The Impact of Crop Return on the Likelihood of Habitat Protection: the Case of Manitoba

by

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A Thesis submitted to the Faculty of Graduate Studies of
The University of Manitoba
in partial fulfilment of the requirements of the degree of

MASTER OF SCIENCE

Department of Agribusiness

University of Manitoba

Winnipeg

Abstract

Wildlife habitat loss in North America has been increasing since the time of European settlement. In Manitoba, conservation agencies are mainly using two methods to slow down the process: fee simple and conservation easement protections. The thesis estimates whether crop return impacts the likelihood of a quarter section getting protected by either fee simple or easement, while controlling for other factors. I utilize the discrete time hazard model for the estimation in this thesis. My results suggest that crop return has a negative impact on the likelihood of both fee simple and easement protections, and when crop return changes from low to medium and high regimes, agencies also change the type of land they protect. Moreover, fee simple method protects different type of land after the Manitoba Conservation Agreements Act was passed in 1997.

Acknowledgements

I would like to offer my deep sense of gratitude to my advisor Dr. Chad Lawley for his guidance, help, and dedication. I am also very grateful for the committee members, Dr. Gary Johnson and Dr. Charles Towe for the time they spent on my thesis, as well as their support and comments.

Deep thanks to my colleague Patrick Ndolo for the help on the data processing.

I would also like to thank my father, Wende Wang and my mother, Yun Luo for their financial support.

Special thanks to my girlfriend, Luying Wang for her support and love.

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Chapter 1. Introduction

1.1 Wetland Loss in the North American Prairie Pothole Region

Wetland conservation in the North American prairie pothole region has become a popular research topic over the last few years, as more people start to realize the important functions that wetlands serve in the ecosystem and the society. These functions include provision of plant and wildlife habitat, flood control, sustaining watershed and water quality, carbon sequestration, reduction of soil erosion, provision of beautiful sceneries, and spots for recreational activities (Cortus et al. 2011). However, often times these ecological functions realize more benefits to the public than the individual landowner; therefore, when habitat conservation does not yield as much benefits as agriculture does, it is in private landowner's incentive to drain the wetlands for agricultural production to gain more private economic benefits. The drainage and development of wetlands, hence, are done at the expense of losing wildlife habitat and diminishing social benefits that are associated with biodiversity and other ecological functions.

It is estimated that nearly 50% of the historical wetland area in the United States and 71% in Canada have been drained for agricultural development, and more than 40% of prairie wetlands have been lost in the past century due to drainage activities (Cortus et al. 2011; Rashford et al. 2011); between 1985 and 2001, over 500,000 acres of wetlands were lost in Canadian prairie pothole region, and 62% of those acres were converted to grow annual crops (Cortus et al. 2011; Rashford et al. 2011). In spite of the rising attention from the public on environmental subjects, this trend of conversion is expected to continue due to a several reasons. According to Lawley (2014), the first factor that might keep the trend continue is the increase of relative returns on annual crops due to the adoption of larger farm machinery, and agronomic advances that have improved agricultural productivity. Another factor for this continuous land conversion trend is the decreasing cost of converting habitat to cropland due to advances in and greater availability of drainage and clearing equipment, adoption of geographic information system (GIS) technology, and an expanded rural drainage network. The declining cost of converting encourages farmers to develop those land parcels that were too expensive to develop before, but profitable now. As a result, the risk of conversion of these land parcels will increase.

1.2 Identifying the Issue and Objective

In order to slow the process of habitat loss, conservation agencies have two ways to protect existing habitats. One is owning the land outright by fee simple purchases; another is placing conservation easements on targeted land, which prohibits landowners from developing and converting eased land parcels, but the land titles still belong to landowners (Parker 2004). Conservation agencies have limited annual budgets, and their decision-making process of habitat selection is influenced by various factors including crop return, land characteristics of land cover and soil productivity, surrounding land characteristics and protection status, and the distance from urban centers. These factors not only affect conservation agencies (i.e. demand side), but also influence landowners (i.e. supply). However, previous literatures focus more on building frameworks of habitat selection for agencies on the demand side, instead of taking into consideration the impact of above-mentioned factors on the supply side. Therefore, it is very important, and at the same time, interesting to fill the gap by estimating what factors affect the likelihood of a land parcel being protected in terms of both supply and demand, and also compare the differences between the two conservation methods of fee simple and conservation easement. Among these factors, crop return is the one that I am most interested in due to the following reason.

Crop returns are largely correlated with crop prices, and crop prices, according to Rashford, Bastian, and Cole (2011) are expected to have a long-term growth and volatility due to removal of agricultural trade barriers, economic growth in developing countries, and expansion of biofuels. Moreover, according to Carter, Rausser, and Smith (2011), there has been a sharp food commodity price increase from Fall 2005 to mid-2008, when the four major food commodities (corn, rice, soybeans, and wheat) approximately tripled. Then after July 2008, these prices dropped as quickly as they rose, though these prices remain about double their 2005 levels. The huge price fluctuation is likely due to the following reasons: 1) biofuel policies in the U.S., Brazil, and the European Union (EU) that shift crop utilization from food to biofuel; 2) reducing food supplies from Australia and EU due to poor weather; 3) growing food demand from emerging economies such as China, India, and Russia; 4) increasing energy prices that drive up costs of food production (Carter, Rausser, and Smith, 2011).

The increasing trend of crop prices and farm returns are expected to impact the likelihood of habitat protection through both sides of the market. For landowners, the increasing long-term crop returns would give them incentives to convert more arable and productive land to grow annual crops. As a consequence, for conservation agencies, it is more expensive to make easements or fee simple purchases to protect habitat. Therefore, this thesis focuses on examining whether the impact of increasing crop return would have a negative impact on the likelihood of habitat protection, while controlling for other factors, and whether fee simple and easements protections respond differently to crop return changes.

Since crop prices had an extreme boom and bust from 2005 to 2008, the thesis also estimates when crop return fluctuates, whether conservation agencies still target the same type of land for conservation. Moreover, the Manitoba Conservation Agreement Act was passed in 1997, which allows conservation agencies to conserve habitat through conservation easement (Government of Manitoba, 1997). With the new alternative, fee simple should face the competition from easements on targeting land with higher ecological benefits and lower transaction costs. Therefore, the thesis estimates whether fee simple protection still protect the same type of land after the legislation, or it starts to shift the target to other types of land, such as quarter sections with higher soil quality (while easements compete for lower soil quality parcels for lower costs), parcels that need more management and enhancement on amenities, and parcels with less gains from specialization.

1.3 Thesis Outline

This study consists of five chapters. Following Chapter 1, Chapter 2 introduces the background of wetland loss in Canada, methods to mitigate the loss, and wildlife habitat conservation in the Prairie Pothole Region, especially in Manitoba. Chapter 2 also provides a review of the previous literatures associated with habitat conservation, from the early stage of the research that develops frameworks for conservation agencies to target habitat, to later stages where researchers concentrate more on finding out the factors actually have the impact on the likelihood of habitat conservation from both sides of supply and demand. Chapter 3 discusses the empirical models that I use for the estimations and the rationale behind choosing the models and specific variables. I estimate the determinants of fee simple and easements separately using baseline logistic models. Then I use the logistic model with interactions of crop return and land characteristics to estimate when crop return changes, how agencies change their criteria of habitat selection. Last but not least, I use logistic model for fee simple to estimate whether fee simple agencies' criteria of habitat selection change before and after conservation easement legislation. Chapter 3 also provides a description of the data for the model, including the sources of the data and the way it has been organized, constructed, and presented. Chapter 4 provides the regression results from the estimations, and discusses them further in details. Last but not least, Chapter 5 summarizes the research results, the limitations of the research, and future research opportunities.

Chapter 2. Background

As is mentioned in Chapter 1, wetland loss has become a serious problem all over the world, especially in the U.S. and Canada. Globally, around 50% of the world's wetlands have been lost in the 20th century, while global wetland extent has declined by 6% from 1993 to 2007 (Rashford, Bastian, and Cole, 2011). Canada has approximately 25% of the world's wetlands, and these wetlands cover approximately 14% of the land of Canada (Government of Canada, 2016). However, a large amount of the wetlands have been converted; in some areas more than 90% of the wetlands have been lost (Cortus et al. 2011). DUC (2009) has estimated that in southern Saskatchewan and southwestern Manitoba alone, around 350,000 hectares of wetlands have been lost over the past 40 to 60 years.

Since the trend of wetland loss is not slowing down by itself, a variety of methods have been proposed to mitigate the loss. Landowners can be both supporters and opponents of habitat conservation. For supporters, they are the private landowners who benefit from habitat conservation, because they have special and affective relationships with their rural and natural land that increases their quality of life, gives a sense of belonging and motivation to protect against conversion. It is also possible for those landowners to gain compensations from conservation agencies if they enroll habitats that are less suitable for agricultural production. On the other hand, it is easy to imagine other landowners, who are driven by financial motives, especially for farmers who are more dependent on their land for generating incomes to oppose habitat conservation. Land conservation restricts their use of land for agricultural purposes; therefore, these landowners are less likely to conserve the land voluntarily (Drescher, 2014). Governments have come up with various ways to promote habitat conservation, including promoting educational programs, enacting legislations and regulations. However, these methods require large monetary and time investments from governments, which put great pressures on both regulators and landowners, in terms of implementing, enforcing, and monitoring the regulations (Zhang and Flick, 2001).

There are also various environmental policies have been established in North America to slow the process of land conversion. In the U.S., the Conservation Reserve Program (CRP) was established in 1985 under the United States Department of Agriculture (USDA), and is administered by the USDA Farm Service Agency (FSA). The Agricultural Act of 2014 established the Agricultural Conservation Easement Program (ACEP), which provides financial and technical assistance to help conserve agricultural lands and wetlands and their related benefits (USDA Farm Service Agency, 2017; USDA Natural Resource Conservation Service, 2017). In Manitoba, the Manitoba Conservation Agreements Act was passed in 1997, which allows conservation agencies to purchase easements from landowners in Manitoba on existing habitat on agricultural land. The three active conservation agencies in Manitoba include the Manitoba Habitat Heritage Corporation (MHHC), Ducks Unlimited Canada (DUC), and Nature Conservancy of Canada (NCC). Their activities of protecting land are partly funded by the Prairie Habitat Joint Venture (PHJV) of the North American Waterfowl Management Plan (NAWMP) (Lawley and Towe, 2014).

In addition to the above-mentioned attempts of governments, acquisition of full or partial property rights of land by conservation agencies is becoming more prevalent. Conservation agencies (more commonly referred to as land trusts in the U.S.) are non-profit organizations that conserve environmental amenities on private land. In this case, land conservation occurs under two circumstances. One is when landowners grant land titles to agencies with the purpose of land conservation; the other is when landowners only grant the use of land to agencies for conservation but retain the right of disposition. Under the former circumstance, agencies acquire land titles through fee simple purchases, and obtain the full interest from the land, including the right of possession, use, and disposition. Under the latter circumstance, land conservation is done through conservation easement. As introduced in Chapter 1, agencies pay the negotiated compensations to landowners in order to obtain the partial property right in perpetuity, which means future owners are still bound by the terms of the easement that prohibits cultivating and developing.

