AN EMPIRICAL ANALYSIS OF HUNTING LEASES BY TIMBER FIRMS

by

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A thesis submitted in partial fulfillment
of the requirements for the degree

of

Master of Science

in

Applied Economics

MONTANA STATE UNIVERSITY
Bozeman, Montana

January 2007

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of a thesis submitted by

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January 2007

ACKNOWLEDGMENTS

Without the help of many individuals, the current form of this thesis would not have been possible. Dr. Buschena provided guidance, feedback, and encouragement with boundless patience. Dr. Rucker and Dr. Anderson offered insightful, pragmatic questions and suggestions throughout this process. My committee has continually requested pertinent, useful refinement that I hope the final product satisfies. Thanks to Donna Kelly for diligently proofing and formatting the final draft.

I owe thanks to the many forestry and wildlife professionals who patiently answered my long list of questions and requests. In particular I would like to thank the companies and numerous staff members for providing data to make this empirical analysis possible.

Finally, I would like to thank my family for their endless support and encouragement from the beginning to the end of this educational experience. Just as she always does, my wife helped me to keep perspective throughout this endeavor.

TABLE OF CONTENTS

TABLE OF CONTENTS - CONTINUED

LIST OF TABLES

Table Page

LIST OF TABLES - CONTINUED

Table Page

LIST OF FIGURES

ABSTRACT

Private hunting lease agreements offer an example of the private provision (land access) of a public resource (wildlife). Privately owned forests play an important role in wildlife conservation because of land ownership and recreation trends in the United States. The implicit values in hunting lease markets are important to understanding market incentives of wildlife access leasing. The purpose of this thesis is to identify the underlying marginal values of annual hunting leases agreements. In this thesis, the hedonic valuation technique is used to empirically estimate two forms of consumer response: competitive bidding results in the Georgia hunting lease market and consumer response to take-it-or-leave-it prices in a Northern hunting lease market. The Georgia lease regressions use forest stand and regional attributes to predict observed lease prices. The Northern lease regressions use the firm's lease offering price and additional lease information to predict observed consumer response to lease offering prices. The consumer responses for the Northern regressions include lease applications per new hunting lease offering and renewal of pre-existing hunting lease agreements. The Georgia lease price regression results suggest statistically significant price determinants include the percentage of non-plantation acreage, distance from populations greater than 100,000 people, total county acres of public hunting access substitutes, and average forest property taxes paid per county. The Northern regression results indicate that the lease offering price, lease acres, distance from populations greater than 100,000 people, number of hunters per county, and predicted game crime prosecutions are statistically significant to predicting the number of lease applications received for each lease offering. The empirical results from the Northern lease renewal regression results suggest additional information not included in the firm's pricing methodology are jointly statistically significant to predicting lease renewals. The implicit values underlying hunting lease agreements are important for forest management, public hunting access, and lease pricing considerations; the results of this thesis identify lease and regional attributes that affect lease pricing.

CHAPTER 1

INTRODUCTION

Most natural resources, including wildlife, are governed by a combination of private and public institutions (Lueck, 1995). Following the substantial wildlife stock declines of the late 1800s, significant wildlife recoveries occurred in America, which were attributed to hunting regulation, habitat conservation, and species range recovery programs (Harrington, 1991). Beyond direct influences on habitat conservation, land ownership incentives also impact government wildlife programs. According to the forest service, more than half of the U.S. forests belong to private owners. Land owners clearly play a direct role in habitat provision and protection, but landowners also play a critical role in the government wildlife regulation and recovery programs.

Due in part to legislation such as the Lacey and the Pittman Robertson Acts, government wildlife agencies rely on consumptive recreation for funding (Parker, 2001). Federal and state game agency funding comes partly from hunting, and a significant proportion of hunting occurs on private land; more than 70 percent of the days spent deer hunting in 2004 occurred on private lands (Leonard, 2004). Through this funding relationship and the relative importance of private lands for hunting recreation, private landowners are an integral component in larger scale wildlife management and, ultimately, wildlife protection. Within these institutions, private access enables the provision of wildlife, conventionally considered a public good.

Individual forest owners face a myriad of investment decisions pertaining to land utilization. Forest and non-forest values are based on the estimated current market value of anticipated future net benefits. Land use conversion to residential and suburban uses from timber lands is observed when the anticipated benefits of development outweigh the anticipated returns of forest income such as timber, recreation, wildlife habitat, and watershed services (Beuter & Alig, 2004). Clear understandings of these benefits are important to forest valuation and to land use decisions.

Unlike the situation for public access lands, markets allow private forest owners to realize some monetary gain from wildlife as it relates to land management choices (Anderson & Leal, 2001; Leal & Grewell, 1999). Increasing numbers of industrial timberland managers consider hunting lease value in management decisions (Marsinko, Guynn, & Roach II, 1998). From an agricultural perspective, Baen (1997) presents hunting leases as an, "important revenue source for American agriculture land investors/owners." Further, the current volume of trade related advertisements indicate hunting access value is an important consideration for forest land owners large and small.[1] Increasingly clear market signals of hunting demand have prompted private firms to formalize and obtain revenue from hunting leases.

Within the context of land management and hunting leases, deer hunting activities are a significant component of the hunting lease market. In 2001 for the United States,

[1] An internet search of "hunting lease" provides support for this assertion. The Alabama Forest Owners Association collects and publishes county level non-industrial private forest owners' hunting lease prices online, Ram Adventures advertises available hunting leases for the Midwest online, private firms such as Westervelt Wildlife Services and The Wildlife Company (SFCI Division) advertise hunting lease consultation services to forest owners online, and several corporate forest owners now advertise available lease information online.

there were four times more deer hunters than turkey hunters, the second most popular game species (Leonard, 2004). Further, deer hunters spent over ten billion dollars on travel and hunting expenditures in 2001, approximately half of expenditures by all hunter types reported (IAFWA, 2002; USFWS, 2001). The empirical analysis of this thesis focuses on deer hunting access leasing.

This thesis evaluates to what degree differentiable lease attributes influence private hunting lease prices. Hedonic valuation is used to analyze private hunting access lease agreements. One series of regressions estimates the observed lease price as a function of lease attributes and regional characteristics. A second series of regressions estimates the ability of a firm, using a structured lease pricing method, to accurately predict the true market value of its lease offerings based on consumer response. This pricing assessment is accomplished by estimating both lease offering applications and lease renewals as a function of the firm's offering price, additional lease attributes, and regional characteristics.

This study of lease values should be of interest to landowners, hunters, and state game agencies. The implicit values in these lease markets are important to understanding market incentives of wildlife access leasing. The observed values for wildlife attributes, inherent in lease agreements, are also of interest. At the margin, landowners are expected to make management decisions that impact wildlife habitat, responding to all applicable costs and benefits.

One of the participating firms providing data for this study expressed interest in this analysis of lease prices on the grounds for a better understanding of their hunting lease revenues. Through the competitive bidding process used by this and other forest land leasing firms, buyers are presumably placing value on lease attributes. Therefore, the observed prices for these leases correspond to an "as if" systematic pricing process that may be estimated by hedonic valuation. The first series of regressions assesses the degree to which observed market prices vary as if the market systematically prices individual leases. The second series of regressions assesses a firm's ability to accurately predict the true market value of its lease offerings using a hedonic approach.

Previous studies (Hussain, Zhang, & Armstrong, 2004; Livengood, 1983; Loomis & Fitzhugh, 1989; Pope III & Stoll, 1985; Zhang, Hussain, & Armstrong, 2003) analyzed values of private hunting access; however, the results had limited application to specific land attributes. A limitation of this previous work was reliance on hunter or landowner surveys. Survey results are by their nature subjective, and can provide only limited tract-level information. Further, the technical expertise of individual hunters and landowners may be limited in the context of quantifying land attributes and habitat acreages beyond personal opinion. These factors potentially limit the degree to which analysis may focus on quality attributes of individual hunting leases.

Unlike data utilized in other studies of hunting leases, the lease data from forest industry sources used here offer the advantage of consistent information systems for lease transactions in competitive hunting lease markets, while maintaining geographic variation among lease observations. Two forestry firms agreed to provide data for the evaluation in this thesis. Each firm has requested anonymity and, to respect this request, the firms are referenced by geographic location. Firm lease information from a Northern State and a Southeastern state will provide a data cross section encompassing 918 leases over approximately 640,000 acres and 703 leases over approximately 102,000 acres, respectively. The hedonic valuation method is used to estimate price functions incorporating lease attributes and regional attributes as explanatory variables.

Chapter 2 provides a review of the existing literature of wildlife economic institutions, general lease trends, and current economic valuation methods and applications to hunting access valuation studies. The hedonic framework is developed, and the empirical designs for lease price analyses are discussed in Chapter 3. The empirical variables and available data are presented in Chapter 4. Chapter 5 provides a discussion of the empirical results and the implications for hunting lease and the private lease market. Chapter 6 concludes with this thesis' contribution to the academic literature, wildlife access leasing implications, and future research suggestions.

CHAPTER 2

LITERATURE REVIEW

Wildlife management and regulation encompass a combination of public and private ownership. Wildlife's institutional underpinnings as identified by Lueck (various years) are first discussed here, followed by background on hunting lease organization and trends. Many natural resource commodities, such as wildlife access, are infrequently traded in centralized, formal markets. To overcome the lack of consolidated market data, researchers may employ various empirical tools in order to analyze "markets" for wildlife access. Two analytical tools and their relevant applications, contingent valuation and hedonic pricing, are reviewed in this chapter.

Economic Foundations

Lueck was among the first to analyze the regulations of wildlife within an economic framework. Like many natural resources, wildlife is neither open-access nor completely private property, but rather a mix of these property rights regimes. Lueck (1995) proposes that, after accounting for this intermediary ownership regime, a modern property rights economic framework adequately explains the economic logic of wildlife institutions. Lueck's empirical results suggest that the value of wildlife stocks, wildlife territory size, and land ownership patterns determine the balance between private control and government regulation observed today. In developing his economic framework, Lueck presents concepts that are relevant to this analysis of wildlife access values. These concepts include the economically rational coexistence of private and public wildlife regulation, contracting costs of ownership size, and wildlife access provision incentives for private landowners.

The current state of American wildlife institutions, or the conglomeration of private landowner and government regulation, serves to, "economically mitigate the wealth dissipation that results from incomplete ownership" (Lueck, 1991). Further, the current systems of ownership stems from individuals attempting to maximize wildlife values. Lueck supports this claim empirically with a cross-section analysis of state regulation and hunting data. Lueck notes that the current combination of private and public institutions can never be proven efficient, but that his empirical results suggest the wildlife institutions vary or shift in response to exogenous changes in ways that are consistent with wildlife wealth maximization.

Assignments of wildlife property rights depend on landowner contracting costs and wildlife values (Lueck, 1995). One primary contracting cost originates from how ownership of wildlife may be indirectly acquired. Private landowners do not own wildlife in the sense that a rancher owns cattle; however, sufficient ownership of land that wildlife may inhabit or contracting among landowners may implicitly establish a degree of ownership. Wildlife ownership can be costly because corral conditions do not apply to wild animals (Lueck, 1991). In other words, "wild" animals exist within habitat acreages and spatial distributions that are not necessarily consistent with private property boundaries.[2] If this contracting cost to landowners exceeds the financial benefits of

[2] Lueck offers the basic example: If control of wildlife requires 1000 acres and a farmer owns 1000 acres, then she can "essentially" own the wildlife. If several farmers, however, own 100 acres each, a contract

wildlife ownership, it is not feasible for a landowner(s) to control the full range of an animal or herd, than third party intervention may ensue.

Governmental wildlife agencies can be a “rational economic outcome of the high costs of establishing rights to wildlife by private landowners” (Lueck, 1991). When contracting costs outweigh gains to wildlife ownership, a third party or game manager may emerge as a more “efficient” owner of game stocks; Lueck identifies government wildlife departments as one such third party agent (1995). Gains can arise from the existence of game departments, however, Lueck notes that a game department cannot “effectively” control land use by private owners and are subject to the same inefficiencies of any bureaucracy. Because of these governmental limitations, private landowners are crucial to wildlife management.

Although agencies are limited in their control of habitat on private land, wildlife take (harvest) limitations and concession to private landowners can increase the value of wildlife habitat to land owners (Lueck, 1995). To illustrate, Lueck examines special concessions for landowners in state wildlife law, private preservation of biodiversity, and the market for private hunting rights; the latter concession is the focus of this thesis.

Lueck (1991) suggests landowner incentives for owning wildlife are based on resolution of conflict between animal population spatial requirements and optimal land size for other uses. From this argument four predictions arise, all else equal: 1) gains to landowners increase with increasing value of wildlife, 2) gains to landowners increase with increasing productivity of the land for wildlife, 3) increases in the size of

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between ten farmers is necessary for wildlife control. Transaction costs of this agreement could negate the gains from wildlife control.

landholding decreases the cost of contracting (or increases gains to landowners), and 4) increases in the territory of wildlife decrease gains to landowner (as contracting costs increase). The second and third predictions are empirically tested in this thesis.

Larger landowners are more likely to define and offer lease-hunting rights, *ceteris paribus*. Increases of habitat ownership size (via increases of adjacent property ownership), increases of wildlife herd density, decreases of game populations' territories, and increases in wildlife value all lead to increases in the supply of fee hunting (Lueck, 1995). The establishment of private hunting rights (fee hunting) provides incentives for landowners as well as allowing for hunter choices within the market. Lueck supports these assertions with hunter survey data from New Mexico and Texas that indicate higher success rates and higher average income for hunters participating in fee hunts (Lueck, 1995).

Lease Market Background

Land ownership patterns and wildlife diversity vary greatly among states and accordingly, the observed private wildlife access agreements vary as well. Consumer leasing arrangements also differ within state boundaries. In Texas for instance, lease arrangements include seasonal leases, day hunts, bag or take based fees, and outfitter contracts in addition to public access opportunities (Pope III & Stoll, 1985). Annual lease arrangements are the focus of this thesis and it is instructive to review previous survey work addressing private lease arrangements.

The National Private Landowner Survey (NPLOS) was conducted in 1995-1996 for the purpose of estimating the supply of recreational access to private lands and providing better understanding of landowner behavior towards recreational access (Teasley, Bergstrom, Cordell, & Others, 1999).[3] The raw survey data set represents the lower 48 states and includes approximately 6,300 responses. These data include approximately 200 lease price observations. Generally, the specific lease price information from these survey responses appears to be imperfect, for example there are conflicting acreage observations and lease rate inconsistencies. There are some informative differences among regional market structures and motivation in hunting lease arrangements.

Landowners in the South region reported similar preferences for access agreements, agreement specifications, and motivations behind access agreements.[4] The South region had the lowest percentage of landowners who open land up to the public without posting (8.4 percent); the national average was (14.5 percent). Thus, it is not surprising that 77.3 percent of South region land owners lease land by written agreement with a fee, the largest percentage of landowners leasing in the country.[5]

South region land owners reported "helps pay property taxes" (80.5 percent), "control trespassing and unwanted use" (70.2 percent), and "help care for and protect

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[3] The NPLOS was conducted by cooperators of the Forest Service, Natural Resource Conservation Service, and the University of Georgia Agricultural and Applied Economics Department.

[4] The South region, as defined in NPLOS, includes Alabama, Arkansas, Florida, Georgia, Kentucky, Louisiana, Mississippi, North Carolina, Oklahoma, South Carolina, Tennessee, Texas, and Virginia.

[5] Generally, the Eastern United States has a much higher proportion of private land than the Western United States (Forest Inventory Analysis 1997 summary publication). The Northeastern United States average farm size is smaller than that of the Southeastern United States (NASS Agricultural Survey 2005 overview map). Although not empirically tested here, the correlation between land ownership patterns and establishment of wildlife access lease agreements are consistent with the wildlife institutional framework proposed by Lueck.

land" (60.7 percent) as primary motivations for leasing land. The proportion of respondents listing these positive responses was significantly higher from the Southern region than the other regions of the country.

The number of respondents in the NPLOS survey, relative to its geographic scope, is not ideal for a sufficiently detailed econometric analysis, particularly with respect to lease price observations.

Guynn and Marsinko (2003) provide general trend information for hunting leases on forest industry land in the Southeastern United States between 1984 and 1999.[6] Total land owned among forest industry respondents declined, but both the percentage of companies with hunting lease programs and the number of leases to hunting clubs increased. Across timber firm respondents, a general shift of leasing acreage to private individuals, rather than leasing to state agencies, occurred. The primary reasons that private forest lands were not leased were reported to be poor access and limited aggregate acreage within lease unit.

With respect to pricing, the forest industry respondents to Guynn and Marsinko's survey consistently reported that property taxes and neighboring lease fees were primary considerations for lease rate adjustments. Lease price increases outpaced inflation over the fifteen-year period and the number of lease managers considering lease revenue in economic analysis of property also increased in the study period. Respondents were asked to assign dollar values for lease fees, the value derived from access control under leases, and the value of public relations garnered by leasing. Over the fifteen-year

[6] The Southeastern region includes Alabama, Arkansas, Florida, Georgia, Louisiana, Mississippi, North Carolina, South Carolina, Tennessee, Texas, and Virginia.

period, the average lease fees grew proportionally larger than the perceived benefits of the other categories.

