in endangered species recovery efforts. Wilcove & Lee (2004) saw that the success of conservation bank depends on biological and economic contexts and that habitat conservation banking has been effective ecologically and financially. Bauer, Fox, & Bean (2004) studied landowners’ perspective and reported that the Hickory Pass Ranch Conservation Bank owners were willing to continue to keep their land in their family if they receive $5,000 per credit for the habitat of golden-cheeked warbler.

Fox & Nino-Murcia (2005) summarized the biological, financial, and political experience of habitat conservation banking program. They found that a majority of for-profit conservation banks was breaking even or making money and that the credit prices were in the range from $3,000 to $125,000 per acre across different species. They concluded that more information sharing and less bureaucratic delay could increase the number and size of conservation banks. Recently, Pawliczek & Sullivan (2011) shed some light on the ecological and economic pattern associated with habitat conservation banking in the U.S. They, too, reported increased numbers of conservation banks and bank area. They recommended that actual trade and credit prices data should be made available and published for the better understanding of habitat conservation banking market.

Often taken as an extension of wetland mitigation banking, habitat conservation banking, however, is different regarding legislative instruments, policy frameworks, and agencies in charge of implementation (Boisvert 2015). Hence, it is inappropriate to compare previous wetland mitigation banking studies with habitat conservation banking. The following sections give an overview of issues associated with habitat conservation banking program.

2.2.2 The logic and challenge of habitat conservation banking

Biodiversity conservation provides non-rival and non-excludable benefits (Zhang & Pearse 2011) and hence markets may not emerge on its own. Government regulations sometimes enable such markets to form. Habitat conservation banking is a market induced by a government regulation. It is a floor (regulation) and trade (market) system in which private landowners/ bankers are paid for creating or protecting habitat which is then used to offset the loss of endangered species on others' land. The economic benefits from habitat conservation banking are realized through the gains from trade.

Typically, regulators establish the standard for instrument design, implementation, enforcement, and monitoring of conservation credits (Figure 2.1). The buyers are developers whose development activities are required to comply with the ESA. Their objective is to minimize the cost of regulatory compliance. Developers will only trade with sellers (bankers) when the cost of self-mitigation is higher than the price of credits. Bankers, on the other hand, are suppliers who wish to create and sell credits from their land for profit opportunities. The banker's goal is to minimize the cost of credit production and thereby maximize their profit. However, some habitat conservation banks are operated by a non-profit organization, and generally, these non-profit firms are service and budget maximizer (Steinberg 1986).

Habitat conservation credits are a quantity-based policy instrument. If a quantity is fixed, as in the case of habitat conservation banking in which the level of habitat (the floor) is precisely limited, a range of potential cost outcomes are generated. A quantity-based instrument is fundamentally a property right-based instrument (Zhang 2016). Figure 2.2 shows the example of floor and trade regulation system using the case of a developer whose land has endangered species habitat and a landowner whose land may provide endangered species habitat. The vertical axis represents the cost of providing endangered species habitat, and the horizontal axis represents the level of habitat. As the marginal cost of the developer for providing habitat (M_A) is higher than that of the landowner (M_B) and as the developer is required to comply with ESA and provide Q* amount of habitat, he/she could pay the landowner to a price that is between P_A and P_B and induces the landowner to provide the required amount of habitat, Q*. In this way, he/she could release his responsibility for providing the required habitat. As long as his offered price is between P_A and P_B, both gain from this exchange of property rights. Thus, when information is complete (that is, both buyers and sellers know each other's marginal cost of providing the habitat) and this transaction occurs at no additional cost, habitat conservation banking achieves economic efficiency.

However, incomplete information is one of the major problems in the habitat conservation banking market. Information on the cost of individual bankers and the supply curve of conservation credit is not readily available. Bankers have private information on these supply prices and have local knowledge of their land on the likely ecological outcomes of certain actions, but do not know the opportunity cost of potential buyers. In habitat conservation banking, the outcome is under the control of the bankers who manage the conservation bank and incur a cost if they do not deliver the conservation credits. To reduce this cost and ensure delivery, the government offers bankers a two-part credit release, one which depends on actions (initial approval of credits), and one which depends on outcomes (final credit approval).

Finally, since the objective of habitat conservation banking is to provide entities with an alternative to meet their ESA compliance responsibilities, an obvious question is whether payments should be targeted at outcomes (more endangered species population and habitat, higher species density) rather than at the conservation and management actions which may lead to such outcomes. Outcome-based agreements are riskier for the bankers than action-based and may be more expensive for the regulators to monitor than management actions. On the other hand, outcome-based payments can be more efficient because bankers have better information on the best land for promoting target species population. Outcome-based payments encourage bankers to make use of their best area of land information to generate endangered species habitat more efficiently than payment for actions.

2.3 Methods

We collected data on conservation banks in the U.S. by retrieving data in Regulatory In-Lieu Fee Banking Information System (RIBITS). RIBITS is a web-based system that tracks third-party compensatory mitigation program, initially designed by the U.S. Army Corp of Engineering's Engineering Research Development Center and the Applied Research Associates under the Corp's Wetland Regulatory Assistant Program with support from the United States Environmental Protection Agency (Martin & Brumbaugh 2011). Price and cost information was mostly obtained by communicating, networking, and surveying the bankers, regulators, and consultants. Additional price and cost information was retrieved by reviewing the habitat conservation banking case studies, publicly available documents, and previous literature on endangered species habitat conservation banking in the U.S. (Table 2.1).

2.3.1 Data Source

As of December 2014, there was no any data source that had a complete list of conservation banks and their detail contact information. Additionally, credit transaction is a bilateral negotiation, and hence, most private banks do not want to disclose their price information. In May-August 2015, we started to manually compile the information from four different sources: USFWS, National Mitigation Banking Association, RIBITS, and web page "www.speciesbanking.com." Freedom of Information Act (FOIA) allows to request the information that is not publicly available. FOI was requested with Department of Interior, U.S Fish and Wildlife Service in October, 2015 seeking for the name and address of the contact person of the organization or firms that have made the purchase of conservation bank credits, the name of the bank and bank sponsor from which the credits were purchased, and the contact information of the firms that served as the agents in the transactions of conservation bank credits.

The total of 35 bankers/consultants/buyers contact details were obtained from the documents provided by USFWS.

In December 2008, Ecosystem Marketplace launched a platform by establishing website- www.speciesbanking.com to streamline the mitigation process and to reduce transaction costs (Pawliczek & Sullivan 2011). Pawliczek & Sullivan (2011) used this data source to analyze the species banking industry in the United States. However, their study was only able to obtain the survey response from 7 conservation banks out of total 91 banks. We used the same data source and were able to obtain detail contact information of 38 bankers/bank owners from the webpage: www.speciesbanking.com.

The National Mitigation Banking Association (NMBA) was established in 1998 that bring together leaders who are involved and committed to restoring and conserving wetland and endangered species habitat[2]. The total of 441 detail contact information of bankers, developers, consultants, investors, and regulators was obtained from the National Wetland and Ecosystem Banking Annual Conference 2016 Conference participate list. Similarly, twenty-seven buyer's information was retrieved from the documents upload by the bankers in RIBITS.

After analyzing the total 541 contacts information, we selected 315 individuals (total population) for the mail survey. Formal statistical methods can only be used for designing survey samples where there is adequate prior knowledge about the total population level. The objective of the survey was to obtain as many transaction records as possible and hence, does not intend to capture the range of different variables and their associated distributions and characteristics. The question was oriented to obtain the detail transaction information or records only. Thirteen (4%

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[2] http://mitigationbanking.org/index.php/about/

of total) mail survey bounced back (USPS reported as incorrect address or address does not exist). Twenty-nine mail survey were returned (9.20% of total), 37 responded back via email (11.74% of total), and three individuals responded back via phone (0.95% of total). Overall the response rate of the survey was (21.90% of total). Several non-response follow-up attempts were made through email and phone, and found that the bankers do not wish to share their credit pricing information.

Twenty-four transactions information were obtained from returned mail survey. These 24 transactions were from 4 different banks. Twelve transactions records were obtained from email response which includes one conservation bank. J. Whalen Associates, Inc provided 201 transaction record, City of Escondido provided 212 transaction records, and 140 transaction records were obtained from Eco-Asset Solutions and Innovations. Overall, we were able to obtain 589 transaction records which represent about 27.6% of the total transaction.

2.4 Results

As of December 2015, there were 137 conservation banks, which are 61 more than those in 2003 as reported by Fox and Murcia (2005) and there were 2,134 transactions records, which included credit availability, credit sold, acres of land area, and bank approved. Transactions data with price information were provided by bankers and environmental consultants. Data on bank characteristics including type, location, species and habitat type, total credit supply, total credits sold, and credit prices were assembled. The trends and some key characteristics are reported below.

2.4.1 Region

Figure 2.3 shows the distribution of conservation banks by the U.S. states. As of December 2015, California had 108 banks (79% of total banks) followed by Florida with 8 and

Texas with 6. These banks conserved about 153,000 acres of land. A cumulative total of 519,536 credits were in the process of getting approval or available from these 137 banks. Cumulatively, almost 71% of credits sold are in California, followed by Florida with 23% of credits. Within California, Los Angeles and Sacramento have sold 35% and 34% of conservation credits, respectively. Sacramento has total 42 conservation banks that conserve about 23,268 acres of land. Los Angles has 17 conservation banks with total 13,541.61 acres of land conserved. Regarding transactions, Sacramento and Los Angles had about 24,541 and 25,011 credits in 994 and 778 transactions, respectively. On the supply side, about 51% of credits were available in California, followed by Florida with about 41%. A large number of credit sales in these areas are associated with the large number of mitigated and permitted project entities which includes retail developments, oil and gas exploration, housing developers, utility companies, and government agencies.

2.4.2 Ownership

Table 2.2 shows the species conservation credits sales by bank ownership type. About 66% of credits sold were from the private companies (such as the Wildlands, Alton Preserve, Westervelt Ecological Services) that own/manage about 73 conservation banks in total. These banks conserved about 91,148 acres of land (about 60% of total land under conservation banks). Individuals or landowners own about 30% of conservation credits sales from seven different banks located in Portland, Oregon and Los Angeles. Public and private partnerships own/manage six banks. Three banks are public, and one is a private non-profit bank.

Cumulatively, about 63% of credit sales were from three individual banks. Rancho San Miguel Conservation Bank owned by the private company (Emerald Properties) in San Diego, California, has sold about 29% (20,365 credits) of total conservation credits in 28 different transactions. This is followed by Florida Panther Conservation Bank with about 17.5% (11,973) conservation credits and located in the Southern U.S. Cosumnes Floodplain Conservation Bank has sold about 17% (11,841) of total credits in 89 different transactions as well.

2.4.3 Species credit availability and sales

Table 2.3 shows the annual conservation credit available and credit sold from 1995 to 2014 and the annual pattern in logarithmic scale is provided in Figure 2.4. Credits availability sharply rose from 2007 to 2010 where almost 207,564 credits (about 40% of the cumulative total number of credits) were approved for sale in 2009. As of December 2015, we found that 2,134 transactions were associated with a total of 71,365 credits, averaging about 33.45 credits per transaction. Even though substantial amounts of conservation credits were available, sales of credits were considerably low (Figure 2.4). The annual demand for credits increased until 2008. The annual fluctuations in demand for credits were observed between 2009 to 2014 (Figure 2.4).

The annual number of transactions is shown in Figure 2.5. The numbers of transactions in 2000 were 20,571 credits, 11,454 credits in 2008, and 9,762 credits in 2012. The average number of credits per transaction was highest in 2000 (306.5 credits), followed by in 2012 (81 credits). The overall average credit sales per transaction were 32.2. These fluctuations may have been influenced by the expectations of changes in program and policies (such as the preparation and process of releasing the guidelines for the conservation banking by Fish and Wildlife Service, 2003 and 2008 Recovery Crediting Guidance).

Endangered species credits were sold under different species credit classification. Species credit classification, in habitat conservation banking, means the bundling and stacking of various endangered animals, plants, and habitats. These species credit classifications are either stacking (for example Florida Panther credit) or bundling (for example combined credit of Florida Panther with woodstork value). Table 2.4 shows the top ten species credits availability in the market. Almost 36% of species credits available are of Florida Panther. Most traded conservation credits by species types are also reported in Table 2.4. Florida Panther was the highest selling species with 16,149 credits (22.6%), followed by Longhorn Beetle with 5,623 credits (7.8%). Other highest selling species includes: Golden-Cheeked Warbler (5.45%), San Joaquin Kit Fox (2.44%), Giant Garter Snake (1.57%), California Adolphia (1.04%), and all other different species shared almost 59% of total species credits sold.

2.4.4 Trends in credit price

Credits price information were obtained from 599 transactions (about 27.8% of total transactions) records that have been achieved from anecdotal observations and hence, may not be generalizable beyond the sample. Most of these transaction records are from two states-California and Florida. Cumulatively, about $50.4 million revenue (2015 $ value) was generated from 1,977 credits sales between 1995 to 2015. Twenty-eight different species credits were traded in those credit transactions. The average total cost obtained from the 61 different conservation banks was about $30.4 million (2015$), averaging almost $0.50 million per bank. These costs only include startup cost of construction and annual operation cost and do not include land acquisition and opportunity cost. The total revenue and the total cost could be higher than our estimates. Revenue and cost data were obtained from 43 and 61 different banks respectively and represented less than 50% of total banks. This information is not likely to be representative of the remaining bank. As of December 2015, and based on 2,134 transaction records obtained from RIBITS, only 14% of total credits that were available were sold in last 21 years.

Figure 2.6 shows the annual average cost and revenue of conservation banks. The yearly average credit price per acres is provided in Figure 2.7. The range of credit price across different species varied between $1,505 to $205,055 per credit. Average credit price in constant terms (2015$ value) was increasing from 2005 with highest in 2012, followed by decreasing trends with lowest in 2014. Table 2.6 shows the variation in the price of conservation credits across different species. The California Tiger Salamander has generated overall $16 million (2015$ value) in revenue from the sale of total 222 conservation credits over 20 years. In 2009, California Tiger Salamander alone had generated highest revenue of about $11 million (2015$) from 154 credits sales. Multi-species credits (bundling) have generated the total of $27.8 million (2015$) revenue from 755.12 credit sales. Burke's Goldfields, a rare species of flowering plant and listed endangered species on the federal level and state level in California, has the highest credit price of $205,055 per credit. The second largest is Vernal Pool Habitat with credit price of $110,086 per credit, followed by California Tiger Salamander with $72,404 per credit. Other endangered animal species with the high credit price include Florida Panther ($1,502/credit), Giant Garter Snake ($24,786/credit), San Joaquin Kit Fox ($7,950/credit), and Swainson's Hawk ($8,286/credit). The credit price of the same species from the same bank can also vary across different buyers.

2.5 Discussion and conclusion

Habitat conservation banking is a means for achieving the conservation outcome and financial incentives for the landowners. Since the release of the USFWS guidelines in 2003, the area of land under conservation banks increased by almost 113,512 acres (288%), suggesting that the interest of landowners, entrepreneurs, and investors are growing in the habitat conservation banking market. This increasing interest is likely to grow in future due to the potential demand for habitat conservation credits induced by the proposed programs and policy process, such as the development of mitigation framework for Greater Sage-Grouse Conservation, proposed revisions to the USFWS Mitigation Policy 1981, and proposed revisions to USFWS 2003 "Guidance for the Establishment, Use, and Operation of Conservation Banks". These policy revisions likely change the habitat conservation banking market conditions. Recently, the USFWS released the ESA Compensatory Mitigation Policy (81 FR 95316) which shift the focus from project-by-project to landscape-scale approaches in planning and implementing compensatory mitigation and replaces both the 2003 and 2008 Service guidance documents (USFWS 2017)[3]. This policy also allows establishing mitigation projects for the candidate and other at-risk species. These changes can expand the regional conservation credit market for listed as well as candidate species.

The policy process involves a diverse group of stakeholders such as Bureau of Land Management, USFWS, states, tribes, local government, industry and investors, and hence, it is important to ensure the long-term commitments of mitigation policies to help reduce the risk of investment in habitat conservation banking. A recent survey found that most of the bank sponsors (61%) support changes to the 2003 habitat conservation banking guidance and called for a revision of habitat conservation banking regulations (DOI 2016). These bank sponsors were concerned about the issues of maintaining uniform and consistent metrics, shortening the bank approval process timelines, requiring financial assurances, and lowering the cost of banking entitlements. Recently released the ESA Compensatory Mitigation Policy (81 FR 95316) is expected to address the issues.

[3] When this study was conducted, ESA Compensatory Mitigation Policy (81 FR 95316) was not released.

Credit availability, increased area of land, and increased number of species involved in habitat conservation banking indicate the positive conservation effort or action for endangered species from the ecological perspective. However, in terms of economic aspects, the conservation credits demand was less compared to credit supply in the market. Such lack of demand could be closely linked to higher credit price and/or cost efficient permittee responsible self-mitigation project and/or reduced level of economic activities. Even though, time to permit for permittee-responsible off-site mitigation (237 days) and permittee responsible on-site mitigation (179 days) were higher than purchasing credits from mitigation banks (121 days) (Birnie, 2016), and that these waiting time increase the cost for the developers, less demand for credit suggest that the credit price in market is higher than the cost of performing self-mitigation projects.

Economic activity, especially associated with projects such as housing and commercial developments, transport projects, gas and oil exploration/development, and public infrastructure projects influences the demand for credits. Birnie (2016) reported that based on 2012 to 2015 data, transportation sector shared 35% of wetland impacted and 30% of stream impacted. Similarly, commercial, residential, and industrial development shared 38% of wetland impacted and 19% of stream impacted. Since wetlands and streams are intimately related to endangered species and their habitat, these industrial sectors likely influences the habitat conservation banking market. The large states like California and Florida have the greater number of credits sale. These states ranked first and fourth respectively regarding infrastructures related employments (Bureau of Labor Statistics, 2012), an indicator of the development activities in the area. Both states ranked first and second in gross domestic product (Bureau of Economic

Analysis, 2015)[4] and embrace strong commitments to environmental stewardship, active presence of environmental and conservation organizations, and state endangered species legislation.

State endangered species legislation (for example in California) can be more restrictive than federal and can be applied to more species. In 2012, the California legislature enacted California Fish and Game Code[5], section 1797-1799.1 to govern fees to fund bank review at the state level and this statute requires California Department of Fish and Wildlife (CDFW) to create and maintain a database and annually report to the Legislature on the status of the banking program. Similarly, conservation banks can be used to compensate for impacts to state regulated resources such as CA Environmental Quality Act, CA Lake and Streambed Alternation program, CA Endangered Species and these regulations provide benefits to conservation credit market for resources not regulated at federal levels, that is species listed by California only. Florida also has mitigation bank statute and authorizes mitigation banks by state permit which allows credit market for resources impact unregulated by federal levels.

Our results show that ecological services companies have a strong hold in the habitat conservation banking market compared to individual landowners. This could be because of large establishment and transaction cost for the individual landowners (Personal communication with

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4 https://www.bea.gov/iTable/drilldown.cfm?reqid=70&stepnum=11&AreaTypeKeyGdp=5&GeoFipsGdp=XX&ClassKeyGdp=NAICS&ComponentKey=200&IndustryKey=1&YearGdp=2015Q2&YearGdpBegin=-1&YearGdpEnd=-1&UnitOfMeasureKeyGdp=Levels&RankKeyGdp=1&Drill=1&nRange=5

5 https://leginfo.legislature.ca.gov/faces/codes_displayText.xhtml?lawCode=FGC&division=2.&title=&part=&chapter=7.9.&article=

individual bank owner, February 2016). Landowners are required to bear costs associated with biological surveys, attorney fees, engineers, monitoring, and documentation. Furthermore, time-consuming and frustrating documentation requirements, local level political issues, and lack of information about habitat conservation banking market and price have discouraged individual landowners to involve in habitat conservation banking. Those involved in habitat conservation banking market, more than half of the managers who responded to the Department of Interior survey, had not participated in conservation bank training, and that almost 71% of the bank manager have very limited information on the USFWS habitat conservation banking guidance (DOI, 2016). This finding indicates the need for educational and training programs for landowners and conservation bank managers about the guidance and potential regulatory changes.