Conservation easements became more and more prevalent after 1998 in Manitoba after the Manitoba Conservation Agreement Act was passed in 1997. Since conservation easement is a voluntary program, there are two ways for conservation agencies such as DUC, MHHC, and NCC to protect habitats. According to Lawley and Towe (2014), one way is simply waiting for interested landowners to initiate the contact with them for participation in the program; while the other way, which is more proactive, is that agency staff approach potential landowners to solicit them into enrolling their land in easements. Once landowners and agencies start the negotiation, the most important part would be calculating the compensation. The amount of compensation that the landowner will receive is based on the acreage of the habitat that is enrolled in the easement and the average assessed values of surrounding land parcels (typically 30-40% of the assessed per-acre value of the surrounding agricultural land). After the landowner agrees to enroll the habitat in an easement and receive the compensation, the conservation agency will propose an annual compliance monitoring plan through a baseline assessment, which records the extent, type and condition of existing habitat. The monitoring is done through either entering into the eased habitat in person, or aerial monitoring (Government of Manitoba, 1997; Lawley and Towe, 2014).

Conservation easement and fee simple conservation are two ways of habitat conservation, and they are suitable for different conditions. According to Chamblee and his colleagues (2011), easement method is better in the U.S. when the landowner develops the habitat into agricultural land for farming and wants to take advantage of federal and state tax benefits from conservation, while fee simple is better when the land is converted to a specialized activity that needs more management and monitoring than the landowner is capable of. Parker (2004) also indicates the differences between the two methods. The first difference is that fee simple protection is better than easements when transaction costs are high. If agencies need to manage wildlife, monitor activities, and enhance amenities, the transaction costs are high; agencies are better off if they own the full property right to avoid unnecessary costs from negotiating with landowners under easements. The second difference is that conservation easement is a better approach than fee simple if there are gains from specialization. For example, an agency is better off to put an easement on a grassland than purchasing the land to prevent the grassland from being converted to cropland, so that landowners can still raise cattles and make profits with their specialization in ranching.

Over the past few decades, economists and other researchers have been focusing on studying the approaches that conservation agencies should adopt for cost effective selection of reserves and the ecological or economic rationales behind the approaches. Most of them focus on analysis of the conservation agencies' perspective instead of both the supply and demand sides of the market.

Church et al. (1995) develop a "site-constraint" optimization framework, which helps select reserves using the maximal coverage location model to identify sets of locations and parcels that cover the maximum possible representation of specific species, subject to selection of a specific number of reserve sites. They use vertebrate data of Southwestern California as an example application. The model addresses the question that is proposed in the paper, however, only in terms of biology conservation.

Often times the agencies have limited funds and resources to purchase easements or habitats, and they may not be able to conserve certain habitats they desire most due to land costs. Ando et al. (1998) introduce conservation cost into reserve selection decision models. They utilize U.S. county-level data on land prices and the incidence of endangered species to develop a more systematic approach to efficiently allocate conservation resources in selection of reserve sites. In other words, the objective becomes targeting and protecting land that covers the maximal representation of certain species given limited annual funds. It is a more thorough approach to habitat selection, because conservation agencies like NCC, DUC, or MHHC are always faced with limited budgets and trying to maximizing ecological benefits within the budgets.

Abbitt et al. (2000), on the contrary to what Ando et al. (1998) have done, take the land's risk of conversion into consideration instead of the land cost factor. They map the distribution of restricted-range birds and butterflies not listed as threatened or endangered species under the Endangered Species Act, and identify "hotspots of vulnerability" where there is a projection of increases in human population and development like urban centers in coastal California. Their finding indicates that many areas in the U.S. currently at risk of conversion, which are identified as "hotspots of vulnerability," are habitats for a large number of unlisted bird and butterfly species that are under great threat of extinction. Therefore, the implication of this study for reserve selection and management brings another important factor, risk of conversion, into consideration. If a land parcel is not suitable for agriculture or does not have high potential of human activity, even though it contains a large number of species, it should not be in conservation agencies' priority to conserve since it may not be converted anyway in the short term.

As an extension of both reserve-site selection frameworks from Ando et al. (1998) and Abbitt et al. (2000), Newburn, Berck, and Merenlender (2006) incorporate both heterogeneity in land costs and probability of land-use conversion into the reserve selection decision-making framework. The analysis compares this framework with two alternative strategies that assume either homogeneous land costs or homogeneous probability of land-use conversion. The authors utilize the data from the unincorporated area of Sonoma County in California, where a large number of developable parcels such as pasture and forest areas with environmental amenities are being converted rapidly for either residential use or vineyards. Based on dynamic programming and Monte Carlo simulations with alternating periods of conservation and development, it is suggested that there is a positive correlation between land costs and probability of land-use conversion and it explains how that affects targeting efficiency of reserve site selection in a dynamic setting.

Lawley and Yang (2015), different from all above-mentioned literatures, conduct an empirical study of spatial interactions in habitat conservation by showing evidence that easements increase the likelihood of subsequent easements on neighboring land. The study starts to focus on both habitat supply and demand. This suggests that, on the one hand, agencies explicitly target habitat that are close to those already protected to increase connectivity of conserved habitat, so that animals can have bigger secured living space; on the other hand, landowner's awareness of habitat conservation may be raised by his or her neighbors who have protected habitat on their properties. The authors use quarter section dataset of all permanently protected habitat in southwestern Manitoba from 2000 to 2011, which is used to identify spatial interactions between quarter sections (i.e. frequencies of the number of neighboring protected quarter sections), to merge with geo-referenced data (land characteristics) including soil productivity, land cover, distance of quarter sections to cities and major elevators, elevation, and suitability of the quarter section as waterfowl habitat. The main result suggests that on average, an additional neighboring eased quarter section within one mile increases the likelihood of an easement by 9.4 percent annually.

Chapter 3. Empirical Model and Data

3.1 Empirical Model

In this study I estimate the parameters of a series of discrete time hazard models. The discrete time hazard model is used to estimate the impact of crop return on the likelihood of a quarter section getting protected either by fee simple or conservation easement, while controlling other factors.

The probabilities of a quarter section i getting protected by fee simple and conservation easement at time t conditional on not being protected by any type of protection at the previous time period is written as:

$$(1)\ \Pr(f_{it} = 1 | f_{it-1} = 0; c_{it-1} = 0) = \Pr(f_{it}^{*} > 0 | f_{it-1}^{*} \leq 0; c_{it-1}^{*} \leq 0)$$

$$(2)\ \Pr(c_{it} = 1 | c_{it-1} = 0; f_{it-1} = 0) = \Pr(c_{it}^{*} > 0 | c_{it-1}^{*} \leq 0; f_{it-1}^{*} \leq 0)$$

where f_{it} and c_{it} are dummy variables, and if they are equal to 1, it means the quarter section is protected. If they are equal to zero, it means it is not protected; f_{it}^{*} and c_{it}^{*} are latent variables. If f_{it}^{*} and c_{it}^{*} are greater than zero, it means the quarter section is protected. If they are less than or equal to zero, it means the quarter section is not protected.

Standard errors are clustered at the quarter section level in all regressions. Though clustered errors will not affect the estimated coefficients, it specifies the intragroup coloration of standard errors (Nichols and Schaffer, 2007). In this case, the panel data has each quarter section showing up 22 times from 1990 to 2011, and clustered errors control the quarter section's standard error correlation during the 22 years.

3.1.1 Baseline logistic models

The probability of protection f_{it}^* and c_{it}^* are further specified into two equations below, representing both fee simple and easements. The latent variables, f_{it}^* and c_{it}^* are written as:

(3) $$f_{it}^* = \alpha_f X_{it} + \beta_f W_i + \theta_f N_i + \gamma_f L_{it} + \mu_f Y_{it} + \delta_f Z_t + \varepsilon_f S_{n(i)t} + \eta_f G_r + e_{fit}$$

(4) $$c_{it}^* = \alpha_c X_{it} + \beta_c W_i + \theta_c N_i + \gamma_c L_{it} + \mu_c Y_{it} + \delta_c Z_t + \varepsilon_c S_{n(i)t} + \eta_c G_r + e_{cit}$$

where α, β, θ, γ, μ, δ, ε, and η are parameters to be estimated and the subscripts f and c denote fee simple and easements respectively; X_{it} denotes crop returns; W_i and N_i denote time invariant characteristics, where W_i denotes soil productivity and N_i denotes the neighbouring quarter section's soil productivity and the quarter section's distance from urban centers; L_{it} and Y_{it} are time variant land characteristics, where L_{it} denotes the quarter section's land cover and Y_{it} denotes the neighbouring quarter section's land cover; Z_t is a set of year fixed effects; $S_{n(i)t}$ denotes protection status of neighbouring quarter sections; G_r denotes time invariant fixed effects, and the subscript r denotes that the fixed effects are on the level of census agricultural region; e_{it} denotes the error terms.

The crop return of quarter section i at time t is denoted X_{it}. Crop return is expected to have a negative impact on the likelihood of habitat protection, because if farming profits go up, on the one hand, farmers should be less likely to enroll their land into conservation easement programs or sell their land to agencies for conservation as a fee simple; on the other hand, it would be more expensive for agencies to purchase fee simples and easements from farmers. According to Just and Miranowski (1993) farmers view farming as risky in terms of operating income (output prices and yields) and wealth accumulation (land prices), so they make decisions based upon information from previous years instead of the current year. Moreover, Goodwin and his colleagues (2011) conducted a research on the distribution of agricultural subsidy benefits from government support. In the research, they use the expected payment benefits constructed by the average benefits of the previous four years instead of the current-year benefits to avoid the bias that forces coefficients toward zero and yields inconsistent estimates. Therefore the crop returns for this study include the mean values of the previous 5-year revenues. The other part of crop return data in this thesis is risk of crop returns. According to Parks (1995), landowners are risk averse, and make dynamic land conversion decisions based upon profit maximizations, where he counts risk as a part of costs. In the case of Manitoba, I use crop return variance (i.e. crop return risk) as a part of crop production costs. Therefore, crop return risk is expected to have a positive impact on the likelihood of protection, which suggests that the higher crop return risk landowners expect, the more likely for them to conserve the quarter section instead of converting it into cropland.

Time invariant characteristics of quarter section i are denoted as W_i and N_i. W_i includes the quarter section's soil productivity, and N_i includes the quarter section's distance from urban centers, and soil productivity of neighboring quarter sections. For soil productivity and neighbouring soil productivity (soil productivity buffers), on the agency's stand point, the higher soil quality, the more likely it will be to increase the risk of conversion. Thus, all else equal, conservation agencies are expected to target more on high quality soils. However, landowners are less likely to conserve high quality soil because they would be able to yield higher agricultural benefits from it if they convert the habitat. Therefore, the offsetting forces from buyers and sellers makes the impact of soil quality hard to predict. The other part of W_i is the distance factor. The close distance to towns and villages increases the chance of agricultural activities, therefore, it is expected to increase the risk of conversion and the likelihood of the agency's protection. But the distance from cities is not expected to have impact in the case of Manitoba.