Contingent Valuation

Contingent Valuation Overview

It is instructive to consider some of the empirical tools researchers employ to investigate wildlife valuation. Contingent valuation (CV) is a survey based approach designed to elicit peoples' value of conditions or activities, particularly when revealed preference or observed markets are not available (Boyle, 2003). Although the CV method is widely used, the method is not free from criticism, primarily related to the reliability and validity of CV methodology (Venkatachalam, 2004). Reliability in this context refers to the consistency of the method over time. The validity, or accuracy, of CV is composed of criterion, content, and convergent validity types (Boyle, 2003). Convergence validity compares CV results to other non-market methods, such as travel cost, for consistency. The criterion component of CV draws upon a comparison of CV results to external measurements, such as observed market values. Content validity compares CV for consistency with respect to economic theory, established practices, and the valuation objective (Boyle, 2003).

The validity and reliability of CV results have been widely studied. Boyles finds support for the validity and reliability of CV in some cases relative to alternate valuation results, but he reports that the CV method is potentially biased and also reports operational concerns. Boyle states that CV methodology has been shown to provide useful Hicksian (compensated demand) estimations, primarily on the grounds of convergent validity testing. The general literature consensus indicates that although CV is reliable, it may generally overestimate values (Boyle, 2003).

Abstracting from theoretical explanations for CV bias, both Boyle (2003) and Venkatachalam (2004) conclude that research credibility gains would be made from proper administration and implementation of modern CV guidelines. Bateman and Turner (1993), the 1993 NOAA report on CV (Arrow et al.), and Boyle (2003), provide comprehensive guidelines. The following are three examples of CV methodology concerns highlighted by Venkatachalam.

The first methodology concern is the embedding effect. This effect concerns the validity of value estimation, particularly for multi-good valuations (Venkatachalam, 2004). Definitions vary, but in essence, embedding occurs when one good's estimated value significantly depends on whether or not it is included in a larger bundle of goods (Venkatachalam, 2004). The individual value of interest may either be lower when not included with a bundle, such as the value of a lock without a key, or not significantly different in value, such as the estimated value of clear visibility in half of the Grand Canyon versus estimated value of clear visibility in all of the Grand Canyon.

Two additional methodology concerns include sequencing and information effects. The sequencing effect refers to a condition where the sequential order of goods that may impact the valuation of a specific good within the sequence. Although the magnitude of bias is not generally agreed upon, studies do suggest appropriate administration procedures that may minimize the influence of the sequencing effect

(Venkatachalam, 2004). Another source of research design concern is the information effect, whereby the design or nature of information presented to participants has been shown to influence their valuation (Venkatachalam, 2004). Although studies yield mixed results as to the directional bias of this effect, Venkatachalam stresses the importance of considering asymmetrical information across survey respondents, including both information within the survey questions or *a priori* knowledge of a respondent, as a source of survey bias.

Some of the potential shortcomings of CV methodology could present systematic concerns for an analysis of hunting lease attributes. Sequencing may present a problem for value estimation; for example, the survey respondents may disproportionately allocate willingness to pay for the items presented earlier in the survey or questions positioned closer to deer quality questions. Additionally, information bias is possible if survey respondents do not have complete or comparable knowledge regarding the lease property or region.

As mentioned, careful design and implementation could minimize many of the potential estimation problems of CV. Additional "quality control" procedures could include pre-testing and peer review of survey instruments (Venkatachalam, 2004). CV applications related to hunting access valuations are presented below.

Contingent Valuation Applications

While some studies have examined hunters' willingness to pay for hunting access, very few studies have considered lease characteristics explicitly. This review focuses on one study with findings directly related to individual lease attribute values. Hussain, Zhang, and Armstrong (2004) estimated hunter willingness to pay for hunting leases in Alabama. In this study, data were generated from dichotomous choice contingent valuation (DCCV) hunter surveys that were used to jointly analyze a hunter's decision to lease and his or her marginal willingness to pay for various lease attributes. The authors' methodology for estimating hunter willingness to pay is particularly relevant to this thesis focus. The statistical significance of variables included in their regressions are applicable to this thesis but their willingness to pay estimates apply are specific to Alabama survey respondents.

With respect to the hunter's likelihood of leasing, Hussain, Zhang, and Armstrong found income, hunting club membership, and equipment expenditures to be statistically significant and positive. The likelihood of leasing function was specified as the selection equation. Under the DCCV framework, the selection equation establishes the attributes for the good of interest. With respect to the conditional bid price, hunting experience, income, harvest success, lack of game quality, and predetermined bid price were all statistically significant (Hussain, Zhang, & Armstrong, 2004). The outcome equation was specified as the conditional bid price equation, indicating the respondent's acceptance or refusal of a bid price. The authors inferred the magnitudes of willingness to pay from the outcome equation.

Two potential empirical design errors exist within the selection and outcome equations of Hussain, Zhang, and Armstrong's empirical analysis. First, the selection equation includes (non-lagged) hunting club membership and investment in hunting equipment as explanatory variables for a decision to lease. These variables are likely endogenous to lease choice, the dependent variable. It would be more appropriate to instrument for these variables rather than include them directly in the regressions. Secondly, dummy variables were used for lack of game quality (1 if dissatisfied) and site quality (1 if primitive). As with any qualitative survey data, participant response is somewhat subjective and the explanatory power across hunter responses is a cause for concern. The perceived difference in game quality among hunters may vary significantly and the implications for wildlife or lease management are ambiguous.

Hedonic Valuation

Hedonic Overview

Hedonic valuation provides an alternative to contingent valuation if observable market transaction data exist. Typically, when goods in a market have different attributes, these goods' prices vary. In this case, price differentials allow indirect observation of the respective value of desirable attributes, and the hedonic price method utilizes market transactions of differentiable goods to, "determine the value of key underlying characteristics" (Taylor, 2004).

Hedonic market analysis is composed of two stages. The first stage employs the hedonic price function to derive implicit prices of underlying characteristics. This price function is estimated with observed market transactions, including information about differentiated commodity characteristics (Taylor, 2004). The resulting "hedonic prices" can then be used with socio-economic characteristics of purchasers to estimate the second stage component, or in Taylor's words, "demand for characteristics of a differentiated product" (2004).[7] As an example, Boyle and others (2003) use the second stage component to estimate own-price elasticity of water clarity and estimated consumer surplus for a discrete water clarity improvement using data from lake home purchases. The first stage component of the hedonic price method is most relevant to this thesis.

Rosen (1974) establishes the derivation and interpretation of hedonic price functions. The hedonic model is a description of competitive equilibrium where buyers and sellers locate and all "locations" of equilibrium are described by a vector of characteristic quantities. Rosen explicitly reminds us that the first stage results do not identify the underlying demand and supply functions, but rather the interaction points of the market and the relationship of product attributes to that observed price. Of application to this analysis, Rosen also notes that the function cost shifters (e.g., property taxes) and consumer similarities (e.g., income) may influence outcome and justification for inclusion into the hedonic function.

Hedonic Applications

In a departure from contingent valuations used in earlier wildlife literature, Livengood (1983) proposes the hedonic valuation method as a plausible application for wildlife valuation. According to Livengood, the observed value of a site relates to the differing characteristics offered in the market, and the implicit values can be described by a hedonic price function. Further, the hedonic price function is estimated by regressing

[7] Modeling and data requirements are more complex for second stage analysis and a more detailed discussion of associated concepts may be found in Taylor, 2004.

observed price against varying quantities of differentiated goods; the various characteristics distinguish differentiated goods.[8]

Livengood (1983) drew data from hunter surveys conducted for 1978-1979 Texas whitetail deer season. At the time of Livengood's study, less than 2 percent of the total Texas deer range was open to public hunting. In an ordinary least squares regression, lease prices were modeled as a function of distance traveled, deer kills per hunter, lease acres, hunter congestion, a dummy variable for free access options, and a lease duration dummy variable. All right hand side variables were statistically significant with an R-squared value of 0.46. All right hand side coefficients exhibited positive signs except the hunter congestion variable.

Unfortunately, some of Livengood's variable specifications are questionable. Distance traveled (right hand side variable), measuring the miles a hunter drove to his or her lease, is likely endogenous to lease price paid per hunter (left hand side variable). The approximation for hunter congestion reflects hunting club membership in a particular lease. *Ceteris paribus*, this hunting club membership should always negatively correlate to per person lease prices, but this measurement does not necessarily reflect the quantity of hunters in a region as Livengood intended. Ignoring the concerns regarding the explanatory variables, Livengood's paper introduced an important model, hedonic pricing, for wildlife valuation as an alternative to contingent valuation. Livengood's paper does not however address the significance of particular habitat characteristics for

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[8] Two key assumptions in this theoretical framework are that rent functions for hunting sites are non-linear and that households are not identical. Thus, marginal willingness to pay depends on the hunting site supply curve. If supply of deer cannot be manipulated in the short run, the variation in site qualities are based on geographic factors rather than landowner response to implicit prices

the production of both wildlife and overall hunter experience implicit in recreational hunting.

In reference to Livengood's paper, Pope and Stoll (1985) point out that estimated willingness to pay for deer harvested are significantly less than average deer lease prices which indicates the, "right to engage in the recreational activity of hunting deer is much more valuable than the harvested deer itself." Thus, hunting lease value encompasses both right to access and attributes of the property, the latter being the focus of Pope and Stoll's paper.

The Pope and Stoll paper is based on hunter survey data from the Texas 1977-1978 deer hunting season, focusing on hunters who leased property. Lease prices were regressed against three independent variable groups: size and location of lease, game diversity offered in lease, and facility attributes of the lease.[9] Pope and Stoll's empirical results suggest that facility characteristics or services, such as game feeders or trailer hookups, are not significant to lease value. Location, distance from metropolitan areas, and additional game species were all found to be statistically significant. The location variable is defined by six physiographic regions within Texas and, although not explicitly discussed in the Pope and Stoll paper, this variable potentially incorporates environmental attributes and the associated deer herd characteristics of the regions.

Pope and Stoll conclude by acknowledging that their overall results must be viewed with caution. Statistical results, such as the adjusted R-squared of .43, compare

[9] As with Livengood's paper, hedonic prices are estimated at the margin by regressing observed lease exchange values against relative lease characteristics. Citing previous econometrics literature, Pope and Stoll acknowledge underlying supply and demand relationships are not clearly defined by hedonic prices; however, marginal effects of various characteristics are valid (Pope III and Stoll, 1985).

favorably with previous papers, but the authors note the empirical framework presented fails to explain the majority of observed price variation.

Applying a similar hedonic framework to a different region, Loomis and Fitzhugh (1989) analyzed fee-hunting enterprises to determine the financial return of a California wildlife initiative for private landowners. Loomis and Fitzhugh used the hedonic price method to decompose the total observed hunting fee into individual components of the hunting experience. Data were collected from California ranchers offering fee hunts, where the ranches were equally distributed between participant and non-participants in the state initiative. Loomis and Fitzhugh theorized price per hunter to be a function of: 1) hunting experience quality, 2) ranch characteristics, 3) hunter characteristics, 4) services provided and 5) wildlife management inputs. Empirical results indicate that success rates, trophy quality, hunter income, advertising, and efforts to match hunter compatibility were statistically significant contributors. Success rate and trophy quality presented the greatest price impact. The explanatory power of Loomis and Fitzhugh's study was relatively high (R-squared of 0.75).

Buschena, Anderson, and Leonard (2001) suggest an alternative method for analyzing the marginal values of hunting permits offered in (non-market) lottery systems. The Colorado elk hunting permit system allocates individual permits via a lottery; elk permit applicants may increase probability of drawing a permit through a preference point system.[10] Building on previous hunting permit lottery applications, the authors hypothesize that, in the context of Colorado elk permit lottery, competition for and

[10] From Buschena, Anderson, and Leonard (2001), unsuccessful "applicants are awarded one [non-transferable] preference point [per year], and these points can be accumulated and used in lotteries during subsequent years to enhance or even guarantee acquisition of a permit."

investment in preference points reveals a cardinal value for marginal value of elk hunting permits. Dollars spent on preference point attainment over time is used in a hedonic regression model to, "quantify the contribution of hunt characteristics to the inferred marginal value" (Buschena, Anderson, & Leonard, 2001).

More specific to a hunter's marginal value, the regression of interest in Buschena, Anderson, and Leonard specifies the expected market clearing level of preference points as a function of permit supply, public land, distance from metropolitan area, harvest type probabilities, permit limitations, herd ratio descriptor, trophy indicator, and wildlife ranch indicator.[11] This functional form was applied to then-available data for each year between 1993 and 1997. The Poisson regression results indicate the number of tags available, rifle cow elk permit, trophy indicator and interaction of percent public land and wildlife ranch indicator were statistically significant with the hypothesized signs in three or more of the five years examined.

Other Methodologies and Applications

From a general perspective within the wildlife economics literature, the travel cost method is a popular valuation technique. The travel cost method is used for single site valuations or discrete choice of one of many sites in a random utility maximization framework (Parsons, 2004). However, this travel cost method is generally applied to public recreational opportunities that often do not have observable market values,

[11] Buschena, Anderson, and Leonard excluded socio-economic data because it is not available. As a benefit, this maintains generality, and thus applicability, to the findings. As a limitation, the framework may suffer from omitted variable bias. The authors suggest that inclusion of travel cost and socio-economic data from additional sources into this framework would enhance academic exploration of the determinants of willingness-to-pay for hunting permits.

whereas the focus of this thesis is the analysis of private access agreements with observed values. Therefore, a discussion of the travel cost literature will not be undertaken here.

Wallace, Stribling, and Conts (1989) examined the structural relationship among land access choice and various hunter characteristics using hunter surveys from the state of Alabama. Using a log-linear hierarchical model, the authors conclude that income (as both a socioeconomic characteristic and an economic constraint), commitment (pre-determined preference), and regional residence (access or supply factors) affect land access choices of hunters. Wallace Stribling, and Conts found that hunter characteristics, excluding access availability, were relatively homogenous across the state and that supply of hunting access did not affect demand, or in other words, hunter's preference for access did not vary because of differences in available access options. These findings support their paper's position that fee hunting developments within Alabama were not decreasing hunter participation, but rather, fee hunting was re-apportioning hunting areas.

Literature examining the impacts of stand characteristics, such as forest ages or hardwood component, on hunting lease fees is relatively limited, especially from the standpoint of landowner data perspectives. Zhang, Hussain, and Armstrong (2003) employ joint analysis of lease participation and lease fee determinations that include the effects of tract specific stand information. Data were drawn from Alabama landowner surveys and included information on ownership characteristics and tract specific information. Variables pertaining to lease fee determination included dummy variables for lease attributes such as game diversity, site quality based on seclusion, access roads, habitat improvement, stream side management, and services. Continuous variables included ratios of aquatic habitat acres and agriculture crop acres relative to forest land acres (Zhang, Hussain, & Armstrong, 2003). With respect to lease fee determination, all identified variables were statistically significant with anticipated signs except the aquatic habitat acre ratio (Zhang, Hussain, & Armstrong, 2003).

Several empirical concerns limit the potential implications of Zhang, Hussain, and Armstrong's results. For example, their variable for stream side management zone, as a dummy variable, may ignore the marginal impact of increasing stream side management zone acreage as preferable deer habitat. Ideally, a continuous variable for stream side management zone acreage would control for this desirable habitat attribute. Similarly, site quality in Zhang, Hussain, and Armstrong is quantified as a dummy variable for self-reported seclusion. This variable, as with other self-reported data, is limited by the respondent's personal interpretation and lack of standardized measurement tools.[12]

The thesis extends the finding of previous lease value analysis and includes refinements in empirical design and data sources. This analysis provides a valuation of land characteristics not addressed in previous studies. These forestry firm data provide a consistent, detailed attribute information source yet the results remain applicable to non-industrial private hunting lease offerings. By examining particular land attributes, these results offer management implications to forest owners and hunting lease managers. In contrast to previous studies, this thesis offers a comparison of lease bidding prices and lease prices established from a hedonic method *a priori*.

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[12] Standardized measurement tools might include Geographic Information Systems (GIS) technologies more commonly used in the industrial forestry sector.

CHAPTER 3

THEORY

This thesis examines hunting lease values as an application of Rosen's hedonic model. In his methodology, Rosen (1974) employs a utility maximization framework with a focus on market equilibrium and consumer behavior to model product differentiation, which is applied in this case to a private wildlife access market.

The hedonic function is a description of a competitive equilibrium of buyers and sellers for a particular class of goods; the goods are access leases in this analysis. Each point of competitive equilibrium is described by a vector of characteristics $(\underline{l})=(l_1,l_2,\ldots,l_n)$ where l_i is a measurable quantity of a particular characteristic.

Hedonic prices are defined as the implicit, individual prices of a good's attributes. These prices, revealed by agents in the market, relate to specific amounts of a product's characteristics for each observable transaction. Empirically, the prices in this model equal the estimated statistical coefficients multiplied by the level of the attribute within the good (Rosen, 1974). Following the hedonic framework derived from Rosen's model, a discussion is provided of the appropriateness and applicability of the underlying assumptions for hunting lease price observations in a competitive market.