There is an encouraging financial incentive for private companies or entrepreneurs to adopt habitat conservation banking into their forest/land management plans. The achievement of habitat conservation banking program is demonstrated by the increase in acres of land conserved and species involved over the years. However, analyzing ecological success need further evaluation. Since the landowners are often unsure of the opportunities, cost and benefits of habitat conservation banking program, landowner assistant or educational program are necessary to inform current market status and financial incentives for endangered species habitat conservation. Furthermore, bank managers training programs are required for efficient habitat conservation program outcome. Finally, more work will be needed to broaden the applicability of these findings, and empirical analysis is needed to assess the dynamics of supply and demand for conservation credit market.

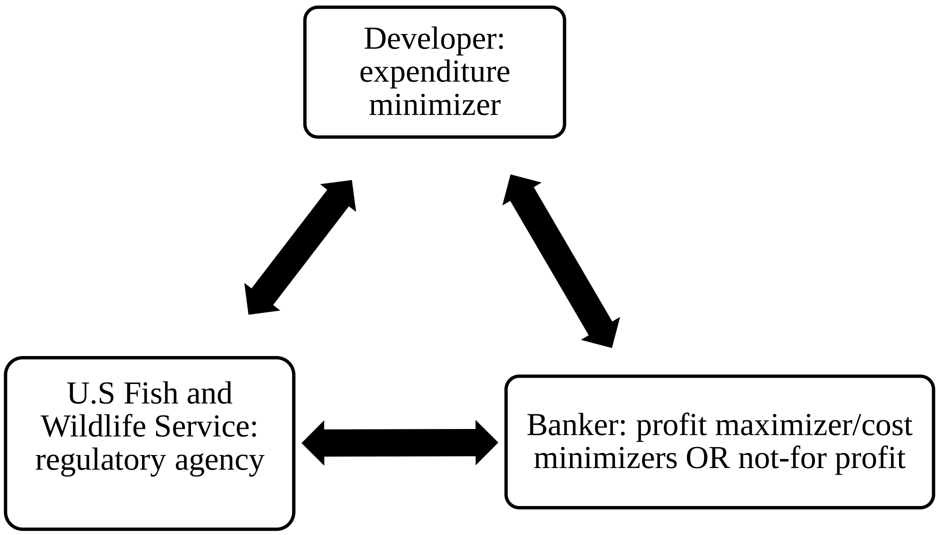


Figure 2.1 Relationship among the regulator, developer, and banker in habitat conservation banking program

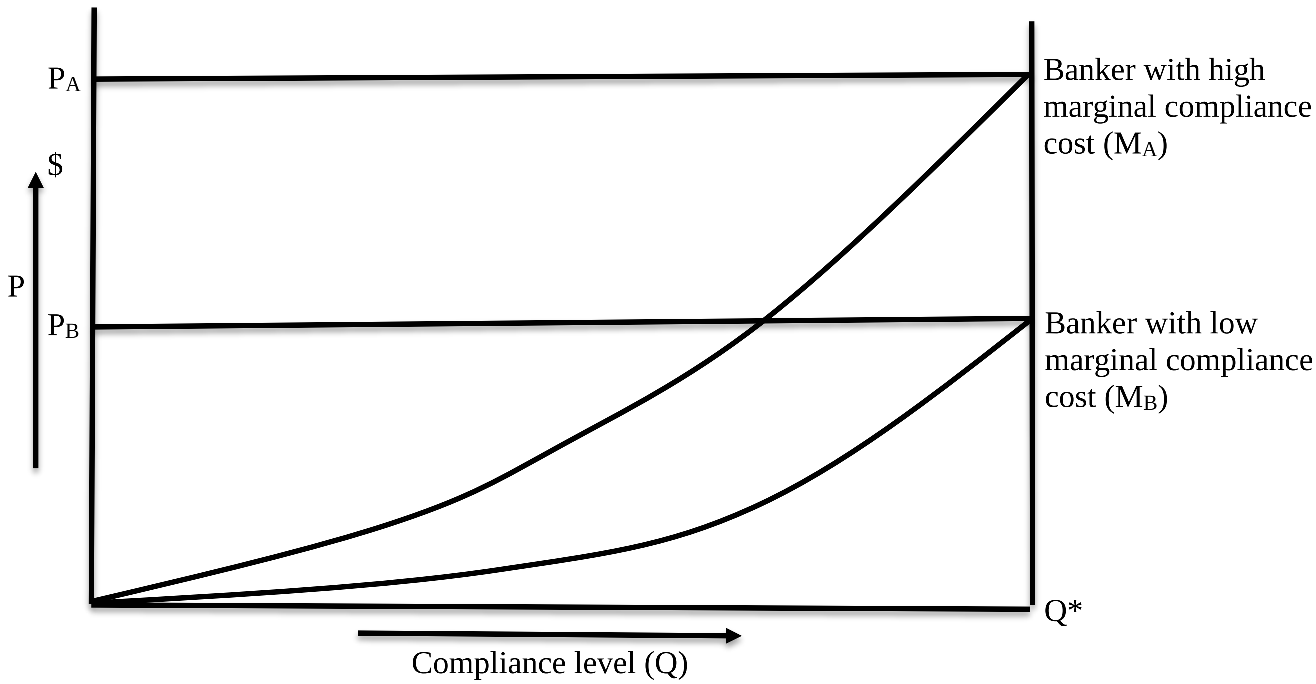
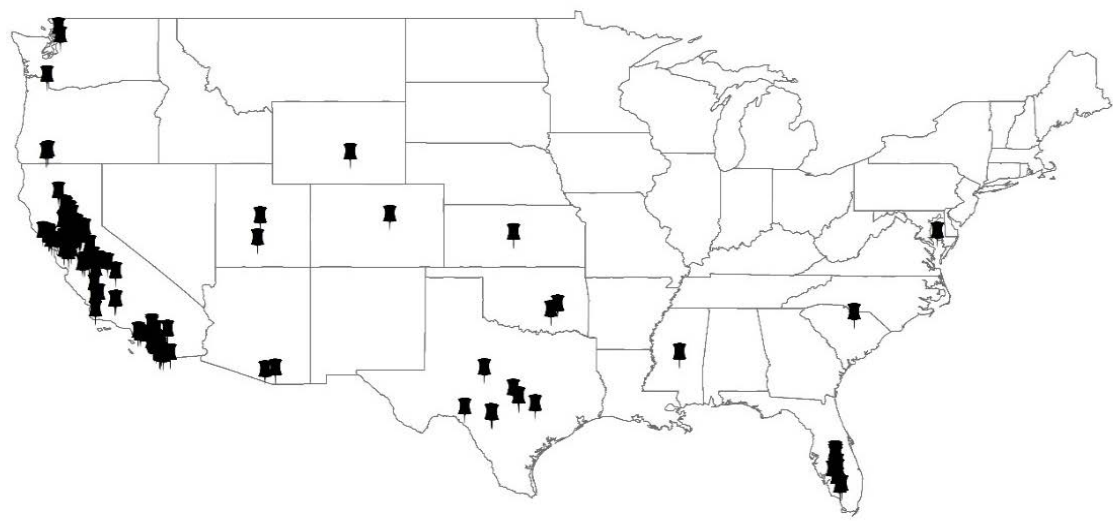
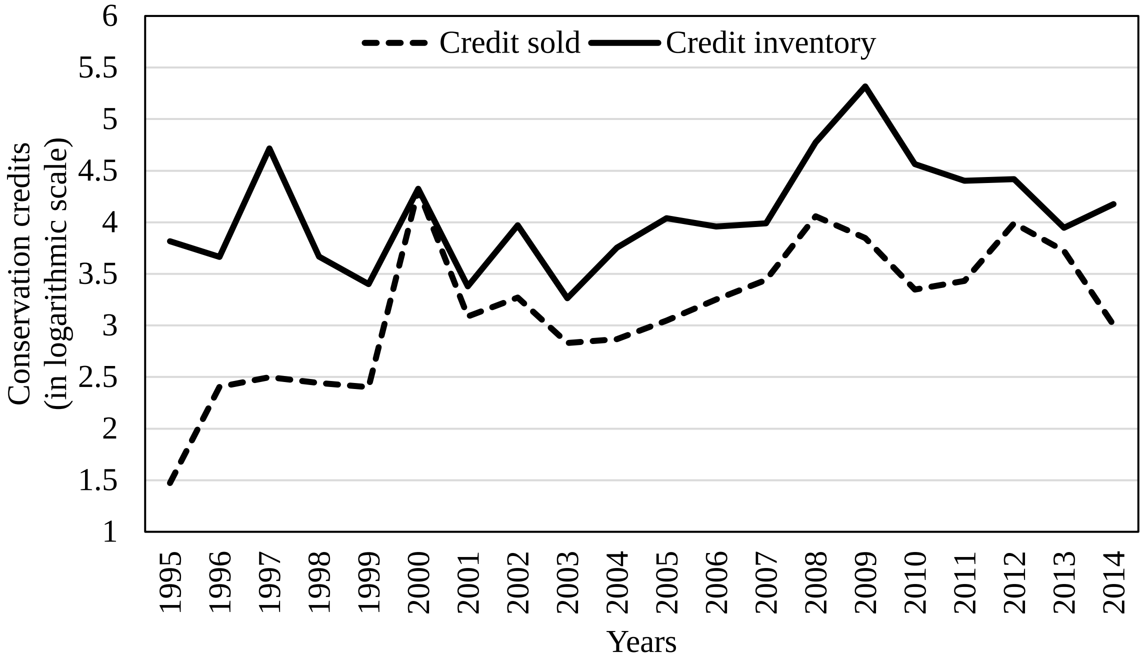


Figure 2.2 Floor and trade system of conservation credits with two bankers (A and B)



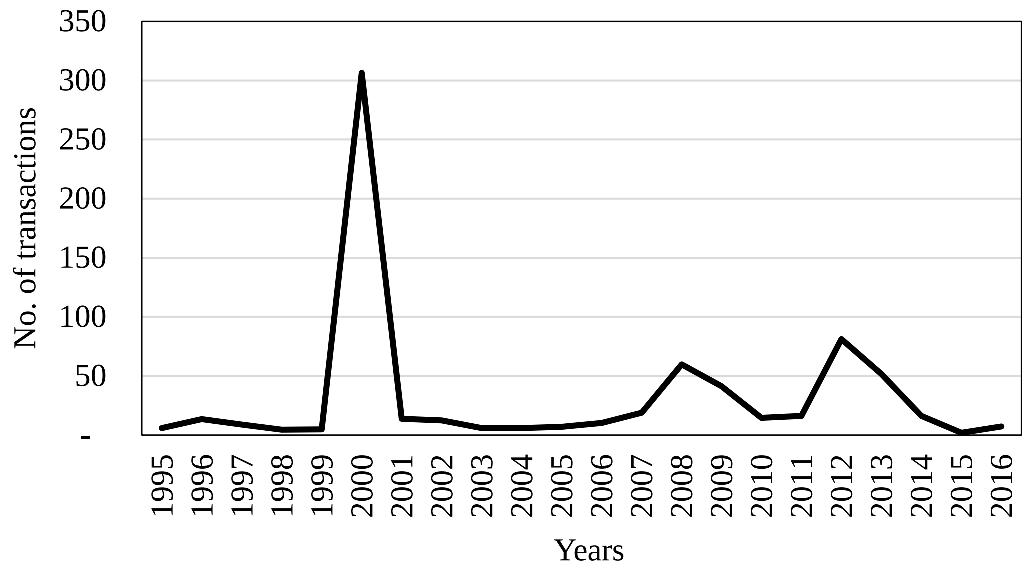
Banks by U.S. states: CA (108), FL (8), TX (6), OR (3), AL (2),
OK (2) UT (2), AZ (1), CO (1), MD (1), SC (1), WA (1), VA (1)

Figure 2.3 Total number of conservation banks across the different U.S. states, as of December 2015



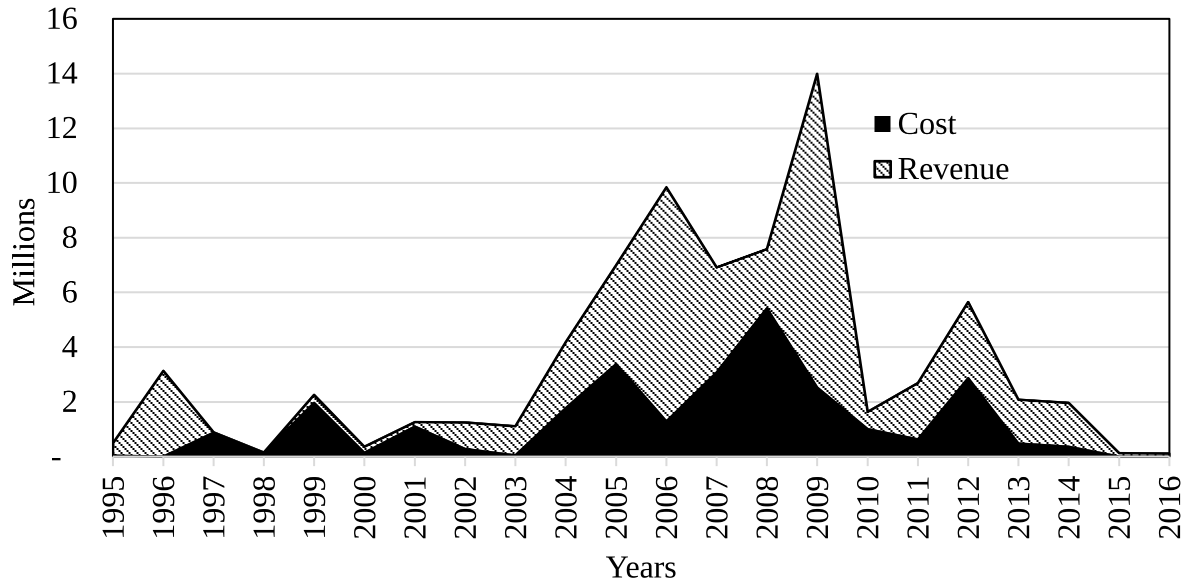
*Total number of credit sold and credit supply are based on data retrieved from RIBITS as of December 2015

Figure 2.4 Annual trend of conservation credit supply and credit sold



*Total number of transactions are based on data retrieved from RIBITS as of December 2015

Figure 2.5 Annual number of conservation credit transactions



*Annual average cost data were obtained from 61 banks. This cost information was reported in the documents upload by banks in the RIBITS and only includes initial establishment and annual operational cost. Revenue data were obtained from 43 banks retrieved from the transaction records. Both cost and revenue are in 2015$.

Figure 2.6 Annual average establishment and operating cost and annual revenue from conservation credit sales

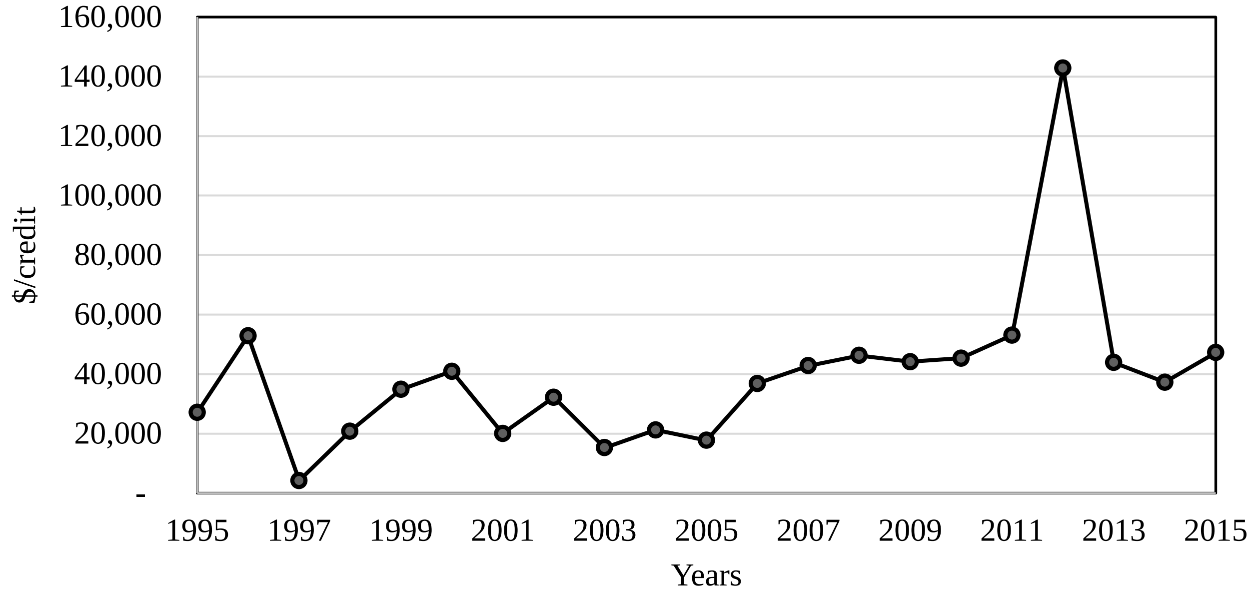


Figure 2.7 Annual average credit price in constant terms (2015$ value) for 43 banks

Table 2.1 Price of habitat conservation credit (previous studies)

Study	State	Credit price $/acre (unless otherwise specified)	Species
Fox and Nino-Murcia 2005	National	$3,000/ac-$125,000/ac	San Joaquin Kit Fox- Breeding pair of least Bell's Vireo
Bauer, Fox, and Bean 2004	TX	$5,000/credit	Golden-Cheeked Warbler
Madsen et al. 2010	TX	$5,000-$5,500	Black-capped vireo
Madsen et al. 2010	TX	$10,000	Bone Cave Harvestman and Coffin Cave Mold Beetle
Madsen et al. 2010	TX	$400,000	Bone Cave Harvestman and Coffin Cave Mold Beetle
Madsen et al. 2010	CA	$5,000-$15,000	Burrowing owl
Madsen et al. 2010	CA	$15,000-$90,000	California red legged frog
Madsen et al. 2010	CA	$4,500-$15,000	California tiger salamander
Madsen et al. 2010	CA	$8,000-$15,000	Chaparral
Madsen et al. 2010	CA	$15,000-$25,000	Coastal sage
Madsen et al. 2010	CA	$100,000-$150,000	Delhi sands flower-loving fly
Madsen et al. 2010	CA	$100,000-$150,000	Delta smelt/native fisheries
Madsen et al. 2010	CA	$150,000-$300,000	Fairy shrimp
Madsen et al. 2010	CA	$30,000 - $45,000	Giant garter snake
Madsen et al. 2010	TX	$2,750-$7,000	Golden-cheeked warbler
Madsen et al. 2010	SE US	$1,500 - $3,000	Gopher tortoise (relocation)
Madsen et al. 2010	SE US	$12,000 - $20,000	Gopher tortoise
Madsen et al. 2010	CA	$125,000	Least vireo breeding pair
Madsen et al. 2010	CA	$80,000-$120,000	Salmonids
Madsen et al. 2010	CA	$326,700	Sandhills habitat
Madsen et al. 2010	CA	$2,500-$15,000	San Joaquin kit fox
Madsen et al. 2010	CA	$5,000-$25,000	Swainson's Hawk
Madsen et al. 2010	UT	$1,836	Utah prairie dog
Madsen et al. 2010	CA	$3,500	Valley elderberry longhorn beetle
Madsen et al. 2010	CA	$50,000-$325,000	Vernal pool (preservation)

Table 2.2 Species conservation credit sales by bank ownership type (1995-2014)

Bank ownership type	Number of banks	Total number of credits sold	Percentage of total
Combination public/private	5	1,888.01	2.65
Private bank	73	47,127.07	66.04
Non-profit	1	17.00	0.02
Public bank	1	805.00	1.13
Single-client	7	21,528.03	30.17
Total	87	71,365.11	100.00