Time variant characteristic of quarter section i at time t are denoted as L_{it} and Y_{it}. L_{it} includes the quarter section's land cover type, and Y_{it} includes land cover type of neighboring quarter sections. For the neighboring quarter section land cover type, agencies tend to target quarter sections with more permanent habitat cover (including wetlands, grassland, and shrubs) within one mile, independent of its protected status; land with more annual crops is less likely to be protected (Lawley and Yang, 2015).

Year fixed effects denoted as Z_t, have impact on all quarter sections including interest rate, exchange rate, and livestock prices. Because they are unobserved, I incorporate year fixed effects to mitigate the bias the unobservables have on the estimates.

The cumulative number of protected quarter sections in the neighborhood of quarter section i at time t is denoted as $S_{n(i)t}$, and it is used to identify the spatial spillover effect in habitat conservation. According to the study of Lawley and Yang (2015) that has been discussed in Chapter 2, the more protected quarter sections in the neighborhood, the more likely the parcel will be protected.

Time invariant unobserved census agricultural region characteristics are denoted as G_r. These unobservables include unobserved landscape characteristics, different municipal policies on habitat conservation, and natural disasters like droughts and floods. For instance, quarter sections with more suitable environment for waterfowls are more likely to be targeted by conservation agencies. And quarter sections located in municipalities that have more favorable conservation policies and projects are more likely to be protected. I incorporate "census agricultural region" fixed effects in order to mitigate the bias from the unobservables on the estimates.

3.1.2 Varying impact of parcel characteristics in different crop return regimes

The baseline model estimates the impact of previous 5-year average crop return on the likelihood of habitat protection, and the marginal effects are estimated based on the average level of crop return. However, there are many unexpected events that will make farm income turns out to be different from anticipation, such as frequent revisions of government policies (Just and Miranowski, 1993). It is interesting to see when crop return changes from low to high, how conservation agencies would revise their criteria of habitat selection in terms of parcel characteristics (i.e. land cover types and soil productivity).

In order to estimate the changes, I add the interactions of crop return and land characteristics into the base model. Now the equations for the latent variables f_{it}^{*} and

c_{it}^* are:

$$(5) \qquad f_{it}^* = \alpha_f X_{it} + \beta_f W_i + \theta_f N_i + \gamma_f L_{it} + \mu_f Y_{it} + \delta_f Z_t + \varepsilon_f S_{n(i)t} + \eta_f G_r + \omega_f X_{it} \times W_i + \rho_f X_{it} \times L_{it} + e'_{fit}$$

$$(6) \qquad c_{it}^* = \alpha_c X_{it} + \beta_c W_i + \theta_c N_i + \gamma_c L_{it} + \mu_c Y_{it} + \delta_c Z_t + \varepsilon_c S_{n(i)t} + \eta_c G_r + \omega_c X_{it} \times W_i + \rho_c X_{it} \times L_{it} + e'_{cit}$$

where α, β, θ, γ, μ, δ, ε, η , ω, and ρ are the parameters of the vectors to be estimated in the new model. As in the base model, the lower subscripts f and c indicate whether they belong to fee simple section or easement section. The vectors X_{it}, N_i, Y_{it}, Z_t, $S_{n(i)t}$, G_r stay the same as in the base model. However, W_i and L_{it} in the new equations are interacted with crop return variable X_{it}.

Crop return has three levels for both fee simple and easements: low, medium, and high. I use the mean value of crop return as “medium crop return”, then use mean value minus one standard deviation to get “low crop return”, and plus one standard deviation to get “high crop return”. The mean value of crop return and the standard deviation could be found on Table 3.1. Summary Statistics.

3.1.3 Impact of conservation easement legislation on fee simple protection

As the Manitoba Conservation Agreement Act was passed in 1997, conservation easement is gradually becoming a popular method of habitat conservation after 1998 in Manitoba. Before 1998, apart from regulatory conservation methods, fee simple was the only conservation tool by conservation agencies. But since the Manitoba Conservation Agreement Act is passed, which allows agencies to have an alternative tool for habitat conservation, it is appealing for agencies to use the new tool. It is interesting to see if there is any change in the use of fee simple method, and if the factors that impact the likelihood of fee simple protection change when agencies target habitat to protect by fee simple before and after 1998. In order to estimate the fee simple change, I add a new variable into equation (2), which is easement dummy variable (equals to 0 if the year is before and on 1998, equals to 1 if the year is after 1998), and use the dummy to interact with all the variables in the equation excluding the fixed effects.

When estimating if the agency's target changes when selecting habitat to protect before and after 1998, the latent variable f_{it}^{*} is written as:

(7) $$f_{it}^{*} = \alpha_f E_t X_{it} + \beta_f E_t W_i + \theta_f E_t N_i + \gamma_f E_t L_{it} + \mu_f E_t Y_{it} + \delta_f Z_t + \varepsilon_f E_t S_{n(i)t} + \eta_f G_r + e_{fit}''$$

Where α, β, θ, γ, μ, δ, ε, and η are the parameters of the vectors to be estimated in equation (7); E_t is the easement dummy variable, where E_t=0 if the year is before or on 1998 and E_t=1 if the year is after than 1998; and e_{fit}'' is the error term. The remainder of the variables stay the same as the logistic base model for fee simple. The easement dummy variable is interacted with X_{it}, W_i, N_i, L_{it}, Y_{it}, and $S_{n(i)t}$.

3.1.4 Marginal effects and semi-elasticicities

Models of binary dependent variables like the one from this study are often estimated using logistic regression. Because the model is nonlinear, the coefficients and odds ratios from the estimation are difficult to interpret directly. In order to quantify the extent to which independent variables impact the likelihood of habitat protection, the study uses marginal effect for interpretation. Marginal effect measures the instantaneous impact of a change in an independent variable on the probability that the parcel is protected, while controlling other factors.

In this study, assume the probability of habitat conservation is:

(8) $Pr(P^* = 1) = \frac{e^{\sigma v}}{1+e^{\sigma v}}$

where P^* is the protection status of the quarter section, which is equal to 1 if the quarter section is protected and zero otherwise; v represents all independent variables that impact on the likelihood of protection; and σ is the vector of coefficients on v. Then the marginal effect of the independent variable on the probability of protection is:

(9) $\frac{\Delta Pr}{\Delta v} = \frac{\partial Pr}{\partial v} = \sigma Pr(1 - Pr)$

Marginal effect will give us the amount of change in the probability of protection when the independent variable changes by 1 unit. However, because both fee simple and easement conservations are low probability events (481 fee simple protections and 1557 easement protections out of more than 151,000 potential quarter sections that could be protected in the original dataset), the absolute value of marginal effects will also be low and hard to interpret. Therefore, I introduce semielasticity in order to make the results more presentable and easier to interpret. The semi-elasticities are calculated as follow:

(10) $\frac{\Delta Pr/Pr}{\Delta v} = \sigma(1 - Pr)$

From (10) we can see that the semi-elasticity will be larger than the marginal effects. It gives us the percentage change in the likelihood of protection when the independent variable changes by 1 unit (Wooldridge, 2013).

3.2 Data

In this section, I discuss dependent variable and independent variables that I use for the study in terms of the summary statistics, data description, data source, and the way I process them. My dependent variable is protection status, and the rest are independent variables.

Quarter section is the basic unit of observation for this research. The Dominion Land Survey System divides most of the land in western Canada into square mile sections. The sections are further divided into quarter sections, which are 160-acre square plots (Lawley and Yang 2015). The data of quarter sections in Manitoba is obtained from the Manitoba Land Initiative (MLI) website as a shape file.[1] Each quarter section has a legal description that identifies its geographical locations in Manitoba. The study area is southern Manitoba where most agricultural activities occur, which is shown by Figure 1. The grey area is the quarter sections of the study region, and they are divided into 12 census agricultural regions. Each quarter section is merged with geo-referenced data of conservation status, crop return, land cover, soil quality, distance to cities, distance to towns and villages, and neighbouring quarter section characteristics.

[1] Source: http://mli2.gov.mb.ca/quarter_sec/index.html.