Market Equilibrium Conditions

Let the lease price be a function of its characteristics, such that $p(\underline{l})=p(l_1,l_2,\ldots,l_n)$ where $p(\underline{l})$ guides the firm and hunter in the choice of leases offered and purchased.

Neither the individual producer (forestry firm) nor the consumer (hunter) possesses significant market share in this model so that all market participants are price takers. As discussed later in this chapter, this assumption is reasonable for the empirical applications of this thesis. The price of an attribute bundle $\underline{l}$ satisfies market-clearing conditions that include: quantity offered equaling quantity demanded; consumers and producers basing choice of purchase characteristics and quantity on maximizing behavior; Pareto optimality; and market clearing prices determined by consumers' tastes and producers' costs (Rosen, 1974).

As noted earlier, an access lease is described by the vector $\underline{l}$ and each attribute l_i is quantified by some standard measurement or quality estimate; this standard measurement of the attribute l_i is known to all consumers (*i.e.* there is symmetric information among hunters). Assume a continuous set of differentiable attribute bundles (leases) exists such that the spectrum of options is sufficiently large enough to facilitate consumer choice. This assumption insures smoothness of the demands for good characteristics.

Each lease has a market price that relates to its lease attributes. If two lease options offer identical characteristics $\underline{l}$, the consumer would derive the same utility from either product, and the hunter would choose the lower priced option.

All l_i are treated as "goods" such that consumers receive only positive marginal utility from each individual attribute. Firms incur positive costs for increased levels of l_i so that $p(\underline{l})$ is increasing in all arguments and continuous second derivatives are assumed.

The Consumption Decision

Suppose a consumer purchases only one lease with attributes $\underline{l}$ such that the utility is a function of a composite good x and attributes $\underline{l}$; the composite good represents the consumption of all goods other than hunting leases. Let the price of x equal unity and define income Y as the sum of spending on all other goods and a lease purchase. The price of the lease $p(\underline{l})$ depends on the individual lease characteristics. The individual characteristic prices $p(l_i)$ are not directly observed, but the aggregate price of the lease $p(\underline{l})$ is explicit and observable. The hunter's objective function is:

$$\underset{x,\underline{l}}{Max}\, U(x,\underline{l}) \text{ subject to } Y = x + p(\underline{l}) \tag{3.1}$$

In words, the hunter achieves maximum utility given the budget constraint by choosing a lease of desirable attribute quantities ($\underline{l}$) and the amount of other goods (x), while satisfying the budget constraint and the first order conditions:

$$\begin{gathered} \frac{p_i}{1} = \frac{U_{li}}{U_x} \\ \text{and} \\ \frac{p_i}{p_j} = \frac{U_{li}}{U_{lj}} \\ \text{where } i, j = 1, \cdots, n \text{ for all } i, j \end{gathered} \tag{3.2}$$

The first order conditions amount to the standard utility maximum condition where the price ratio equals the marginal rate of substitution for each attribute and all other goods. Assume second order conditions hold with respect to all other goods x, all lease dimensions ($l_1, l_2, \ldots, l_n$), prices, and income as consistent with the general assumptions of constrained utility maximization.

Demand functions of attributes in this utility framework warrant brief derivation and discussion. By the Lagrangian method:

$$L = U(\underline{l}, x) + \lambda(Y - \underline{x} - p(\underline{l})) \tag{3.3}$$

Expanding the first order conditions listed above:

$$\begin{aligned}
&\frac{\partial U}{\partial l_i} = U_{li}(\underline{l}, x) - \lambda p_i(\underline{l}) = 0 \\
&\frac{\partial U}{\partial x} = U_x(\underline{l}, x) - \lambda = 0 \\
&\frac{\partial U}{\partial \lambda} = Y - x - p(\underline{l}) = 0 \\
&\text{where } i, j = 1, \cdots, n \text{ for all } i, j
\end{aligned} \tag{3.4}$$

Assuming the implicit function theorem holds:

$$\begin{aligned}
&l_i = l_i^m(Y, p(\underline{l})) \\
&x = x^m(Y, p(\underline{l})) \\
&\text{where } i = 1, ..., n
\end{aligned} \tag{3.5}$$

The Marshallian demands in equation (3.5) for each particular lease attribute and all other goods are represented by l_i^m and x^m, and are functions of income and prices. Marshallian demands, or "money-income-held-constant demand curves," convey demand relationships while holding income constant (Silberberg & Suen, 2001).

This utility maximization model also provides a framework allowing us to define the individual's willingness to pay for a vector $\underline{l}=(l_1, l_2, ..., l_n)$, represented by the hunter's bid function:

$$\begin{aligned}
&\theta(l_1, \cdots, l_n; Y) \\
&\quad where \\
&u^o = U^m(Y - \theta, l_1, \cdots, l_n)
\end{aligned} \tag{3.6}$$

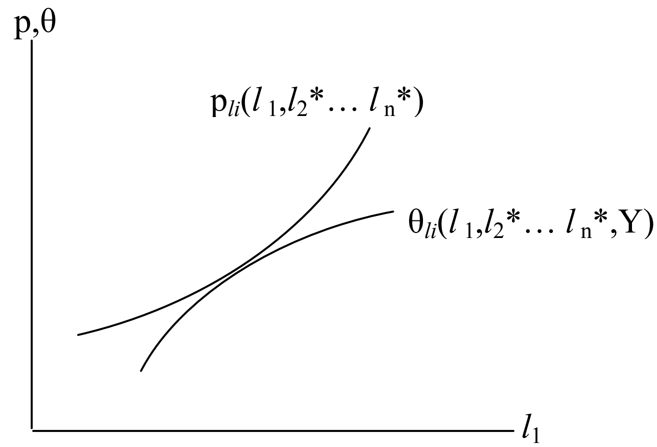
The hunter's optimum level of utility (u^o) is defined by the combination of lease attributes and all other goods; the available income (Y) limits the total consumption possibilities. Thus, the bid (θ) represents the maximum "expenditure a consumer is willing to pay for alternative values of $\underline{l}$ at a given level of utility [limited by the level of Y]…[the bid function] defines a family of indifference surfaces" which relate the attribute l_i to foregone income (Rosen, 1974).

Equilibrium for a market of leases is defined for every lease represented by a vector $\underline{l}$* when:

$$\begin{array}{c} \theta(\underline{l}^*;Y) = p(\underline{l}^*) \\ \textit{and} \\ \theta_{l_i}(\underline{l}^*;Y) = p_{li}(\underline{l}^*) \\ \text{where } i = 1,\cdots,n \end{array} \tag{3.7}$$

The optimum choice of lease attributes $\underline{l}$* in equation (3.7) provides the highest attainable utility to the hunter given the budget constraint. When the consumer's bid price for this combination of attributes, $\theta(\underline{l}^*;Y)$, equals the minimum offering price of this combination of attributes in the market, $p(\underline{l}^*)$, equilibrium (a purchase) is observed.

Graphically, the optimum location on the lease attribute plane for each lease attribute l_i occurs where the $p(\underline{l})$ and $\theta(\underline{l};Y)$ are tangent, as illustrated for attribute l_i by Figure 1 below. The l_1 attribute dimension of the hunter's utility maximization problem, illustrated for the indifference curve of u^o as defined by Y. The price function reflects the price of varying levels of l_1 and the optimum market level of all other attributes for this hunter. The equilibrium price observed in the marketplace follows from the point where the consumer's willingness to pay, θ, just touches the market offering price, $p(\underline{l})$, of the specified attribute bundle in dimension l_i.



Source: Rosen 1974

Figure 1: Hunter's Utility Maximization.

The Production Decision

Rosen (1974) also provides a framework for the firm's production decision. The model applied to the Georgia and Northern lease markets in this thesis is simplified from Rosen's general goods production example. Based on discussions with forest industry personnel, land management practices and the resulting forest conditions are largely independent of lease program decisions; the lease offerings are secondary products to the timber revenue and are administered by a separate division within the firm. In the context of this application, the forest attributes (elements of $\underline{l}$) are taken to be determined prior to the lease offerings.

The firm chooses how many leases to offer to consumers. The last or marginal lease offered by the firm produces a marginal benefit equal to the marginal cost of offering that lease. The marginal benefits and marginal costs of offering a particular lease depend on the lease attributes $\underline{l}$. The total costs of the firms lease program is dependent on the number of leases offered and cost shifters for the lease areas. The cost shifters are the underlying production costs such as factor prices and production function parameters that may vary (Rosen, 1974). The shift parameters in this analysis include production costs that vary based on the geographic region.[13] Assuming the cost function is convex and marginal costs of offering a lease are positive, an interior solution with a positive price exists. The firm maximizes the profit of its leasing program by choosing optimal number of leases to offer. As a secondary product, the firm "produces" or offers leases as long as the marginal cost of a lease offering is less than or equal to its marginal benefit.

Each firm in the market is assumed to behave as a price taker so that individual "production" decisions do not influence the market equilibrium. State specific forest ownership information suggests that the firms empirically evaluated in this thesis are price-takers in their respective hunting lease markets.

According to the Georgia Forestry Association (GFA), 280 million commercial forest acres are distributed among private (72 percent), corporate (21 percent), and government (7 percent) forest owners (GFA, 2006). Private forests are owned by

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[13] In this lease market application, surveys suggest (Guynn & Marsinko, 2003; Teasley, Bergstrom, Cordell, & Others, 1999) ownership costs due to property taxes are generally included in firms' (and individuals') lease pricing practices. Because property taxes vary by county, the observed tax rate is included as a shift parameter within this analysis.

individuals and may range from a few acres to several thousand-acre properties; private ownership includes an estimated 260,000 individual owners. Corporate forests are, as the name implies, incorporated entities that specialize in the investment and management of forest land. In Georgia this category includes fewer than 100 companies. By comparison, the Georgia forestry firm lease data in this thesis represents fewer than 700,000 acres of commercial forest land, or less than 1 percent of the total Georgia forest land. Within this state's diverse ownership structure, no legal or tax impediments to access leasing are identified, so the assumption of competition should be valid for this setting. The Northern forest ownership conditions are comparable to the Georgia forest ownership conditions but are not reported here upon request of the timber firm providing the Northern data.

Application of Theory

The relationship between the hunting lease consumption and production decisions, as well as the plausibility of implicit assumptions, is important for the development of the hedonic function. A portion of the hedonic framework employs income Y as a modeling component. Although consumer information is not available for this analysis, the model framework is still applicable in the context of a representative consumer model of dispersed buyers.

The consumption of a hunting lease is not restricted to same-county residents although, variables to control for differences in consumer demand, such as income, are included in this empirical framework. In the simplified form, the hedonic regression for a lease with attributes ($\underline{l}_j$), consumer preference shift vector ($\underline{\gamma}_j$), and cost shift vector ($\underline{\varphi}_j$) is represented as:

$$p(\underline{l}_j) = \beta_0 + \beta_1 \underline{l}_j + \beta_2 \underline{\gamma}_j + \beta_3 \underline{\phi}_j \tag{3.9}$$

The lease price in equation (3.9) is regressed against the vector of lease attributes $\underline{l}_j$, consumer shifters $\underline{\gamma}_j$, and cost shifters $\underline{\varphi}_j$. The lease attributes will include explicit characteristics of the lease as well as regional attributes and hunting quality attributes. The consumer preference shifters include proxies for hunting demand and income. Cost shifters, as discussed in the production decision, will include characteristics which increase the cost of offering a particular lease.

The empirical applications to the Northern data differ from the empirical applications to Georgia data due to differences in the Northern firm's lease pricing mechanisms, described with more detail in Chapter 4. Unlike the Georgia firm, the Northern firm sets its lease price offerings internally as a take-it-or-leave-it offer and absent a competitive bidding process. The process is absent competitive bidding in the sense that a consumer may not expend additional money or effort to improve their odds of obtaining a particular lease from the Northern firm. If the Northern firm's pricing scheme does not reflect the true market value for hunting leases, based on either differing attribute values or unrecognized attributes, consumers will presumably respond in some predictable manner to under- or over-valued lease offering prices. Let the pricing error (P_e) be defined as the difference between a lease offering price (P_o) and the "true" market price $P(\underline{l}_j)$, represented as:

$$P_e = P_o - P(\underline{l}_j) \tag{3.10}$$

If the firm's pricing model is incomplete, then it should be possible to predict observed consumer response, such as number of lease applications or lease renewals, by augmenting the firm's predicted price with additional lease attribute information. Testing this assertion with the Northern data requires two steps. First, the firm's pricing model is reconstructed with the company provided attribute data to produce the predicted lease offering prices. Next, two separate regressions will test the ability to predict the observed consumer behavior using the firm's predicted price and additional lease attribute information. One regression will employ the number of lease applications per offering received as the dependent variable. The other regression will employ lease renewal observations as the dependent variable. Each of these dependent variables is regressed against the firm's predicted price and additional variables.

The number of applications (number of hunters willing to accept a lease offer price) for new lease offerings should not vary substantially among available leases if the firm's offering prices are equal to the market equilibrium price. If the offering price differs from the true market price, it is hypothesized that the variation in applications can be explained by the firm's lease price and additional lease attributes not included in the firm's lease pricing model.[14] A higher (lower) number of applications should be observed if the offering price is below (above) the true market value and zero applications would be observed when the offering price is above the true market value.

Because the firm is asking for buyers (lessees) in a take-it-or leave it manner, the asking price and the unobserved market equilibrium prices are unlikely to be equal.

[14] Empirically, regression results would fail to reject the null hypothesis if additional lease attribute variables were statistically insignificant for a lease application regression.

Additional explanatory variables that the firm does not use, representing desirable lease features, should be statistically significant for lease application prediction.

The second empirical regression, based on lease renewals, is similar to the lease applications model but uses a binary variable, whether or not a lease was renewed, as the dependent variable. Under a Logit specification, lease renewals are regressed against the firm's predicted price and additional lease attribute information. If the additional explanatory information is a statistically significant determinant of renewals, then there is empirical support that the firm's predicted price omits information used by the market for lease valuation.

Summary

This chapter uses Rosen's framework to model utility maximizing behavior and market competition for the analysis of hunting lease markets. This model provides a hedonic price model that is used to evaluate observed lease values in Chapter 5.

CHAPTER 4

EMPIRICAL MODEL

The empirical focus of this thesis is an analysis of hunting lease prices, employing a hedonic function. In order to investigate the implicit values of lease attributes, the lease price is regressed against these lease attributes and cost shifters. For the subsequent discussion, empirical variables are divided into three categories: 1) forest stand attributes of the lease, 2) regional attributes of the lease area, and 3) supply cost shifters. Each variable category discussion is comprised of two parts: the empirical purpose of the variable and descriptions of the available data. Applications to the Georgia lease market are presented first and the analogous, and subsequently shorter, discussion of the northern lease market data follows. To respect the Northern firm's request for anonymity, data sources or descriptors that could identify the company's operating area will not be disclosed.

Lease Attributes Variables

Lease attributes include quality parameters specific to an individual lease. As discussed in Chapter 3, the observed lease rate is the dependent variable of the Hedonic model. The independent explanatory variables in this analysis include size and wildlife habitat features. Lease acreage addresses the wildlife range, or relative control over the spatial "home" of a particular animal implied by a lease agreement. The closer a lease boundary matches the typical spatial range of a species, the greater "control" the owner has over the species of interest (Lueck, 1991). Assuming increased control over a species (via increased lease acres) is a normal good for a hunter, lease size should positively influence observed lease price.

Higher quality wildlife habitat is hypothesized to command higher prices in the lease market. As the focus of this analysis is hunting leases, and deer are the main species of interest to the participating lease holders, deer habitat features and the subsequent values observed in the market are used.

Ideally, explicit measures of lease desirability universal to all hunters would be utilized. Prior work has attempted to define this measure in a general sense (Hussain, Zhang, & Armstrong, 2004; Zhang, Hussain, & Armstrong, 2003) but, as noted, self-reported descriptors are subjective and difficult to compare across hunters. Proxy measures for lease desirability are devised here and used in the empirical estimations reported in Chapter 5.

General silvicultural principles allow for inference of desirable deer habitat features, given forest stand information. As examples, early succession woody growth associated with clear cuts provide browse for deer. More generally, the transition zones between “tall” and “short” ground cover are noted as desirable habitat features for deer species (Steinbeck, 1999). Presumably, these desirable lease features command a positive value.

As an alternative to hunter survey data used in other studies, forest stand information and lease attributes provided by the forestry firms are employed in this thesis. Corporate data sources offer several important advantages over survey data.

Generally, selection bias concerns are inherent in survey methods; which individuals are surveyed and, ultimately who chooses to complete a survey may introduce unobserved data errors. Regarding analysis of lease values, hunter surveys are limited by the subjectivity of questions designed to address quality features of wildlife access. Forest company data, on the other hand, avoid the selection and subjectivity concerns of survey data. Forest firms maintain standardized data collection procedures and the available information are centralized. The firm's products (lease offerings), are dispersed among geographic boundaries and are comparable to hunting access offered by neighboring forest properties.[15] The firm's lease offering vary in acreage, habitat characteristics, and the implicit regional characteristics.