Data source: RIBITS, retrieved on December 2015

Table 2.3 Annual conservation credit supply and credit sold

Year	Number of credits sold	Percentage of total sold	Total annual credit supply	Percentage of total supply
1995	29.70	0.04	6,562.04	1.26
1996	254.70	0.36	4,612.55	0.88
1997	314.88	0.44	51,963.55	10.00
1998	276.62	0.39	4,652.60	0.89
1999	252.82	0.35	2,510.25	0.48
2000	20,571.36	28.83	21,163.21	4.07
2001	1,220.74	1.71	2,400.11	0.46
2002	1,867.49	2.62	9,394.48	1.80
2003	678.06	0.95	1,836.32	0.35
2004	735.77	1.03	5,670.82	1.09
2005	1,117.12	1.57	10,942.89	2.10
2006	1,790.41	2.51	9,095.84	1.75
2007	2,759.99	3.87	9,745.84	1.87
2008	11,453.65	16.05	59,756.59	11.50
2009	7,042.96	9.87	207,564.75	39.95
2010	2,227.86	3.12	36,508.46	7.027
2011	2,695.36	3.78	25,217.14	4.85
2012	9,761.61	13.68	26,145.20	5.03
2013	5,303.24	7.43	8,840.99	1.70
2014	1,010.77	1.42	14,952.56	2.87
Total	71,365.11	100.00	519,536.20	100

Data source: RIBITS, retrieved on December 2015

Table 2.4 Top ten species conservation credit supply and highest selling species credit

Species	Total credits available	Percentage of total available	Total credits sold[1]	Percentage of total sold
Florida Panther	186,799.58	35.96	16,149	22.63
Shaded Riverine Aquatic Re-establishment for ESA offsets	89,492.00	17.23	-	-
Otay Tarplant	60,000.00	11.55	-	-
Florida Panther with woodstork value	22,350.30	4.30	-	-
Valley elderberry longhorn beetle	20,689.61	3.98	5,623	7.88
Golden-cheeked warbler	19,893.00	3.83	3,888	5.45
Shaded Riverine Aquatic Preservation for ESA offsets	18,291.00	3.52	-	-
Chinook Salmon	10,500.00	2.02	-	-
Coastal Sage Scrub	8,115.38	1.56	-	-
San Joaquin Kit Fox	7,158.75	1.38	1,739	2.44
Giant garter snake	-	-	1,124	1.57
California Adolphia	-	-	745	1.04
All other species*	76,246.59	14.68	42,098	58.99
Total	519,536.20	100.00	71,365	100.00

Data source: RIBITS, retrieved on December 2015

[1]Column shows the six highest selling species conservation credit

*All other species includes the combination of different species (multispecies)

Table 2.5 Price of species/habitat conservation credits over the period of 1995 to 2015

Species	Sum of total price (2015$)	Number of credits sold	Average price per credit
Burke's Goldfields	539,294	3	205,055
California Tiger Salamander	16,048,282	222	72,404
CFWO MSCP Tier I	27,890,733	755	36,935
Coast Live Oak Woodland	598,418	25	23,616
Coastal Sage/Chaparral Scrub	6,698,848	368	18,187
Engelman Oak Woodland	173,519	7	23,354
Florida Panther	46,150	31	1,502
Giant Garter Snake	1,748,164	71	24,786
Lakeside Ceanothus	36,132	1	36,132
Non-native grassland	4,053,578	211	19,224
San Joaquin Kit Fox	1,400,281	176	7,950
Swainson's Hawk	8,534	1	8,286
Vernal Pool Fairy Shrimp	481,812	14	35,498
Vernal Pool habitat	9,838,830	103	110,086
Water dependent habitat	192,208	7	27,458
Total	69,754,781	1,981	35,217

Data Source: Based on 599 transaction data

CHAPTER III

ESTIMATING DEMAND AND SUPPLY OF HABITAT CONSERVATION BANKING MARKET

3.1 Introduction

The value of a habitat conservation bank depends on the present value of the stream of net revenue associated with the bank. The demand for credits varies across potential purchasers and is affected by the intensity, type, and location of mitigation requirements. While the demand for credits (quantity) is persuaded by the government regulation, the unit price of a credit can substantially vary across the regions (e.g., states), across endangered species and habitat type (e.g., animal, plant), between bank type (public and private), and other economic factors (e.g., construction activities, land value). The equilibrium price of credit is determined by the interaction between demanders (developers or others who need to offset the adverse environmental impacts of development activities) and suppliers (bankers who generate conservation credits by establishing the conservation bank for endangered species habitat). Furthermore, some of the factors that may play a role in determining credit prices include the land value of the conservation bank area, the acreage of land area, costs associated with the production of credits, government regulation, and market forces.

Typically, regulatory agencies limit the purchase of the credits to the banks located in the same ecological regions where development activities occur. Some areas might not have any banks. In such case, bankers may engage in monopolistic pricing behavior, developers may perform own mitigation requirements, and developer may delay or change their development activities. On the other hand, an ecological region in which there is high demand for credits will attract additional banks, which could undercut efforts to set monopolistic prices. Also, small ecological regions may not contain suitable land area to develop conservation banks which in turn increase the demand for the land with potential of endangered species habitat.

Previous studies of habitat conservation banks include Bonnie, 1999; Wilcove & Lee, 2003; Ferraro et al., 2007; Drechsler & Watzold, 2008; Wissel & Watzold, 2008; Vatn, 2014; and Boisvert, 2015. Apart from few studies (e.g., Fox & Murcis, 2005; Wilcove & Lee, 2004; Pawliczek & Sullivan, 2011), there have been no empirical studies on the market for habitat conservation credits. The purpose of this chapter is to address the fundamental questions about habitat conservation banking, such as: "What factors determine the supply of and the demand for conservation credits? How does the price vary across different species types?" To help understand the market structure for habitat conservation credits and to analyze the effects of various economic and ecological factors, this chapter develops an empirical supply and demand model for the conservation credits using transaction data and econometric techniques. The balance of the chapter proceeds as follows. A background on the factors affecting demand and supply is presented. This is followed by a description of a model of the market of habitat conservation credit; an explanation of the endogeneity problem, and a theoretical framework of 2SLS estimation technique. A description of the data set is provided, followed by the presentation of the results. The conclusion is provided with some discussion.

3.2 Background

Economic models typically hypothesize that the market price acts to equilibrate demand and supply, under the assumptions of perfect competition. While the economic theory of habitat conservation banking market is still developing, to acquaint how habitat conservation banking might function under different assumptions, empirical applications of the ecosystem service market theory to actual market data are necessary. Empirical studies on habitat conservation banking market are lacking because of the youthfulness of theoretical models and market itself. In any of the previous literature mentioned above, not one has produced a model that explains habitat conservation banking historical data and none of them attempted the empirical analysis of conservation credit supply and demand.

The most important factors that affect the demand and supply of conservation credits are associated with the level of development/economic activities, the price of the credit, the cost of credit production, land value, availability of endangered species and its habitat, acreages of land used, and the changes in policies. These factors can be categorized into three major groups: ecological factors, economic factors, and regulations.

Ecological factors

Ecological factors include the habitat and species type and associated acres of land acquired for the conservation bank. The area of land allocated for a conservation bank varies with the quantity of land acquired for the bank establishment which depends on the types of endangered species and its habitat. For example, about half of the presently known endangered species Florida Panther population in South Florida occurs on the private lands and needs a large range of habitat (land area) compare to other range-limited organisms (Maehr, 1990). Hence, conservation bank development requires information on the land area, ownership, and opportunity cost associated with the bank establishment or credit production. There is a relationship between the land area in a bank and the species it is designed to serve. Since the production of large habitat range species credit needs more land area and investments, it is important for landowners to understand the current market price for those species before making any investment decisions.

Economic factors

Economic factors including interest rates, development alternatives, and land value influence the conservation credit market. The demand for conservation credits is a function of development alternatives, relative return from self-mitigation projects compared to the cost of credits purchased from a bank, and any expectations of future permit requirements. The supply of conservation credits is influenced by the costs associated with credit production. Costs include startup costs (e.g. land acquisition, environment restoration), annual operation costs, monitoring costs, and the opportunity cost of alternative land uses. Private land that has alternative uses would have opportunity costs associated with using the land to produce credits. Furthermore, the magnitude of these costs depends on the forgone opportunity cost (time of initial establishment to final credit sales).

Regulations

Finally, the stringency of regulations also affects habitat conservation banking market. This could include the ESA enforcement activities undertaken by the FWS and the extent to which additional species are listed. It also includes the protocols and rules administered by the FWS for conservation credit production and subsequent monitoring.

3.2.1 Model specification

In a competitive market, the interaction of buyers and sellers will result in an equilibrium price and quantity. Banker seeks to maximize profits by offering their conservation credit at the highest price possible to the developers. Developers strive to maximize their profits by minimizing the costs they incur in complying with ESA requirements. The equilibrium price for a credit occurs where the bid function and offer function converges.

The General Habitat conservation banking Framework

For the habitat conservation banking market, let p denote the price of credits, q denote the quantity of credits, x denote a vector of covariates characterizing the habitat conservation banking market[6] (e.g., species types, bank type, prime rate, land value), and S denote the substitution effects. The demand function q^d gives the quantity of credits that a price-taking developer would purchase, while the supply function q^s gives the quantity of credits that a price-taking banker would offer, both as functions of price. Habitat conservation banking markets are assumed to clear, which means that the transaction (p, q) is assumed to be an equilibrium outcome. In other words, the price p acts to equate supply and demand:

$$q^d = q^s \qquad (1)$$

Habitat conservation banking markets vary in different exhibit levels of q^d and q^s . We only observe the equilibrium price p, the equilibrium quantity q, and the covariates x, but cannot observe either the demand function $q^d(f)$ or the supply function $q^s\ (f)$.

A Linear Habitat conservation banking Market Model

In ordinary market, it is often observed that the higher the price the lower the demand for the product. In conservation banking, we assume that both demand and supply function are linear. Higher the price for credit, developer would prefer low cost alternatives and hence reduce the demand. Then, the structural form of this model can be expressed as follow:

Demand: $q^d(p, x) = \beta_0^d + \beta_p^d p + x'\beta_x^d + S\beta_S^d + \varepsilon^d \qquad (2)$

Supply: $q^s(p, x) = \beta_0^s + \beta_p^s p + x'\beta_x^s + S\beta_S^s + \varepsilon^s \qquad (3)$

Market clearing condition: $q^d(p, x) = q^s(p, x) = q$

[6] The notation and exposition were drawn from Hayashi (2000), Wooldridge (2010), and Greene (2011).

The demand equation (2) and the supply equation (3) are considered structural equations. Since the economic theory of demand and supply predicts that demand curves should be downward-sloping while supply curves should be upward sloping, we expect that $\beta_p^d \leq 0$ and $\beta_p^s \geq 0$. The partial derivative of each variable in the demand and supply equations with respect to an attribute provides the marginal effects. Similarly, as the cost of alternative mitigation options becomes relatively less expensive, it will trigger substitution effect. Solving the structural equations (2) and (3) for price and quantity as a function of the covariates, we can obtain the following reduced-form equations:

$$\text{Price: } p = x'\gamma_x^p + u^p \qquad (4)$$

$$\text{Quantity: } q = x'\gamma_x^q + u^q \qquad (5)$$

Where γ_x^p and γ_x^q are the reduced form coefficients. Our objective is to estimate the structural parameters ($\beta_p^d, \beta_p^s, \beta_x^d, \beta_x^s$). Estimating demand and supply equations separately by ordinary least squares (OLS) will not yield efficient or consistent estimates of these structural parameters (Hayashi, 2000; Greene, 2011). Since prices are endogenously determined in the supply-and-demand system, the coefficient on price cannot be identified (Greene, 2011). To address the endogeneity problem, the instrumental variables technique will be used to obtain consistent and efficient coefficients (Wooldridge, 2010; Greene, 2011).

Methods of Estimation

We identified several covariates as follows: $x = (x^d, x^s, x^n, x^c)$. Where the demand shifters x^d are exogenous covariates (e.g., development/economic activities) that shift the demand curve but not the supply curve. The supply shifters x^s are exogenous covariates (e.g., land value, area of land) that shift the supply curve but not the demand curve. The endogenous covariates x^n may enter the structural equation for supply or demand, or both (e.g., bank types and types of endangered species) and finally, the market controls x^c are exogenous covariates (e.g., U.S prime rates) that affect both demand and supply. Substituting $x = (x^d, x^s, x^n, x^c)$ into the structural equations (2) and (3) for demand and supply, respectively, we get:

Demand: $q = \beta_0^d + \beta_p^d p + x^{d\prime}\beta_{x,d}^d + x^{s\prime}\beta_{x,s}^d + x^{n\prime}\beta_{x,n}^d + x^{c\prime}\beta_{x,c}^d + \varepsilon^d$ (6)

Supply: $q = \beta_0^s + \beta_p^s p + x^{d\prime}\beta_{x,d}^s + x^{s\prime}\beta_{x,s}^s + x^{n\prime}\beta_{x,n}^s + x^{c\prime}\beta_{x,c}^s + \varepsilon^s$ (7)

In the expanded structural equations (6) and (7) for demand and supply, we impose an exclusion restriction: $\beta_{x,s}^d = 0$ and $\beta_{x,d}^s = 0$. This restriction implies that the demand for credit does not depend on exogenous covariates x^s (e.g., land value, area of land) and that the supply of credit does not depend on exogenous covariates x^d (e.g., development/economic activities) respectively. The structural model can be rewritten as:

Demand: $q = \beta_0^d + \beta_p^d p + x^{d\prime}\beta_{x,d}^d + x^{n\prime}\beta_{x,n}^d + x^{c\prime}\beta_{x,c}^d + \varepsilon^d$ (8)

Supply: $q = \beta_0^s + \beta_p^s p + x^{s\prime}\beta_{x,s}^s + x^{n\prime}\beta_{x,n}^s + x^{c\prime}\beta_{x,c}^s + \varepsilon^s$ (9)

We can identify each equation by using the exogenous variables excluded in that equation as instruments (Manski, 1995). Since the exogenous demand shifters x^d do not affect supply except through their effect on price, they can be used as instruments for price in the supply equation. Similarly, because the exogenous supply shifters x^s do not affect demand except through their effect on price, they can be used as instruments for price in the demand equation. The exogenous market controls x^c can serve as instruments for both equations. The vector of instruments z therefore can be given as: $z = (x^d, x^s, x^c)$. The instruments z have a non-zero correlation with price p. The instruments z can be used to obtain consistent and identified estimates of the structural parameters. Exogenous demand shifters, supply shifters, and market controls can be valid instruments not only for price but also for any endogenous covariates x^n as well. To enhance the efficiency of these OLS estimates, the structural equations can be estimated using two stage least squares (2SLS) technique. The application of 2SLS mitigates the problem of heteroscedasticity, multicollinearity, and endogeneity of price and quantity of goods. The following section describes the 2SLS estimation technique.

3.2.2 Two stage least square (2SLS)

The 2SLS technique can be summarized as follows:

Step 1: The endogenous regressor P is regressed on a constant and the independent variables X, to obtain the fitted value, $\hat{P}$, of price (P).

Step 2: The dependent variable Q is regressed on a constant and the fitted value, $\hat{P}$.

The use of the fitted value, $\hat{P}$, rather than observed value P distinguishes 2SLS from the simple OLS to the demand equation. The 2SLS estimator β_{2sls} is the OLS estimate of the $\hat{P}$ coefficient in the second-stage regression. If the general model can be expressed as a linear function of selected explanatory variables (X) as specified in equation (10):

$$Y_i \ = \ X\beta \ + \ \varepsilon \qquad (10)$$

where Y_i indicates a dependent variable representing conservation credit demand; X represents the characteristics and factors affecting conservation credit demand, then the 2SLS estimator is given as follow:

$$\hat{\beta}_{2sls} = \left(\hat{X}'\,\hat{X}\right)^{-1}\hat{X}'y \qquad (11)$$

The estimated R-square from the reduced form of equations gives some idea of the adequacy of the instrument. By using instrumental variables and 2SLS technique, we will get the same coefficient if the equations are just identified. The simultaneous equation models are just-identified when predetermined variables (K) is just equal to the number of regressors (J). That is, if $K = J$, then $\hat{\beta}_{2sls} = \hat{\beta}_{IV}$. Where, $\hat{\beta}_{IV}$ is the instrumental variables (IV) estimator. This implies that

2SLS estimator can be written as an IV estimator with an appropriate choice of instruments. Identification test was performed using Anderson cannon under-identification test.

3.3 Data

In this analysis, a dataset composed of 599 transactions records (28% of total transactions) occurring during the period from 1995 to 2016 are used. This dataset only includes the transaction records from two states- California and Florida. While these two states represent about 85% of conservation banks in the United States, the dataset is not representative of all states where banks exist. The dataset represents about 33% of transaction records from California (out of 1,772 transactions), and about 17% records from Florida (out of 84 transactions), and thus does not include a significant portion of the transactions that have occurred. This incomplete, yet best available, dataset is used because of lack of response of survey, bankers not willing to disclose the price and their characteristics and transaction information. This limits our analysis to 28% of habitat conservation banking market data and cannot be generalized beyond our observations. We base our choices of attributes on the theoretical framework, partly on the literature, and partly on the insights obtained through discussions and personal communication with bankers, developers, and regulators.

The description of variables is presented in Table 3.1. *lq* is the quantity of conservation credits and *lp* indicates the price per credit per acres (here by price). *lns* is a continuous variable describing the annual total number of species listed as endangered and threatened, the numbers that the bankers/developers cannot change. *lns* in our case, can also be considered as a proxy of the ESA and government regulations on endangered species conservation. It is reasonable to assume that as the number of the listed species increases, mitigation requirement increases and thus increases the demand for the credit. *lcon* is the estimated annual total construction cost of all development projects incurred by developers and is taken as an indicator for construction or development activities of the state. As the development activities expand, the developers may be required to mitigate more by either purchasing additional conservation credits or by performing self-mitigation projects, or scaling back their projects. Information on land values and construction activities at the date of the transaction in or near the same ecological region as the conservation bank were difficult to obtain. In such case, the annual state-level land value and construction activities data were used as a proxy.

On the supply side, we assume that as land value (*llv*) of ecological regions rises, the supply of credits declines. Other variables include bank characteristics such as bank type: *private* or *public* ownership; type of species: *animal, plant, multispecies,* and *other.* Animal species includes such as Florida Panther, California Tiger Salamander. Plant species includes such as Coastal Sag, Coast Live Oak Woodland. Multispecies includes such as combined credit of vernal Pool Fairy Shrimp with California Tiger Salamander, combined credit of San Francisco Garter Snake with California Red-Legged Frog. Other species includes such as Water Dependent Habitat. U.S annual prime rate is indicated by *lprate*. Table 3.2 provides the descriptive statistics for each of the dependent and independent variables used in the empirical estimation. All the price data were converted to real terms 2015-dollars. Some of the variables were converted to a natural log to help reduce problems associated with the large variation in the values of the variables. Large variation in data implies the presence of outliers in the values.

3.4 Results and Discussion

3.4.1 Annual trends

First, we present the annual trends of the variables. Trends are estimated by regressing the annual averages on years. The trend of average credit sales is significantly negative (-1.44; $p <$

0.1). This implies that the average credit sales are estimated to decrease by 1.44 credits per year, which is very low in terms of conservation credit sales and suggest that the conservation credit market does not have huge negative trends and is close to constant trend over the 20 years' period. However, the annual average price has a positive trend over 1995-2015. Price per credit is estimated to increase by $36.17 annually while the average land value per acre is estimated to increase by $239.26 annually. This suggests that price per credit increased by 15% when compared to the trend of land value. The number of acres of land area allocated for conservation banks is in decreasing trends (31.24 acres per year ($p < 0.1$)[7]). The numbers of private banks that sold credits (44 banks) are in significant positive trends (2.70; $p < 0.001$) (Figure 3.1). This implies that the number of private bank selling conservation credit are estimated to increase by 2.70 banks per year.

Annual development and infrastructure construction costs are in decreasing trends in California and Florida. Additionally, average land value per acre has the positive trend over 1995-2016 for California ($245.27/acre) and negative trend over 2008-2013 for Florida (-$155.53/acre). The annual average price and annual average quantity of credits sold have somewhat negative correlation over 1995-2015, with a correlation of -0.14. Figure 3.2 displays a scatter plot of the combinations of price and quantity in a level form that will later be used for the supply and demand estimations. Since these prices and quantities are equilibrium observations, we cannot identify either a supply curve or a demand curve.

[7] The total area of land used for conservation bank to supply endangered species habitat over the years is different. The trends we presented only includes the banks who sold the credits.