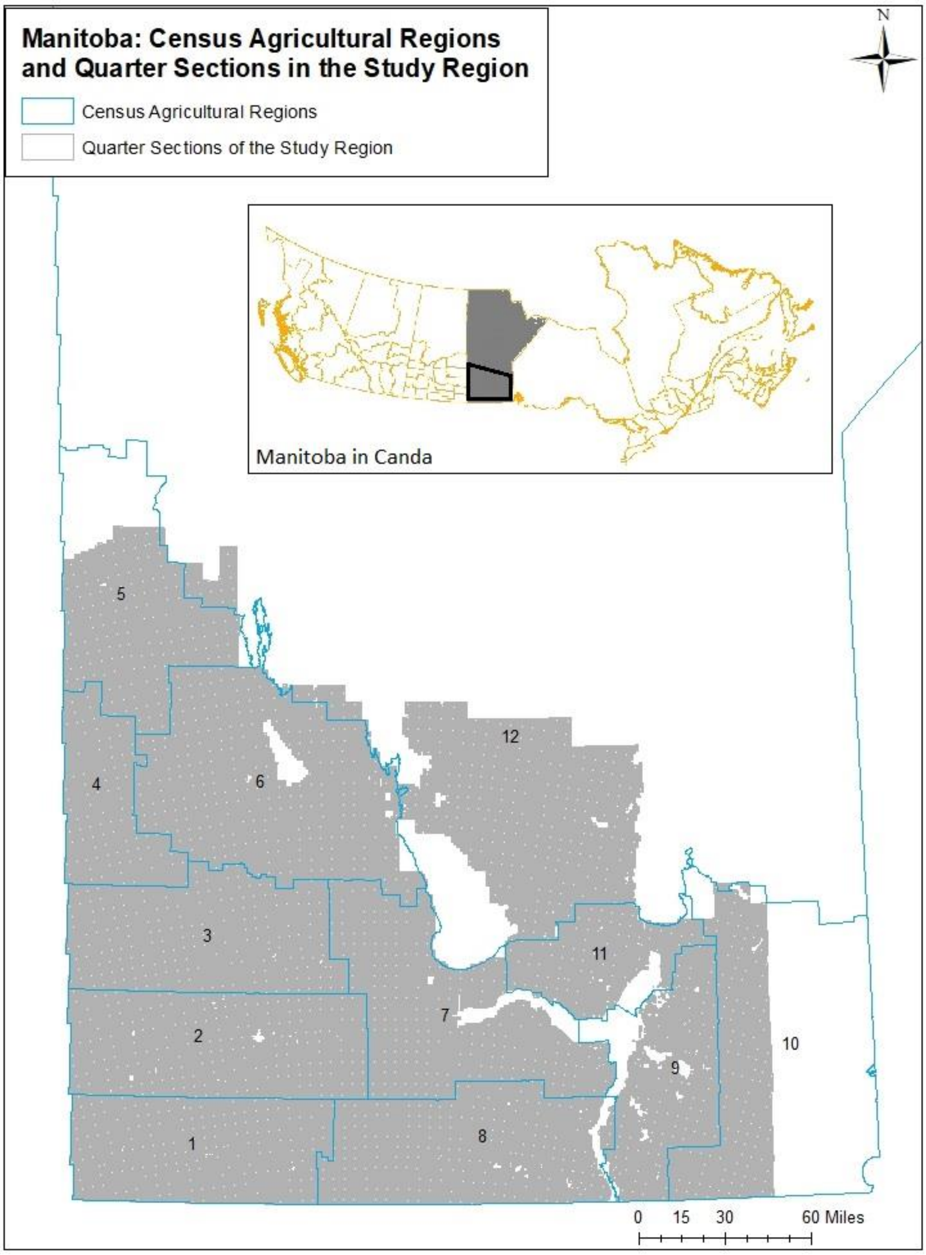

Figure 1. The Study Region of Southern Manitoba

3.2.1 Protection status: easements and fee simple

The dependent variable in the model is the protection status of each quarter section in the study region on a certain year from 1990 to 2011. The protection status includes conservation easement protection and fee simple protection. It is a binary variable; if it equals to 1, it means the parcel is either protected by an easement or fee simple; if it equals to 0, it means the land is not protected by either of these programs. Once a quarter section is protected, the observations of the years of that quarter section are dropped after the year it gets conserved. For easement section, “easements” is the dependent variable; while for fee simple sector, “feesimple” is the dependent variable.

The data on which parcels are under conservation status has been obtained through a data-use agreement with the conservation agencies that actively conserve land in the study region. This data geo-references each of the conserved parcels and documents information on the date that the parcel was acquired and essentially put under conservation. I have also gathered data on all the Government-protected areas in Manitoba including areas such as National Parks of Canada, wildlife management areas, and provincial forests. This data also geo-references these protected quarter sections and provide the date when they are protected. The three conservation agencies that I have gathered the information from are DUC, MHHC, and NCC. Figure 2 shows the dispersion of each type of protection in the study region.

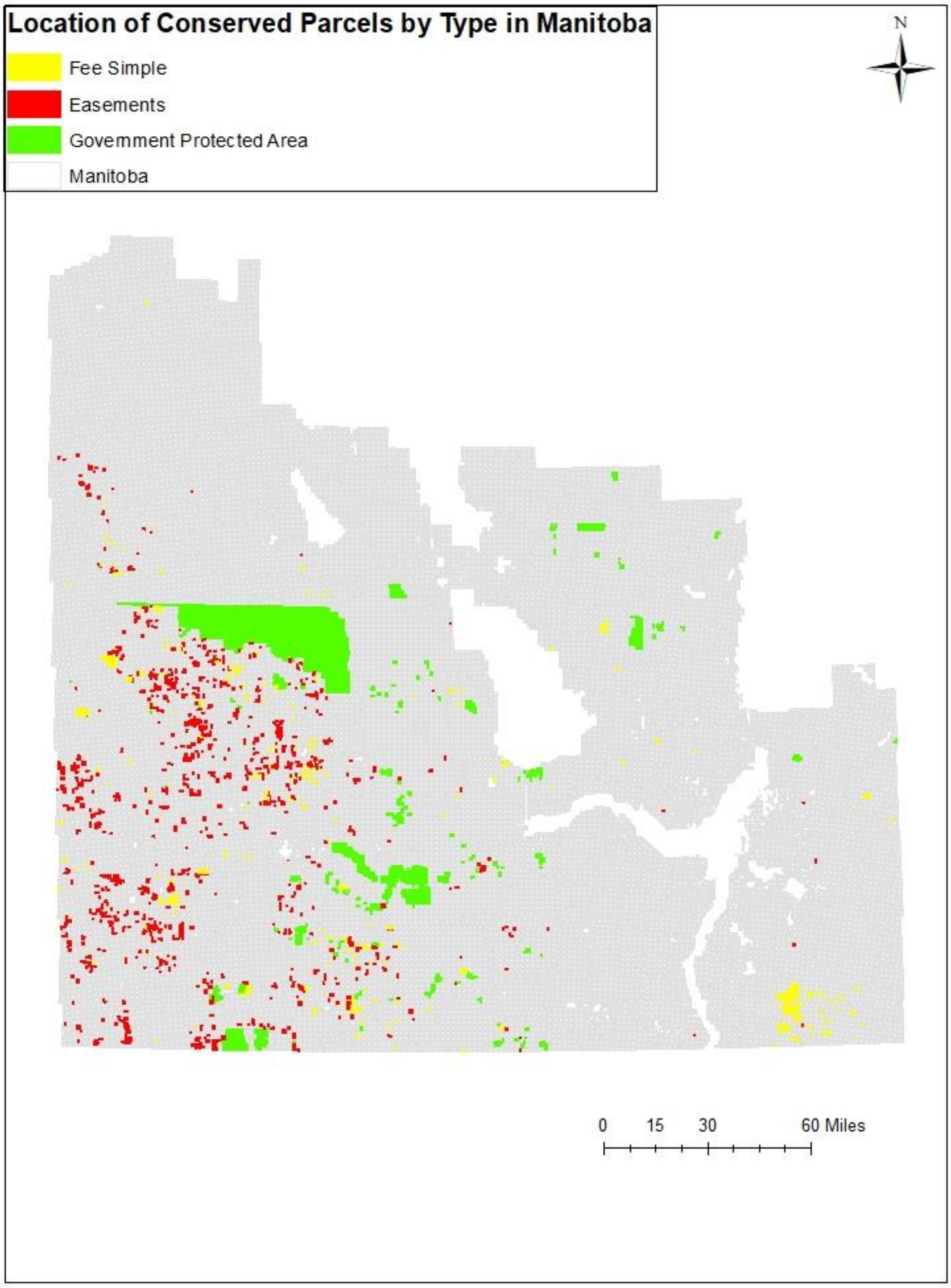

Figure 2. Location of Conserved Parcels by Type in Manitoba

The yellow parcels indicate the habitats protected by fee simple conservation; red areas are conservation easement-protected habitats; green areas are government-protected land. Fee simple protected parcels are mainly aggregated in the area southeast of Winnipeg, and some smaller fee simple protected areas are dispersed among easements-protected areas in the western part of the study region. Conservation easement-protected parcels are spread widely across southwestern Manitoba, and they are located farther away from Winnipeg than fee simple-protected areas are. Government-protected areas are mainly national parks, provincial forests and wildlife management areas. For example, the big green area in the north part of the study region is Riding Mountain National Park, and the green area in the south border is Turtle Mountain Provincial Park.

3.2.2 Crop return mean value and crop return variance

In order to arrive at the variable of crop return ($ per acre), there are few steps that have to be taken. First of all, I gather data from Statistics Canada that reports each crop production at the census agricultural region level in Manitoba, while the dataset also reports the seeded area for each crop.[2] The production level is measured in metric tonnes, while seeded area is reported by acre. Then I obtain the price data for the same crops from Statistics Canada.[3] The prices are presented in dollars per metric tonne. To arrive at the crop return per acre for each region, I multiply production of each crop by its price to get the total revenue for that crop for each region. I then sum up each crop's revenue for each region to get the total crop return for each region. Lastly, the total crop return is divided by the total seeded area to get the revenue per acre for each region. This provides an estimate of the crop return per acre for each census agricultural region.

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[2] Source: http://www5.statcan.gc.ca/cansim/a26?lang=eng&retrLang=eng&id=0010071&tabMode=dataTable&srchLan=-1&p1=-1&p2=9

[3] Source: http://www5.statcan.gc.ca/cansim/a26?lang=eng&retrLang=eng&id=0020043&&pattern=&stByVal=1&p1=1&p2=31&tabMode=dataTable&csid=

However, my goal is to report the total crop return per acre in terms of quarter sections. In order to incorporate this dataset into my final dataset with Manitoba quarter sections, a few more steps have to be taken. First, I have gathered data from Manitoba Land Initiative that provides information of the names of all Manitoba municipalities that matches the census agricultural regions.[4] This dataset has geo-referenced coordinates that can be shown and located in ArcGIS. Then I used ArcGIS to spatially join the Manitoba quarter section layer with this new layer to identify the quarter sections present in each region and municipality. Thirdly, since I already have crop return for each region, I use Stata to merge crop return data with the quarter section dataset using the common variable census agricultural region.

It is important to note that crop return dataset is time variant, because both production and prices vary across time (1990 to 2011). Therefore, it matches the final dataset, which is a panel data. Further, both farmers and agencies make decisions based upon revenues from previous years instead of the current year. Therefore, the variable "Crop return mean value ($)" is calculated as the mean of the crop returns of the previous 5 years. In order to control farming risk, I incorporate crop return variance into the model, which is calculated based on previous 5-year crop returns.

3.2.3 High, medium, and low productivity soil %

Soil characteristics data for the study region is obtained from MLI shape files for each municipality in Manitoba.[5] MLI classifies soil into seven agricultural capability

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[4] Source: http://www23.statcan.gc.ca/imdb-bmdi/document/3401_D2_T9_V1-eng.htm.

[5] Source: http://mli2.gov.mb.ca/soils/index_soilsmuf.html

classes (ACCs). ACC 1 and 2 stand for soils that pose no significant limitations to farming; ACC 3 and 4 stand for soils that have moderate limitations for agricultural production; and finally classes ACC 5, 6, and 7 are those that are not suitable for crop production. As in Lawley and Towe (2014), I collapse these seven classes into three categories: high agricultural productivity soils as those that include classes ACC 1 and 2, medium agricultural productivity soils as those that include classes ACC 3 and 4, and low agricultural productivity soils as those that include classes ACC 5, 6, and 7.

I incorporate this data into the final panel dataset through the following steps. First of all, I join all soil layers from different municipalities to form a soil layer for all of Manitoba. Then I intersect the soil layer with the Manitoba quarter section layer so that I can know different soil characteristics for each quarter section. Thirdly, I kept the agricultural productivity information from all the information provided by the soil layer and export the data into text file so that I can process it further in Stata. Fourth, in Stata I group different productivity level into three categories: low, medium and high; later I add up the areas for each category in each quarter section. Lastly, in order to get the percentage for each productivity level in each quarter section, the areas for each category is divided by each quarter section area. Because soil characteristics are not time variant, so agricultural productivity level for each quarter section should remain the same from 1990 to 2011.

3.2.4 Land cover

Data describing the land cover for the study region is obtained from the

Government of Canada website.[6] The data is available only in a TIF format as a raster shape file. This format causes huge difficulties in terms of its versatility for use in the research. To make the data versatile enough, I convert it into a polygon shape file in ArcGIS using the change feature tool. Since, for this study, it is imperative that I know the exact land cover type and its proportion on each quarter section, I intersect the layer that accounts for the land cover in Manitoba with the quarter section layer in ArcGIS.