For the Georgia regressions, forest stand data is used to create lease attributes hypothesized to be of value to deer hunters. Proxies for desirable deer habitat are based on food provision, animal utilization, and hunter visibility. For example, regeneration areas, here defined as forest stands less than six years of age, provide browse for deer and improved shooting visibility for hunters. Non-plantation acreage indicates forest areas under less-intensive management practices, potentially affording more browse and otherwise "natural" settings.[16] Hardwood stands are more likely to include mast producing tree species, a desired wildlife food component. These constructed variables are hypothesized to measure deer habitat quality for the purpose of this economic analysis and should positively influence the observed market price.

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[15] The implications of this analysis should apply to non-industrial lease providers because of the similarities between forestry firm leases and non-industrial leases.

[16] This relationship is based on the premise that non-plantation management does not include the use of chemical vegetation control methods and otherwise more "intensive" management practices.

The Northern data set construction varies from the Georgia data set. The Northern lease information contains lease attribute data, but due to the differing attribute data format and firm pricing methodology, the habitat variables used for the Georgia data are not feasible. Instead, the Northern regressions focus on the ability to predict consumer behavior with lease attribute variables in addition to those variables relate to those used in the firm's lease pricing model. The additional attribute variables included are based on the Georgia lease price framework.

Stand Attribute Data

This section describes lease and supporting data used for analysis of hunting lease prices in a Southeastern and a Northern state. The Georgia stand attribute data include lease and forest information provided by the Georgia firm as well as constructed variables for desirable deer habitat. A description of the Georgia leasing program precedes the data tables and variable descriptions.

The Northern firm also provided lease attribute data but requested that the specific pricing methodology, including lease pricing variables, not be disclosed. A description of the Northern leasing program and a general overview of the data provided by the firm follows the analogous Georgia information. The general description of the Northern data includes observation counts for current lease price, lease applications, and lease renewals. However, to honor the company's confidentiality request, the specific lease attribute variables provided by the Northern firm will not be disclosed.

Georgia Forestry Firm Data

An industrial forestry firm provided proprietary hunting lease data and forest cover data for leases in the state of Georgia. Because the company requested anonymity, information, which would identify it, will not be disclosed. These lease data represent over 640,000 acres of forest property, or less than 1 percent of Georgia's estimated 250 million acres of forest property (GFA, 2006).[17] The corporate forest entities of Georgia, including the participating firm, own approximately 21 percent of Georgia's forested acres and are geographically distributed among the private forest ownership acreage.

The firm provided detailed lease information for a cross-section of 918 observations covering over 640,000 acres. The firm's cooperation facilitates a richer data set than previously available for an economic analysis of hunting leases.

The company providing the data began leasing hunting access in Georgia in the late 1980's. Under the existing lease program, current clubs or individuals are given the chance to renew an agreement after annual rate adjustments are made by district managers. When tracts become available, adjacent landowners, adjacent hunting clubs, or lessee displaced by a recent land sale are contacted and given an opportunity to directly negotiate for an open lease. If these actions do not produce a lease agreement, the available tract is moved to an online open bid process. Based on private correspondence with company lease managers, approximately half of the existing lease agreements were established by open bidding within the last two years. With regards to

[17] The participating Georgia firm currently manages less than 1 million acres within the state. Approximately 87 percent of their Georgia land holdings are leased by the company to individual lessees. The difference between total company acres leased and total acres leased in this analysis is due to a limit in the electronic records availability at the time of data request.

lease coverage, the majority of the lease boundaries match existing forest tract boundaries; the exceptions were some very large tracts or instances where a natural feature may impede a club from total tract access.

The Georgia lease data cover access agreements between the firm and individuals or clubs for the 2005 hunting season. These data consist of 918 individual lease observations located in 80 of Georgia's 159 counties. Separating the observations into three regions, the Northwestern third of the state represents 441 observations, the central third of the state represents 196 observations, and the Southeastern third of the state represents 281 observations. These delineations represent a crude breakdown into three major physiographic regions of Georgia: Upper Coastal Plain, Lower Coastal Plain, and Piedmont. The Blue Ridge, Ridge and Valley, and Appalachian Plateau regions, in the Northwest corner of the state, are not represented by this firm's lease observations.

These forestry firm data include lease price and forest stand information. An expanded list of lease and forest variables is presented in Table 1 below. The variability of the lease sizes (acres) reflects the wide range of forest tract sizes. As discussed earlier, the sizes and stand characteristics of individual leases are taken to be exogenous to the firm's leasing program production decisions; leases are offered to the consumer "as-is." The lease acres summary statistics exclude leases held by the Georgia Department of Natural Resources, which range in size from 450 to 18,000 total acres.

Table 1: Georgia Firm Lease Data.

Variable	Observations*	Average	Minimum	Maximum	Standard Deviation
Lease Acres	918	615.2	17.0	10,255.0	992.3
Lease Rate Per Acre	918	8.27	1.22	18.78	2.51
Managed Pine Over 5 Years of Age, %	918	0.58	0.00	0.99	0.29
Managed Pine Acres Under 6 Years of Age, %	918	0.14	0.00	1.00	0.22
Natural Pine Over 5 Years of Age, %	918	0.06	0.00	0.97	0.18
Natural Pine Under 6Years of Age, %	918	0.00	0.00	0.56	0.02
Natural Hardwood Acres, %	918	0.20	0.00	0.82	0.13
Non-Productive Natural, %	918	0.01	0.00	0.47	0.03
Non-Productive Man-Made, %	918	0.02	0.00	0.18	0.02

**excludes leases held by the Georgia Department of Natural Resources*

These state leases are offered for permitted, public access on behalf of the Department of Natural Resources; these leases may supplement adjacent state property or may serve as the sole Wildlife Management Area in a local region. These state lease agreement rates and terms are periodically negotiated, but in different manner from the private lease agreements on which this analysis focuses.

The forest company provided estimates of pine, hardwood, and non-pine acreage, which are further divided into groups above and below five years of age. Managed acres, as opposed to natural acres, are forest stands under more intensive management practices such as vegetative competition control, establishment fertilization, *et cetera*. Forest age subdivisions infer general forest cover height composition within tracts; forest stands less than six years of age are considered regeneration areas (newly reforested acreage) and "short" relative to forest stands older than this age. Non-productive natural acres include all areas not under active forest management, such as swamps, inaccessible bottom lands, and open pits or rock outcroppings. Non-productive man-made acres are also not under active forest management but instead include constructed features such as railroads, county roads, and utility right-of-ways.

The variable *Acres* is used in the analysis to represent the relative size of the lease. As discussed in Chapter 2, it is hypothesized that increased lease acres implies increased control of deer territory. As total lease size approaches total deer territory size it is anticipated that the marginal returns to lease size decrease. A quadratic term, *Acres Squared*, is used to test this hypothesized non-linear relationship between size and lease price.

For the empirical analysis, the variable *Hardwood%* is adjusted to represent the sum of all hardwood and natural, non-pine acreage as a percentage of total lease acres. *Hardwood %* is hypothesized to provide important deer browse as forms of soft vegetation and mast such as acorns. The coefficient of *Hardwood%* is expected to be positive because of the wildlife food benefit created by additional wildlife browse.

Except for the variables *Lease Acres* and *Hardwood%*, the forest attributes will not be used directly in the price regressions but rather are used to create habitat proxies as described in the next section.

Georgia Habitat Variables

The habitat variables are constructed from available forest attributes from the firm. Summary statistics of the habitat variables are presented in Table 2.

Table 2: Constructed Habitat Variables Summary.

Variable	Observations	Average	Minimum	Maximum	Standard Deviation
Regeneration,%	918	0.14	0.00	1.00	0.23
Non-plantation, %	918	0.28	0.00	1.01	0.21
Edge Habitat	918	0.60	0.50	1.00	0.16

The variable *Regeneration%* is the sum of managed and non-managed acreage under six years of age as a percentage of total lease acreage. This variable is hypothesized to measure forest conditions with good deer browse and better hunter visibility, both desirable characteristics. *Regeneration%* is expected to exhibit a non-linear relationship to the observed market price. For example, as this stand component increases from a value of zero, *ceteris paribus*, the hunter's willingness to pay for the lease is expected to increase. As this regeneration feature begins to overshadow all other stand conditions, its marginal value diminishes and may eventually become negative.

The variable *Non-plantation%* is the sum of all non-plantation acreage in Table 1 as a percentage of the total lease acreage. Although the concept is not rigorously defined, mono-culture or plantation-style forest management is presupposed to lack the "natural" outdoor settings preferred for outdoor recreation and to be less compatible for wildlife. Based on this generalization, *Non-plantation%* is anticipated to positively influence the observed lease price such that more "natural" settings are more valuable at the margin, all else held constant.

The variable *Edge Habitat* is an index value of edge habitat quality, where the ideal condition quantity is equal to one.[18] Although edge benefits are not rigorously defined here, other sources identify this forest feature as a desirable deer habitat feature (Steinbeck, 1999). Taller forest cover provides visual concealment for deer but shorter vegetation cover typically provide for forage for deer. The transition zone, or edge habitat, provides a balance between "tall" and "short" vegetation zones. *Edge Habitat* would ideally be measured in linear feet and weighted by the depth and forest density of adjacent stands, but this quantitative estimate is not available. The empirical measure of edge employed here defines ideal edge conditions as one and increasing numbers indicate an increase of edge quality; this qualitative index proxy for edge is anticipated to positively influence the observed lease price.

<u>Northern Forestry Firm Data</u>

The Northern data set encompasses 703 lease observations including 346 offerings (over 44,000 acres) and 357 lease renewals (over 58,000 acres) for the 2006 hunting season. The 2006 offerings include first time lease offering and leases not renewed from the previous period. These lease properties are distributed among 16 counties within a single state.

The Northern firm leasing program began in approximately 2003. Prior to 2003, state property tax incentives discouraged private forest owners from engaging in formal hunting leases. Prior to 2003, by virtue of state forest property tax regulation, forest

[18] The index value is computed as the absolute value of indexed ratio of tall to total pine acreage: 1-|("tall"/total)-.5|. "Tall" stands include only the over five years of age subcategories. Edge quality improves as the value approaches one.

owners could qualify for reduced property tax rates only if they provided unrestricted public hunting access. In 2003, new tax regulations permitted a grace period in which forest owners could opt out of tax reduction programs tied to open access hunting rules, without retro-active penalties. In light of the projected gains from hunting lease offerings, this Northern forest company stopped providing unrestricted access and established a formal lease program shortly after 2003 state laws were modified. Since 2003, this participating forest company has continually maintained a formal hunting lease program in this state.

Unlike the competitive bidding process of the Georgia lease program, the Northern firm systematically sets lease prices prior to lease offering and selects customers from an annual application process. Although the pricing formula is not publicly disclosed, personal communication with the company revealed that the total package asking price for each lease property is established on the basis of a company formula based on stand attributes. According to personal communication, this initial "asking" price is annually adjusted on the basis of local property taxes, publicly advertised regional hunting lease rates, and other unspecified considerations. Public offering information made available by the firm includes whether or not the tract features an open body of water, all weather roads, and whether the tract is adjacent to public land. In addition, applicants may view a general location map and, in some instances, an aerial image of the lease property.

Subject to price adjustments, current lease holders are given an option for renewal annually. Price adjustments, not publicly disclosed, are internally set by the lease program administrator and current lease holders are notified of these adjustments before the next lease renewal period of the property. Following the renewal deadline, any available leases, including non-renewals, are advertised online during the summer and fall of the preceding hunting season at a fixed price. If the Northern firm receives multiple applications for an opening, the list of potential lessees is ranked by the descending categories: 1-leased other company property before, 2-adjacent landowner, 3-local landowner, and 4-all others. Given this ranking, multiple applicants may be encouraged to lease the property jointly, or one applicant may be selected from the shorter list. If a property remains un-leased after this process, the property remains available at the initially offered price until the next new offering period.[19]

The lease data provided by the Northern firm includes current lease prices, individual lease attributes, and number of applications received for new lease offerings. The number of applications received for lease offerings prior to 2006 is not observed. A full description of the lease attributes will not be provided due to confidentiality requirements placed by the firm as a condition for the use of the data. In general terms, the Northern lease attribute data includes specific lease characteristics such as size, adjacency to open water, and access descriptors. An abbreviated list of lease variables is presented in Table 3.

[19] The Northern data do not reflect the frequency of un-leased properties between offering periods.

Table 3: Northern Firm Lease Data.

Variable	Observations	Average	Minimum	Maximum	Standard Deviation
Total Lease Price	703	849.52	300.00	7920.10	589.27
Per Acre Lease Price	703	6.90	3.04	15.21	1.04
Acres	703	127.25	20	1165	89.25
Applications	345	5.24	0	70	8.72
Renewals	703	0.51	0	1	0.50

As with the Georgia data, a wide range of forest tract sizes is reflected in the variability of the lease sizes (acres). Per acre values were calculated by dividing the individual, total lease price by the individual lease acreage. Applications data represent information for 2006 lease offering offerings only; these data do not include applications information for initial offerings prior to 2006. The variable *Renewals* reflects whether or not a tract was listed as a new offering; a zero value indicates the lease is a new offering in 2006 and a one value indicates the lease is renewal. For leasing date, 357 out of 703 lease observations are lease renewals.

Consistent with the Georgia data discussion, the sizes and stand characteristics of individual leases are taken to be exogenous to the firm's leasing program decisions; leases are offered to the consumer "as-is." The Northern firm does impose a total lease price floor of $300, such that tracts with a calculated value below this minimum offer price are all offered at $300; minimum price tracts represent approximately 20 percent of the total lease renewals and offerings.

The majority of lease attribute stand variables were originally provided from the firm as discrete numbers. Some but not all stand attributes were described by either zero or one numeric values representing positive or negative price influence.[20] For this analysis, all of the lease attribute variables were converted to binary (0 or 1) variables.

Regional Attribute Variables

The regional attributes, as a supplement to the firm data, include general characteristics as reported for the county or region. Relevant characteristics include deer herd quality as commonly reported by state wildlife agencies. For example *Deer Per Hunter* measures the hunting desirability of an area. The quantity of *Harvested Bucks* variable equals the total number of bucks taken in a county and reflects another desired component of the deer herd. All else equal, an area with such desirable features should positively influence observed prices.

Other regional characteristics, such as rural character, are also hypothesized to be goods. Increasing the rural character or solitude of a region should positively influence price. The rural character of an area, measured as distance from a populated area, is hypothesized to have a non-linear relationship to observed lease price. An increase in distance from a large population center may initially have a positive price effect. This positive price effect may diminish or become negative as travel costs offset gains from rural character or solitude.

Regional attributes also include demand "shifters," or factors likely to influence the consumer's choice for private access. Examples of demand shifters include

[20] A lease without all weather roads would list -.1 as the road attribute measurement versus a lease with all weather roads would list 0 as the road attribute measurement. Alternatively, a lease observation with open water would list 1 as the attribute measurement versus a lease without open water would list 0 as the attribute measurement.

substitutes, within a region, for a firm's lease offerings as well as conditions or settings of the leasing region.

Regional Attribute Data

The specific regional data used in the regressions are county or regional level measures of deer herd information, population, and distance measurements. For the empirical regressions, regional attributes are assigned to each observation based on the lease observation's county. An overview of all Northern regional attribute data follows the descriptions of the individual Georgia regional attribute data.

Georgia Deer Harvest Data

Harvest data for the Georgia 2003 deer season were obtained from the Georgia Department of Natural Resources (McDonald, 2005). These data are used to estimate regional deer quality. Deer management unit (DMU) reports harvest information. The Georgia Department of Natural resources delineates DMU's for the purposes of deer management jurisdiction and statistical reporting; 137 counties are represented by nine deer management units and are depicted in Figure 2. Summary deer harvest statistics are listed in Table 4.

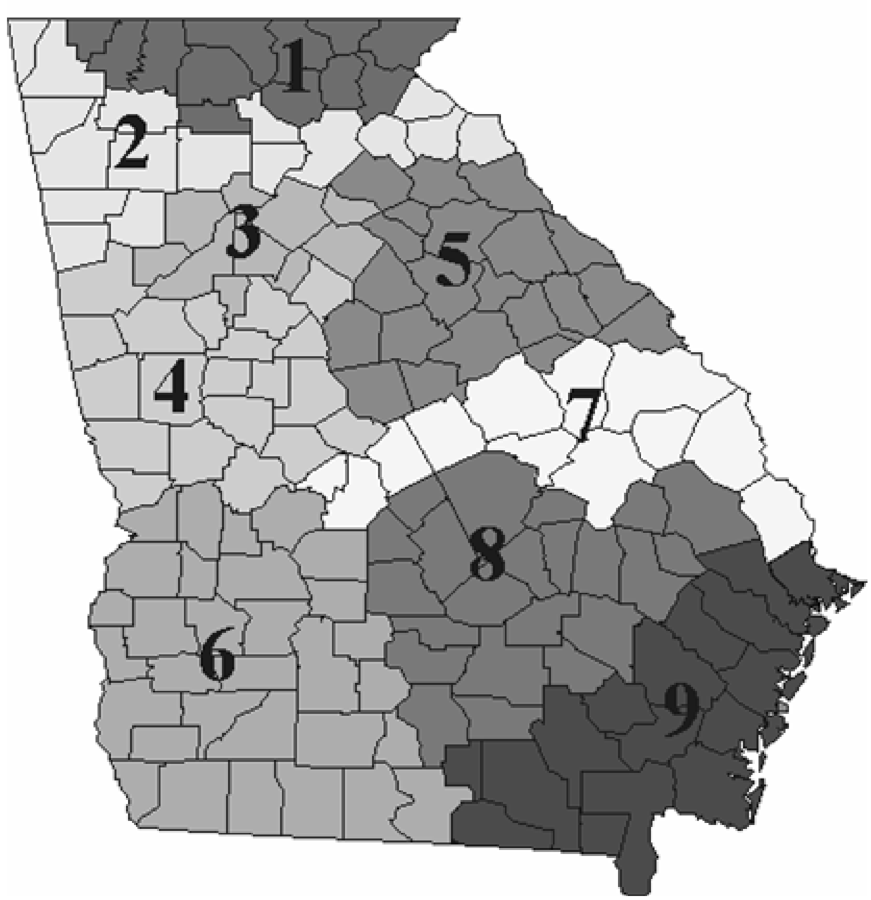

Figure 2: Georgia Deer Management Units.