3.4.2 Econometrics results

The estimation employed a double-log model as it was useful in providing the regression coefficient for the direct estimation of elasticity. Table 3.3 reports the first and the second stage results of 2SLS estimates. In the first stage, in which the dependent variable is the natural log of price, the independent variables- private banks, land value, and area of conservation banks were significant at the 1% level. The R-square for this regression is 0.9. The estimated coefficient on the variable representing private banks, land value, and area of land allocated for conservation banks were 1.03 ($p < 0.01$), 0.91 ($p < 0.01$), and -0.86 ($p < 0.01$) respectively. All other variables included in the model were insignificant in 1st stage model. The coefficient of private bank in the model may help explain the direct effect upon the price. All else equal, a unit change in private bank is estimated to result in an increase in the credit price by 180% percent compared to public bank. This result appears to be inconsistent with the anticipated result, which would imply that an increase in credit supply would be accompanied by a decrease in unit prices. This counterintuitive result is probably due to the endogeneity problem that can be associated with the correlation of explanatory variables with error term.

A White's test rejects the null hypothesis of homoscedasticity (constant variance) ($\chi 2$ (1) =5.71, P-value = 0.016), indicating the presence of heteroscedasticity. Hence, we presented the robust standard errors. As mentioned earlier, the first stage regression using OLS does not provide the information on the relationship between price and quantity because of the endogeneity problem. A test for endogeneity was performed using the Hausman test which indicated the presence of endogeneity in OLS estimations (Wu-Hausman F (1,585) = 1.0, p-value=0.31). Furthermore, the null hypothesis of consistent estimators in the OLS model failed to be rejected by the Hausman specification test (n = 595, H = 0.99, df = 9 p = 0.99) indicating that the parameter estimates produced by the 2SLS model were consistent when compared to OLS. Therefore, to correct for endogeneity and to obtain consistent estimators, the second order 2SLS model was used. Furthermore, R-squared for the 1st stage OLS regression was 0.90, indicating that the variables land value (*llv*) and land area (*la)* are good instrumental variable in explaining the price (*lp).* Also, land value and area of land used for the conservation bank are important factors in the production of conservation credits, and hence these variables were an important attribute in explaining price and were selected to serve as an instrumental variable.

The 2nd stage results of 2SLS estimates are reported in Table 3.3. These estimates are consistent and efficient. The R^2 value is low (R^2=0.10). Although R^2 is not fully appropriate in 2SLS because it is not bounded between 0 and 1, it is still the best available measure of goodness of fit. Demand and supply coefficients result are normalized to quantity. To produce the identified coefficients, identification tests were performed. The Anderson Canonical Correlations LM statistics of under-identification test of all instrument is rejected at 1% level. This suggests that the model is not under-identified. Thus, our model produced identified coefficients which imply that estimated coefficient using 2SLS and IV estimation are consistence.

All variables except dummy variables are log-transformed. Hence, the estimated coefficients of log-transformed variables represent the elasticity values. All the coefficients except the annual number of listed species (*lns*) in demand equation are statistically significant at 1% and 5% level. The price coefficient in the demand equation is negative and significant at 1% level. This suggests that prices and quantity of credits demand are inversely related. The coefficient on price is -0.44, indicating that the price elasticity of demand is inelastic. From the perspective of a banker, this is a highly desirable situation because price and total revenue are directly related and if the price elasticity is less than one in absolute value terms, a price increase results in total revenue increasing despite a fall in the quantity of credit demanded.

In regard to bank types, a private bank has a positive effect on demand equation. All else equal, a unit change in private bank is estimated to result in an increase in the quantity of credit demand by 385% compared to public bank. Our estimate shows that *animal*, *plant*, and *multispecies* all have negative coefficient at 5% and 1% significant level in demand equation. A unit change in animal species credit is estimated to result in a decrease in the quantity of credit demand by 72% compared to other species type credit. Similarly, the changes in *plant* and *multispecies* type credit is estimated to result in a decrease in the demand for the quantity of credits by 83% and 92% compared to other species type credit, respectively.

The number of the listed species (*lns*) coefficient in the demand equation is negative and insignificant. Similarly, the development activities (*lcon)* has a negative and significant effect on quantity demand. A percent increase in development activities leads to 1.35% decrease in the demand for credit. The best possible explanation of these unexpected results could be the substitution effects. The developers could choose to undertake self-mitigation projects rather than buying conservation credits from the banks. Since our data only includes the transaction records and does not have data or information on the self-mitigation project activities or alternative options (substitution effects) performed by the developers, the effect of the numbers of listed species and the development activities on the demand for conservation credit observed unexpected sign. This unexpected sign is a highly undesirable situation from the banker's perspective because the increase in the number of listed species and the increase in the development activities generates the possibility of investing in new conservation banks and possibility of increase in credit demand. However, results suggest that higher development activities do not lead to increase in credit demand.

The price coefficient in the supply equation is positive and significant at 1% level. This suggests that prices and quantity of credit supply are directly related. The price elasticity of supply is inelastic (0.65) implying that a one percentage change in the supply of credit is associated with a 0.65% changes in the price of credit. Land area (*la*) and land value (*llv*) are exogenous supply shifters that affect the supply of credits but not its demand. The coefficient of land value is negative (-1.35) and significant at 1% level, which indicates that a one percent change in land value results in a decrease in the supply of credit by 1.35%. The coefficient on land value indicates that supply is elastic which implies that the supply is sensitive to changes in land value. Similarly, the coefficient of the area of land is positive (0.70), inelastic, and significant at 5% level. The result indicates that the percent increase in the area of conservation bank acreage results in 0.70% increase in credit supply. Both variables (*llv* and *la*) are expected to shift the marginal production of habitat credits and therefore its supply.

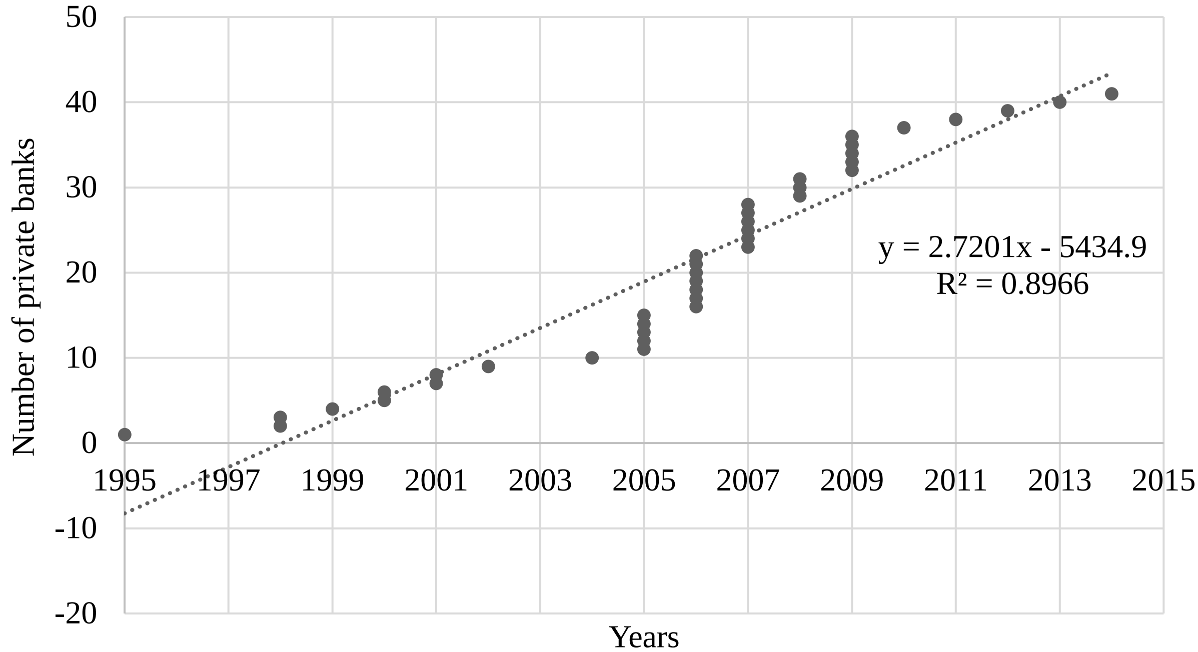
The estimates of supply and demand are consistent with a theoretical model of a static and competitive habitat conservation banking market. Demand and supply functions are consistent with economic theory and appear inelastic to price. However, these results do not provide the whole picture of habitat conservation banking market in the U.S because we were only able to obtain transaction data from Florida and California. Stating that, it is an important result because since 1995 and based on the presence of number of conservation banks, about 80% of habitat conservation banking market occurs in California and Florida.

3.5 Conclusion

Habitat conservation banking is a means for landowners to fulfill their ESA mitigation requirements. The main purpose of this study was to develop and estimate a demand and supply model for the habitat conservation banking market in U.S by using 2SLS approach. This study estimated the parameters of both demand and supply equations for the habitat conservation banking. The estimated 2SLS model passes the major specification tests, which implies that our choice of the 2SLS approach is statistically appropriate. This study uses a best available transaction data and extends the literature on the econometric modeling of habitat conservation banking markets by estimating the price elasticities of demand and supply.

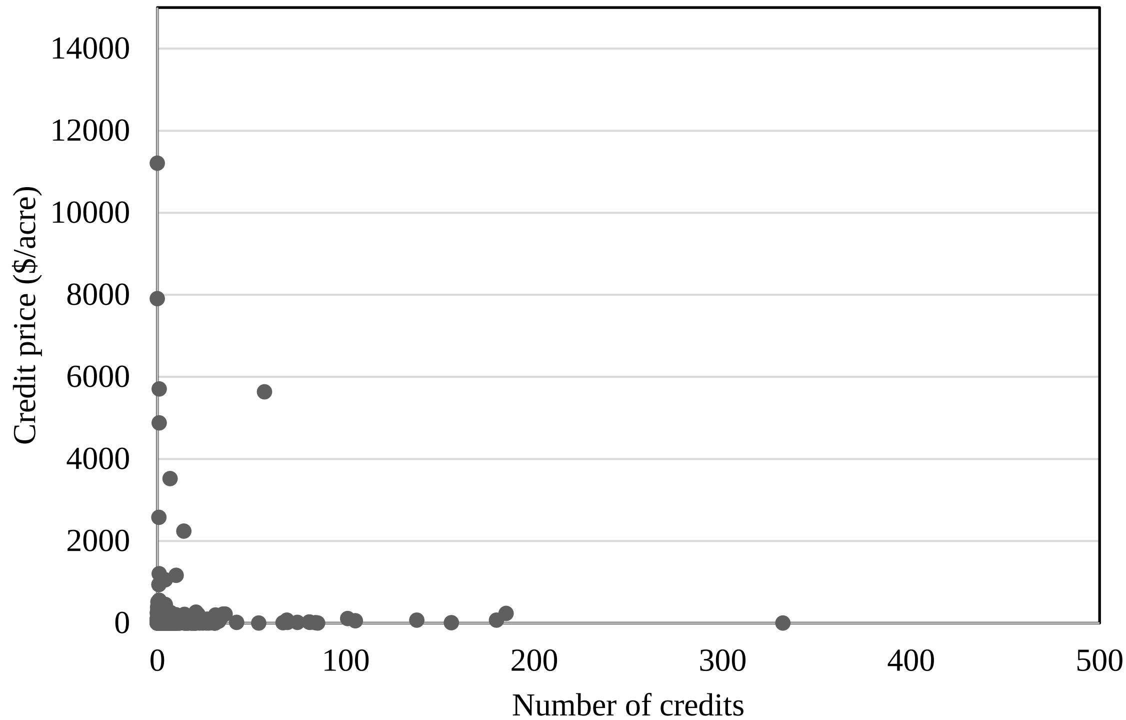
The results reveal that both habitat conservation credit supply and demand are price inelastic, suggesting that the quantity response is less than proportional in response to price changes. We found that the 2SLS estimation yields inelastic price coefficients of the expected sign for both credit demand and supply model indicating that the pricing policies does not have strong influences in a habitat conservation banking market structure in California and Florida. Habitat conservation credit can be produced in short range of time (1-3 years), and the market price can control its demand and supply scenarios. The marginal production of quantity of credit is likely to increase overtime with more land area allocated for the conservation bank, but is likely to decrease overtime with increase in land value.

Clearly, future research needs to be conducted using a dynamic model to better estimate the demand and supply for conservation credits. An advance econometric model that incorporates the dynamic aspects of the habitat conservation banking market seems to be a more promising prospect for future research. Although this study uses the 2SLS method of estimating coefficients of the demand and supply models of the habitat conservation banking market in the United States, some research shortcomings might still exist. Because we compiled the best possible transaction data within the limited time frame and the purpose is to understand the effect of price on the demand and supply of conservation credit, species-wise and bank-wise analysis is not included in this study and hence, will be addressed in next study.



Data source: RIBITS, retrieved on December 2015

Figure 3.1 Annual trends of private banks that sold conservation credit (N=44)



Data Source: Based on 599 transaction records (as of March 2016)

Figure 3.2 Scatter plot of number of credits and credit price

Table 3.1 Variables and their descriptions

Variables	Description	Expected sign
lq	Quantity of conservation credit sales (in logarithmic scale)	
years	Year of credit sales	
lp	Price per credit per acre (in logarithmic scale)	-
la	Total acreage of conservation bank area (in logarithmic scale)	+
Private	If conservation bank is private, private=1, otherwise=0	?
lprate	Annual U.S prime rate in logarithmic scale	?
lcon	Annual infrastructure and development cost (in logarithmic scale)	+
llv	land value per acres (in logarithmic scale)	-
lns	Annual number of listed endangered species (in logarithmic scale)	+
animal	If credit is animal species, animal=1, otherwise=0	?
plant	If credit is plant species, plant=1, otherwise=0	?
multispecies	If credit is multispecies, multispecies=1, otherwise=0	?
other	If credit is any other species, other=1, otherwise=0 (reference level)	?

Data sources:

- The quantity of credit sales and price per credit were obtained from transaction records.
- Total acreage of conservation bank area obtained from RIBITS.
- Prime rate was obtained from wall street prime rate history (http://www.fedprimerate.com/wall_street_journal_prime_rate_history.htm)
- Annual total construction spending for California and Florida have been achieved from Economic Research, Federal Reserve Bank of St. Louis (https://fred.stlouisfed.org/release/tables?rid=229&eid=22348)
- Land value data for California and Florida was compiled from Farm Real Estate Historical Series Data, USDA Statistical Bulletin and "Agricultural Land Values: Final Estimates, USDA NASS Statistical Bulletins (1994-2015, various issues)
- Annual number of listed species data was compiled from U.S Fish and Wildlife Service expenditure reports

* *animal* includes species such as Florida Panther, California Tiger Salamander
**plant* includes species such as Coastal Sage, Coast Live Oak Woodland
**multispecies* includes species such as combined credit of Vernal Pool Fairy Shrimp+ California Tiger Salamander, combined credit of San Francisco garter snake +California red-legged frog
**other* includes species such as Water Dependent Habitat

Table 3.2 Summary statistics of the variables used in empirical estimation (before log-transformed)

Variables	N	Mean	SD	Min	Max	Time trends
lq	599	11.05	94.45	0.00	2,252	-1.44 (0.74) ***
years	599	2006	3.88	1995	2015	
lp	599	235.02	1,775.90	0.16	23,163.41	36.17 (22.72)
la	599	2,041.15	1,098.68	21.62	4,000	-31.24 (16.06) ***
public	599	0.68	0.46	0	1	-
private	599	0.31	0.46	0	1	-
lprate	599	5.38	1.94	3.25	9.23	-0.29 (0.04) *
lcon	599	22,074.91	5,679.88	7,897.33	35,635.13	-
llv	599	6,144.48	1,130.07	3,452.61	7,700	239.26(18.16) *
lns	599	1,339.53	78.16	957	1,523	21.59 (2.62) *
animal	599	0.21	0.41	0	1	-
plant	599	0.75	0.43	0	1	-
multispecies	599	0.01	0.11	0	1	-
other	599	0.01	0.13	0	1	-

* Significant at 0.01, ** Significant at 0.05, ***Significant at 0.1

Notes: Trends are the coefficient on the year when the variable is regressed on the year and a constant (standard error in parentheses). Fourteen transaction records are of Florida and 585 transaction records are of California

Table 3.3 2SLS estimation results of factors related to the demand and supply of conservation credit

Variable	1st stage OLS regression Estimation of price	2nd stage IV regression Estimation of quantity Demand Coefficient (standard errors)[1]	Supply Coefficient (standard error)[1]
constant	10.67 (6.90)	25.72 (12.94) **	5.34 (3.89)
lq			
lp		-0.44 (0.155) *	0.65 (0.21) *
private	1.03 (0.23) *	1.58 (0.55) *	
animal	0.04 (0.31)	-1.28 (0.57) **	
plant	-0.39(0.32)	-1.77 (0.60) *	
multispecies	0.72 (0.47)	-2.47 (0.87) *	
lcon	-0.37 (0.28)	-1.35 (0.52) *	
lns	-0.89 (0.85)	-1.56 (1.47)	
lprate		1.04 (0.37) *	
llv	0.91 (0.25) *		-1.35 (0.45) *
la	-0.86 (0.07) *		0.70 (0.30) **
Centered R^2	0.72	0.05	0.02
Uncentered R^2	0.90	0.10	0.02
N	595	595	595
Under-identification test		117.58, χ^2 (2), P-value = 0.0001[a]	

* Significant at 0.01, ** Significant at 0.05, *** Significant at 0.1
**public* and *other* are taken as baseline dummy variable
Instrumented: *lp*
Instruments: *lns, lprate, lcon, multispecies, plant, animal, private, llv, la*
[a]Under-identification test (Anderson canon. corr. LM statistic): a matrix of reduced form coefficient has rank= K1-1; H_0 is rejected at 1% level, so the model is not under-identified.
[1] Normalized to quantity

CHAPTER IV

A HEDONIC PRICE ANALYSIS OF HABITAT CONSERVATION BANKING MARKET IN THE UNITED STATES

4.1 Introduction

The conflict between endangered species habitat protection and economic development have led many policy analysts to turn to markets to help address issues associated with species protection. Several incentive-based policy instruments such as Habitat Conservation Plans and the Safe Harbor Program have been put in place to provide incentives for those participants who provide habitat for endangered species (Bonnie, 1999). Since the past decades, habitat conservation banking has become a market-based policy instrument for the protection of endangered species habitat.

Habitat conservation banks are permanently protected lands which are conserved and managed for endangered species and their habitat. Since the establishment of the habitat conservation banking program in the mid-1990s, the U.S. Fish and Wildlife Service (USFWS) has approved 135 conservation banks[8]. More than 142,000 acres of land was conserved by these 135 banks (USFWS 2016). Although the numbers of conservation banks in recent years have been increasing, the annual demand for conservation credits has been low. High species credit price and/or cost-effective self-mitigation projects, and the economic conditions may have negatively affected the demand for conservation credits. Furthermore, lack of information on the variation of credit price across different species types has necessitated an examination of the economic and ecological characteristics of the habitat conservation banking market.

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[8] As of December, 2015

In the habitat conservation banking market framework, developers who adversely impact endangered species habitat can purchase "credits" from a habitat conservation bank to fulfill their mitigation requirements. In the process of fulfilling mitigation requirements for the entities that purchase credits, bankers take on all ecological, legal, and financial responsibilities. The bank sponsor will provide mitigation for the developer and guarantee the protection of the endangered species habitat (conservation credit) in perpetuity. Habitat conservation banking is a floor (regulation) and trade (market) system. The economic benefits from habitat conservation banking are realized through the gains from trade between the developer (buyer) and the banker (seller). The developers' objective is to minimize the cost of regulatory compliance and thus trading with banker occurs when the cost of self-mitigation exceeds the price of a credit. On the other hand, the banker's goal is to minimize the cost of credit production and thereby maximize their profit.

The demand for credits varies among developers, and hence, the price of credits can vary across regions, endangered species and habitat type, between bank ownership (private and public), and other economic factors. The price at which a credit is traded is determined by the interaction between buyers and sellers and some of the factors that may play a role in determining credit prices include the land value, the acreage of land area, cost associated with credit production, economic activities, and a number of listed species. The extent to which credit price for particular endangered species varies across different banks and the factors affecting the price are not well understood.