To account for changing land covers across Manitoba over the years, I download land cover files covering three time periods: 1990, 2000 and 2010. This data documents the different land cover types and its acreage across Manitoba. It has the information such as the acreage under arable land, acreage in slough, brush, hay, pasture, waterways and other uses such as trees, wetlands, roads and ditches. I collapse these different land uses into five categories: annual crops, grassland, forests, wetlands, and other. Lastly, I have used this information to calculate the percentage cover in annual crops, grassland, forest, wetlands, and other cover on each quarter section. Other land cover category includes the urban areas, roads, rock, beaches, ice, and barren land.

In order to fit the land cover dataset into the final panel dataset, I assume land cover from 1990 to 1999 is the same as 1990; land cover from 2000 to 2009 is the same as 2000; land cover from 2010 to 2011 is the same as 2010. When estimating, I omit the land cover of annual crops so that it is set to default as 1, and other land cover can be compared to annual crops.

[6] Source: http://open.canada.ca/data/en/dataset/18e3ef1a-497c-40c6-8326-aac1a34a0dec

3.2.5 Soil productivity buffers and land cover buffers

This study utilizes buffers to account for the effect of proximity of neighboring parcels' characteristics, including soil productivity, land cover type and the number of parcels that have already been protected within certain ranges. The buffer size that is incorporated in this study is 1 mile.

Several steps are involved in the development of these buffers. 1) Using ArcGIS, the Manitoba quarter section layer is converted from polygon feature into point feature, which means each quarter section now is presented as a point instead of a square polygon. 2) Using the ArcGIS spatial intersect tool, I join the Manitoba polygon layer with the Manitoba points layer with specific instructions that the join should include only those quarter section points that are within 1 mile of each polygon shape. This gives me a new layer that provides the information of all the quarter sections that are within 1 mile of each quarter section in the polygon shape layer. To illustrate this, the new data gives me information on the ID of the quarter sections present in the polygon shape layer, and it matches all the IDs of the quarter sections in the point layer that are neighboring quarter sections within the one mile radius. 3) After acquiring the buffer file, I merge it with land characteristics information using the common variable (IDs) of the quarter sections in the point layer in Stata using a one to many merge. This procedure gives me the final dataset of soil productivity buffer and land cover buffer for 1 mile.

3.2.6 Protection status buffers

Neighboring conservation activities may also influence the likelihood of quarter sections being protected due to spatial spillovers as discussed in Chapter 3. In order to capture this impact, I use the number of protected neighbouring quarter sections (protection status buffer) as the proxy of neighboring conservation activities. The protection methods include conservation easement, fee simple, and Government conservation.

The procedure to build the protection status buffer is similar to soil productivity and land cover buffers. I use the buffer files from previous buffer building process to merge with protection status dataset using a one to many merge. One thing different from soil and land cover layers is that for protection status, I count how many protected quarter sections are within the range instead of calculating the proportions. Then the final protection status buffer dataset tells me the number of protected quarter sections within a one mile radius for each quarter section, as well as what type of conservation are placed and by which agency they are acquired.

3.2.7 Distance to closest city centers and to towns and villages

This is the variable that indicates the distance from each quarter section of the study region to its nearest city, or town and village. It is developed using the near tool in ArcGIS. First, a shape file layer that indicates the towns and cities in Manitoba is downloaded from the Manitoba Land Initiative website.[7] Then the features of this layer are changed from polygons into points. After uploading the Manitoba quarter section layer in ArcGIS, the near tool was used to generate the distances from each quarter section to the nearest city or town.

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[7] Source: http://www12.statcan.gc.ca/census-recensement/2011/geo/bound-limit/bound-limit-2011-eng.cfm

Table 3.1 shows the summary statistics of the dependent and independent variables that have been discussed above. From the table we can see that for soil productivity, the average share of medium quality soil is the highest among all three levels of soil productivities, which indicates that in the study region, there are more medium quality soil than high quality soil, and low quality soil is even less than high quality soil. As for land covers, the share of annual crops is the highest among all types of land covers in the study region, followed by forests and wetlands. It is consistent with my expectation because the study region includes southern Manitoba where most agricultural activities take place in the province.

Table 3.1. Summary Statistics

Variables	Obs	Mean	Std. Dev.	Min	Max
Easements	4,108,374	0.000	0.019	0.000	1.000
Feesimple	4,108,374	0.000	0.011	0.000	1.000
Crop return mean value	3,347,564	138.532	56.053	33.734	404.946
Crop return variance	3,347,564	2,142.195	4,821.571	11.245	40,195.950
High productivity soil (%)	2,991,890	32.614	40.333	0.000	100.000
Medium productivity soil (%)	2,991,890	46.190	40.182	0.000	100.000
Low productivity soil (%)	2,991,890	21.196	31.645	0.000	100.000
High productivity soil 1mile buffer (%)	3,811,779	31.979	32.933	0.000	100.000
Medium productivity soil 1mile buffer (%)	3,811,779	46.707	30.000	0.000	100.000
Low productivity soil 1mile buffer (%)	3,811,779	21.314	24.086	0.000	100.000
Annual crop (%)	3,347,564	56.608	42.344	0.000	100.000
Grassland (%)	3,347,564	2.545	12.596	0.000	100.000
Forests (%)	3,347,564	25.774	33.715	0.000	100.000
Wetland (%)	3,347,564	13.882	24.669	0.000	100.000
Other (%)	3,347,564	1.190	3.525	0.000	100.000

Annualcrop 1mile buffer (%)	3,347,542	56.669	37.537	0.000	99.876
Grassland 1mile buffer (%)	3,347,542	2.545	9.622	0.000	100.000
Forests 1mile buffer (%)	3,347,542	25.765	27.880	0.000	100.000
Wetland 1mile buffer (%)	3,347,542	13.840	19.616	0.000	100.000
Other 1mile buffer (%)	3,347,542	1.181	1.559	0.000	45.682
Easement 1mile buffer	4,108,374	0.047	0.429	0.000	17.000
Feesimple 1mile buffer	4,108,374	0.032	0.369	0.000	23.000
Govt_land 1mile buffer	3,347,564	0.505	2.889	0.000	22.000
Distance to cities (km)	3,347,564	63.812	32.975	1.155	161.156
Distance towns & villages (km)	3,347,564	49.588	31.138	0.363	148.122

Chapter 4. Results

I begin by presenting the results from the baseline discrete time hazard model as specified in equations (3) and (4). Next, I present the results for the logistic regression with interactions between crop returns and land characteristics (soil productivities and land cover) as specified in equations (5) and (6) to see whether conservation agencies change the criteria on reserve selection on different regimes of crop returns. Last, I show the results for the additional fee simple estimation, as specified in equation (7), to see if agencies' targets change when selecting habitat to conserve by fee simple before and after conservation easement legislation.

4.1. Results from Baseline Regression

Table 4.1 shows the results from the two separate logistic regressions for fee simple and easements in terms of logit coefficients and odds ratios. The results suggest that crop return does have a negative impact on the likelihood of habitat protection for both fee simple and easement conservation, which is consistent with expectations. I introduce marginal effects and semi-elasticities to interpret the impact of the covariates on the likelihood of protection. I focus more on semi-elasticities as explained in Chapter 3.

Table 4.2 shows the results of both marginal effects and semi-elasticities of fee simple and conservation easement's estimation results.

On the fee simple conservation side, the results suggest that a $1 increase in the average crop return decreases the likelihood of habitat being protected by fee simple by 1.7%. The estimates are statistically significant at the 1% level. Same case for conservation easement, when the average crop returns increases by $1, the likelihood of habitat protection by easement drops by 1.4%, and it is also statistically significant at the 1% level. The results are consistent with the expectation that farmers are less likely to enroll their land in fee simple or conservation easement programs when crop returns are high, and they can make more economic benefits from converting their land to annual crop production; as farmers are less willing to conserve habitats on their land, it becomes more expensive for conservation agencies to purchase fee simple or easements for conservation purposes. The impact of crop return on fee simple is slightly stronger than the impact on conservation easement. This is probably because landowners respond to crop return changes differently under the two approaches. Under fee simple protection, agencies compete with landowners to purchase land; however, under conservation easement, agencies offer incentives to landowners for partial property rights for conservation purposes while landowners can still have production activities that are not prohibited under agreement. When crop return increases, the landowner's willingness to convert habitat into cropland is higher under fee simple approach than under easements. Therefore, the increase of crop return has a stronger negative impact on the likelihood of fee simple than it has on the likelihood of easements.

Soil quality plays an important role when agencies select habitat to protect. Conservation agencies tend to use soil productivity as a proxy for the risk of habitat conversion, so they are more likely to protect habitat with high quality soil, or parcels near high quality soils. However, on the supply side, landowners are less likely to sell their high-quality land to agencies for conservation or enroll habitat with high soil productivity in conservation easement programs. The results suggest that 1% increase in the share of high productivity soil in a quarter section, relative to low productivity soil, reduces the likelihood of the parcel being conserved by fee simple by 0.9%, and reduces the likelihood of easement protection by 0.6%. A 1% increase in the share of medium productivity soil reduces the likelihood of fee simple conservation by 0.7%, but has no significant impact on easement protection. The results are largely consistent with expectations. This is possible because landowners see the higher potential benefits from their land with high-quality soil if they develop them into agricultural uses; thus, they are less likely to enroll the habitat into conservation programs.

On the contrary to the quarter section's soil quality variable, an additional 1% high quality soil in the 1-mile neighbouring quarter sections increases the likelihood of fee simple conservation by 1.3% and easements by 1.7%. A 1% increase in medium quality soil share in the 1-mile neighbouring quarter sections also increases the likelihood of fee simple protection by 2.3% and easements by 1.4%. This is likely due to the fact that conservation agencies regard higher quality land as the land with higher risk of conversion, therefore, there is higher chance of human activities and conversion into agricultural land in the area including its neighbouring quarter sections, which may not have high quality soil itself but share the same risk of conversion.

Among all factors that have the impact on habitat protection, land cover always stands out significantly. Grassland, forests, and wetlands are all ideal natural habitats for wildlife, and agencies target more on these types of lands as compared to cropland.

The results indicate that a 1% increase in the share of acreage in grassland relative to annual crops increases the likelihood of fee simple conservation by 1.1% and easements protection by 1.5%. A 1% increase in the share in forest, while holding others constant, increases the likelihood of fee simple protection by 2.6% and easements by 2.0%. A 1% increase in wetland increases the likelihood of fee simple by 2.5% and easements by 2.7%. The results are consistent with those in Lawley and Yang (2015). However, 1% increase in other land cover type, decreases the likelihood of easements by 1.9%, but it does not affect fee simple protection. This is likely due to the fact that other land cover includes the areas that have already been developed or will never be developed such as urban settlements, roads, and beaches; there is no point for agencies to protect quarter sections near those areas.