Table 4: 2003 Georgia Harvest Summary by Deer Management Unit.

Deer Management Unit	Total Deer	Total Bucks	Total Does	Total Hunters	Bucks per Hunter
1	18,360	9,180	9,180	26,618	0.34
2	55,081	21,702	33,379	53,765	0.40
3	19,612	7,649	11,963	17,658	0.43
4	89,299	29,558	59,741	60,880	0.49
5	93,054	29,870	63,184	69,050	0.43
6	35,469	13,336	22,133	39,256	0.34
7	47,571	17,811	29,760	34,262	0.52
8	41,311	23,175	18,136	29,518	0.79
9	18,778	7,774	11,004	16,604	0.47

Total Deer, Total Bucks, and *Total Does* represent the estimated summation of either sex, male, and female deer harvested within the specified deer management unit.

Total Hunters represent the estimated number of hunters within the specified deer management unit. *Bucks per Hunter* is equal to the *Total Buck*s divided by the *Total Hunters*. All else equal, increases in the hunting pressure variable (*Bucks per Hunter*) are expected to positively influence price.

In order to match deer management unit data with individual lease observations, each county within a deer management unit is assigned the same value for the deer harvest statistics. For example, each county within deer management unit three will list 4.3 as the measure of *Bucks per Hunter*.

Georgia Trophy Information

As another proxy for deer herd quality, two sets of trophy deer records from the Georgia Department of Natural Resources are available (DNR, 2006). The first set of trophy records is posted by this state agency but originates from the national Boone and Crockett Club, a national sportsman's organization, which outlines a standard protocol for scoring antlered deer. The second set of trophy records are also maintained by the Georgia Department of Natural Resources. The Georgia Department of Natural Resources deer records use the Boone and Crocket scoring system but include lower minimum scores. The Georgia trophy minimum point rules facilitate more total deer records and subsequent variation in total deer records than observed under the Boone and Crocket minimum score requirements. It is expected that the existence and quantity, or ranking, of county trophy records will positively influence lease price. Georgia deer trophy record information, from 1998 to 2003 for Boone and Crocket or 2004 for Department of Natural Resources records, is shown in Table 5.

Table 5: Georgia Trophy Deer Data from 1998 to Current Record Year.

Record System	Counties With Records	Number of Records
Georgia DNR	87	288
Boone and Crocket	9	9

Georgia DNR represents the number of deer trophy records for an individual county between 1998 and 2003. The *Boone and Crocket* variable represents analogous information albeit with higher minimum score standards. Table 5 lists the total number of counties with records and the total number of records for each record set. Because of the lower minimum score requirements, the Georgia DNR records provide a larger number of deer quality observations of greater variation and are used in the empirical analysis in Chapter 5.

Georgia Forest Ownership Data

National and state forest acreage is hypothesized to account for hunting access substitutes. Consistent with the general case of substitutes, an increase in the quantity of public access is expected to decrease the value of hunting leases, all else constant. Estimations of forested acres by ownership were obtained from technical reports from the United States Department of Agriculture Southern Research Station (Thompson, 1998). Private and public sums by county of five public ownership categories and three private ownership categories are used in the empirical analysis. These publications stem from the ongoing efforts of the Forest Inventory Analysis Unit of the United States Forest Service. A summary of forest ownership within Georgia is included in Table 6 and includes data from all 159 Georgia counties, with acreages listed in thousands.

Table 6: Georgia Forest Ownership by County.

Ownership Category	Average*	Minimum	Maximum	Standard Deviation
National Forest	27,338	0	132,500	24,661
Miscellaneous Federal	8,687	0	104,900	18,004
State	2,651	0	47,600	5,738
County and Municipal	757	0	10,300	1,453
Forest Corporation	47,908	100	305,600	46,400
Individual	90,741	12,000	239,800	45,429
Total Public	11,016	0	132,800	21,573
Total Private	138,648	26,000	467,900	73,772

*Averages for individual ownership categories do not correspond with total public or private ownership categories due to non-observations in the original data.

Public ownership is defined as national forests, miscellaneous federal, state, and county or municipal forest acreage; total public acreage equals the sum of these ownership categories. Forest corporations are defined as entities that specialize in forest products or hold property as an incorporated investment group. Individual ownership includes all lands owned by individuals, including non-incorporated farms. The ratio of corporate land to total forest land is used as an instrumental variable for game violations, discussed in succeeding sections. As a proxy for public hunting access, however, these measures of public land are limited by the inability to distinguish parks or other areas where hunting is prohibited. An alternative measure of public hunting access exists for the state of Georgia.

Wildlife Management Area acreage estimates offer an alternative proxy for lease substitutes, where this proxy circumvents unobserved hunting prohibitions. Wildlife Management Areas are owned or leased by the Georgia Department of Natural Resources and offered to the public for permitted hunting. This information was obtained from an outdoor recreation website (Outdoors, 2006). Table 7 lists the total Wildlife Management Area acreage by Game Management Office (GMO) unit.

Table 7: Wildlife Management Acres.

Game Management Office	Total Acreage
1	253,300
2	223,140
3	110,900
4	129,546
5	54,000
6	99,700
7	131,800

The GMO's are enforcement and administrative units delineated by the Georgia Department of Natural Resources; 159 counties are divided among 9 GMO units (similar but smaller per unit coverage than the DMU's discussed earlier). Controlling for estimated hunters in the respective area or unit, this public access proxy is expected to negatively influence the observed lease price as an indication of a substitute good offering alternative products for hunters.

Georgia Deer Hunting Licenses

The Georgia Department of Natural Resources (Reynolds, 2005) also provided deer hunting license sales and deer harvest record disbursement by county for 2003. The license data include the total number of license sales by permit type (*i.e.* resident type, weapons category, age group, *et cetera*). These license sales provide a measure of demand for hunting on a county basis. The number of hunting licenses issued provides one measure of total hunters in a county; however, not all hunters are required to purchase licenses annually (qualifying seniors, hunters hunting on their own property, *et* *cetera*). The alternative measure, deer harvest records, is preferred because all deer hunters are required to complete deer harvest records annually. Harvest records outnumber license sales in the majority of counties (277,508 permits versus 391,707 harvest records) and are used in the empirical analysis. All else equal, increased hunting demand is hypothesized to increase the value of hunting access in a region.

Other Georgia County Information

Estimates of 2004 county populations were obtained from the online resources of United States Census Bureau (Census, 2005b). County population provides a measure of the rural character of an area, hypothesized to be a desirable lease attribute. Presumably, an increase of population suggests less rural character; population is hypothesized to negatively impact observed lease price, all else constant.[21]

Distance from a population center also describes the rural character of an area. The distance proxy for this analysis represents the distance of a lease's county center to the nearest county center with population greater than or equal to 100,000. The calculation is based on the census estimates and county center point coordinates. *Distance* is expected to exhibit a positive sign on the lease price.[22]

As an alternative measure of rural character, rural influence index values were obtained from the Economic Research Service of the United States Department of Agriculture (ERS, 2003). The rural influence code incorporates both an area's population

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[21] Alternatively, an increase in population could represent an increase in hunters, suggesting an increase in the demand for hunting within a county.

[22] The observed lease price impact of distance is hypothesized to be non-linear because increasing distance from population centers may also imply increasing transaction costs of travel for consumers. To test this hypothesis, a quadratic variable for distance is included in the regression analysis.

and proximity to metropolitan counties. Individual values are assigned to each county of a state and range from one (largest metropolitan area) to twelve (rural). This proxy for rural influence is used as an instrumental variable for game violations, discussed in the succeeding sections.

Northern Regional Attribute Data

The Northern regional information is similar to the previously described Georgia regional data with respect to deer harvest, deer quality, number of hunters, and forest ownership. All county or regional information for the 16-county leasing area was obtained from sources identified earlier, such as the United States Census Bureau or the appropriate state wildlife agency. Due to empirical differences between the regression frameworks, not all of the variables identified in the Georgia data description are used in the Northern regressions. Table 8 represents the regional information intended to augment the Northern firm's leasing data.

Table 8: Northern Regional Attribute Data.

Variable	Observations	Average	Minimum	Maximum	Standard Deviation
Deer Harvested Per Square Mile	16	4.7	0.9	9.6	2.6
Bucks Harvested Per Square Mile	16	2.0	0.7	3.6	0.9
Boone And Crocket Record Count	16	0.6	0	3	0.8
Total Public Forest Acres	16	400	14	1,618	448
Total Number Of Hunters	16	7,897	2,030	28,094	6,163
County Population	16	37,813	8,480	198,135	44,889
Distance from Metropolitan Area	16	64	0	147	39

**Summary statistics based on respective 16-county data only*

As with the Georgia deer harvest data, the Northern state deer harvest data were reported in geographic districts different from county boundaries. Where the county boundaries covered more than one Northern deer management zone, the sum of deer harvest values per zone is reported for the county deer harvest category. *Deer Harvested Per Square Mile* and *Bucks Harvested Per Square Mile* represent the number of deer per square mile and the number of bucks per square mile harvested in 2004. *Boone and Crockett Record Count* represents the total number of record deer taken in each county between 1998 and 2003 according to national records of the Boone and Crockett Club (Buckner & Reneau, 2005). *Total Number of Hunters* represents the number of deer licenses sold by county in 2005. All else equal, increasing deer quality or quantity should increase the observed hunting lease market value and increasing hunting demand, measured by the number of hunters, should also increase observed lease market value.

County Population represents the population of a county as estimated by the United States Census Bureau for 2004. *Distance From Metropolitan Area* describes the distance of the county center for the lease property to the nearest county center with more than 100,000 people. Population and distance from metropolitan areas are estimations for the rural character of an area. Increasing population is hypothesized to negatively impact lease value but increasing distance is hypothesized to increase lease value.

Cost Shifter Variables

Cost shifters within the lease value regression include transaction costs directly incurred by the landowner and believed to differ by lease (Rosen, 1974). In this analysis, Rosen's "shifters" are hypothesized to include ownership costs and crime. For instance, the property taxes constitute a cost of owning forest property that varies by county. As discussed in Chapter 2, survey data from both Guynn and Teasley (2003; 1999) found that forest landowners are likely pass along property taxes, at least in part, to hunting leasers so that hedonic lease price regressions should exhibit a positive coefficient for the property tax proxy.

Another potential cost shifter, the costs of criminal activity, is hypothesized to reduce the willingness to pay for an access lease. The analysis of criminal activity, social costs of crime, and enforcement equilibrium is well represented in economic literature (Andreano & Siegfried, 1980; McPheters & Stronge, 1976). Becker's (1976) work demonstrates that the general utility maximizing framework can be applied to the analysis of criminal behavior. Becker suggested that the "supply" of crime partially depends on the opportunity cost of individuals (*i.e.* the opportunity costs of a criminal act for a neurosurgeon are assumed to be greater than those for a high school drop-out). Becker also suggests that legal deterrents (policing and punishment) are constrained by budgets, among other variables; budget constraints may vary across state and county jurisdictions. Further, social costs of crime are tangible, enforcement is costly, and the social optimum is less than "complete" legal enforcement (Becker, 1976; Stigler, 1976). In the context of wildlife access, criminal violations such as poaching and trespass impose costs on landowners, but because the costs of complete control outweigh its benefits, some positive violation level is socially optimal. Theoretically, rogue constituents of an area decrease the value of wildlife leases because, within areas of increased criminal activity, the cost to either a landowner or lessee of asserting property rights is increased.

A direct estimation of game violation prosecutions by county is available but, this variable may give rise to an errors-in-variables problem if used as an explanatory variable. Different enforcement regions may vary in budget allocations, success of prosecution, *et cetera*. This variation in enforcement level may lead to varying levels of game violation prosecutions. Because the direct but unobserved level of game violations as opposed to prosecutions is not homogenous across reporting regions, this game crime proxy may be correlated with the hunting lease price error term. For illustration, consider two simplified models representing game crime prosecution (C_g) and lease price (P_l), respectively.

$$C_g = \beta_0 + X\beta_1' + \varepsilon_g \tag{4.1}$$

and

$$P_l = \Gamma_0 + X_g\Gamma_1 + X_l\Gamma_2' + \varepsilon_p \tag{4.2}$$

In equation (4.1), game crime prosecutions are predicted by an intercept term (β_o), an explanatory variable vector X including among other terms county median income, and an error term (ε_g). Assume that underlying but unobserved game crime has a negative relationship with income in a county, represented graphically in Figure 3.

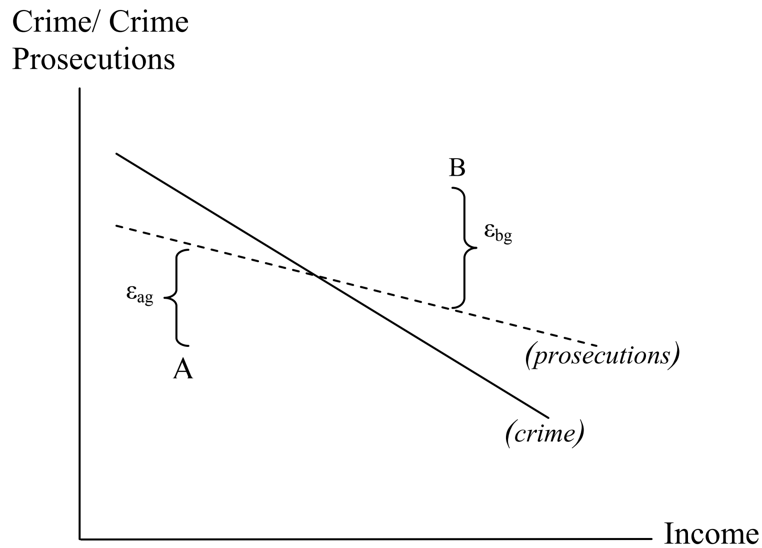

Figure 3: Relationship between Game Crime and Income.

The solid line illustrates the hypothesized relationship between income and game crime. The dashed line in Figure 3 indicates the relationship between game crime prosecutions and income. Suppose county A has a low income and hence high crime, but few game crime violators are successfully prosecuted. Alternatively, county B has a high income and hence low crime, but most game crime violators are successfully caught and prosecuted. The game crime prosecution measurement errors for county A (ε_{ag}) and county B (ε_{bg}) are represented by the vertical distance between the respective points and the estimated relationship for dashed line indicating game crime prosecutions.

In equation (4.2), the lease price is predicted by an intercept term (Γ_o), game crime prosecutions (X_g), a composite lease attribute vector X_l that includes income among other terms, and an error term (ε_p). Assume that lease price has a negative relationship with game crime, represented by Figure 4.

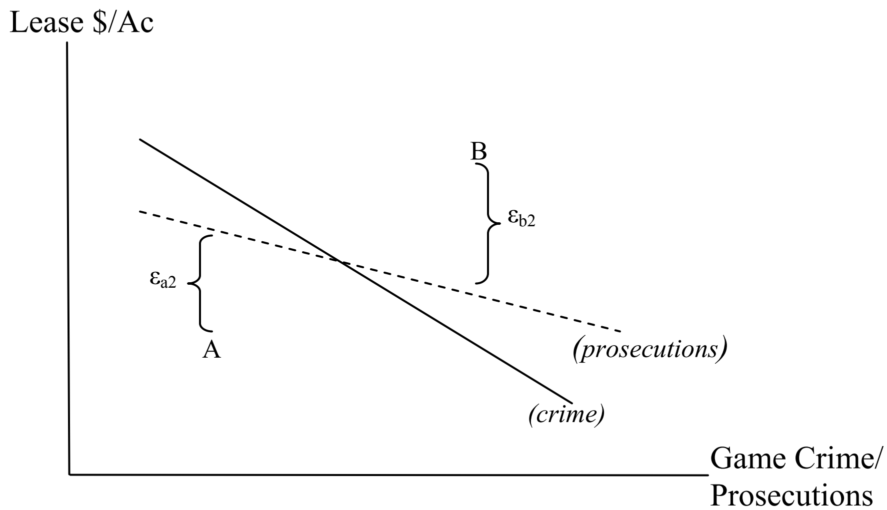

Figure 4: Relationship between Lease Price and Game Crime.