As the interest of private sectors in the habitat conservation banking market is rapidly expanding, it is important to identify the revealed value or implicit price of each of conservation credit attributes. This chapter contributes by examining the various attributes of conservation credits using a hedonic pricing framework. The balance of the chapter proceeds as follows. A background with literature review of the hedonic price framework with some insights on the attributes affecting conservation credit price is presented. This is followed by a description of the data set, a presentation of the results, and the conclusion with some discussion.

4.2 Background

As the importance of endangered species conservation has grown over the past few decades, increased emphasis has been placed on the valuation of endangered species habitat. To identify the adequate levels of production and investment in such ecosystem services, it is essential to evaluate each type of benefits (Zhang and Pearse 2011). Many natural resources are not traded in an open market due to the uncertainty of property rights, and for the fact that these resources have the characteristics of public goods (e.g., clean air). Public goods are typically under provided by markets (Zhang and Pearse 2011).

Several approaches have been used to measure the relationship causing differences in prices of goods. Based on the housing market, Rosen (1974) developed a two-step technique to estimate influential characteristics involving a hedonic price equation: where the price of a good is the function of the characteristics of a good and demonstrated that buyers and sellers in a perfectly competitive market will reach a market equilibrium guided by the implicit prices of house characteristics (locations, neighborhood, and environmental). A similar framework is applied in our habitat conservation banking model.

Hedonic pricing method is a widely used technique that is motivated by a utility maximizing approach and applies to heterogeneous goods (Tylor 2003). The hedonic price analysis can result in a better understanding of a market by dividing the actual price of a heterogeneous good into the marginal implicit prices of its different characteristics. The theoretical rationale for this analysis is that the utility benefits of marginal changes in one attribute of the bundles of attributes in a good like conservation credit can be measured by the additional changes in equilibrium. A heterogeneous good has a high degree of variation across a market in its attributes, which is the source of observable price differences, which make the method desirable from a policy perspective. By estimating a hedonic price function of these attributes, it is possible to statistically estimate the marginal valuations or implicit price for each attribute (Tylor 2003).

There is a considerable literature that has applied the hedonic approach to estimating the value of environmental goods and services, though to date there have been no applications to habitat conservation banking. As a novel contribution of this study, we utilize the hedonic price model for evaluating the conservation credit transaction data. By modeling the credit price as a Hedonic function of multiple independent variables including land value and dummy-variable of different species, we can estimate the marginal impact of these variables. Some characteristics, e.g., species types, public and private banks, and location exist in all credit purchase options, meaning that any buyers who buy a species credit and chooses a bank for his environmental offsets indirectly put a value on the package of features accessible at their selected bank location.

4.3 Model specification

The hedonic analysis is used where different goods and services with different characteristics generate different prices in the market. By conducting the hedonic price analysis in a market offering various quality services, we can find the marginal effects of multiple service variations on the market price (Taylor, 2003). Henceforth, the objective of our study is to analyze developers' preferences and their values for different conservation credit characteristics. The price for credit is estimated as a weighted summation of credit features including species types, bank types, land value, and development/economic activities.

Habitat conservation banking markets are assumed to be clear, and the relationship between credit price and attributes of credit can be specified as follows:

$$P(X) = F(X_1, \dots\dots, X_n) \qquad (1)$$

Where $P(X)$ is the implicit value for conservation credit attributes X_i $(i = 1, \dots\dots n)$. The credit price serves as the dependent variable in the analysis. Here X_i can represent an ecological, economical, and policy attributes of conservation bank. When supply and demand function are assumed to be independent of price and separable in X_i, quantity attributes can be entered as exogenous variables. This would allow us to estimate the demand model using the hedonic price function specified in equation (1). This is a short-run characterization of the market equilibrium as explained by Rosen. Implicit price estimate provides a consistent measure of welfare change. Several functional forms including, standard linear, semi-log, and Box-Cox transformations were assessed for goodness of fit. A semi-log function form was supported by the standard goodness-of-fit criteria (AIC, BIC, R2) and can be represented as follow:

$$\ln(P) = X'\beta$$

Where X is the vector of explanatory variables and β is a vector of coefficients. We evaluated the implicit price for an attribute at the corresponding sample mean price. Following the semi-log form, a hedonic price model can be specified as a function of habitat conservation banking attributes that include species characteristics (X_i), economic attributes (E_i), management (M_i), time scale (T_i), and regional market (S_i).

$$Log(P) = \alpha_0 + \sum_{i=1}^{n} \alpha_i X_i + \sum_{i=1}^{n} \beta_i E_i + \sum_{i=1}^{n} \gamma_i M_i + \sum_{i=1}^{n} \theta_i T_i + \sum_{i=1}^{n} \sigma_i S_i \qquad (2)$$

Where α, β, γ, θ , and σ are slope parameters to be estimated. As mentioned before, the objective is to find the implicit price for each credit characteristic which quantifies the contribution of each feature to the total credit price. The resulting marginal implicit value can be determined as follows:

$$\hat{P}_i = \partial P(X)/\partial X_i \qquad (3)$$

After calculating the implicit price for each characteristic, the relative effect of each credit characteristic on the total price provides us a better understanding of the developers' economic preferences for these credits offered by bankers.

4.4 Data

We collected data from 135 conservation banks out of 148 (as of March 2016) from the Regulatory in Lieu Fee Tracking System (RIBITS) and obtained data on 611 transactions, representing 28.6% of total transaction spanning the years 1995- 2016. This dataset includes the transaction records from California and Florida. These two states represent about 85% of conservation banks in the United States. However, the dataset is not representative of all states where banks exist. The dataset represents about 33% of transaction records from California (out of 1,772 transactions), and about 17% records from Florida (out of 84 transactions), and thus does not include a significant portion of the transactions that have occurred. This incomplete, yet best available, dataset is used because of lack of survey response and bankers not willing to disclose the price, buyers' characteristics, and transaction information. Table 4.1 summarizes the types of species, bank name, the number of transactions, and the descriptive statistics of credit price. Table 4.2 shows the dependent and independent variables used in the hedonic price analysis. The dependent variable is the credit price and denoted as PRICE. The credit from bank type (M) is represented by the variable PRIVATE and PUBLIC, which identifies the credits sold by private banks as opposed to those sold by public banks. Twenty-seven different types of endangered species credit (X) were included in the model as a dummy variable. The variable (T) indicates the year of transaction. The regional credit transaction (S) is represented by CALIFORNIA and FLORIDA. NOOFSPECIES is a continuous variable indicating the annual total number of species listed as endangered and threatened, the numbers that the bankers/developers cannot change. It can be assumed that as the number of the listed species increases, the demand for the mitigation services increases.

ECONINDEX is the coincident economic activity index, which shows the current state of economic activity within a particular area and can be taken as an indicator of economic activities in the states-California and Florida. As the economic activities increases, the developers are required to offset their harmful environmental effects via mitigation, which may include purchasing conservation credits. The price per credit, the area of the conservation bank, and the land value variables were converted to a natural log to help reduce problems associated with the large variation in these variables.

4.5 Results

The test for the variation in credit price across different species and different banks are presented in Table 4.3. The method of least squares is used to fit general linear models and for the analysis of variance. Mathematically, the general linear model can be represented as follow:

$$Y_{ijk} = \mu + \tau_i + \theta_j + \vartheta_k + \varepsilon_{ijk} \qquad (4)$$

Where Y_{ijk} is the price per credit observation, μ is the overall mean for all variable, τ_i is the types of species (species effect on price), θ_j is the different banks (bank effect on price), ϑ_k is the year (annual effect on price), and ε_{ijk} is a random error component. The null hypothesis is that there is no species, bank, and annual effect on the price of credit. Tests of hypotheses for the effects of a linear model is reported in Table 4.3. The results show the significant species effect ($F = 27.28, p < 0.0001$), bank effect ($F = 19.91, p < 0.0001$), and annual effect ($F =$

$1.79, p = 0.01$) on credit price. The R^2 indicates that the model accounts for 77% of the variation in credit price. Similarly, the results show the significant species effect ($F = 725.33, p < 0.0001$), bank effect ($F = 4.52, p < 0.0001$), and annual effect ($F = 2.69, p = 0.0001$) on quantity of credit sold. The R^2 indicates that the model accounts for 97% of the variation in quantity of credit sold.

A trend in credit prices from the descriptive analysis indicated the necessity of analyzing separate markets at the regional level and by bank ownership type. To further examine this trend, transaction data were segregated into regional levels- California and Florida, and by ownership types- private and public banks. Estimated coefficients and the associated implicit prices from separate semi-log hedonic price equations are presented in Table 4.4. Given the large number of transaction in California, the first model used the observations only from California (N=581), followed by a model for Florida (N=13). Similarly, the objective function of private and public banks differs in many ways. Model 3 uses private bank observation (N=186), and model 4 uses public bank observation (N=408). The White Test results indicate a presence of heteroscedasticity. SAS software and programming corrects for heteroscedasticity using a weighted regression approach which is also referred to as the weighted least square (WLS). For all models, a Huber-White robust estimator of the variance was used to obtain robust standard errors for inference testing. We used up to 10% significant level for decision criteria in hypothesis testing because unlike in large sample studies, this study involves a small sample size (from 13 observations in Florida to 581 observations in California) to have a significant impact on the outcome. A lower significance level is generally used in analysis involving larger sample sizes (Vaske 2008). A Variance Inflation Factor (VIF) indices were used to check for multicollinearity (Greene 2012). Few VIF score above 10 in each of the four models were observed. Given that factors above 10 are common when the sample size is low (e.g. Florida), and variables (e.g. types of species) are closely related, multicollinearity was not considered a concern. Mean prices are reported in Table 4.4. Estimated coefficients were interpreted relative to this baseline.

The adjusted R^2 is high for California (R^2 =0.78) which indicates that the model accounts for 78% of the variation in credit price. Overall, nineteen out of the 29 independent variables in the model California were statistically significant at the 1%, 5%, and 10% significance levels. Area of conservation bank was correlated with credit price through a significant and negative acreage term, indicating the bank area and credit price were inversely related. The implicit price of an increase in acreage of bank area on credit price thus varies by acres. For example, at the mean size of 2,041.16 acres, an increase of one acre led to decrease of $255.90 in expected credit price per acre or 108%. The effect of conservation bank area on credit price indicates a strong negative relationship. The variable number of listed species was negative but not significant, suggesting that each additional listed species could be associated with a $474.58 or 200% decrease in credit price on average, suggesting significant negative effect in credit price that experience a policy effect.

Among the variables representing different types of endangered species, five endangered species are positive and thirteen species are negative and significant. These results indicate the significant differences in credit price among different endangered species compared to the reference level species. For example, presence of Burke’s Goldfields led to 93.6% decrease in expected credit price compared to reference level species, Alameda Whip Snake. The implicit credit price for all the different species included in model 1 is reported in Table 4.4.

The second model for Florida only includes 13 transactions of species: Florida scrub-jay (*Aphelocoma coerulescens*) over the years 2008-2013 (Table 4.5). The adjusted R^2 for the model is 0.82, which indicates that the model accounts for 82% of the variation in credit price of Florida scrub-jay. All the included independent variables in the model were significant at 10% level. Results show that land value, interest rate, and number of listed species have positive effect on price whereas, economic activity has negative effect. One percent increase in land value per acre in Florida led to 25% increase in the credit price of Florida scrub-jay ($5,000 per credit on average). On the other hand, an increase in economic activities in Florida does not increase credit price which indicates that the developers may have cost efficient alternative mitigation activities options.

The third model for the private conservation banks includes 23 different species. The adjusted R^2 for the model is 0.55, which indicates that the model accounts for 55% of the variation in credit price of different species. Twenty-three species coefficients were significant at 1%, 5% and 10% levels. The acreage of land used by private conservation bank has significant negative effect on credit price. The results show that one percent increase in the area of private conservation bank led to 1.03% decrease in credit price ($762.88 on average). Similarly, an increase in economic activities in California and Florida does not led to higher credit price, suggesting the availability of alternative mitigation options to the developers. Unlike other species types included in this model, Chaparral and water dependent habitat has positive effect on price. For example, presence of Chaparral led to an increase of $407.9 or 55% in expected credit price compared to reference level species: Alameda Whip Snake. The implicit credit price for all the different species included in model 3 are reported in Table 4.6.

The fourth model includes transaction data from public banks. These public banks include ten different endangered species with California Gnatcatcher as reference level species. The adjusted R^2 for the model is 0.30, which indicates that the model accounts for 30% of the variation in credit price in public banks. Six different species coefficients were negative and significant. Results show that land value, economic activities, and interest rate were not a significant predictor of variation of credit price associated with public banks.

4.6 Discussion and conclusion

This chapter presented a hedonic pricing analysis of habitat conservation banking market in the United States. A complex mix of conservation credit transaction (both publicly and privately owned) and a diverse array of endangered species credit types, and the regional market (California and Florida) were analyzed. Habitat conservation credits are highly heterogeneous goods, and credit price of these species varies overtime, across banks, and by regional economic activities. Hedonic pricing analysis provides a perspective of a regional market and the implicit prices for various species credit. The results indicated that there is a significant variation in the quantity of credit sales and price per credit across different species types, across various banks, and at different years. Marginal increase in the area of land allocated for conservation banks in California as well as for privately owned bank has significant negative effect on credit price. The land value has a negative effect on credit price in California, unlike Florida where land value has a positive effect on credit price. Both, privately and publicly owned conservation banks credit price has negative effect on land value. This indicates that although many private landowners are likely constrained by the area of land they can devote to a conservation bank, results suggested that marginal increase in the area of land allocated for conservation bank decreased the credit price in all privately and publicly owned bank.

Unlike publicly owned conservation bank, an increase in economic activities does not lead to increase in credit price in California, Florida, and in privately owned banks. For private companies, an understanding of implicit credit price can help in setting potential conservation bank size that may have potential to increase alternative revenue for the enterprise. However, increasing the area of conservation bank does not increase the credit price.

The habitat conservation banking market includes a diverse array of stakeholders, such as landowners seeking additional revenues, developers seeking for low-cost mitigation process, and investors trying to identify potential land area for the production of conservation credit. Hedonic analysis can be of use in most cases. For example, landowners or investors seeking for alternative or additional revenue can benefit from these results through the understanding the value of establishing conservation bank and marginal changes in land allocation for conservation bank effects of the credit price. Potential investors can use these findings to have a better understanding of the profit opportunities they could generate in investing on particular species types. Private bankers are deriving their income from the sale of credits, and trends in prices are reflecting the value of conservation banks.

Finally, the application of hedonic pricing analysis in habitat conservation banking market remains relatively new and under-investigated and represents an important future research avenue as more transaction and credit price observations and geographic information system (GIS) data of conservation banks becomes increasingly available. Since our models only represent 28% of transaction and do not fully capture the spatial factors or interactions that might be affecting credit prices, results cannot be generalized beyond our sample. Future research can be expanded to incorporate spatial econometric modeling of hedonic price functions.

Table 4.1 Conservation credit price across different species and different conservation banks

Name of species	Bank name (coded)	No. of transactions	Min	Max	Mean	SD
Vernal Pool Fairy Shrimp	15	3	1.17	345.81	129.89	188.14
	22	1	73.92	73.92	73.92	
	32	1	179.28	179.28	179.28	
	34	1	2,578.09	2,578.09	2,578.09	
	37	7	248.31	265.19	253.59	6.76
	49	28	88.56	110.73	98.84	7.38
	55	2	27.62	71.34	49.48	30.92
	75	2	179.24	202.63	190.94	16.54
	94	1	36.76	36.76	36.76	
	107	1	247.48	247.48	247.48	
	123	1	128.36	128.36	128.36	
Burke's Goldfields	3	7	66.82	23,163.41	3,367.14	8,729.34
	85	1	268.21	268.21	268.21	
Chaparral	3	1	23,163.40	23,163.40	23,163.40	
Coastal Sag	36	138	0.16	18.00	4.35	2.01
	43	1	32.62	32.62	32.62	
	106	10	39.04	65.16	55.87	11.44
Coastal Live Oak Woodlands	36	24	0.18	8.21	5.77	2.04
	43	1	23.42	23.42	23.42	
	106	1	44.59	44.59	44.59	
California Tiger Salamander	3	1	23,163.41	23,163.41	23,163.41	
	32	1	179.28	179.28	179.28	
	38	1	13.84	13.84	13.84	
	43	1	97.49	97.49	97.49	
	49	9	87.44	114.45	94.11	8.37
	55	1	57.61	57.61	57.61	
	82	1	287.95	287.95	287.95	
CFWO MSCP	35	194	2.90	22.90	8.08	3.99

Name of species	Bank name (coded)	No. of transactions	Min	Max	Mean	SD
Non Native Grassland	36	38	0.19	9.92	3.31	2.25
	47	1	161.95	161.95	161.95	
	106	2	45.60	49.65	47.62	2.86
Water Dependent Habitat	36	7	3.93	14.36	8.45	3.16
	47	1	311.14	311.14	311.14	
Engelmann Oak Woodland	36	6	5.90	7.23	6.64	0.65
Giant Garter Snake	41	22	90.98	112.52	98.44	4.82
	57	1	67.73	67.73	67.73	
	59	2	53.71	67.14	60.43	9.50
	62	1	1,164.04	1,164.04	1,164.04	
	63	1	91.76	91.76	91.76	
	72	2	4.69	6.21	5.45	1.08
	108	6	21.30	560.48	190.71	255.36
	128	1	166.71	166.71	166.71	
San Joaquin Kit Fox	38	3	13.84	15.03	14.24	0.69
	43	1	27.94	27.94	27.94	
	55	1	66.26	66.26	66.26	
Swainson's Hawk	22	1	69.63	69.63	69.63	
	36	1	5.61	5.61	5.61	
	43	1	32.62	32.62	32.62	
	55	1	39.40	39.40	39.40	
	73	1	40.35	40.35	40.35	
	116	1	1,205.55	1,205.55	1,205.55	
Burying Beetle	36	1	5.61	5.61	5.61	
Multispecies	36	1	7.48	7.48	7.48	
	52	1	940.54	940.54	940.54	
	55	2	58.18	66.26	62.22	5.71
	107	4	199.25	1,057.16	426.08	421.06
	108	1	20.49	20.49	20.49	
	123	2	89.81	455.89	272.85	258.85

Name of species	Bank name (coded)	No. of transactions	Min	Max	Mean	SD
	92	1	319.12	319.12	319.12	
	94	1	39.76	39.76	39.76	
	108	1	22.55	22.55	22.55	
Valley Elderberry Longhorn Beetle	112	2	12.63	253.71	133.17	170.47
	116	2	297.05	516.66	406.86	155.29
	119	1	3,521.48	3,521.48	3,521.48	
	121	1	169.68	169.68	169.68	
	125	1	7,911.24	7,911.24	7,911.24	
Scrub Jay	113	13	142.43	219.49	199.33	27.99
	137	3	4,877.39	5,708.71	5,407.58	460.57
	36	1	7.66	7.66	7.66	
Endangered Plant	55	1	244.95	244.95	244.95	
	106	2	44.59	247.17	145.88	143.24
California Gnatcatcher	36	1	7.66	7.66	7.66	
Delhi Sands Fly	38	1	14.98	14.98	14.98	
	43	1	32.62	32.62	32.62	
Shaded Riverine Aquatic	54	1	110.91	110.91	110.91	
	57	1	64.29	64.29	64.29	
	94	1	35.20	35.20	35.20	
Desert Tortoise	55	1	28.40	28.40	28.40	
Burrowing Owl	79	1	2,245.87	2,245.87	2,245.87	
	80	1	11,209.52	11,209.52	11,209.52	
Mohave Ground Squirrel	94	1	115.63	115.63	115.63	
Florida Panther	99	1	0.41	0.41	0.41	
	107	1	200.24	200.24	200.24	
Pima Pineapple Cactus	108	1	21.65	21.65	21.65	
Alameda Whip Snake	130	1	392.00	392.00	392.00	

Data Source: based on 599 transaction records obtained from survey and networking with bankers, developers, and environmental consultants

Table 4.2 Summary statistics of the variables used in a hedonic analysis of habitat conservation banking market (before log-transformed)