The characteristics of neighbouring quarter sections, in this case, the neighbouring quarter sections' land cover, are important factors that may impact agencies when targeting habitat. As Lawley & Yang (2015) point out, agencies are more likely to target quarter sections if its neighbouring quarter sections have large amount of wetlands and other habitats, regardless of whether these neighbouring parcels are protected or not. However, the results from this study suggest that, for fee simple, a 1% increase in neighbouring forestland cover within 1 mile decreases the likelihood of conservation by 1.9%. And, a 1% increase in other land cover of the neighbouring quarter sections decrease the likelihood of fee simple conservation by 11.3%. Neighbouring grassland and wetland cover, on contrary, does not have a significant impact on the likelihood of fee simple conservation. For easements, a 1% increase in neighbouring grassland cover decreases the likelihood by 1.7%, and a 1% increase in neighbouring wetland cover decreases the likelihood by 1.7%. And neither neighbouring forest nor other land cover has any impact on conservation easements. As the results show, for both fee simple and easements, neighbouring grassland, forests and wetlands, either have negative impact or no impact on the likelihood of protection, which is opposite to our expectations. However, it is possible due to two reasons. Firstly, when agencies see a parcel surrounded by other large habitats of grassland, forests or wetlands, they see low risk of conversion since it is already a part of habitat that has not been converted, and if landowners want to convert the land, the cost would be too high. Secondly, the model is estimated with fixed effects of census agricultural regions, which may not pick up every specific characteristic of each municipality or even quarter section, leaving unobservables influencing the results. As for "other" land cover surroundings, the negative impact on the likelihood of fee simple is probably due to that agencies are less likely to target areas that have already been developed into roads and other facilities.

Spatial interactions in habitat conservation, as discussed in Chapter 3, are expected to have a positive impact on the likelihood of habitat protection. On the one hand, conservation agencies want to target those parcels whose neighbouring quarter sections are protected in order to increase the connectivity of the habitat so that wildlife has more living space. On the other hand, when landowners observe their neighbours conserving habitats, their awareness tends to be raised, which defines a positive spillover effect. The results indicate that an additional neighbouring quarter section with easement within 1 mile increases the likelihood of fee simple conservation by 11.2%, and easement protection by 77.7%. One additional neighbouring quarter section with fee simple protection within 1 mile increases the likelihood of fee simple protection by 73.0%, but has no significant impact on the likelihood of easement conservation. Different from the positive spillover effect of neighbouring fee simple and easement protections, neighbouring government-protected quarter section does not have impact on the likelihood of fee simple. When we increase 1 quarter section with government protection within the 1 mile neighbouring area, the likelihood of easement protection decreases by 5.4%. According to Lawley and Yang (2015), this crowding out phenomenon is possible, because agencies might have lower incremental benefits if they purchase easements on parcels adjacent to government protected land. Governments tend to protect large tracks of land like natural parks, and agencies' benefits will be diminishing or even reduced as more quarter sections are put under easements. Another reason is for the crowding out phenomenon is there are increasing development opportunities near government-protected areas, and it is expensive for agencies to protect the quarter sections there by competing with other developers.

Distance to cities and distance to towns and villages have significant impact on the likelihood of fee simple conservation, but not easement protection. The results suggest that 1 km closer to cities increases the likelihood of fee simple protection by 1.7%, and 1 km closer to towns and villages decreases the likelihood of fee simple by 1.7%. The results indicate that fee simple protection targets more habitats that are close to cities and far from towns and villages. This contradicts the expectation that fee simple mainly protects parcels close to mountain ranges instead of cities in Manitoba. The results are likely due to the unprotected parcels in the northern part of the study region (could be seen from Figure 2). They are relatively farther away from cities than those parcels under fee simple protection, which affected the estimation of the impact of the distance factor on the likelihood of fee simple protection.

4.2. Results from varying impact of parcel characteristics in different crop return regimes

The marginal effect and semi-elasticity results in the previous section are calculated when the crop return is set to mean value. However, it would be interesting to see the impact of different crop return regimes (for example low return and to high return regimes) on the selection criteria of conservation agencies targeting habitat conservation.

Table 4.3 shows the results of coefficients and odds ratio for the logistic model with the interactions. The results are largely consistent with the results from the baseline model in terms of the variable's statistical significance and the coefficient's value.

Table 4.4 shows the results of semi-elasticities of the estimates of parcel characteristics that are interacted with the crop return variable. I estimate the likelihood of habitat protection three times as I set crop return into low, medium, and high values, as is explained in Chapter 3. Low, medium and high crop return values are: \$82.48, \$138.53 and \$194.59 per acre. The parcel characteristics that are included in the estimation are: the shares of land covers of grassland, forests, wetland, and other land cover; the shares of high and medium productivity soil. From Table 4.4, it is easy to notice that each land characteristic has three rows, each representing one level of the crop returns (low, medium, and high). The two columns of results include the semielasticities of the estimates of the variables for both fee simple and easement protections.

For grassland cover, on fee simple protection sector, a 1% increase in grassland increases the likelihood of fee simple protection by 1.2% when crop return is low; as crop return increases to medium regime, a 1.0% increase in grassland increases the likelihood of fee simple by 1.0%. On easement sector, a 1% increase in grassland increases the likelihood of easement by 2.0% at low crop return regime; as crop return increases to medium, a 1% increase in grassland increases the likelihood of easement by 1.3%. The results suggest that as landowners gain more benefits from annual crops, conservation agencies are less likely to target grassland for habitat conservation, and it is the same case for both fee simple and easement protections. It is probably because in southern Manitoba, as crop return increases, landowners tend to convert more grassland into agricultural uses, and thus they are less willing to conserve quarter sections with large share of grassland.

For forestland cover, on the fee simple side, the results indicate that there is no statistically significant difference in the estimates when crop return changes between low, medium, and high. However, on the easement side, when crop return changes from low to high regime, a 1% increase in forest land cover increases on likelihood of easements by 1.6% under low crop return regime, and by 2.3% under high crop return regime. This is probably because in the prairies, landowners tend to convert grassland instead of forests into cropland if they expect the benefits from crops to increase in the future. Therefore, forests are more likely to be protected by agencies under high crop return regime due to less competition from landowners and less costs for conservation.

Wetlands, different from grassland and forests, do not have significant changes in the estimates when crop return values change. According to the results, they all keep statistical significant positive impact on the likelihood of protection for both fee simple and easements.

For other land cover type, on the fee simple side, conservation agencies do not include this land cover type in their criteria when selecting habitat to conserve. On conservation easement side, when crop return is low, the more other land cover the parcel has, the less likelihood the agencies will choose the parcel to protect. However, when crop return increases to medium and high, agencies become indifferent to this land cover type.

For high productivity soil on fee simple sector, when crop return is low, it does not have an impact on the likelihood of fee simple conservation. However, when crop return increases to medium and high, the negative impact of 1% increase in high quality soil share changes from 1.0% to 1.4. This suggests that when crop return increases, fee simple agencies will turn away from high productivity land to low productivity land for conservation selection. This might be because landowners are less likely to sell their land for conservation purposes when agricultural revenue rises. However, it is the opposite in the case of conservation easement. The negative impact of 1% increase in high productivity soil changes from 0.7% to 0.5% when crop return increases from low to medium. But when crop return gets to high regime, there is no impact at all. It suggests that when crop returns increase, agencies start to shift from lower soil quality land to higher soil quality land for easements while fee simple is competing for quarter sections with lower quality soil.

Last but not least, the results suggest that the negative impact of medium soil productivity on the likelihood of fee simple protection changes from 0.8% to 0.7% both at 1% significance when crop return increases from low to medium. This implies that under low and medium crop return regimes, agencies tend to target on quarter sections that have less medium quality soil but more low-quality soil for fee simple protection, and landowners are less willing to conserve quarter sections with medium and high quality soil. However, when crop return increases to high regime, the impact disappears, which means agencies may shift to medium quality soil for fee simple protection. On the easement side, medium quality soil does not have any significant impact on the likelihood of habitat at any level of crop return.

4.3 Results from impact of conservation easement legislation on fee simple protection

As mentioned in Chapter 2, the Manitoba Conservation Agreement Act was passed in 1997, which allows conservation agencies to place easements on habitats for private lands. After 1998, as landowners and conservation agencies became more familiar and comfortable with this habitat conservation method, conservation easements became more prevalent than fee simple in recent years. Therefore, it is interesting to see whether agencies' targets change when selecting habitats for fee simple protection after conservation easement legislation (i.e. whether the factors that have the impact on the likelihood of fee simple protection remain the same before and after 1998).

Table 4.5 shows the results from the additional fee simple model as specified in equation (7). There are three columns of results presented in the table. The first column is the coefficients of each variable in the model when easement dummy equals to 0, which represents the first period before 1998. The second column shows the coefficients when easement dummy equals to 1, which represents the second period after 1998. The third column indicates the changes from period one to period two for each variable. And the results are presented in forms of coefficients instead of semielasticities because margins are non-estimable for this model in Stata.

The impact of crop return on the likelihood of fee simple protection changes significantly after the Manitoba Conservation Agreement Act comes into effect. Before 1998, it does not have statistical significant impact on the agency's decision-making process when choosing habitats to protect, however, after 1998, crop return has a statistical significant negative impact on the probability of fee simple protection. In the meanwhile, crop return variance, which used to have negative impact on the likelihood, after 1998, does not have any significant impact at all. Crop variance is calculated based upon variation in the previous five-year crop returns, as serves as a proxy for expected future crop returns risk. The higher the variance, the higher the risk will be. The results indicate that in the first period, fee simple agencies target habitat with low crop risk, and crop return does not have an impact on the likelihood of fee simple protection. However, in the second period when easements appear, they target habitat with low crop returns, but became indifferent to crop risks. In other words, in the second period, with conservation easement competing habitat resources, agencies start to target low crop return habitat for fee simple without considering crop risks as much as before. And landowners are more willingly to conserve their land through conservation easement method when crop return is high comparing to fee simple method.

For soil productivity, the most significant change indicated by the results is the impact of high quality soil on the likelihood of fee simple protection. Before 1998, a 1% increase in high productivity soil share in a quarter section decreases the likelihood of fee simple by 1.6%, but after 1998, it has no impact at all. This might be because conservation easement targets more low soil quality land with lower transaction costs that makes fee simple protection shift from low soil quality land to higher soil quality quarter sections. However, it is a different case for the variable of the neighbouring high quality soil share. In the first period, fee simple agencies target habitats with high quality soil surroundings; after easements became popular, they start to target more habitats with lower quality soil surroundings. This might be because easements compete for more quarter sections with high quality soil environment, which is consistent with one of the results from Parker (2004) that indicates easements are likely to protect the land with higher average size of agricultural landholding in the agency's area of operation; and normally the more high quality soil the land has, the more likely it will be converted to agricultural land.