In Figure 4, the solid line represents the hypothesized relationship for the unobserved game crime and the dashed line represents observed game crime prosecutions. The game lease price measurement errors for county A (ε_{ap}) and county B (ε_{bp}) are represented by the vertical distance between the respective points and the estimated relationship for dashed line. The measurement error, or bias, in Figure 3 and 4 are correlated. The error terms ε_g and ε_p (equations (4.1) and (4.2)) may be related because game crime is represented by the number of game crime prosecutions in each of these models. Correlation of these error terms violates a core assumption of least squares regression that independent variables are unrelated to the error term of the lease price regression (Green, 1997). Instrumental variables provide a solution for this empirical problem.

It is also possible that lease prices are endogenous to observed crime prosecutions, in that areas with strong lease markets may lead to (1) more game crime by lower income consumers, and (2) more prosecutions as lease holders protect their lease rights. The relative percentage of property owners who lease within a county is unknown; however, forestry firms may be more likely to lease property than smaller, non-industrial forest owners. Forestry firm property represents approximately 19 percent of total land holdings in Georgia and a maximum of 74 percent and total land holdings in any one county. If lease prices do affect game crime, the instrumental variables approach would correct for the potential bias in an OLS estimation. The ratio of corporate forest land to total forest land is included in the Georgia game crime instrumental variables regressions.

To avoid the potential bias in coefficient estimates arising from an-errors-in-variables simultaneity problem, instrumental variables for game prosecutions are used in this regression analysis. Following the crime economics literature, variables hypothesized to measure opportunity costs and enforcement constraints, such as county poverty level, median county income, and game enforcement area variables are tested for inclusion in the hedonic price regression.

Cost Shifter Data

The cost shifters proxies incorporate data from observed forest property tax, game violations, and regional demographics for the Georgia data. The Northern regressions also use data for game violations and regional demographics of the respective state but property tax information is not relevant to the Northern application and renewal regressions. The Northern firm presumably considers property tax variation in its pricing process; however, taxes do not represent a lease attribute to consumers. The Northern regressions are intended to assess only attributes hypothesized to influence consumers' response to an offer price and property taxes are not relevant to these regressions.

Georgia Tax Data

Georgia forest property tax information, by county, was obtained from the University of Georgia Center for Forest Business. This tax information is intended as a proxy for forest ownership costs that vary by county. These data include 2002 average per acre forest property taxes paid by county. These tax averages were derived from surveys of nine major forest companies' self-reported tax records. A summary of these tax data are included in Table 9.

Table 9: Georgia Forest Property Tax Data.

Variable	Average	Minimum	Maximum	Standard Deviation
Tax dollars per acre	8.09	1.81	47.53	3.9

Game Violations

Crime statistics are intended to measure another form of transaction cost faced by the firm (and lessee). Crimes, in the form of game violations which vary by region, are hypothesized to negatively influence the observed lease values. Game violation records were also obtained from the Georgia Department of Natural Resources (England, 2006). These data include number of prosecutions per county, subdivided as major or minor offenses, for the year 2004. The numbers of game violations across Georgia counties are shown in Table 10.

Table 10: Georgia Game Violation Prosecution.

Variable	Observations	Average	Minimum	Maximum	Standard Deviation
Minor Crime 04	145	9.3	0	50	8.4
Major Crime 04	145	14.4	0	394	33.6
Total Crime 04	145	23.8	1	415	36.6
Game Crime 04 Per Capita in 1000's	145	1.4	0.01	19.70	2.2

Per capita game crime estimate are equal to the total reported prosecutions divided by the estimated county population multiplied by one thousand. In counties where no prosecutions were reported in the state database, the per capita prosecution count is treated as no information entry in order to avoid representing counties with missing crime information as environments absent of game violations. This treatment eliminates two observations from the original data set of Georgia game violation prosecutions per county.

Categories of major and minor violations were not delineated by the state agency but ad hoc subcategories of major prosecutions were devised on the basis of rule violation (e.g. illegal take or attempted take) versus rule deviation (e.g. unapproved take method). For example, deer hunting without a big game license is classified as a major offense while deer hunting with prohibited ammunition is classified as a minor violation. Major offenses, as defined here, include hunting without a license, hunting without permission, and hunting out of bounds (including property, season, or time boundaries). Non-major offences, as defined here, include incorrect record keeping, harassment of wildlife, hunting with prohibited equipment, or baiting wildlife.

Violation numbers by county are instrumented in the empirical analysis of lease prices discussed in Chapter 5. Binary variables for the game management office districts are included in the crime instrumental variable construction. The game management office units differ from the deer management units mentioned earlier by virtue of geographic coverage as well as larger jurisdictions. The numbers of lease observations, by GMO divisions, are shown in Table 11.

Table 11: Enforcement Area Distribution of Georgia Lease Observations.

Game Management Office	Number of Leases	Percentage of Leases
1	3	0.3
2	17	1.8
3	270	28.6
4	288	30.5
5	136	14.4
6	113	12.0
7	118	12.5

The distribution of lease observations within game management office units is exogenous to lease location. The land holdings of the company, and subsequent lease offerings, are not related or determined by the jurisdictional divisions of the Georgia Department of Natural Resources.

Other Georgia County Data

Other county specific variables used in the regressions include population, income, unemployment, and poverty. These estimates, along with the urban influence proxy discussed earlier, are used to construct instrumental variables for game violations. Estimates of county median income were obtained from the online resources of United States Census Bureau (2005a). Median income estimates are used to proxy for county tax revenues, which are presumably correlated with property tax values and the available level of law enforcement expenditures; this proxy is hypothesized to exhibit a negative relationship with observed game prosecutions. Median income is also hypothesized as a proxy for an area's relative willingness to pay for leases in a county. All else equal, an increase in income is expected to positively influence observed lease price. The unemployment rate, also obtained from the Census Bureau, includes the percentage of the county population actively seeking a job. Poverty estimates, as a percentage of total county population, were obtained from the United States Bureau of Labor (Statistics, 2005). Unemployment and poverty level variables are both hypothesized estimations of the criminal opportunity cost of an area and exhibit a positive relationship to observed game prosecutions.

CHAPTER 5

EMPIRICAL RESULTS

This chapter empirically assesses implicit values of hunting lease prices for two timber firms in different regions of the United States. The Georgia regression framework and results sections are presented first. An analogous discussion of the Northern regressions framework and results follow.

For the Georgia data, explanatory variables for a county's game crime prosecutions are first evaluated with ordinary least squares regressions. The results of this analysis are used for the selection of instrumental variables for game crime used in the two-stage least squares regressions for lease prices. For the Northern data, the firm's prices and additional lease attribute data, including an instrument for game crime prosecutions, are regressed separately against number of lease applications and lease renewals. STATA statistical software is used for all ordinary least squares (OLS), two-stage least squares (2SLS), Tobit, and Logit regression analyses.

Georgia Lease Price Regression Framework

As presented in Chapter 3, the price regression has the form:

$$P = \beta_0 + X_1\beta_1' + X_2\beta_2' + X_3\beta_3' + \varepsilon \qquad (5.1)$$

The variable (P) represents the observed lease price and variable (ε) represents the random error term. The terms (X_1), (X_2), and (X_3) represent the matrices of stand attributes, regional attributes, and cost shifters, respectively.

Lease price P is specified as a per acre value for the lease. An alternative dependent variable is the total lease price, or the product of per-acre lease rate and the lease property acreage. Regressing total lease price against total acres and other lease attributes produces a t-value for total acres that is disproportionately larger than the t-values for other explanatory variables. In other words, the variable for total acres obscures the relative impact of the other variable coefficients when regressed against total lease price. For clarity, per acre lease prices are preferred and are used throughout the empirical analysis.

The stand attribute matrix X_1 includes components or characteristics of an individual lease that are hypothesized to positively influence the observed market lease value. Following the discussion of Chapter 4, this matrix includes the total acreage of the lease, *Lease Acres*, an attribute hypothesized to be of value to hunters. A quadratic variable for acres, *Acres Squared*, is included to test for a non-linear relationship between lease price and lease acres. The matrix X_1 also includes deer habitat variables such as percentage of regeneration acres, percentage of acreage under less intensive forest management practices, percentage of non-pine forest acreage, and desirable habitat transition zones of "tall" to "short" forest cover. These variables are represented as *%Regeneration, %Non-plantation, %Hardwood,* and *Edge*. From the discussion in Chapter 4, the percentage of regeneration acres are hypothesized to have a non-linear impact on observed lease value. The percentage of regeneration is anticipated to positively impact lease price but at a decreasing rate, so a quadratic variable for regeneration percentage, *%Regeneration Squared*, is used in the regressions in addition to *%Regeneration*.

The regional attribute matrix X_2 of the lease price regression includes county characteristics and regional deer quality. The rural character of an area may influence observed lease price. County population, as a proxy for urban development in an area, and distance from a county of large population, as a proxy for separation from urban influence, provides an approximation of the rural character of an area. County population and distance from population center of 100,000 or greater are represented by *Population* and *Distance*, respectively. All else equal, *Population* is expected to exhibit a negative sign and *Distance* is expected to exhibit a positive sign on the lease price.[23] The impact of *Distance* on lease price is hypothesized to be non-linear and increasing at a decreasing rate, so the variable *Distance Squared* will also be included.

The Georgia trophy records provide a measure of deer quality in a region and are represented by the variable *Georgia Trophy*. It is anticipated that an increase in deer quality positively influences lease price.

Other regional variables within matrix X_2 reflect hunting demand, hunting pressure, and available hunting access. One measure for hunting demand is deer harvest records by county, which all hunters are required to complete in Georgia; the variable *Deer Hunters* represents the number of deer harvest records issued per county. A second hunting demand variable, *County Income*, represents willingness to pay for hunting leases

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[23] Alternatively, an increase in population could represent an increase in hunters, suggesting an increase in the demand for hunting within a county. As discussed on page 30, however, lease consumption is not restricted to same-county residents.

within a county. *Deer Hunters* and *County Income* are each anticipated to positively influence lease prices.

A proxy for hunting pressure is the estimated number of harvested bucks per hunter, represented by variable the *Bucks per Hunter*. *Bucks per Hunter* relates specifically to the hunting pressure and success on a desirable component of the deer herd; this proxy is anticipated to positively influence observed lease price.

Available hunting access is another component within the matrix X_2 of regional quality variables. The variable for public hunting land, *Public Hunting,* represents the acreage of Wildlife Management Areas divided by the estimated number of hunters within a specific region. *Public Hunting*, as a proxy for public hunting access, does not include state and federal parklands where hunting is prohibited; this variable is hypothesized to negatively influence observed lease price.

Forest property tax and criminal activity are represented within the matrix X_3 of cost shifters. Forest property tax, as a proxy for property ownership costs, varies by county and is represented by the variable *Forest Tax.* The second cost shifter, as discussed in Chapter 4, is a measure of game violation prosecutions per county. As a proxy, game violation prosecutions may inaccurately measure game violations because observed prosecutions may reflect variation in enforcement, rather than variations of game violation, across counties. Game crime instrumental variables are used in order to address this potential problem with using game violation prosecutions directly. The set of game crime instrumental variables considered includes median county income, unemployment in the county, county rural character index value, ratio of corporate forest land ownership to total forest land, and the percentage of the county's population below poverty level.[24] The instrumental variables are represented as *Income*, *Unemployed, Rural Influence*, *Corporate Land%*, and *Poverty*, respectively. The median county income, *Income*, measures available expenditures for game enforcement across counties. *Unemployment* and *Poverty* individually estimate the opportunity costs of potential game violators in a county. *Corporate Land%* provides an estimate of property more likely to be leased relative to total forest acres in a county. The variable *Rural Influence*, as a measure of rural influence within a county, controls for correlation of game violations and rural character of the county.

Estimating Georgia Game Prosecutions

Estimating the relationship between explanatory variables and observed game violation prosecutions is a difficult, if not idiosyncratic process.[25] The economics of crime literature provides rigorous methodologies and data sources previously employed for the study of various criminal activities (Andreano & Siegfried, 1980; McPheters & Stronge, 1976). For this application, the empirical goal is to identify plausible explanatory variables for game violation prosecutions; these variables are used as instruments for game crime in the lease price regressions.

Ordinary least squares regressions are used to estimate the statistical relationships between observed game law prosecutions and the explanatory variables. The dependent variable *Game Violations* represents the 2004 game violation prosecutions per 1000

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[24] A description of the Economic Research Service rural character index value may be found on page 51.
[25] The process is idiosyncratic because game crime may be peculiar to a subset of the general population (hunters). General demographic information may not adequately represent the subset of interest if tastes and preferences for game crime are not proportionally represented in the general population.

people in each county. Three separate regression models, *Crime Regression 1* through *Crime Regression 3*, estimate the influence of demographic variables on observed game crime violations. *Crime Regression 1* employs the independent county variables *Rural Influence*, *Income*, *Corporate Land%*, and *Unemployed*. *Crime Regression 2* augments variables in the first model with the variable *Poverty*. As indicated by the matrix of pair-wise correlation coefficients for the variables in the Georgia Crime Regression Table 17 of Appendix A, median county income exhibits a negative correlation with county's poverty and unemployment levels. The correlation between median income and poverty, however, is relatively larger in absolute terms than other variable relationships as indicated by a correlation coefficient of -0.86. *Crime Regression 3* augments the variables of the first model with Georgia's Game Management Organization (GMO) unit binary variables, (*GMO1*) through (*GMO6)*, in order to address unobserved variation among enforcement regions. Based on a graphical analysis of the squared residuals in preliminary regression runs, two outliers are removed from the game violations data set. Coefficient signs and relative coefficient magnitudes with the identified outliers included do not differ from the regressions excluding these outliers. Excluding the outliers does improve the statistical significance of some coefficients based on p-values as well as adjusted R-squared values of all regressions in Table 12. The game crime regression results, with the identified outliers excluded, are listed in Table 12.

Table 12: County Game Crime Prosecution OLS Regressions (Dependent Variable Game Violation Prosecutions).

Variable	Predicted Effect	Regression 1 Coefficient		Regression 1 Partial Effect	Regression 2 Coefficient		Regression 2 Partial Effect	Regression 3 Coefficient		Regression 3 Partial Effect
Rural Influence	+	0.094	(0.041)**	0.289	0.097	(0.041)**	0.297	0.087	(0.048)*	0.268
Income (1000s)	-	-0.008	(0.015)	-0.082	-0.027	(0.022)	-0.269	-0.010	(0.016)	-0.098
Unemployment	+	0.344	(0.110)***	0.392	0.385	(0.116)***	0.438	0.319	(0.122)***	0.363
Corporate Forest %	+	2.508	(0.711)***	0.391	2.400	(0.716)***	0.374	2.590	(0.813)***	0.404
Poverty	+				-0.046	(0.040)	-0.243			
GMO1	na							-0.110	(0.520)	
GMO2	na							0.240	(0.556)	
GMO3	na							0.213	(0.513)	
GMO4	na							0.282	(0.498)	
GMO5	na							0.234	(0.507)	
GMO6	na							0.128	(0.508)	
Observations		143			143			143		
Mean Game Prosecutions		1.3			1.3			1.3		
R-squared		0.3			0.3			0.3		
Adjusted R-squared		0.3			0.3			0.3		
F-statistic		16.6			13.5			0.0		
Probability > F		0			0			0		

Notes: Standard errors are in parentheses to the right of coefficients. Partial effect is a one standard deviation change from the mean of the variable. ***, **, and * show significance at 1%, 5%, and 10%

As evidenced from the estimates of *Regression 1* and *Regression 2*, adding the variable *Poverty* does not statistically significantly improve the estimation results and the *Poverty* p-value (.252) does not support the variable's individual statistical significance. Similarly, the estimates from *Regression 1* and *Regression 3* show that adding GMO binary variables does not statistically significantly improve estimation results; the joint F-test statistics suggest an 97 percent probability the binary GMO variable group is not statistically different from zero.

A Breusch-Pagan/Cook-Weisberg test for heteroscedasticity rejects the null hypothesis of homoscedastic error structure in all models in Table 12. To account for the potential presence of heteroscedasticity in the error structure, these regressions were alternatively specified with the STATA robust command in which standard errors are computed by the Huber/White sandwich estimator of variances. The robust model specification results, not reported, are qualitatively consistent with the regression results presented in Table 12.

Regression 1 is selected to define instrumental variables for game crime prosecution based on F-test statistics, adjusted R-squared values, and regression coefficient significance. Accordingly, *Rural Influence*, *Income*, *Corporate Land%,* and *Unemployed* are used to explain game crime prosecutions in the subsequent two stage least squares regressions for lease prices.

Georgia Lease Price Regression Results

Regression analysis is used to empirically assess the attributes directly related to hunting lease access agreements. Attributes of these hedonic regression equations include property specific attributes, regional quality attributes, and firm cost shifters. Property or stand attributes relate to characteristics specific to each lease observation, regional quality attributes include a relative measure of desirability of an area. Cost shifters, hypothesized to differ by property location, include variables hypothesized to influence the value or cost of offering a lease for the Georgia firm.