Variable	Variable description	Mean	SD	Min	Max
YEARS	Year of credit transaction	2006	3.88	1995	2015
TOTALAREA	Area of conservation bank that reported price information (acres)	2,041.16	1,098.68	21.62	4,000.00
PRIVATE	If the bank is private then 1, else 0	0.31	0.46	0	1
PRICE*	Price per credit per acres ($)	235.02	1,775.90	0.16	23,163.41
SPECIES	Different types of species	-		1	27
CALIFORNIA	If the state is California then 1, else 0	0.98	0.15	0	1
FLORIDA	If the state is Florida then 1, else 0	0.02	0.15	0	1
NOOFSPECIES	Number of listed endangered species	-	-	957	1523
PRATE	U.S prime rate	5.39	1.95	3.25	9.23
ECONINDEX	Coincident economic index	147.80	24.616	103.03	196.79
LANDVALUE	Annual land value per acres ($)	6,144.48	1,130.07	3,452.61	7,700.00

*The price of a habitat conservation credit is for 43 selected banks

Data sources:

- Total acreage of conservation bank area obtained from RIBITS.
- Prime rate was obtained from the wall street prime rate history (http://www.fedprimerate.com/wall_street_journal_prime_rate_history.htm)
- Coincident economic index was obtained from Economic Research, Federal Reserve Bank of St. Louis (https://fred.stlouisfed.org/series/CAPHCI)
- Land value data for California and Florida were obtained from Farm Real Estate Historical Series Data 1950-92, USDA Statistical Bulletin No. 855 and "Agricultural land Values: Final Estimates 1994-98", USDA NASS Statistical Bulletin, No 957 and various other issues of diffferent year
- Annual number of listed species data was compiled from U.S Fish and Wildlife Service expenditure reports

Table 4.3 General linear model for the test of a variation of credit price and quantity of credit sold across species types, banks, and years

Variables	Effects	F-Value	R-Square
Price per credit per acre	SPECIES	27.28 (<.01) [22]	0.77
	BANKNAME	19.91(<.01) [38]	
	YEARS	1.79 (0.01) [20]	
Quantity of credits	SPECIES	725.33 (<.01) [22]	0.97
	BANKNAME	4.52 (<.01) [38]	
	YEARS	2.69 (0.01) [20]	

* P-value in the parenthesis followed by degree of freedom

Table 4.4 Parameter estimates and implicit price from the hedonic pricing models of selected habitat conservation banking markets in California

Variable	Coefficient	SE	VIF	Implicit price
AREA	-1.08***	0.10	5.44	($255.90)
LAND VALUE	-0.16	0.59	8.30	($40.05)
ECONINDEX	-0.01	0.01	20.81	($2.57)
PRATE	0.20	0.28	6.73	$48.23
NOOFSPECIES	-2.00	1.32	5.35	($474.58)
Vernal Pool Fairy Shrimp	0.53**	0.26	3.17	$169.02
Burke's Goldfields	-2.76***	0.85	2.05	($221.34)
Chaparral	1.82***	0.44	1.14	$1,222.36
Coastal Sag	-1.25***	0.25	7.58	($168.64)
Coastal Live Oak Woodlands	-1.06***	0.31	2.50	($154.62)
California Tiger Salamander	0.24	0.32	1.73	$66.63
CFWO MSCP	-0.80***	0.24	8.26	($130.61)
Non-Native Grassland	-1.52***	0.31	3.30	($184.81)
Engelmann Oak Woodland	-0.62**	0.25	1.37	($109.96)
Giant Garter Snake	-0.58*	0.31	3.00	($105.20)
San Joaquin Kit Fox	-1.42***	0.39	1.24	($179.38)
Swainson's Hawk	-0.60	0.48	1.29	($107.12)
Burying Beetle	-0.91***	0.25	1.06	($141.76)
Valley Elderberry Longhorn Beetle	0.15	0.50	1.60	$38.52
Scrub Jay	1.72***	0.37	1.30	$1,095.90
Endangered Plant	0.04	0.46	1.20	$11.95
California Gnatcatcher	-0.60**	0.25	1.06	($107.13)
Delhi Sand Fly	-1.59***	0.26	1.05	($188.15)
Shaded Riverine Aquatic	-0.17	0.75	1.19	($37.47)
Desert Tortoise	-0.84***	0.24	1.05	($134.74)
Burrowing Owl	1.48***	0.46	1.20	$807.43
Mohave Ground Squirrel	0.67***	0.24	1.05	$229.36
Pima Pineapple Cactus	-2.79***	0.29	1.06	($221.78)
TIME	0.12	0.06	35.57	$31.34
CONSTANT	26.94*	11.02	0	
OBS.	581			
R^2	0.78			
MEAN PRICE	$236.21			

*** p<0.01, ** p<0.05, * p<0.1

SE (Robust standard errors); VIF (Variance inflation factor); Implicit Price (IP) is calculated as:

For dummy species variables, IP = $(Exp\ (coefficient) - 1) \times Mean\ Price$

Negative implicit prices are in parenthesis

Table 4.5 Parameter estimates and implicit price from the hedonic pricing models of habitat conservation banking markets in Florida

Variable	Coefficient	SE	VIF	Implicit price
LAND VALUE	25.08*	11.39	313.26	$5,000.16
ECONINDEX	-0.31*	0.13	425.84	($63.36)
PRATE	3.29*	1.92	50.35	$737.31
NOOFSPECIES	37.74*	17.58	514.65	$7,522.41
CONSTANT	-438.32*	205.72	0	-
OBS.	13			
R^2	0.82			
MEAN PRICE	$199.32			

*** p<0.01, ** p<0.05, * p<0.1

SE (Robust standard errors); VIF (Variance inflation factor); IP (Implicit Price) and calculated as: For dummy species variables, IP $= \ (Exp\ (coefficient) - 1) \times Mean\ Price$

Negative implicit prices are in parenthesis

This model only includes species Florida scrub-jay.

Table 4.6 Parameter estimates and implicit price from the hedonic pricing models of the private conservation banks

Variables	Coefficient	Standard Error	VIF	Implicit value
LA	-1.03***	0.18	3.01	($762.88)
LLV	1.41	1.07	6.74	$1048.66
ECONINDEX	-0.04	0.03	17.96	($32.34)
LPRATE	0.62	0.42	7.47	$458.55
LNS	6.33*	3.01	6.37	$4705.32
Vernal Pool Fairy Shrimp	-1.40***	0.22	37.74	($558.94)
Burke's Goldfields	-4.35***	0.95	10.03	($733.28)
Chaparral	0.44	0.67	2.22	$407.91
Coastal Sag	-2.51***	0.20	11.50	($682.33)
Coastal Live Oak Woodlands	-3.34***	0.51	3.06	($716.62)
California Tiger Salamander	-1.61***	0.25	15.10	($594.55)
Non-Native Grassland	-1.75***	0.58	4.05	($613.60)
Water Dependent Habitat	0.67*	0.35	2.10	$711.08
Giant Garter Snake	-2.65***	0.38	31.60	($690.23)
San Joaquin Kit Fox	-3.37***	0.29	6.01	($717.20)
Swainson's Hawk	-2.29***	0.67	5.06	($667.49)
Multispecies	-1.94***	0.40	10.81	($635.93)
Valley Elderberry Longhorn Beetle	-1.74***	0.55	11.11	($612.97)
Scrub Jay	-1.69***	0.54	17.53	($605.16)
Endangered Plant	-1.40**	0.57	4.05	($560.41)
Delhi Sands Fly	-3.23***	0.21	2.03	($713.40)
Shaded Riverine Aquatic	-2.01***	0.66	5.01	($642.96)
Desert Tortoise	-3.21***	0.26	2.08	($712.94)
Burrowing Owl	-0.21	0.56	3.26	($140.50)
Mohave Ground Squirrel	-1.73***	0.23	2.05	($610.61)
Florida Panther	-3.47***	0.99	3.07	($719.63)
Pima Pineapple Cactus	-4.37***	0.36	2.08	($733.44)
TIME	0.02	0.11	33.08	$13.52
CONSTANT	-39.50	24.93	0.00	
OBS.	186			
R2	0.55			
MEAN PRICE	$742.85			

*** p<0.01, ** p<0.05, * p<0.1

SE (Robust standard errors); VIF (Variance inflation factor); Implicit Price (IP) is calculated as:

For dummy species variables, IP = $(Exp\ (coefficient) - 1) \times Mean\ Price$

Negative implicit prices are in parenthesis

Table 4.7 Parameter estimates and implicit price from the hedonic pricing models of public conservation banks

Variables	Coefficient	Standard error	VIF	Implicit price
Land value	0.35	0.64	8.42	$2.16
Econindex	0.01	0.02	21.98	$0.09
Interest rate	-0.25	0.33	6.43	($1.56)
No. of species listed	-3.90***	1.44	5.12	($24.27)
Coastal Sag	-0.62***	0.10	92.61	($2.89)
Coastal Live Oak Woodlands	-0.34	0.22	23.88	($1.78)
CFWO MSCP	0.14*	0.07	103.13	$0.94
Non-native grassland	-0.97***	0.21	35.93	($3.86)
Water dependent habitat	0.51***	0.17	8.01	$4.10
Engelmann Oak Woodland	-0.02	0.11	6.97	($0.12)
Swainson's Hawk	-0.31***	0.00	2.00	($1.67)
Burying Beetle	-0.31***	0.00	2.00	($1.67)
Multispecies	-0.02***	0.00	2.00	($0.15)
Time	0.03	0.07	34.57	$0.21
Constant	24.73*	11.57	0.00	
Observations	408.00			
R-squared	0.30			
Mean price	6.22			

*** p<0.01, ** p<0.05, * p<0.1

SE (Robust standard errors); VIF (Variance inflation factor); Implicit Price (IP) is calculated as:

For dummy species variables, IP $= \ (Exp\ (coefficient) - 1) \times Mean\ Price$

Negative implicit prices are in parenthesis

CHAPTER V

FINANCIAL ANALYSIS OF HABITAT CONSERVATION BANKING IN THE UNITED STATES

5.1 Introduction

Habitat conservation banking is a market-based policy instrument that allows landowners to manage land for endangered species habitat, generate habitat conservation credits, and maximize their profit by selling credits to the developers who are required to mitigate their harmful environmental impacts on listed endangered species. The market for habitat conservation credits is distinct from other ordinary markets in a way that the decisions of U.S. Fish and Wildlife Service regulate the demand side of conservation credits. The efficient utilization of resource in the habitat conservation banking is vital, particularly at this stage where habitat conservation banking market has imperfect competition and monopolistic market structure. Thus, the actions aimed at raising habitat conservation banking values have gained importance.

Bankers (or landowners) often are challenged with wide-ranging values when making endangered species habitat management decisions in their land, and they increasingly use economic tools to assess investment decisions. Economics concepts and tools allow to compare the costs and the benefits of alternative land management (Bullard and Straka 2011). However, private investment is habitat conservation banking market is driven primarily by financial performance, which is often unknown for new ecosystem service markets. Hence, it seems relevant to investigate the financial performance of existing habitat conservation banks in order to provide information to potential investors/bankers. Even though most banks have their own initial financial assessment before making an investment decision; there is almost no information available on the financial performance of these conservation banks. For ecological companies, the decision to invest in a habitat conservation banking hinges on the cost structure and financial performance of such an operation. Unfortunately, there is a high degree of uncertainty related to the performance of the habitat conservation banks and little market data to support selling their outputs, conservation credit. This is primarily due to the fact that habitat conservation banking is not yet widely deployed in industrial settings, resulting in a lack of economic data and market transactions for conservation credits. Most of the existing studies tend to rely on theoretical estimates based on economic specifications rather than empirical data. To our knowledge, prior to this work, no study examined the financial performance of habitat conservation banks. More specifically, are these banks achieving good financial performance? Answering this question is important to assess the potential for future investment decisions.

This study specifically investigates the financial performance of eight banks, all located in California. We addressed the gap in the literature by presenting evidence from a very limited set of banks that may not fully reflect the total population of banks. The objective of this chapter is to estimate the present value cost, present value revenue, net present value, and benefit-cost ratio using different discount rates. The remainder of this chapter proceeds as follows. We first discuss the background of the relationship between financial analysis of the habitat conservation banking. Then, we introduce the data and methods employed in our analysis. Next, we report the results from the financial analysis and finally, we discuss our conclusions.

5.2 Background

The main reasons why U.S Fish and Wildlife service would want successful habitat conservation banking program is to conserve the endangered species habitat, provide the mitigation options for the developers' adverse environmental effects, and provide the opportunity for private land owners to generate an alternative source of revenue while managing their private land for endangered species habitat. In habitat conservation banking market, the bankers incur costs to avoid or reduce externalities and get something in return, such as revenues from conservation credit sales. Assessing the financial performance of a conservation banks has a great importance for entrepreneurs, individual bankers, managers, creditors and current/potential investors who want to invest in habitat conservation banking. The net present value, benefit-cost ratio, profit maximization and optimization approach are a commonly used technique for financial analysis to provide meaningful information for making decisions (Zhang and Pearse, 2011). The investors are interested in conservation bank value creation as this is the payment they expect in return of the capital invested. The following sub-section provides the different aspect of conservation bank development.

5.2.1 Production function

A production function describes a relationship between inputs and outputs. Assuming a homogenous product and adapting the ecological production function defined by Simpson (2014), the conservation credit production function can be express as follow:

$$Q = f(x, S, A, M) \qquad (1)$$

Where Q is the quantity of output (conservation credits), x is the quantity of inputs (labor and capital), S is the number of listed endangered species in the area, A is the area of land allocated for the production of the credit, and M is the management actions. The land required by a bank is important for their value, both ecologically and economically. However, the location and size of economically achievable habitat are uncertain. Bankers typically explore for habitat site with the presence of endangered species because the economic value of conservation bank depends on economic activities around the areas, alternative mitigation opportunities, species types and their habitat quality, location, technology used for bank establishment, market credit price, and associated cost. Simpson (2014) analyzed the ecosystem service production function and investigated its properties adapting joint-production decision in farming in Augusta County, Virginia.

5.2.2 Cost-effective condition for conservation credit

Minimizing the cost of producing conservation credit is the primary objective of the bankers from the economic perspective. In general, a banker can minimize the cost of credit production when the marginal benefit exceeds the marginal cost. For homogeneous conservation credits, the following constrained optimization will minimize the cost of conservation credit production:

$$\text{Minimize } \sum_{j=1}^{n} C_j \left(X_j\right) \textit{ subject to } \sum_{j=1}^{n} X_j \geq (\bar{X}) \qquad (2)$$

Where $C_j\left(X_j\right)$ is the opportunity cost of credit production (endangered species habitat conservation) to banker j, X_j is the quantity of additional habitat credit produced and $(\bar{X})$ is a constant which is equal to the current level of habitat conservation in the land. The constraint ensures that conservation value must be higher or equal to baseline. The optimum condition for the habitat conservation banking market can be given by first order condition with respect to the level of habitat conservation as follows:

$$\frac{\partial c_j(x_j)}{\partial x_j} \geq \omega, X_j \geq 0, \text{ and } X_j \left[\frac{\partial c_j(x_j)}{\partial x_j} - \omega\right] = 0 \qquad (3)$$

When the marginal cost of conservation credit production equals the marginal revenue of conservation credit (ω) and when there are no transaction costs, then the habitat conservation banking market will be efficient. If the marginal cost of producing the conservation credit for firm j exceeds marginal revenue, then firm j develops the land for other activities. If the quantity of endangered species habitat conservation at the optimum for firm j exceeds the quantity of endangered species habitat prior to solving the problem, then the firm is a banker (producer of a conservation credit). On the other hand, if the quantity of endangered species habitat conserved at the optimum for firm j is less than the quantity of endangered species habitat prior to solving this problem, the firm is a developer (consumer of conservation credit). A case, where same individual acts as a banker and developer, as in themselves are producers and consumers, the joint-production decision and opportunity cost and benefit is used (for example, Simpson 2014)

5.2.3 Net present value

Net present value is a standard concept used in capital budgeting to evaluate investment projects (Bullard and Straka 2011; Zhang and Pearse 2011). NPV is the sum of all the discounted future cash flows to determine the present value. A conservation bank project is worthwhile if its NPV is greater than zero. Hence, it is important to assess NPV for currently operating conservation bank to see whether the investments increase or decreases over the years. Suppose that a parcel of land has been established for a conservation bank and a banker wishes to maximize the net present value of this bank. After the bank establishment is complete, credits are generated that can be sold in the market. After using this land for the conservation bank, often there is no other financial stake of the land by alternative use, and the land will be used as conservation bank for perpetuity.

Bankers must consider the risk associated with uncertain future cash flows. As the uncertainty of future cash flow increases, certainty equivalent is calculated for various outcomes (Clutter et al. 1983), and the discount rate used to adjust for risk (Foster 1979). The higher the uncertainty over the future cash flows, the higher the discount rate used to calculate their present value (Bullard and Straka 2011). Increased risk reduces conservation bank's NPV and makes it less attractive to investors.

5.3 Method and data

We compiled a list of conservation banks, the quantity of credits produced, and area of conservation banks by retrieving data in Regulatory In-Lieu Fee Banking Information System (RIBITS). Total number of credit approved and/or available, the total number of credit withdrawal and/or sold out, the total area of the conservation banks, the total number of transaction records, different types of endangered involved, bank name, and ownership type were retrieved from RIBITS (as of December 2016). RIBITS includes over 29,000 credit ledger transaction and more than 8,000 bank-related files which include Wetland Mitigation Banks, In Lieu Fee, and habitat conservation banking documents (Martin & Brumbaugh 2011). Data query have been performed in RIBITS to download the habitat conservation banking data. Each conservation bank name was treated as a unique observation. After compiling the list of conservation banks, we manually reviewed all the documents uploaded by the conservation banks to obtain estimated cost structure and habitat management plans.

Most of the credit ledger transaction files have not reported and have removed the credit price information. To get the price information, we created the database of 315 contact information of bankers, developers (who were required to perform mitigation process), and environmental consultants. These contacts were obtained from USFWS, website: www.speciesbanking.com, National Mitigation Banking Association, and from documents uploaded by bankers in RIBITS. A mail survey was sent to these 315 individuals. Cover letter and the question were oriented to obtain only the transaction information (e.g., Conservation Bank name, species involved, date of credit transaction, the number of credits sold, the total price for all the credits sold). Overall, we were able to obtain 589 transaction records which represent about 27.6% of total transaction as of December 2016.

We matched the transaction details with the RIBITS data using the unique identification using bank name. This enabled us to generate ranges for both the revenue and cost aspects of habitat conservation banking, which we integrated into a benefit-cost analysis. The first database is created by including only the information of revenue (obtained from survey process), the second database is created for the costs information (obtained from documents uploaded by bankers in RIBITS), and in the third database, we matched the bank name and only included the observations that have both revenue and cost information from the same bank.

The estimated cost information in the bank documents only includes the initial bank establishment and annual operational cost structure. In almost all documents we reviewed, none of them reported land purchase price or land value of the conservation bank. To estimate more accurate financial analysis, we compiled the list of banks that reported their Assessor's Parcel Number (APN) in their conservation bank management plan. These APN numbers were then matched with the tax records from the respective county tax office. The county tax office website has detailed property sale history in their third-party property records database: ParcelQuest Lite[9]. ParcelQuest Lite database can be used to obtained the recent sale history or assessed value of land parcel by querying with APN . We used the recent land sale amount and land value as the land acquisition cost for conservation bank establishment. This allows us to estimate the more accurate NPV and B-C ratio for eight conservation banks.

[9] http://www.parcelquest.com/county/pq-lite?utm_medium=pqlite&utm_campaign=assessor

Through our data compilation and management process, we were able to form seven sets of data. These excel dataset were based on the number of conservation banks. For example, credit cost per acre was obtained for 54 banks, the number of credit supplied was obtained for 106 banks, the number of credit sold was obtained for 57 banks, and the credit price per acre was obtained for 43 banks (Table 5.1). In most cases, price information was reported as the price per acre, price per credit, and price per unit. To maintain consistency, the price per credit is then converted into per acre basis by dividing the price by the total area of the conservation bank. Finally, total cost with land price and total revenue information of 8 different conservation banks were assembled. All these banks are in California. These banks were coded to hide the name and location information because of non-disclosure agreements.

5.4 Results

We present the financial analysis results in several different sections. The first section provides exploratory analysis, followed by present value results in the second section. The third section provides benefit/cost results followed by net present value results in section fourth.