As for land covers, the only significant change is the share of wetlands in a parcel. Before 1998, a 1% increase in wetland increases the likelihood of fee simple by 1.4%, but after 1998, the impact increases to 2.4% at the same statistical significance level of

1%. The results suggest that after 1998, fee simple agencies target more habitats with wetlands. This contradicts the expectation that with the competition from easements, fee simple would protect less wetlands. This is likely because the agency's targeting strategy for easements are not focusing on protecting wetlands but other types of land covers, which makes fee simple protection shifts to protect more wetlands. However, for the neighbouring land covers, fee simple agencies target more habitats with forest-neighbouring environment, and less wetland surroundings after 1998.

For neighbouring protection status, fee simple agencies start to target more quarter sections with easement protected neighbouring habitat after 1998, and less quarter sections with fee simple neighbours since conservation easement became a more and more popular conservation method.

Last but not least, the results suggest that the impact of distance to towns and villages on the likelihood of fee simple protection increases significantly after 1998. It means fee simple agencies start to protect more habitats further away from towns and villages but closer to cities after 1998.

Table 4.1. Regression Results for Logistic Baseline Models

	Feesimple		Easements	
	Coefficients	Odds Ratios	Coefficients	Odds Ratios
Crop return mean value	-0.017*** (0.004)	0.983*** (0.004)	-0.014*** (0.003)	0.986*** (0.003)
Crop return variance	0.216e-04 (0.214e-04)	1.000 (0.214e-04)	0.313e-04 (0.196e-04)	1.000 (0.196e-04)
High productivity soil (%)	-0.009** (0.004)	0.991** (0.004)	-0.006** (0.002)	0.994** (0.002)
Medium productivity soil (%)	-0.007*** (0.003)	0.993*** (0.003)	-0.003 (0.002)	0.997 (0.002)
High productivity soil 1mile buffer (%)	0.013** (0.006)	1.013** (0.006)	0.017*** (0.004)	1.018*** (0.004)
Medium productivity soil 1mile buffer (%)	0.023*** (0.005)	1.023*** (0.005)	0.014*** (0.003)	1.014*** (0.004)
Grassland (%)	0.011** (0.005)	1.011** (0.005)	0.015*** (0.003)	1.015*** (0.003)
Forests (%)	0.026*** (0.004)	1.027*** (0.004)	0.020*** (0.002)	1.020*** (0.002)
Wetland (%)	0.025*** (0.005)	1.025*** (0.005)	0.027*** (0.003)	1.027*** (0.003)
Other land cover (%)	0.001 (0.033)	1.001 (0.033)	-0.019* (0.010)	0.982* (0.010)
Grassland 1mile buffer (%)	1.785e-04 (0.008)	1.000 (0.008)	-0.017*** (0.005)	0.983*** (0.005)
Forests 1mile buffer (%)	-0.019*** (0.006)	0.981*** (0.005)	-0.001 (0.003)	0.999 (0.003)
Wetland 1mile buffer (%)	-0.011 (0.007)	0.989 (0.007)	-0.017*** (0.006)	0.983*** (0.006)
Other land cover 1mile buffer (%)	-0.113* (0.056)	0.893* (0.050)	0.034 (0.023)	1.035 (0.023)
Easement 1mile buffer	0.112* (0.062)	1.118* (0.069)	0.777*** (0.019)	2.174*** (0.042)
Feesimple 1mile buffer	0.730*** (0.035)	2.076*** (0.073)	0.066 (0.041)	1.068 (0.044)
Govt land 1mile buffer	-0.029 (0.032)	0.971 (0.031)	-0.054*** (0.018)	0.947*** (0.017)
Distance to cities (km)	-0.017*** (0.004)	0.984*** (0.004)	-0.001 (0.002)	0.999 (0.002)

Distance towns & villages (km)	0.017*** (0.004)	1.017*** (0.004)	0.922e-04 (0.002)	1.000 (0.002)
Census agricultural region fixed effects	Yes		Yes	
Year fixed effects	Yes		Yes	
Log pseudolikelihood	-2665.3572		-7684.15	
Pseudo R2	0.3962		0.3706	
Observations	2,844,908		1,469,919	
Year	1990-2011		1999-2011	

Note: Standard error (in parentheses) are adjusted for clusters in quarter sections.
***Statistical significance at 1%.
**Statistical significance at 5%.
*Statistical significance at 10%.

Table 4.2. Marginal effects and Semi-elasticities of Logistic Baseline Models

	Feesimple		Easements	
	Marginal Effects	Semielasticities	Marginal Effects	Semielasticities
Crop return mean value ($)	-2.21e-07***	-0.017***	-1.61e-06***	-0.014***
	(5.38e-08)	(0.004)	(3.56e-07)	(0.003)
Crop return variance	2.78e-10	0.216e-04	3.49e-09	0.313e-04
	(2.72e-10)	(0.214e-04)	(2.26e-09)	(0.196e-04)
High productivity soil (%)	-1.11e-07**	-0.009**	-6.17e-07**	-0.006**
	(5.16e-08)	(0.004)	(2.67e-07)	(0.002)
Medium productivity soil (%)	-9.30e-08***	-0.007***	-2.93e-07	-0.003
	(3.62e-08)	(0.003)	(2.28e-07)	(0.002)
High productivity soil 1mile buffer	1.69e-07**	0.013**	1.95e-06***	0.017***
	(7.71e-08)	(0.006)	(4.76e-07)	(0.004)
Medium productivity soil 1mile buffer (%)	2.99e-07***	0.023***	1.53e-06***	0.014***
	(7.47e-08)	(0.005)	(4.24e-07)	(0.003)
Grassland (%)	1.38e-07*	0.011**	1.67e-06***	0.015***
	(6.73e-08)	(0.005)	(4.04e-07)	(0.003)
Forests (%)	3.37e-07***	0.026***	2.17e-06***	0.020***
	(7.59e-08)	(0.004)	(3.73e-07)	(0.002)
Wetland (%)	3.21e-07***	0.025***	2.98e-06***	0.027***
	(8.42e-08)	(0.005)	(5.06e-07)	(0.003)
Other land cover (%)	1.16e-08	0.001	-2.07e-06*	-0.019*
	(4.30e-07)	(0.033)	(1.11e-06)	(0.010)
Grassland 1mile buffer (%)	2.30e-09	1.785e-04	-1.88e-06***	-0.017***
	(1.00e-07)	(0.008)	(6.13e-07)	(0.005)
Forests 1mile buffer (%)	-2.46e-07***	-0.019***	-1.06e-07	-0.001
	(8.80e-08)	(0.006)	(3.67e-07)	(0.003)
Wetland 1mile buffer (%)	-1.46e-07	-0.011	-1.93e-06***	-0.017***
	(9.91e-08)	(0.007)	(7.07e-07)	(0.006)
Other land cover 1mile buffer (%)	-1.46e-06*	-0.113**	3.88e-06	0.035
	(7.48e-07)	(0.056)	(2.56e-06)	(0.023)
Easement 1mile buffer	1.43e-06*	0.112*	0.866e-04***	0.777***
	(8.42e-07)	(0.062)	(0.110e-04)	(0.019)
Feesimple 1mile buffer	9.39e-06***	0.730***	7.32e-06	0.066
	(1.67e-06)	(0.035)	(4.68e-06)	(0.041)
Govt land 1mile buffer	-3.75e-07	-0.029	-6.02e-06***	-0.054***
	(4.15e-07)	(0.032)	(2.08e-06)	(0.018)
Distance to cities (km)	-2.13e-07***	-0.017***	-5.78e-08	-0.001
	(5.59e-11)	(0.004)	(1.85e-10)	(0.002)
Distance to towns & villages (km)	2.19e-10***	0.017***	1.03e-08	0.992e-04
	(5.77e-11)	(0.004)	(2.12e-07)	(0.002)

Observations	2,844,908	1,469,919
Year	1990-2011	1999-2011

Note: Standard errors (in parentheses) are adjusted for clusters in quarter sections.

***Statistical significance at 1%.

**Statistical significance at 5%.

*Statistical significance at 10%.

Table 4.3. Regression Results for Varying Impact of Parcel Characteristics in Different Crop Return Regimes

	Feesimple		Easements	
	Coefficients	Odds Ratios	Coefficient s	Odds Ratios
Crop return mean value ($)	-0.0397*** (0.007)	0.961*** (0.007)	-0.022*** (0.004)	0.978*** (0.004)
Crop return variance	0.306e-04 (0.219e-04)	1.000 (0.219e-4)	0.270e-04 (0.191e-04)	1.000 (0.191e-04)
High productivity soil (%)	-0.389e-03 (0.007)	1.000 (0.007)	-0.010** (0.004)	0.990** (0.004)
Medium productivity soil (%)	-0.011* (0.005)	0.989* (0.005)	-0.005 (0.004)	0.995 (0.004)
High productivity soil 1mile buffer (%)	0.013** (0.006)	1.012** (0.006)	0.019*** (0.004)	1.019*** (0.004)
Medium productivity soil 1mile buffer (%)	0.023*** (0.005)	1.023*** (0.005)	0.015*** (0.003)	1.016*** (0.004)
Grassland (%)	0.015* (0.008)	1.015* (0.008)	0.030*** (0.005)	1.030*** (0.005)
Forests (%)	0.029*** (0.006)	1.030*** (0.006)	0.011*** (0.004)	1.011*** (0.004)
Wetland (%)	0.025*** (0.009)	1.026*** (0.009)	0.034*** (0.006)	1.034*** (0.006)
Other land cover (%)	-0.041 (0.051)	0.960 (0.049)	-0.034 (0.021)	0.967 (0.020)
Grassland 1mile buffer (%)	-0.001 (0.008)	0.999 (0.008)	-0.016*** (0.005)	0.985*** (0.005)
Forests 1mile buffer (%)	-0.020*** (0.006)	0.980*** (0.005)	-0.002 (0.003)	0.998 (0.003)
Wetland 1mile buffer (%)	-0.012* (0.007)	0.988* (0.007)	-0.019*** (0.006)	0.981*** (0.006)
Other land cover 1mile buffer (%)	-0.109** (0.055)	0.897** (0.049)	0.032 (0.022)	1.032 (0.023)
Easement 1mile buffer	0.120* (0.063)	1.127* (0.071)	0.780*** (0.019)	2.182*** (0.042)
Feesimple 1mile buffer	0.739*** (0.036)	2.095*** (0.074)	0.060 (0.040)	1.062 (0.042)
Govt land 1mile buffer	-0.034 (0.033)	0.966 (0.032)	-0.048*** (0.018)	0.953*** (0.017)
Distance to cities	-0.036*** (0.010)	0.964*** (0.010)	3.74e-06 (0.004)	1.000 (0.004)
Distance towns & villages	-0.009 (0.008)	0.991 (0.008)	-0.019*** (0.005)	0.981 (0.004)

Crop return mean value ($)#Grassland (%)	-0.324e-04 (0.618e-04)	1.000 (0.618e-04)	-1.160e-04*** (0.421e-04)	1.000*** (0.421e-04)
Crop return mean value ($)#Forests (%)	-0.192e-04 (0.377e-04)	1.000 (0.377e-04)	0.630e-04*** (0.236e-04)	1.000*** (0.236e-04)
Crop return mean value ($)#Wetland (%)	-6.13e-07 (0.543e-04)	1.000 (0.543e-04)	-0.487e-04 (0.382e-04)	1.000 (0.382e-04)
Crop return mean value ($)#Other land cover (%)	2.724e-04** (1.323e-04)	1.000** (1.323e-04)	1.266e-04 (1.405e-04)	1.000 (1.405e-04)
Crop return mean value ($)#High productivity soil (%)	0.679e-04 (0.471e-04)	1.000 (0.471e-04)	0.343e-04 (0.288e-04)	1.000 (0.288e-04)
Crop return mean value ($)#Medium productivity soil (%)	0.265e-04 (0.397e-04)	1.000 (0.397e-04)	0.152e-04 (0.254e-04)	1.000 (0.254e-04)
Census agricultural region fixed effects	Yes		Yes	
Year fixed effects	Yes		Yes	
Log pseudolikelihood	-2648.3833		-7658.7812	
Pseudo R2	0.4001		0.3727	
Observations	2,844,908		1,469,919	
Year	1990-2011		1999-2011	

Note: Standard error (in parentheses) are adjusted for clusters in quarter sections.