The appropriate functional form of a hedonic price regression is determined by varied, incompletely observed interactions of buyers and sellers in the market place. Due to the nature of these incompletely observed transactions, limited theoretical guidance exists for the choice of hedonic regression functional form and practical considerations should guide the functional form choice (Taylor, 2004). Alternate functional forms of linear, semi-log, log-log and inverse log regressions were evaluated for this lease price analysis. The linear model specification is favored on the basis residual squared error criteria (Rao & Miller, 1971).

The matrices X_1 through X_3 discussed previously within equation 5.1 represent stand attributes, regional quality attributes, and cost shifters. The specific stand attribute variables of matrix X_1 include *%Regeneration, %Regeneration Squared, %Non-plantation, %Hardwood* and *Edge.* The components of the regional attribute matrix X_2 are divided into four variable groups: deer quality, hunting pressure, hunting demand, rural character, and substitute hunting access. The deer quality variable group includes *Georgia Trophy* and the hunting pressure variable group includes *Bucks per Hunter*. The hunting demand group includes *Deer Hunters* and *County Income*; the rural character variable group includes *Population*, *Distance*, and *Distance Squared*. The hunting access substitute variable group is represented by *Public Hunting*. The cost shifter variable group of matrix X_3 includes *Forest Tax* and *Game Crime Prosecutions*.

Two model specifications are considered for the lease price regressions: *No Binaries* regression and the *DMU Binaries* regression. Deer Management Units (DMU's) are designated by the Georgia Department of Natural Resources primarily for game management and reporting purposes. The major distinction between the two models is the inclusion of DMU binary variables intended to capture unobserved variation among geographic regions.[26] The variable *Bucks per Hunter* is used in the *No Binaries* model, but this variable is not used in the *DMU Binaries* regression due to perfect multicollinearity between it and the DMU binary variables. A discussion of these model results follows Table 14.

Two stage lease squares is used to instrument for game crime violations within the lease price regressions. The two stage least squares estimation procedure provides an estimation for, "obtaining the values of structural parameters in over-identified equations" (Pindyck & Rubinfeld, 1991). The first stage of two stage lease squares generates a variable, in this analysis *Game Crime*, which is linearly related to the lease price model variables X_1, X_2, and X_3, but not related to the disturbance term of the lease price regression. The second stage employs ordinary least squares to consistently estimate the lease price equation with the independent variables and newly created *Game Crime* as instrumented by the variables *Rural Influence, Income, Corporate Land%*, and *Unemployment* discussed above.

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[26] Deer Management Units 4 through 9 are relevant to these data.

Before presenting the complete regression results, the estimation results for the two stage least squares lease price regressions are presented for the probability of statistical significance of variable groups. The variable groups are most informative because they represent the explanatory power of the groups as a whole. The probability of statistical insignificance, as indicated by F-tests of each variable group, is presented in Table 13.

Table 13: Joint F-Test Results For Georgia Lease Price Regressions, P-values.

Variable Group	No Binaries Probability > F	DMU Binaries Probability > F
Stand Attributes	0.0	0.0
Deer Quality	0.012	0.750
Hunting Pressure	0.0	
Hunting Demand	0.007	0.688
Rural Character	0.0	0.005
Access Substitute	0.0	0.0
Cost Shifters	0.0	0.0
DMU Binaries		0.0

As indicated by Table 13, all variable groups are statistically significant at the 5 percent level for the *No Binary* model. The F-tests for the *DMU Binary* model suggest both the deer quality and hunting pressure variable groups are not jointly significant in this model. Note that both deer quality and hunting demand variable groups relate to regional variation potentially addressed by including DMU binary variables.

As a group, stand attributes are statistically significant in both models. The proxies for habitat quality are constructed from forest information because direct measures of habitat quality are not available. Correlation among these forest stand attributes used to construct habitat proxies make predicting individual variable price impacts difficult; theoretical effects of the stand attributes were provided in the previous section but are omitted from Table 14.

Complete empirical results for both Georgia lease price regressions are shown in Table 14 below. Summary statistics for the Georgia forestry firm data and the generated habitat variables are found in Chapter 4 on pages 38 and 39 respectively; the matrix of pair-wise correlation coefficients for the Georgia lease price regression variables are found in Table 18 of Appendix A.

Graphical analysis of the residuals does not suggest apparent outliers or heteroscedasticity within the error structure. Note that the explanatory power, as indicated by the adjusted R-squared values, of the *DMU binary* model (70.8 percent explained variation) is greater than the results from the No Binary model (52.6 percent explained variation). An F-test for the joint significance of the five DMU binary variables indicates that they as a group are statistically different from zero at the one percent significance level.

Focusing on consistent results between the *No Binary* and *DMU Binary* models, *%Non-plantation, Distance, Distance Squared, Public Hunting,* and *Forest Tax* are statistically significant at the one percent level in both models. Also, each model exhibits consistent coefficient signs between the No Binaries and the DMU Binaries specifications, although most coefficient magnitudes are consistently smaller within the DMU Binary specification. The coefficients from the *DMU Binary* model are discussed first and the differences between the models follow.

Table 14: Georgia 2SLS Lease Price Regression Results (Dependent Variable *Lease Rate*).

	Variable	Predicted Effect	No Binaries Coefficient		No Binaries Partial Effect	DMU Binaries Coefficient		DMU Binaries Partial Effect
Stand Attributes	Lease Acres (100s)	+	-0.029	(0.015)*	-0.291	0.022	(0.012)*	0.222
	Acres Squared	-	0.000	(0.000)	0.215	-0.000	(0.000)	-0.124
	%Regeneration	na	0.809	(1.878)	0.183	-0.373	(1.482)	-0.085
	%Regeneration Squared	na	-1.929	(2.295)	-0.317	-0.879	(1.811)	-0.145
	Edge	na	0.499	(0.988)	0.078	0.668	(0.777)	0.104
	%Hardwood	na	-2.399	(0.571)***	-0.310	-0.536	(0.455)	-0.069
	%Non-plantation	na	1.108	(0.333)***	0.231	0.730	(0.265)***	0.152
Rural Character	Population (1000s)	-	0.002	(0.008)	0.029	0.003	(0.006)	0.054
	Distance	+	0.054	(0.015)***	1.132	0.033	(0.012)***	0.689
	Distance Squared	-	-0.001	(0.000)***	-1.939	-0.000	(0.000)***	-0.810
Deer Quality	Georgia Trophy	+	-0.086	(0.034)**	-0.213	-0.008	(0.025)	-0.020
Hunting Pressure	Buck Per Hunter	+	-6.208	(0.594)***	-0.654			
Hunting Demand	Deer Hunters	+	-0.000	(0.000)**	-0.266	-0.000	(0.000)	-0.000
	County Income (1000s)	+	0.029	(0.015)*	0.179	0.010	(0.012)	0.040
Access Substitute	Public Hunting	-	-0.569	(0.050)***	-0.993	-0.211	(0.056)***	-0.369
Cost Shifters	Forest Tax	+	0.151	(0.017)***	0.601	0.076	(0.014)***	0.301
	Game Crime (IV)	-	-0.097	(0.069)		0.010	(0.046)	
Regional Binaries	DMU4	na				3.363	(0.350)***	
	DMU5	na				4.869	(0.327)***	
	DMU6	na				2.508	(0.340)***	
	DMU7	na				2.845	(0.363)***	
	DMU8	na				0.144	(0.322)	
Observations			879			879		
Mean Lease Price			8.345763			8.345763		
R-squared			0.5355			0.7151		
Adjusted R-squared			0.5264			0.7081		
F-statistic			61.7			102.06		
Probability > F			0			0		

Notes: Standard errors are in parentheses to the right of coefficients. Partial effect is a one standard deviation change in the mean of the variable. ***, **, and * show 1%, 5%, and 10% significance respectively.

For the *DMU Binary* model estimates, increasing *%Non-plantation* 1 percentage point increases the per acre lease value approximately \$0.73, an 8.5 percent increase from the lease value at the mean lease price per acre of \$8.35. A one standard deviation change from the mean of this variable equals approximately \$0.15. The empirical results also suggest increasing distance from a population center increases the observed value of a lease, at a decreasing rate. For instance, all else held constant, increasing the distance of a lease 10 miles from a population center greater than 100,000 people increases the lease value \$0.29 per acre.[27] This result supports the hypothesis that increasing solitude of a lease area, as measured by the distance from a population center, increases the observed lease value. Additional distance for leases approximately 82 miles of distance from a population center provides no additional value to hunters; the maximum distance from population for these data is 114 miles. Interestingly, a one acre per hunter increase of public land (*Public Hunting)* decreases the observed lease price \$0.21 per acre. This *Public Access* result is interesting because a portion of Wildlife Management Area acreage is voluntarily provided by private forest companies to the state game agency at a reduced lease rate. This result implies that the forest company incurs reduced revenues from two sources: from "below market" Wildlife Management Area lease rates and the decreased market values of leases in proximity to Wildlife Management Areas. The firm's decision to provide Wildlife Management Area acreage likely provides the firm public image benefits from these public access lease arrangements.

As hypothesized, the cost shifter *Forest Tax* positively influences observed lease price; an increase of \$1 per acre of forest property tax increases the observed lease rate by

[27] The combined effect is computed as distance*(.033) - (.0004)*distance^2.

\$0.08. For this analysis it was assumed that *Forest Tax* represents a cost shifter and not wildlife productivity of the forest land. Presumably the land value, measured by *Forest Tax*, reflects the anticipated return on investment from timber and real estate development land use and is not necessarily highly correlated with desirable hunting qualities.

Turning to differences between the model specifications, the *No Binary* model empirical results suggest the additional variables *Georgia Trophy, Bucks Per Hunter, Deer Hunters, County Income* and *% Hardwood* are each statistically significant at the ten percent or lower significance level. The estimated variable coefficient of *County Income* supports the hypothesized effect on observed lease price. An increase in \$1,000 of median county income results in an increase of lease price by approximately \$0.03.

Contrary to the hypothesized influence on lease price, however, *Georgia Trophy, Bucks Per Hunter*, and *Deer Hunters* exhibit negative relationships to price. Note that the empirical results of the DMU Binary model do not support the statistical significance of the *Georgia Trophy* and *Deer Hunters* in the *No Binaries* model*;* it is possible that the DMU binary variables may control for deer quality, hunting pressure, and hunting demand variations not adequately measured by these proxies.

The lease attribute variable *%Hardwood* does not support the hypothesized impact on lease price. Other lease attribute variables *Lease Acres* and *Lease Acres* Squared are not consistent between the two model specifications. The group of stand variables is jointly statistically significant but because of correlation between the habitat proxies, interpretation of the individual stand attribute coefficients is hampered.

Northern Application and Renewal Regressions

The northern firm uses a hedonic regression to establish its lease prices prior to public offering. The purpose of this analysis is to determine if additional information not included in the firm's pricing process is statistically significant for predicting consumers' response to the take-it-or-leave-it lease prices offered by the firm. Two regressions are used to empirically estimate lease applications and lease renewals, using as an explanatory variable the firm's offer price and additional explanatory terms. The simplified lease application regression is represented as:

$$A = \beta_0 + X_1\beta_1' + X_2\beta_2' + X_3\beta_3' + P\beta_4' + \varepsilon \tag{5.3}$$

The number of applications per 2006 lease offering (*A*) is regressed against lease attributes (X_1), regional attributes (X_2), regional cost shifters (X_3) and the firm's per acre lease price (*P*). The lease attributes of matrix X_1 includes the total lease size, *Acres*. Following the discussion in Chapter 4, the variable *Acres* is expected to positively influence the per-acre value of a tract. If the size (acres) of a lease has implicit positive value to consumers then it should positively influence the number of applications received by the firm, *ceteris paribus*.

The regional attributes of matrix X_2 include rural character, deer quality, hunting demand, hunting pressure, and substitute hunting attributes. The rural character variable group includes *Population*, *Distance*, and *Distance Squared*. *Population* is expected to have a negative impact on observed lease applications because an increase in population implies urban development, or a decrease in rural character. Distance from a population center of 100,000 or more people is hypothesized to have a non-linear relationship with lease applications; *Distance* and *Distance Squared* are used to test this hypothesis. Following the discussion in Chapter 4, *Distance* is expected to have a positive impact on observed lease applications, but at a decreasing rate. The rate of decrease of value (applications) is measured by *Distance Squared*.

Deer quality, measured by *Boone and Crockett Trophy*, is hypothesized to have a positive effect on lease price and should also positively affect the observed lease applications received by the Northern firm. The hunting demand variables *Hunters* and *County Income* are expected to positively influence lease applications.

The hunting pressure variable *Bucks Per Square Mile* is hypothesized to positively influence applications. The access substitute variable *Public Forest* is hypothesized to have a negative impact on observed lease applications.

The cost shifter prosecuted game crime, included in the Georgia regression, is relevant to the Northern regressions. Game crimes are hypothesized to negatively impact consumers' response to lease offering and renewal prices. The discussion of Northern prosecuted game crime regression results is limited to the selection of instrumental variables to be used in the applications regression. The property tax cost shifter, however, is omitted from the Northern regressions. Property taxation is presumably considered by the firm, but property taxes are not relevant to the application or renewal regressions given that the firm's asking price is included as an explanatory term.

The anticipated impact of *Price* on *Applications* is ambiguous. *A priori*, it is not known if the firm under- or over-prices its leases, or if the relationship between offer price and applications or renewals is consistent. Additional explanatory variables may explain some portion of consumer price response, but it is not clear what impact the firm's lease price will have on the observed consumer behavior.

The second regression utilizes lease renewals as the dependent variable for the Northern firm's leases. The dependent variable *Renewal* is regressed against the empirical variables outlined in the applications regression; a Logit regression is used because the dependent variable is a zero-one binary variable. Except for the additional variable *Acres Squared*, the explanatory variables used for the renewal regression match the variables used in the applications regression. The additional variables' influence on *Renewal* should be consistent with the empirical predictions of lease applications. If a lease attribute is desirable (undesirable), the observed impact on the probability of renewal should be positive (negative).

Northern Applications Regression Results

The Northern application regression estimates the number of lease applications as a function of the firm's offering price and additional attribute information not included in the firm's lease pricing data and formula. This is an empirical test of the statistical significance of information not considered in the firm's lease price calculations. The Georgia lease price regression framework is the basis for additional explanatory variables, including game crime violation instruments, in this regression. County median income, county unemployment, and rural character index values were used to instrument for game crime prosecutions in the Northern application regression. [28]

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[28] Game crime instrumental variables are used in the Northern lease price regression based on theoretical concerns presented on page 55. Separate Northern game crime regression results support the corresponding choice of game crime violation instruments, although, percentage of corporate forest holdings to total lands

The number of applications received for each 2006 lease offering, *Application*, is the dependent variable in this first regression. The lease offerings include new leases as well as un-renewed leases from 2005. Because of the zero applications observation bound, a Tobit model specification is used. Following the Georgia results format, the explanatory variable groups in addition to the firm's offering price include stand attributes, rural character, deer quality, hunting demand, hunting pressure, and cost shifters. As with the Georgia regressions, theory does not suggest an appropriate functional form for the Northern applications regression; alternate functional forms were evaluated for this lease application analysis. The semi-log model specification is favored on the basis of estimated standard error, log likelihood, and pseudo R-squared test statistics. The Northern lease application regression results are listed in Table 15 below. Summary statistics for Northern forestry firm data are found on page 43 and the Northern lease application regression correlation matrix is found in Table 20 of Appendix A.

The joint Chi-squared statistic for all variables indicates that the collective group of independent variables is statistically different from zero. A joint F-test statistic for the additional variables indicates that as a group the additional explanatory variables, excluding the firm's predicted price, are statistically different from zero. In particular, the joint significance of the additional variables suggests that the additional variables improve the prediction of consumer response to offering prices. The explanatory variables *Lease Price*, *Acres*, *Population*, *Hunters*, and *Game Crime Prosecutions* are statistically significant at the 10 percent or lower confidence level. Recall that *Game*

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are omitted here due to public access incentive differences between the northern state and Georgia. Predicted game crime prosecutions are generated using the specified instrumental variables; the predicted values are used in the applications and renewals regressions.

Crime Prosecutions represents the predicted number of prosecutions using the instrumental variables discussed earlier. The variables *Distance* and *Distance Squared* are jointly significant.[29]

Table 15: Lease Application Tobit Regression Results (Dependent Variable *Application*).

Variable Group	Variable	Predicted Effect	Coefficient		Partial Effect
	Lease Price	?	20.264	(9.208)**	1.954
Stand Attributes	Acres	+	-4.556	(1.000)***	-2.199
Rural Character	Population	-	-33.987	(13.131)***	-40.036
	Distance	+	24.114	(19.992)	57.638
	Distance Squared	-	-18.410	(13.870)	-62.031
Hunting Demand	Hunters	+	39.569	(12.056)***	37.203
	County Income	+	53.967	(53.350)	4.981
Hunting Pressure	Bucks Per Square Mile	+	-6.902	(6.490)	0.0
Deer Quality	Boone Crockett Trophy	+	-0.763	(1.435)	0.0
Cost Shifter	Game Crime Prosecutions (predicted)	-	-8.604	(4.493)*	-2.795
Observations			259		
Mean Applications			5.4		
Log likelihood			-706.641		
Pseudo R squared			0.119		
Chi2 Statistic (all variables)			190.710		
Probability > chi2			0.00		

Notes: All independent variables are logged. Standard errors are in parentheses to the right of coefficients. Partial effect represents a one standard deviation coefficient effect. ***, **, and * show significance at 1%, 5%, and 10%, respectively.