5.4.1 Exploratory analysis

There has been steady growth in the number of conservation bank establishment. As of December 2016, conservation bank number has increased to 167 from 76 (by almost 120%) in 2004. Table 5.1 shows the descriptive statistics of the cost per acre, credit supplied, total land area, the number of credits sold, and price per acre. All cost and price are reported in the constant term (2015$ value).

5.4.1.1 Cost information

The average credit cost per acre is $84.87 with maximum cost $1,875, and a standard deviation is about $3.24 (N=54). These credit cost per acre are for 54 conservation banks, and it cannot be generalized beyond our sample. The coefficient of variation is low, which implies low variability relative to average credit cost per acre. The standard error of the mean of credit cost is $2.40, that shows the variability between sample means. Skewness of the cost per acres is 5.41 which suggest that distribution is skewed right, asymmetrical and that the right tail is long relative to the left tail. Kurtosis value of the credit cost is 34.88 which implies the data have some outliers.

5.4.1.2 Total area

The average area of conservation bank (N=59) was found to be 1,172 acres with maximum 21,304 acres, minimum 8.11 acres, and the standard deviation 2.61 acres. The standard deviation is low; however, the coefficient of variation is high, implying high variability relative to average acres of land. These land areas produced about 3,829 credits on average with maximum 135,706 credits, minimum 11.39 credits, and standard deviation of 4.26 credits. The distribution of area and credit produced are skewed right and asymmetrical. Similarly, kurtosis value of the area of land and credit produced are high which implies heavy tails or outliers in the values.

5.4.1.3 Price information

The average credit price per acre was $1,115. The credit price per acre ranged from $0.41 to $1,115.5 (Table 5.1). The standard deviation is high, but the coefficient of variation is low, which implies less variability relative to the average credit price. Skewness of the price per credit is 2.79 which means that distribution is skewed right, asymmetrical and that the right tail is long relative to the left tail. High kurtosis value was observed for price per credit per acre 10.07, which indicates the data are heavy-tailed relative to a normal distribution and that have outliers. The interquartile range for price per credit per acre is $326 which implies that the bulk of the values lie in this range.

Table 5.2 shows the summary of 18 conservation banks located in California. The cost and price values were adjusted to 2015-dollar value. Credit cost per acre only includes the initial establishment and annual operation cost for these banks. The average number of credits produced by these 18 banks is 1,376.71, and average credit per acre is $51.44. These average costs in California are lower than the average cost of conservation banks in other states (Table 5.1). Habitat conservation banking program was first developed in California in 1995. California legislature enacted California Fish and Game Code to govern fees to fund bank review, and that the presence of higher number of bankers and environmental consultants, along with increased technology and resources, may have contributed to lowers average credit cost compared to other states. On average 745.61 acres of land was conserved and sold 51.92 credits on average by these 18 banks. The average credit price per acre is about $1,193.94. Results suggest that conservation banks in California have a low credit per acre cost but the high credit price per acre compared to other states.

5.4.2 Net present value

5.4.2.1 Net present value using initial establishment and annual costs

Table 5.3 presents present value cost, revenue, net present value, and benefit-cost ratio of 18 conservation banks in California. The average cost of these banks was about $689,540 in 2015$ value. Based on previous credit sales record, these 18 conservation banks generated on average present value revenue of about $2.2 million. These banks yield an average net present value of $1.6 million. As of 2015, twelve conservation banks have negative NPV, and six banks have positive NPV. The NPV values range from negative $1.2 million to positive $22.2 million. The benefit-cost ratios are also reported in Table 5.3. Benefit-cost ratios range from minimum 0.02 to maximum 460.98 with the average benefit-cost ratio of 27.24. However, it is important to note that these benefit -cost ratios do not include land acquisition cost.

The minimum and maximum credit inventory (available) of 18 banks range from 26.18 credits to 10,206.79 credits respectively with average credit inventory of 1,324.79 (Table 5.4). Our results show that average time to sell the available credits from the bank is 8.8 years. To evaluate the financial performance of the habitat conservation banks, yearly cash flows for an assumed 10-year project period were developed and NPV was calculated based on 8 percent real interest rate (i.e., discount rate). Our interest rate of 8 percent falls between the 3.75 percent rate that Federal agencies use for natural resources projects (US Federal Register 2013) and the 10 percent rate commonly used in economic studies of larger scale projects. Furthermore, our choice of 8 percent discount rate is also influenced by the rate employed by Donlan et al. (2015) for the financial analysis of the gopher tortoise pre-listing conservation program. Additionally, Daniel (2000) also used 7 percent discount rate for the cost analysis of habitat restoration.

Sensitivity analyses were conducted to evaluate the sensitivity of financial performance (i.e., NPV) of the cost and revenue variables. The 5 percent to 10 percent discount rates were used in the sensitivity analyses while the other variables remained constant. Table 5.4 shows the net present value generated by selling the remaining credits in the next ten years' period.

With the current level of credit price, NPV model using 8% discount rate yields an expected net present value (NPV) of $74 million in average. NPV range from minimum $3.2 million to maximum $673 million. Benefit cost ratios range from 8.7 to 1,439 with the average of 244. Overall results show that when all conservation banks sell their entire current credit produced in the next ten years' period, the NPV values are positive and benefit cost ratios are large. This indicates the positive financial performance of habitat conservation banking market in California. However, these results cannot be generalized beyond our sample. Since the total cost data from these 18 conservation banks do not include land acquisition cost, we further analyzed the eight different conservation banks including the land acquisition costs.

5.4.2.2 Net present value using land price, initial establishments, and annual costs information

Table 5.5 shows the summary of 8 conservation banks in California that includes the land acquisition cost, initial establishment, and annual operation cost. The total cost and price values are adjusted in 2015-dollar value. The average credit produced by these eight banks is about 743.04, and average credit cost per acre is $291.37. This average cost per credit is almost 466.5% higher compared to the average cost without land price. On average, 721.35 acres of land are conserved by these banks and sold about 179.40 credits on average. Table 5.6 presents present value cost, present value revenue, net present value, and benefit-cost ratio of 8 conservation banks in California. The average present value cost of these conservation banks is about $1.1 million in 2015$ value. Based on previous credit sales records, these conservation banks generated on average present value revenue of about $270,017. These banks yield an average negative net present value of $888,464. As of 2015, seven conservation banks have negative NPV, and one bank have positive NPV. The NPV values range from negative $2.2 million to positive $17,403. The benefit-cost ratios are reported in Table 5.6. Benefit-cost ratios range from minimum 0.01 to maximum 1.08 with the average benefit-cost ratio of 0.34. The minimum and maximum credit inventory of these eight banks range from 29.72 credits to 3,422.34 credits respectively with average credit inventory of 734.10.

Table 5.7 shows the net present value generated by selling the remaining credits in next ten years' period. With the current level of credit price, NPV model using 8% discount rate yields an expected net present value (NPV) of $10 million in average. NPV range from minimum $1.1 million to maximum $31 million. The conservation bank value increases by almost 87% when the discount rate is decreased by 3%. Benefit cost ratios range from 0.46 to 51.94 with the average of 16. Sensitivity analysis shows that if the discount rate is reduced by 3% (i.e. 5% discount rate), the benefit cost ratio increased by 81%, whereas if the discount rate is increased to 10%, benefit cost ratio decreased by 12.5%. This indicates that discount rate is highly sensitive to the value of conservation bank. Overall results show that when all eight conservation banks sell their entire credit produced from the bank in the next ten years' period, the NPV values are positive and benefit cost ratios are high. This further indicates that investing in habitat conservation banking generates a positive return in long term period.

5.5 Discussion and conclusion

The economic feasibility of habitat conservation banking depends on the area of land conserved, the number of credit produced, species available, and cost and price of conservation credits. In this study, we presented the financial analysis of selected conservation banks. Results showed that under the plausible condition (i.e., the discount rate of 8%) and the assumption of no additional cost, and a constant credit price over the ten years' period, investing in habitat conservation banking provides an economic profit. All eight conservation banks yielded a positive value. Larger benefit-to-cost ratios were found for most conservation banks in California. These benefits could be even greater considering the benefits (and values) of public goods and services of these ecosystems.

Economic analysis has the considerable effect on planning, decision-making, and policy formulation, both in the public and private sectors. Our results showed that all eight conservation banks have positive benefits which indicate that the investment in habitat conservation banking is not merely a cost; rather, it is a worthwhile investment that brings multiple benefits and can help achieve habitat conservation policy goals. Even though the values presented in this study does not entirely reflect the habitat conservation banking market because of limited sample size, results, however, can be considered as a signal of economic profitability in habitat conservation banking market. A different suite of case-specific variables would likely yield different results, and hence, detailed studies that monitor costs and benefits of conservation banks over time are needed to determine the ecological efficiency and return on investment.

Private sector investors, individual landowners, and ecological companies are making preliminary moves to invest in habitat conservation banking projects in different states. While our results provide the valuable information for the potential investors in California, large up-front costs (land acquisition and bank establishment cost) and the local economic condition can affect the investment decision in other states. Since conservation bank value depends on species and habitat types and local economic conditions, there are major knowledge, technology and capacity deficits for a potential banker in other states and scaling up from what is available and known is crucial (Personal communication, NMEB 2016 attendee). Besides California, landowners in other states who may have discouraged, for lack of knowledge and data and out of fear that presence of endangered species habitat in their land would result in a regulatory compliance and that high cost to benefit ratio would discourage investment in habitat conservation banking, may be reassured by our findings that investment in habitat conservation banking, in fact, make profit.

Finally, some benefits of conservation bank are public goods that flow to beneficiaries whether or not they contribute directly to conservation efforts. Investigating the societal benefits could be future research perspective. The findings presented in this study may be extended in several ways such as the change in cost structure and price between periods while considering carrying capacity of conservation banks and inventory planning.

Table 5.1 Descriptive analysis of cost and price of conservation credits from different conservation banks

Statistics	Credit cost per acre ($)	Number of Credits supplied	Total area (supply side)	Number of Credits sold (demand side)	Credit price per acre ($)
Mean	84.87	3,829.83	1,172.22	254.67	1,115.57
Max	1,874.94	135,706.10	21,304.00	7,401.63	11,209.52
Min	-	11.39	8.11	0.03	0.41
Median	274.74	16,325.18	3,062.46	1,072.23	169.68
Std.dev	3.24	4.26	2.61	4.21	2,449.81
Coefficient of variance	37.39	1,585.64	398.70	142.02	2.20
Std.error of mean	2.40	479.97	429.00	22.51	373.59
Skewness	5.41	6.79	5.38	5.83	2.79
Kurtosis	34.88	50.62	34.01	37.40	10.07
Interquartile range (75-25)	18.19	986.06	653.00	68.27	325.99
Sum	4,583.03	405,961.40	69,161.13	14,516.09	47,969.38
Number of conservation bank (N)	54.00	106.00	59.00	57.00	43.00

- Note that the cost, price, acres of land, credit sold and credit supplied are from several different banks and the number of banks is represented by (N)
- Cost only includes initial establishment and annual operation cost

Table 5.2 Summary statistics for select conservation banks in California (N=18)

Bank name (coded)	Year established	Credit cost per acre ($)	Credit produced	Total area (acres)	Number of Credits sold	Credit price per acre ($)
3	2007	341.43	79.05	22.50	5.72	7,766.31
47	2006	0.14	2,825.51	1,814.83	0.94	236.55
49	1999	0.05	1,108.95	808.00	274.90	97.69
54	2004	4.74	179.07	1,810.00	2.26	110.91
55	2007	1.86	840.25	621.00	331.03	73.34
57	2007	0.03	1,073.80	1,067.00	2.72	66.01
59	2001	3.26	545.28	299.00	52.00	60.43
72	2005	0.32	2,323.38	1,295.00	42.30	5.45
80	2011	553.52	26.21	21.62	0.03	11,209.52
85	2012	4.32	256.67	147.00	0.95	268.21
92	2007	4.24	490.58	627.00	0.31	319.12
94	2005	1.18	1,287.80	640.00	15.80	56.84
108	2005	0.22	10,372.19	188.00	165.40	134.33
112	2007	1.88	611.24	498.00	22.51	133.17
121	2000	0.84	310.18	728.00	0.39	169.68
123	2008	4.15	1,024.92	429.00	17.03	224.69
128	2010	3.12	79.34	1,630.00	0.14	166.71
130	2009	0.67	1,346.34	775.03	0.14	392.00
Average	2006	51.44	1,376.70	745.61	51.92	1,193.94
Total	-	925.97	24,780.76	13,420.98	934.57	21,490.96

*Cost only includes initial establishment and annual operation cost

*Both cost and price are in 2015$ value

* Data as of August 2016

Table 5.3 Present value cost, revenue, net present value, and benefit and cost ratio of 18 banks in California

Bank name coded	Present value cost	Present value revenue	Net present value	Benefit-cost ratio
3	607,272.81	2,149,730.46	1,542,457.64	3.54
47	729,565.60	356,333.89	(373,231.71)	0.49
49	48,370.82	22,297,812.09	22,249,441.28	460.98
54	1,536,791.13	453,707.50	(1,083,083.62)	0.30
55	971,932.11	11,714,417.98	10,742,485.86	12.05
57	29,223.09	187,766.99	158,543.91	6.43
59	532,210.90	913,405.43	381,194.53	1.72
72	953,972.19	308,070.89	(645,901.29)	0.32
80	313,659.58	7,270.49	(306,389.09)	0.02
85	162,917.05	37,456.07	(125,460.98)	0.23
92	1,304,377.84	62,026.88	(1,242,350.96)	0.05
94	970,826.73	574,807.95	(396,018.78)	0.59
108	432,468.04	875,510.61	443,042.57	2.02
112	573,378.77	506,879.98	(66,498.79)	0.88
121	189,255.73	48,174.19	(141,081.55)	0.25
123	1,823,927.73	590,129.59	(1,233,798.15)	0.32
128	404,037.38	38,043.42	(365,993.96)	0.09
130	701,540.61	42,534.18	(659,006.44)	0.06
Average	689,540.45	2,286,893.26	1,604,352.80	27.24
Total	12,285,728.11	41,164,078.59	28,878,350.47	-

***** Negative NPV are in parentheses. Values are in constant term (2015$ value)
*Cost only includes initial establishment and annual operation cost

Table 5.4 Net present value and benefit and cost ratio of 18 conservation banks in California

Bank name	Credit inventory	NPV (5%)	NPV (8%)	NPV (10%)	B/C ratio (5%)	B/C ratio (8%)	B/C ratio (10%)
3	73.33	10,085.01	8,661.25	7,949.37	16.61	14.26	13.09
47	2,824.57	808,008.67	673,278.35	605,913.19	1,107.52	922.85	830.51
49	834.05	66,139.84	58,824.78	55,167.24	1,367.35	1,216.12	1,140.51
54	176.81	22,580.64	18,636.69	16,664.71	14.69	12.13	10.84
55	509.22	26,203.10	23,626.33	22,337.94	26.96	24.31	22.98
57	1,071.08	50,450.86	42,068.81	37,877.78	1,726.40	1,439.57	1,296.16
59	493.28	6,322.71	5,332.45	4,837.33	11.88	10.02	9.09
72	2,281.08	10,084.85	8,296.39	7,402.16	10.57	8.70	7.76
80	26.18	3,923.42	3,218.45	2,865.97	12.51	10.26	9.14
85	255.72	6,596.13	5,475.86	4,915.73	40.49	33.61	30.17
92	490.27	64,155.32	53,255.71	47,805.90	49.18	40.83	36.65
94	1,272.00	30,450.79	25,309.65	22,739.09	31.37	26.07	23.42
108	10,206.79	172,286.26	143,645.72	129,325.46	398.38	332.15	299.04
112	588.73	25,962.83	21,624.61	19,455.50	45.28	37.71	33.93
121	309.79	25,369.83	21,118.01	18,992.10	134.05	111.58	100.35
123	1,007.89	63,533.27	52,738.76	47,341.50	34.83	28.91	25.96
128	79.20	13,981.81	11,590.51	10,394.86	34.61	28.69	25.73
130	1,346.20	272,005.31	226,561.26	203,839.23	387.73	322.95	290.56
Average	1,256.63	88,598.39	74,084.18	66,827.08	288.87	244.86	222.86
Total	23,875.91	1,683,369.49	1,407,599.50	1,269,714.50			

Note: (1) Average time to sell all available credits is 8.8 years. Here we assume that all the banks sell their available credit inventory in 10 years' period. (2) Net present value (NPV) were calculated using 8% discount rate. (3) Sensitivity analysis was performed using 5% and 10% discount rate. (4) NPV are in thousands of dollars

Table 5.5 Summary of select conservation banks in California with land price, establishment cost, and annual cost (N=8)

Bank name (coded)	Year established	Total area (acre)	Land price	Total cost	Credit cost per acre	Credit produced	Credit sold (reported)	Credit sold (obtained with price info)	Credit price per acre
15	2001	573.00	192,994.35	216,234.86	1.25	301.91	19.10	4.28	95.27
36	1997	3,058.00	477,425.22	595,564.53	0.06	3,438.38	665.24	16.04	5.38
38	2008	684.00	183,004.38	706,031.85	0.87	1,191.64	507.73	35.51	14.45
82	2001	530.00	1,753,212.00	2,234,880.78	15.72	268.21	42.18	0.07	271.50
106	2009	566.00	739,427.03	1,472,315.19	4.06	640.53	115.36	7.69	57.37
116	2012	215.63	805,702.95	905,675.29	135.36	31.03	60.82	1.20	573.76
119	2006	38.06	1,958,177.34	2,457,039.34	1,504.83	42.90	11.9	6.68	3,521.48
125	2006	34.18	543,197.49	680,111.25	668.84	29.75	12.93	0.03	7,911.24
Average		712.35	831,642.60	1,158,481.63	291.37	743.04	179.40	8.93	1,556.30
Total		5,698.87	6,653,140.76	9,267,853,09	2,330.99	5,944.35	1,435.26	71.50	12,450.45

*Total cost includes land price, initial establishment and annual operation cost
*Both cost and price are in 2015$ value
*Data as of August 2016

Table 5.6 Present value cost, revenue, net present value, and benefit and cost ratio of 8 banks in California (as of 2016)

Bank name coded	Present value cost	Present value revenue	Net present value	Benefit-cost ratio
15	216,234.86	233,638.83	17,403.96	1.08
36	595,564.53	263,769.20	(331,795.34)	0.44
38	706,031.85	351,050.88	(354,980.97)	0.50
82	2,234,880.78	10,072.54	(2,224,808.24)	0.00
106	1,472,315.19	249,726.85	(1,222,588.34)	0.17
116	905,675.29	148,464.85	(757,210.44)	0.16
119	2,457,039.34	895,303.50	(1,561,735.84)	0.36
125	680,111.25	8,112.19	(671,999.06)	0.01
Average	1,158,481.64	270,017.36	(888,464.28)	0.34
Total	10,426,334.73	2,430,156.20	-7,996,178.55	

Negative NPV are in parentheses. Values are in constant term (2015$ value)
*Cost includes land price, initial establishment, and annual operation cost

Table 5.7 Net present value and benefit-cost ratio of 8 conservation banks in California

Bank name	Credit inventory	NPV (5%)	NPV (8%)	NPV (10%)	B/C ratio (5%)	B/C ratio (8%)	B/C ratio (10%)
15	297.63	16,264,582	9,043,614	8,140,993	75.22	41.82	37.65
36	3,422.34	55,946,751	30,934,064	27,807,478	93.94	51.94	46.69
38	1,156.13	11,074,479	5,994,719	5,359,749	15.69	8.49	7.59
82	268.14	36,358,337	19,210,273	17,066,765	16.27	8.60	7.64
106	632.84	19,328,405	10,194,630	9,052,908	13.13	6.92	6.15
116	29.83	2,933,378	1,293,117	1,088,084	3.24	1.43	1.20
119	36.22	3,292,739	1,135,195	865,502	1.34	0.46	0.35
125	29.72	7,364,476	3,792,709	3,346,239	10.83	5.58	4.92
Average	734.10	19,070,393	10,199,790	9,090,965	29	16	14
Total	5,872.85	152,563,147	81,598,321	72,727,718			

Note: (1) Average time to sell all available credits is 8.8 years. Here we assume that all the banks sell their available credit inventory in 10 years' period. (2) Net present value (NPV) were calculated using 8% discount rate. (3) Sensitivity analysis was performed using 5% and 10% discount rate

CHAPTER VI

GENERAL CONCLUSIONS

Protecting the endangered species on private land and providing the opportunities for financial incentives for landowners is a challenging area for the policy makers. Habitat conservation banking is identified as policy solution, and it has been in implementation since 1995. Over the years, few studies have evaluated habitat conservation banking market (such as Fox and Murcia 2005; DOI 2013; DOI 2016). All these studies have reported the increased number of conservation banks and increased area of land allocated for conservation banks. However, the important research questions such as: how many conservation credits have been transacted, how many types of endangered species have been protected, and how the trends of habitat conservation banking market changed overtime, were not addressed before. The annual trends, demand and supply of conservation credits, hedonic pricing analysis, and financial assessment of habitat conservation banking program have been systematically investigated in this dissertation. Four separate studies were conducted. The overall conclusion of this research are as follows:

Chapter 2 quantified the total banks, conservation credit supply, sales, and analyzed the trends and the characteristics of conservation banks. We found that a significant number of credit availability, increased acres of the land area allocated for conservation bank, and increased number of species involved in habitat conservation banking indicates the positive conservation effort or action for endangered species. However, the conservation credits sales were less compared to credit availability in the market, and such lack of demand could be closely linked to higher credit price and/or cost-efficient permittee-responsible mitigation projects, and less local economic activities. Ecological services companies have a strong hold in the habitat conservation banking market compared to individual landowners. Time-consuming and frustrating documentation requirements, local level political issues, and lack of information about habitat conservation banking market and price have discouraged individual landowners to involve in habitat conservation banking.