***Statistical significance at 1%.

**Statistical significance at 5%.

*Statistical significance at 10%.

Table 4.4. Semi-elasticies Results of Varying Impact of Parcel Characteristics in Different Crop Return Regimes

		Feesimple	Easements
Grassland %	Low crop return	0.012**	0.020***
		(0.002, 0.022)	(0.014, 0.025)
	Medium crop return	0.010*	0.013***
		(-0.000, 0.021)	(0.007, 0.020)
	High crop return	0.008	0.007
		(-0.006, 0.023)	(-0.002, 0.017)
Forests %	Low crop return	0.027***	0.016***
		(0.019, 0.036)	(0.011, 0.021)
	Medium crop return	0.026***	0.020***
		(0.019, 0.034)	(0.015, 0.024)
	High crop return	0.025***	0.023***
		(0.017, 0.034)	(0.018, 0.028)
Wetland %	Low crop return	0.025***	0.030***
		(0.014, 0.036)	(0.023, 0.036)
	Medium crop return	0.025***	0.027***
		(0.016, 0.035)	(0.020, 0.033)
	High crop return	0.025***	0.024***
		(0.014, 0.036)	(0.016, 0.032)
Other land cover %	Low crop return	-0.018	-0.023**
		(-0.098, 0.062)	(-0.046, -0.000)
	Medium crop return	-0.003	-0.016*
		(-0.070, 0.064)	(-0.035, 0.003)
	High crop return	0.012	-0.009
		(-0.042, 0.067)	(-0.035, 0.017)
High %	Low crop return	-0.006	-0.007***
		(-0.014, 0.002)	(-0.013, -0.002)
	Medium crop return	-0.010**	-0.005**
		(-0.018, -0.002)	(-0.010, 0.001)
	High crop return	-0.014***	-0.004
		(-0.024, -0.003)	(-0.009, 0.002)
Medium %	Low crop return	-0.008***	-0.003
		(-0.014, -0.003)	(-0.008, 0.001)
	Medium crop return	-0.007***	-0.002
		(-0.012, -0.002)	(-0.007, 0.001)
	High crop return	-0.006	-0.002
		(-0.013, 0.002)	(-0.007, 0.003)

Note: 95% confidence intervals are shown in parentheses.
***Statistical significance at 1%.
**Statistical significance at 5%.
*Statistical significance at 10%.

Table 4.5. Regression Results for Impact of Conservation Easement Legislation on Fee Simple Protection

	Probability (Feesimple) (E=0)	Probability (Feesimple) (E=1)	Interaction coefficients (The change from E=0 to E=1)
Crop return mean value	0.011	-0.015***	-0.026***
	(0.009)	(0.004)	(0.008)
Crop return variance	-0.001***	0.000	0.001***
	(0.0004)	(0.000)	(0.0004)
High productivity soil (%)	-0.016***	0.002	0.018**
	(0.005)	(0.005)	(0.007)
Medium productivity soil	-0.003	-0.010***	-0.006
(%)	(0.004)	(0.004)	(0.005)
High productivity soil	0.021***	-0.007	-0.029***
1mile buffer (%)	(0.008)	(0.008)	(0.010)
Medium productivity soil	0.014*	0.027***	0.013
1mile buffer (%)	(0.007)	(0.006)	(0.009)
Grassland (%)	0.013**	0.009	-0.004
	(0.006)	(0.007)	(0.009)
Forests (%)	0.031***	0.024***	-0.006
	(0.005)	(0.005)	(0.007)
Wetland (%)	0.014**	0.032***	0.017**
	(0.007)	(0.006)	(0.008)
Other land cover (%)	-0.014	0.009	0.023
	(0.041)	(0.040)	(0.057)
Grassland 1mile buffer (%)	-0.002	-0.003	-0.001
	(0.010)	(0.011)	(0.014)
Forests 1mile buffer (%)	-0.040***	-0.010	0.030***
	(0.009)	(0.007)	(0.010)
Wetland 1mile buffer (%)	0.012	-0.026***	-0.037***
	(0.008)	(0.009)	(0.010)
Other land cover 1mile	-0.172	-0.073	0.099
buffer (%)	(0.123)	(0.054)	(0.133)
Easement 1mile buffer	Omitted	0.149**	0.149**
		(0.061)	(0.061)
Feesimple 1mile buffer	0.811***	0.717***	-0.094**
	(0.047)	(0.034)	(0.039)
Govt land 1mile buffer	-0.027	-0.027	Omitted
	(0.033)	(0.033)	
Distance to cities	-0.017***	-0.015***	0.001
	(0.005)	(0.004)	(0.005)
Distance towns & villages	0.001	0.034***	0.033***
	(0.005)	(0.005)	(0.007)

Census agricultural region fixed effects	Yes
Year fixed effects	Yes
Log pseudolikelihood	-2599.4213
Pseudo R2	0.4110
Observations	2835042
Year	1991-2011

Note: Standard errors (in parentheses) are adjusted for clusters in quarter sections.
***Statistical significance at 1%.
**Statistical significance at 5%.
*Statistical significance at 10%.

Chapter 5. Summary and Conclusions

This study analyzes the conservation data from conservation agencies MHHC, DUC, and NCC from 1990 to 2011 for fee simple protection, and 1999 to 2011 for conservation easement protection. The empirical model estimates the impact of crop return on the likelihood of habitat protection (fee simple and conservation easement) by controlling other factors.

The empirical results indicate that a one dollar increase in crop return reduces the probability of fee simple by 1.7% and easements by 1.4%. It is consistent with the expectation that when crop return increases, the habitat is less likely to be conserved. In addition to crop return, there are other factors that have the impact on the likelihood of habitat protection. High quality soil decreases the likelihood of fee simple and easements protections, while medium quality soil only has significant negative impact on the likelihood of fee simple and no impact on easements. The results contradict the expectation that agencies are more likely to protect high quality soil because of higher risk of conversion. Quarter sections with neighbours who have medium and high quality soil increase the likelihood of both protections, maybe due to the high risk of conversion for those surrounding parcels. As for land covers of grassland, forests and wetlands, they all have positive impact on the likelihood of both protections, which largely meets the expectations. Quarter sections with grassland, forests and wetlands neighbouring environment, on the contrary, are less likely to be protected by either protection method. On the spatial interaction side, quarter sections with neighbouring easement-protected parcels are more likely to be protected by both fee simple and easements. And surrounding parcels protected by fee simple only increase the likelihood of fee simple. On the contrary, neighbouring government-protected land decreases the likelihood of easement protection. The results are largely consistent with the ones from the previous literature of Lawley and Yang (2015). Lastly, the results suggest the agencies target more quarter sections that are closer to cities instead of those that are closer to towns and villages.

The results from the varying impact of parcel characteristics in different crop return regimes suggest that as crop return increases from low to high regime, conservation agencies target less grassland for both fee simple and easement protections. There are no significant changes for other land covers. However, for high quality soil, its negative impact on the likelihood of fee simple gets stronger when crop return increases, but its negative impact on easements decreases. The results also indicate that when crop return gets higher, agencies shift their target from high quality soil to parcels with lower quality soil for fee simple protection, and agencies shift easements target from quarter sections with low quality soil to higher quality soil..

The analysis for the impact of conservation easement legislation on fee simple protection reveals that the impact of crop return on the likelihood of fee simple changes significantly after 1998. An increase in crop return reduces the probability of fee simple in the second period, while it has no impact on the likelihood in the first period. The results also suggest that the impact of high quality soil increases after 1998, while the neighbouring high quality soil's impact decreases. Agencies target more quarter sections with wetlands but fewer quarter sections with wetland surroundings after 1998.

After easements legislation, the positive impact of neighbouring fee simple parcels decreases. Lastly, the positive impact of distance to towns and villages increases after 1998.

The results of this study not only meet the objectives, but also draw some interesting conclusions and questions. This study answers the question whether or not crop return has an impact on the likelihood of protection, and it estimates the extent to which crop return has the impact on each type of protection. The study also outlines other factors that have the impact on the likelihood of habitat protection, which allows readers to understand what criteria conservation agencies are actually considering when they target habitats to protect, and how these factors change on different conditions. The results will be useful for policy makers to have a better understanding of the factors that influence the agencies' decision-making process of reserve selection, as well as the changes that will occur when crop return fluctuates from year to year. By knowing the actual factors that have the impact on the likelihood of habitat protection, conservation agencies can have better understanding on landowners' behaviors, enroll habitats into conservation more cost-effectively by lowering unnecessary costs or the chance of enrolling low quality habitats.

However, there are more methods and analyses could be conducted to deepen the research of habitat conservation selection. Firstly, the model could be set as discrete-time survival model with multiple absorbing events and competing risks to be estimated using multinomial logistic regression, since a quarter section could be protected by either fee simple or conservation easement, and once it is protected by one type, it could not be protected as the other type. Secondly, by adding and quantifying the variable of each habitat's wildlife suitability level, the model would be able to control the impact of each habitat's capability to support waterfowl and other wildlife on the likelihood of habitat protection, instead of controlling merely the habitat's land cover type. Thirdly, the model could include rural municipality fixed effects, or even more specifically, fixed effects on quarter section level, in order to better control the unobservables on the quarter section level. Last but not least, the model could incorporate the fact that conservation agencies receive annual budgets to spend based upon the amount they have spent on the previous year, so when the year is coming to the end, agencies' decision-making process on habitat selection may not be the same as the beginning of the year in order to get the same amount of budget next year.

As the increasing trend of crop prices continues, the demand for annual crops will continue to rise, so as the demand for agricultural land. Therefore, there lies a great opportunity for conservation studies in the future, as we see more conflicts between wildlife habitat conservation and farmland expansion. The results and conclusions from this thesis study are able to provide a solid foundation and stimulation for future researches in this field, and the above-mentioned research alternatives would be a great opportunity for both researchers and policy makers to make further contributions to habitat conservation.

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