Chapter 3 developed the supply and the demand model for the conservation credit market using transaction data. We found that the estimation of the 2SLS model yield price coefficients of the expected sign for credit demand. Demand and supply are inelastic to price, suggesting that conservation credit price changes do not result in significant conservation credit demand and that the developers respond less to changes in conservation credit price. Inverse price and quantity relation show the actual distribution of price in the market. Chapter 3 recommends that an advance econometric model that incorporates either the dynamic or oligopolistic aspects of the habitat conservation banking market, or both, seems to be a more promising prospect for future research.

In Chapter 4, a hedonic pricing framework was applied, and we found a significant variation in the quantity of credit sales and price per credit across different species type, across various banks, and in various years. Marginal increase in the area of land allocated for conservation banks in California as well as for privately owned bank has significant negative effect on credit price. Chapter 4 concludes that the land value has a negative effect on credit price in California but positive effect in Florida. Both, privately and publicly owned conservation banks credit price has negative effect on land value. The implicit price information across different species credit can be helpful information for landowners or investors seeking for alternative or additional revenue. This chapter recommends that the application of hedonic pricing analysis in habitat conservation banking can be further expanded as more transaction and credit price observations and geographic information system (GIS) data of conservation banks becomes increasingly available. Future research can be expanded to incorporate spatial econometric modeling of hedonic price functions.

Chapter 5 is focused on estimating the net present value of conservation banks. We conclude that under the best scenario (i.e., the discount rate of 8%) and no additional cost and a constant credit price, investing in conservation bank provides a financial profit. All the eight conservation banks' NPV were estimated to be positive. The net benefit could be even greater provided the benefits of public goods and services of these ecosystems. Chapter 5 conclude that the landowners who may have discouraged, for lack of knowledge and data and out of fear that presence of endangered species habitat in their land would result in a regulatory compliance and that high cost to benefit ratio would discourage investment in endangered species conservation policy, may be reassured by our findings that investment in habitat conservation banking, in fact, make profit.

6.1 Contributions

The key contribution of this dissertation is the advancement of our understanding of the economic aspect of habitat conservation banking industry in the United States. Our findings provide valuable baseline information and will be a good reference source for future studies. This study filled a knowledge gap by conducting economic analyses of habitat conservation banking market in the United States. Particularly, understanding the trends of habitat conservation banking market over the years, analyzing the demand and supply factors of conservation credits, investigating the characteristics of conservation credit and price variation, and displaying the financial performance of selected habitat conservation banking industry. The findings will be helpful in decision making, strategic planning, identifying most suitable locations, species, and market conditions for additional habitat conservation banking investments.

6.2 Future Research

This study itself is the first comprehensive habitat conservation banking market study in the United States, and our finding has generated floor for several future research areas. Our study focuses on the economic aspect of habitat conservation banking, however, understanding the ecological success is also a key area for future studies. We found that the marginal production of credit is likely to increase overtime with more land area allocated for the conservation bank, but is likely to decrease overtime with increased in land value. Hence, an advance econometric model that incorporates the dynamic aspects of the habitat conservation banking market seems to be a more promising prospect for future research. An important future research can be conducted as detailed pricing, attributes, and geographic information system (GIS) data of conservation banks becomes increasingly available. Future research can be expanded to include more years of transaction data to incorporate spatial econometric modeling.

6.3 Limitations

This dissertation research has several limitations. The scope of the study was limited to the economic and financial aspect of habitat conservation banking market. Further study on ecological factors and associated benefits from ecosystem services will help more precise estimates of habitat conservation banking benefits. Transaction data with price information were very limited. Our study only represents 24% of transactions and do not fully capture the spatial factors or interactions that might be affecting credit prices. Only few bank documents have useable data information. Furthermore, obtained data were not consistent, and observations were not sufficient to facilitate a time series econometric analysis. Panel data analysis results are reported in appendix. The inclusion of these factors would produce more accurate results and help better understand the importance of demand and supply factors. As a limiting factor, in most cases, habitat conservation banking units were reported as acres, credits, and units and thus limits the use of the terms credit and acre in some section of this dissertation.

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APPENDIX A

SURVEY INSTRUMENT

Table A.1 Coverletter sample:

Daowei Zhang, Professor
Tel.: (334) 844-1067
Fax: (334) 844-1084
Email: zhangd1@auburn.edu
602 Duncan Drive, Auburn, AL
School of Forestry and Wildlife
Sciences, Auburn University

Jagdish Poudel, Graduate Student
Tel: (662) 630-2248
Email: jzp0046@auburn.edu
602 Duncan Drive, Auburn, AL
School of Forestry and Wildlife
Sciences, Auburn University

June 22, 2016

Troy Anderson
Ecosystem Investment Partners
2002 Clipper Park Road, Suit 201
Baltimore, MD 21211

Dear Troy:

We are undertaking a research project that involves gathering information on **Species Conservation Credits.** Insights gained from this study will improve our understanding factors that affect the well-being of permittees, bankers, and species conservation practice in the U.S.

You are one of some species conservation credit buyers/sellers/consultants we selected for this survey. Your information on the species conservation credits transactions is very important to us. We would be most grateful if you participate in our study.

Your information will be kept in the strictest confidence, and will be added to those of other permittees and reported anonymously in statistical summary only. For your convenience, a postage stamp is already affixed to the questionnaire. Please complete it as soon as possible, preferably by **July 20, 2016**.

If you would like a copy of the study when it is completed, please send your name and address in a separate envelope to me at the above address.

If you have any questions about this study, please refer to the enclosed information sheet or call me or Mr. Jagdish Poudel at the above number. Thank you, in advance, for your contribution to this study.

Sincerely,

Daowei Zhang
Professor, Forest Economics and Policy

Table A.2 Question:

Please write the information on the table below. We would greatly appreciate if you could provide a copy of species credit transactions (credit ledger files)

Sale No.	Conservation bank name	Species involved	Date of credit transaction (M/D/Y)	Number of credits sold	Total price for all credits sold
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					

APPENDIX B

ADDITIONAL DATA ANALYSIS RESULTS

Table B.1 2SLS estimation results of factors related to the demand and supply of conservation credit in California

	2nd stage IV regression Estimation of quantity (California)	
Variable	Demand Coefficient (standard errors)[1]	Supply Coefficient (standard error)[1]
constant	19.59 (13.53)	4.26 (3.93)
lq		
lp	-0.47 (0.16) *	0.65 (0.20) *
private	1.33 (0.59) *	
animal	-1.28 (0.58) **	
plant	-2.09 (0.61) *	
multispecies	-2.77 (0.88) *	
lcon	-1.12 (0.57) *	
lns	-0.96 (1.50)	
lprate	0.95 (0.39) *	
llv		-1.25 (0.44) *
la		0.73 (0.28) **
Centered R^2	0.06	0.02
N	581	581

Table B.2 2SLS estimation results of factors related to the demand and supply of conservation credit in Florida

	Two Stage least square estimation of quantity (Florida)	
Variable	Demand Coefficient (standard errors)[1]	Supply Coefficient (standard error)[1]
constant	57.25 (182)	-59.29 (98.55)
lq		
lp	4.9896 (5.89)	0.933 (3.42)
animal	33.113 (37.144)	
lcon	-2.743 (3.414)	
lns	-1.56 (1.47)	
lprate	11.03 (8.33)	
llv		2.185 (6.39)
la		2.18 (6.98)
Centered R^2	0.30	0.117
N	14	14

Table B.4 Panel data summary

Variable	Obs	Mean	Std. Dev.	Min	Max
Bank name	115	58.31	35.09	3	137
years	115	2007	4.76	1995	2015
lq	115	0.90	1.70	-3.49	5.19
llv	115	8.72	0.23	8.14	8.94
lcon	115	9.88	0.35	8.97	10.48
lns	113	7.19	0.07	6.86	7.32
la	115	6.49	1.25	3.11	8.02
private	115	0.68	0.46	0	1
species_1	115	0.14	0.35	0	1
species_2	115	0.02	0.16	0	1
species_4	115	0.05	0.22	0	1
species_5	115	0.017	0.13	0	1
species_6	115	0.06	0.25	0	1
species_7	115	0.15	0.36	0	1
species_8	115	0.006	0.09	0	1
species_9	115	0.02	0.16	0	1
species_10	115	0	0	0	0
species_11	115	0.09	0.29	0	1
species_12	115	0.01	0.13	0	1
species_13	115	0.01	0.13	0	1
species_15	115	0.05	0.22	0	1
species_16	115	0.03	0.18	0	1
species_17	115	0.06	0.25	0	1
species_18	115	0.008	0.09	0	1

Table B.5 Within and between variations for panel data

Variable		Mean	Std. Dev.	Min	Max	Observations	
Bank name	overall	58.31	35.10	3.00	137.00	N =	115
	between		38.83	3.00	137.00	n =	25
	within		0.00	58.31	58.31	T-bar =	4.6
Years	overall	2007.64	4.77	1995.00	2015.00	N =	115
	between		3.01	2003.00	2014.00	n =	25
	within		3.95	1996.11	2016.64	T-bar =	4.6
lq	overall	0.90	1.71	-3.50	5.19	N =	115
	between		1.32	-1.15	4.71	n =	25
	within		1.29	-2.51	4.61	T-bar =	4.6
llv	overall	8.72	0.23	8.15	8.95	N =	115
	between		0.13	8.49	8.90	n =	25
	within		0.19	8.21	9.08	T-bar =	4.6
lcon	overall	9.88	0.36	8.97	10.48	N =	115
	between		0.23	9.33	10.23	n =	25
	within		0.29	9.20	10.57	T-bar =	4.6
lns	overall	7.20	0.08	6.86	7.33	N =	113
	between		0.05	7.08	7.33	n =	25
	within		0.07	6.89	7.41	T-bar =	4.52
la	overall	6.49	1.25	3.11	8.03	N =	115
	between		1.10	3.11	8.03	n =	25
	within		0.00	6.49	6.49	T-bar =	4.6
private	overall	0.69	0.47	0.00	1.00	N =	115
	between		0.28	0.00	1.00	n =	25
	within		0.00	0.69	0.69	T-bar =	4.6
sp1	overall	0.15	0.36	0.00	1.00	N =	115
	between		0.34	0.00	1.00	n =	25
	within		0.21	-0.35	0.95	T-bar =	4.6
sp2	overall	0.03	0.16	0.00	1.00	N =	115
	between		0.15	0.00	0.75	n =	25
	within		0.08	-0.72	0.28	T-bar =	4.6
sp4	overall	0.05	0.22	0.00	1.00	N =	115
	between		0.10	0.00	0.40	n =	25

	within		0.20	-0.35	0.89	T-bar =	4.6
sp5	overall	0.02	0.13	0.00	1.00	N =	115
	between		0.05	0.00	0.25	n =	25
	within		0.12	-0.23	0.96	T-bar =	4.6
sp6	overall	0.07	0.26	0.00	1.00	N =	115
	between		0.08	0.00	0.25	n =	25
	within		0.24	-0.18	0.91	T-bar =	4.6
sp7	overall	0.16	0.36	0.00	1.00	N =	115
	between		0.20	0.00	1.00	n =	25
	within		0.09	0.10	1.10	T-bar =	4.6
sp8	overall	0.01	0.09	0.00	1.00	N =	115
	between		0.10	0.00	0.50	n =	25
	within		0.07	-0.49	0.51	T-bar =	4.6
sp9	overall	0.03	0.16	0.00	1.00	N =	115
	between		0.14	0.00	0.50	n =	25
	within		0.13	-0.47	0.83	T-bar =	4.6
sp10	overall	0.00	0.00	0.00	0.00	N =	115
	between		0.00	0.00	0.00	n =	25
	within		0.00	0.00	0.00	T-bar =	4.6
sp11	overall	0.10	0.30	0.00	1.00	N =	115
	between		0.30	0.00	1.00	n =	25
	within		0.10	-0.50	0.50	T-bar =	4.6
sp12	overall	0.02	0.13	0.00	1.00	N =	115
	between		0.11	0.00	0.50	n =	25
	within		0.10	-0.48	0.77	T-bar =	4.6
sp13	overall	0.02	0.13	0.00	1.00	N =	115
	between		0.11	0.00	0.50	n =	25
	within		0.11	-0.48	0.82	T-bar =	4.6
sp15	overall	0.05	0.22	0.00	1.00	N =	115
	between		0.20	0.00	0.75	n =	25
	within		0.14	-0.70	0.85	T-bar =	4.6
sp16	overall	0.03	0.18	0.00	1.00	N =	115
	between		0.22	0.00	1.00	n =	25
	within		0.11	-0.47	0.83	T-bar =	4.6

sp17	overall	0.07	0.26	0.00	1.00	N =	115
	between		0.28	0.00	1.00	n =	25
	within		0.00	0.07	0.07	T-bar =	4.6
sp18	overall	0.01	0.09	0.00	1.00	N =	115
	between		0.04	0.00	0.20	n =	25
	within		0.08	-0.19	0.81	T-bar =	4.6

Table B.6 Panel data pooled OLS

lq	Coef.	Std. Err.	t	P>t
llv	1.21	.94	1.28	0.204
lcon	0.00	.58	0.01	0.995
lns	-7.66	2.81	-2.73	0.008
la	0.05	.313	0.15	0.884
private	1.19	.78	1.52	0.133
sp1	-0.44	.57	-0.77	0.442
sp2	-2.90	1.39	-2.08	0.041
sp4	-0.14	.79	-0.17	0.864
sp5	-0.30	1.17	-0.25	0.802
sp6	0.81	.65	1.23	0.220
sp7	-0.01	.57	-0.02	0.982
sp8	-1.59	1.64	-0.96	0.338
sp9	0.22	1.02	0.22	0.830
sp11	0.15	.656	0.24	0.814
sp12	-0.08	1.18	-0.07	0.945
sp13	3.02	1.19	2.54	0.013
sp15	0.81	.78	1.02	0.308
sp16	1.00	.89	1.13	0.263
sp17	0.68	.85	0.80	0.428
sp18	-0.62	1.61	-0.39	0.701
Constant	44.19	21.59	2.05	0.044

Number of Obs=113

F (20,92) =2.31

Prob > F= 0.0039

R-Squared= 0.334

Table B.7 Panel data random-effect IV regression

Quantity demand	Coefficient	Std.error	z	P> |z|
lp	0.07	0.29	0.22	0.82
lcon	-0.13	0.60	-0.21	0.83
lns	-6.00	2.53	-2.37	0.02
Private	1.05	1.12	0.94	0.35
sp1	-0.57	0.57	-1.01	0.31
sp2	-2.91	1.02	-2.85	0.00
sp4	-0.24	0.79	-0.30	0.77
sp5	-0.18	1.20	-0.15	0.88
sp6	0.79	0.71	1.11	0.27
sp7	-0.08	0.60	-0.12	0.90
sp8	-1.62	1.64	-0.99	0.32
sp9	0.17	1.05	0.16	0.87
sp11	-0.01	0.68	-0.01	0.99
sp12	0.15	1.30	0.12	0.91
sp13	2.79	1.22	2.29	0.02
sp15	0.77	0.77	1.00	0.32
sp16	1.05	0.90	1.17	0.24
sp17	0.30	0.85	0.36	0.72
sp18	-0.82	1.64	-0.50	0.62
Constant	44.36	21.94	2.02	0.04
Number of obs	113			
Number of groups	25			
Wald chi-square (19)	43.11			
Prob > Chi-Square	0.0013			

Group variable: Bank name
Instrumented: lp
Instruments: lcon lns private sp1 sp2 sp4 sp5 sp6 sp7 sp11 sp12 sp13 sp15 sp16 sp17 sp18
R-Square: within= 0.11, between= 0.50, overall= 0.305

Table B.8 Panel data fixed-effect (within) IV regression

Quantity demand	Coef.	Std. Err.	z	P>z
llv	1.12	0.95	1.18	0.24
lcon	0.07	0.58	0.12	0.91
lns	-7.56	2.78	-2.72	0.01
la	0.04	0.33	0.13	0.89
private	1.28	0.89	1.45	0.15
sp1	-0.48	0.58	-0.82	0.41
sp2	-2.91	1.41	-2.05	0.04
sp4	-0.13	0.79	-0.17	0.87
sp5	-0.23	1.16	-0.19	0.85
sp6	0.81	0.64	1.25	0.21
sp7	0.02	0.71	0.03	0.97
sp8	-1.57	1.66	-0.94	0.35
sp9	0.19	1.03	0.18	0.86
sp11	0.16	0.69	0.23	0.82
sp12	-0.14	1.19	-0.12	0.91
sp13	2.80	1.19	2.34	0.02
sp15	0.67	0.81	0.83	0.41
sp16	0.93	0.91	1.03	0.31
sp17	0.62	0.90	0.69	0.49
sp18	-0.61	1.62	-0.38	0.71
Constant	43.61	21.37	2.04	0.04
Number of obs	113			
Number of groups	25			
Wald chi-square (17)	44.49			
Prob > Chi-Square	0.0005			

Group variable: Bank name
Instrumented: lp
Instruments: lcon lns private sp1 sp2 sp4 sp5 sp6 sp7 sp11 sp12 sp13 sp15 sp16 sp17 sp18
R-Square: between= 0.08, overall= 0.0056
F test, F (24,71) = 0.80; Prob > F = 0.7211

Table B.9 Hausman fixed and random effect test

	Coefficients			
	Fixed	Random	Difference	S.E.
lp	1.492249	.0654671	1.426782	2.073491
lcon	2.157697	-.1262309	2.283928	2.350873
lns		-10.176263	1.826949	2.267175
sp1		-1.6878192	-0.5395211	0.7681169
sp2	7.389363	-2.908845	10.29821	12.94149
sp4	1.344739	-.2353116	1.58005	1.61576
sp5	.8422733	-.1772314	1.019505	0.9819935
sp6	2.082137	.7903497	1.291787	1.759538
sp7		-0.9305634	-0.7802709	2.044687
sp8	2.491906	-1.617995	4.109901	3.65567
sp9	2.188279	.1672112	2.021068	2.597722
sp11	.4131821	-.0065247	0.4197068	2.049816
Sp12	.3397942	.1524366	0.1873576	1.616568
sp13	1.457813	2.786928	-1.329115	1.807188
sp15	-1.012511	.7723357	-1.784847	1.426141
sp16	1.992494	1.051001	0.9414929	1.869501
sp18		-2.1211489	-0.4811247	2.089869

b = consistent under Ho and Ha; obtained from xtivreg

B = inconsistent under Ha, efficient under Ho; obtained from xtivreg

Test: Ho: difference in coefficients not systematic

chi2(17) = = 0.13

Prob >chi2 = 1