The firm's lease price is statistically significant for the number of applications received by the firm. The results suggest that a one dollar increase in the predicted lease price increases the number of applications by approximately three applications.[30] This

[29] For an alternative interpretation of the linear-log specification, a unit change in applications results from a 1 percent change in the explanatory variable; the unit change in applications is equal to the variable coefficient divided by 100.

[30] Under a linear-log specification, the change in dependent variable (applications) with respect to the change in the independent variable (in this case natural log of lease price) is equal to the independent variable coefficient divided by the average per acre lease price, or 20.264 divided by $6.62/acre.

result suggests that, all else equal, the firm underestimated its higher value 2005 lease offering prices.

The coefficient for *Acres* suggests that an increase by one in the natural log of lease size decreases the number of applications received by five applications. This result does not support the hypothesized effect that the size of a lease positively impacts lease value in the form of applications. Individually, *Acres* does not address one potential consideration for lease size value; interactions among lease size, hunting club membership, and applications are not addressed in this regression due to data limitations.

As predicted, an increase in the county population decreases lease applications observed. The regression coefficient suggests that increasing the natural log of county population by one decreases applications by 33 applications. The coefficient of *Hunters* suggests that increasing the natural log of the number of hunters per county by one would increase the number of applications by approximately 40 applications. This result supports the variable's hypothesized positive effect.

The variable coefficient signs of *Distance* and *Distance Squared* support the hypothesized impact on the number of lease applications. The combined effect, however, suggests that additional distance from a population center of 100,000 or more people decreases the number of applications received, at a decreasing rate.[31]

The results for *Game Crime Prosecutions* support the hypothesized, negative impact on the observed number of applications. An increase in the natural log of predicted game crime prosecutions by one results in a decrease of applications by approximately nine applications.

[31] The combined effect is computed as (24.114)*(1/distance)-(18.410)*(2/distance).

<u>Northern Renewal Regression Results</u>

The lease renewal regression estimates the lease renewal likelihood based on the estimated lease offering price and additional information not included in the firm's lease pricing formula. A Logit regression specification is used because the dependent variable, *Renewal*, is a zero-one variable. As with applications, variation of renewals was hypothesized as an alternative measure to assess the ability of the firm's asking price and additional information to predict consumer response. The explanatory variables in this regression closely match those used in the Northern application regression. An additional term, *Acres Squared*, is included in to test the hypothesized non-linear impact of acres on renewals. The renewal regression results are summarized in Table 16 below. Summary statistics for the Northern forestry firm are found on page 43 and the renewal regression correlation matrix is found in Table 21 of Appendix A.

The Wald test statistic (Chi2 statistic from Table 16) for all explanatory variables indicates that the collective group explanatory variables are statistically significantly different from zero. The Wald test statistic (Chi2 statistic from Table 16) for the additional variables, not including predicted lease price, indicates that the coefficients of the additional explanatory variables as a group are statistically different from zero. This result suggests that the firm's pricing methodology is an incomplete representation of the true lease market value. The joint significance of the additional variables is consistent with the applications regression results, but no single explanatory variable is statistically significant at the 10 percent level in the renewal regression.

Table 16: Northern Lease Renewal Regression Results (Dependent Variable *Renewals*).

Variable Group	Variable	Predicted Effect	Coefficient	
	Actual Price	?	-0.163	(0.273)
Stand Attributes	Acres	+	-0.011	(0.009)
	Acres Squared	-	0.000	(0.000)
Accessibility	Population	-	0.000	(0.000)
	Distance	+	-0.055	(0.059)
	Distance Squared	-	0.000	(0.000)
Hunting Pressure	Hunters	-	0.000	(0.000)
	Bucks Per Hunter	+	0.274	(0.721)
	County Income	+	0.000	(0.000)
Deer Quality	Boone Crockett Trophy	+	-0.817	(1.808)
Cost Shifter	Game Crime Prosecutions (predicted)	+	-0.278	(0.362)
Observations			381	
Log likelihood			-163.4866	
Pseudo R squared			0.232	
Chi2 Statistic (all variables)			98.76	
Probability > chi2			0.00	
Chi2 Statistic (additional variables)			52.85	
Probability > chi2			0.00	

Notes: Standard errors are in parentheses to the right of coefficients. No explanatory variables are statistically significant.

CHAPTER 6

CONCLUSIONS

This thesis identifies underlying marginal values of hunting lease prices and augments the resource economics literature evaluating wildlife access. This research extends the hedonic valuation technique to natural resource access values. Hunting leases represent a private provision (property access) of a public commodity (wildlife). The methodology in this thesis is applicable to that in other resource valuation studies where observed transaction and attribute data are available.

Research relevant to this thesis has addressed wildlife access values (Hussain, Zhang, & Armstrong, 2004; Livengood, 1983; Loomis & Fitzhugh, 1989; Pope III & Stoll, 1985; Zhang, Hussain, & Armstrong, 2003). This previous work relied upon survey data that limited the analysis of specific wildlife and habitat attributes. The corporate data used here provide quantitative lease information not represented in the previous analyses; these data are used to assess the role of specific land and regional attributes to observed lease prices.

Two industrial forest firms provided data for this analysis. Hedonic valuation requires observed transaction data that includes quantitative attribute information. These firm sources provide consistent, detailed lease data difficult to obtain from survey methods. Additionally, the firm's leases are comparable to the leases of the more general category of non-industrial forest owners. The Georgia firm offers hunting leases to the public through a competitive bidding system. The Northern Firm selects customers from a pool of applicants that applied for specific leases at predetermined offering prices. Hedonic valuation is used to empirically estimate two forms of consumer response: competitive bidding results in the Georgia hunting lease market and consumer response to take-it-or-leave-it prices in the Northern hunting lease market.

Summary of Results

Georgia

The Georgia regression results are important for forest management, public hunting access, and lease pricing considerations. The lease price regression results are jointly statistically significant variable groups for (1) forest stand attributes, (2) the rural character of a county, (3) substitute public hunting access, and (4) cost shifters.

Stand attributes, as a group, that are relevant to lease prices include the percentage of non-plantation acreage, the distance from populated centers, measures of public hunting access substitutes, and forest property taxes. Notably, the Georgia regression results indicate that non-plantation acreage, as a percentage of the total lease acreage, positively influences observed lease prices. This result supports the general proposition that “natural” forest conditions positively impact price. In other words, less intensive forest management practices yield positive hunting lease value to consumers, all else equal.

Distance from population centers and forest property taxes have positive impacts on observed lease prices at a decreasing rate. The results suggest that the estimated effect is zero at approximately 80 miles from a population center.

The Georgia regression results suggest that nearby public hunting opportunities negatively influence observed lease prices. The Georgia firm, like many industrial forestry firms, maintains wildlife access leases with the Georgia Department of Natural Resources (GDNR) at per acre prices typically lower than those paid for private leases. With these GDNR rates lower than the competitive lease rates, the firms' total realized cost could include both the discount for state leases and the reduced (observed) lease bids for properties in proximity to state sponsored Wildlife Management Areas.

The Georgia regression results support the hypothesized, positive impact of forest property tax on observed lease prices. Previous hunting lease surveys suggest that landowners pass along this transaction cost directly to lease consumers; these regression results suggest the proportion of tax passed along to hunters is relatively small at less than ten cents per dollar paid in forest property tax.

Northern State

The Northern lease price analysis s a relatively new lease program's ability to predict competitive lease market values. The Northern firm applies a pricing method similar to but more limited than the hedonic approach developed in this thesis to establish lease offering prices in a take-it-or-leave-it manner. The Northern lease price regression uses the firm's price and additional information's ability to predict response to lease prices.

The regression results indicate that the firm's lease offering pricing methods could be improved with additional lease attribute information. The significance of the firm's offer price and the joint significance of additional information offer two lease program implications. The first implication is that the firm under-prices higher value leases based on the coefficient results for lease price. The second implication is that the results support the hypothesis that lease price, lease acres, distance from a population center, number of hunters per county, and predicted game crime prosecutions offer statistically significant improvement in pricing Northern hunting leases.

This analysis does not identify the competitive market equilibrium for lease applications, but empirical results suggest that the firm's offer price and additional attribute information are determinants of lease applications. From a lease price revenue perspective, decreasing the number of applications received is an indicator of lease pricing improvements. The average application rate per lease was 5.4, the third quartile was six applications, and the maximum value was 70 applications. Reducing the number of applications received for the most sought-after leases should increase the company's total lease revenues.

The empirical results from the lease renewal regression results also suggest the additional information not included in the firm's pricing methodology are statistically significant to predicting lease renewals.

Limitations of Research

Statistical analysis is limited by the ability of the proposed variable proxies to accurately reflect a "true" measure of the individual attributes. For example, distance from a population center can be determined with relative certainty. Quantifying regional deer quality is more difficult to measure than distance. In this analysis, deer quality as represented by county trophy buck count but the variable coefficient is not consistently significant; this proxy may inaccurately reflect desirable features to deer hunters. Similar potential for measurement error exists for other independent variables, such as those measuring desirable habitat, if these proxies inaccurately represent desirable conditions for wildlife productivity. Nonetheless, proxies must be used when direct measures are not available.

Hedonic valuation is an important tool for researchers. The better the explanatory variable measurements, the better is hedonic valuation as an empirical tool. In this analysis, a number of proposed explanatory variables lack statistically significant coefficient results. The central issue may be a lack of appropriate proxies. Relevant economic theory determined the explanatory variable framework used in this analysis. Efforts were made to develop preferable measurements for the explanatory framework. The validity of these analytical results is left for the reader to determine.

A limitation specific to the Northern regression analysis is the assumption the Northern firm is attempting to identify the highest obtainable lease prices. The results suggest higher value leases are under-priced but, this conclusion ignores the possibility that the firm’s pricing methodology may incorporate other objectives. For instance, the firm’s pricing strategy could be designed to encourage applications or renewals from a preferred customer group. If the company anticipates lower transaction costs or other unobserved benefits from leasing to a particular group or type of customer, the company may choose to offer leases at a price inconsistent with the market equilibrium criteria proposed.

Future Research

An interesting extension of this research is a refined analysis of deer quality impacts on observed hunting lease values. Deer quality is hypothesized to positively influence lease rates. The Georgia regression results, based on the Georgia trophy variable coefficients, fail to support the hypothesis that deer quality influences observed lease prices. Public interest in quality deer management initiatives and other anecdotal sources suggest that deer quality positively impacts observed lease prices (QDMA, 2006). Although this analysis did not support the hypothesized price impact, the statistical results could be limited by the deer quality proxy used. If county trophy counts inadequately measured deer quality variation, perhaps refined data would produce different statistical results. One potential source of data could include the harvest records advocated for Quality Deer Management Association members.

Another interesting extension of this research is an examination of institutional contract differences. According to the 1995 National Private Landowners Survey and conversations with forest industry wildlife lease managers, access leasing arrangements, and preferences vary throughout the country. Hunting season lengths and game species between Georgia and the Northern state vary yet the observed lease terms are identical. What determines the structure of leasing arrangements? Lease terms appear to be similar yet the companies employ different pricing strategies. Regional institutions, age of leasing programs, or other features may determine the pricing strategies employed by forest owners.

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APPENDIX A

PAIR-WISE CORRELATION TABLES

Table 17: Georgia Crime Pair-Wise Correlation Matrix.

	County Income	Poverty	Unemployment	Rural influence	Game Crime04
County Income	1				
Poverty	-0.8657	1			
Unemployment	-0.5194	0.5651	1		
Rural Influence	-0.5985	0.5364	0.3186	1	
Game Crime04	-0.2932	0.2603	0.2684	0.2853	1

Table 18: Georgia Lease Price Pair-Wise Correlation Matrix.

	lease_rate	lease_acres	acres2	Regen	regen2	edge
lease_rate	1					
lease_acres	-0.3317	1				
Acres2	-0.2372	0.8946	1			
Regen	-0.1322	0.0955	0.0668	1		
Regen2	-0.0733	-0.0298	-0.0051	0.9369	1	
Edge	-0.1826	0.3694	0.2193	0.487	0.1827	1
Woody	-0.2737	0.2668	0.1964	-0.0242	-0.0945	0.128
Nonplant	0.001	0.0957	0.0742	-0.114	-0.1406	-0.0004
Population	-0.2467	0.1869	0.1504	0.0354	0.014	0.0552
Distance	-0.5242	0.3121	0.2164	0.0694	-0.0048	0.1991
distance2	-0.5263	0.3123	0.2194	0.0713	-0.0028	0.1909
ga_trophy	0.2276	-0.1818	-0.1238	-0.0276	0.032	-0.1453
bck_per_hntr	-0.3571	0.0615	0.0193	0.0797	0.0396	0.128
Hunters	-0.3274	0.2414	0.1726	0.0389	0.0016	0.1014
public hunting	-0.4409	0.3892	0.3224	0.0883	0.0242	0.1885
fors_tax	0.3455	-0.1108	-0.067	-0.0664	-0.0211	-0.139
Income	0.013	0.0784	0.0763	0.0048	0.0106	-0.0084
dmu4	0.0918	-0.1324	-0.0854	-0.0255	0.0286	-0.1222
dmu5	0.6115	-0.2299	-0.1431	0.0379	0.0667	-0.0671
dmu6	-0.0766	-0.0333	-0.049	-0.1099	-0.0955	-0.0809
dmu7	0.0019	-0.033	-0.0402	-0.0671	-0.0581	-0.0372
dmu8	-0.3535	0.0242	-0.0197	0.063	0.0212	0.1178
dmu9	-0.6063	0.5106	0.394	0.0948	0.0055	0.2501
crime04	0.2534	-0.119	-0.0928	-0.0803	-0.0475	-0.1117

	woody	nonplant	population	distance	distance2	ga_trophy
Woody	1					
Nonplant	0.5131	1				
Population	0.1481	0.1025	1			
Distance	0.2438	0.0035	-0.0133	1		
distance2	0.2329	0.0101	0.0236	0.9697	1	
ga_trophy	-0.1277	-0.0201	0.1395	-0.3482	-0.3319	1
bck_per_hntr	0.009	-0.0103	0.1978	0.1833	0.1743	-0.0779
Hunters	0.1602	0.0269	0.7399	0.2597	0.238	-0.0819
public hunting	0.2867	0.1108	0.4319	0.1643	0.1219	-0.2328
Fors_tax	-0.0408	0.0238	0.1397	-0.2746	-0.2626	0.2064
Income	0.0478	0.1442	0.5676	-0.3238	-0.2374	0.12
dmu4	-0.1455	-0.0976	0.2032	-0.3664	-0.305	0.3333
dmu5	-0.251	-0.0406	-0.2296	-0.3191	-0.3367	0.0347
dmu6	0.0696	-0.0463	-0.249	0.2233	0.2136	0.0257

	Dmu7	dmu8	dmu9	crime04
dmu7	1			
dmu8	-0.0961	1		
dmu9	-0.1316	-0.1166	1	
crime04	0.3262	-0.1039	-0.2209	1

Table 19: Northern Crime Pair-Wise Correlation Matrix.

	County Income	Poverty	Unemployment	Rural Influence	Game Crime05
County Income	1				
Poverty	-0.7835	1			
Unemployment	-0.3431	0.4747	1		
Rural Influence	-0.6859	0.4063	0.056	1	
Game Crime05	-0.3225	0.3096	0.3526	0.3516	1

Table 20: Northern Application Pair-Wise Correlation Matrix.

	applications	price	acres	population	pop distance
applications	1				
price	0.3159	1			
acres	-0.1417	-0.0457	1		
population	-0.2495	-0.2597	0.013	1	
pop distance	-0.4613	-0.3033	0.0052	0.0687	1
pop distance sq	-0.4896	-0.3228	0.006	0.0839	0.9977
hunters	-0.1619	-0.2179	0.0145	0.986	0.0024
Booncrock trophy	-0.4665	-0.3238	0.0344	0.6292	0.0587
income	-0.4102	-0.38	0.039	0.4151	0.2014
buckssqmile	0.3709	0.3175	-0.0687	0.1757	-0.466
crime05fitted	0.4562	0.4086	-0.0469	-0.7114	-0.2888

	popdistance sq	hunters	Booncrock trophy	income	buckssqmile
popdistance sq	1				
hunters	0.0099	1			
booncrocktrophy	0.1139	0.5392	1		
income	0.2552	0.2768	0.6902	1	
buckssqmile	-0.5062	0.2986	-0.4643	-0.6139	1
crime05fitted	-0.3323	-0.6041	-0.7812	-0.8252	0.3694

	crime05fitted
crime05fitted	1

Table 21: Northern Renewal Pair-Wise Correlation Matrix.

	renewal	price	acres	acres sq	population
renewal	1				
price	0.0372	1			
acres	0.0273	-0.0853	1		
acres sq	0.055	-0.0362	0.9494	1	
population	-0.1925	-0.1537	-0.017	-0.0294	1
pop distance	-0.4399	-0.1195	-0.0617	-0.094	0.311
pop distance sq	-0.4436	-0.0934	-0.0486	-0.0809	0.1569
public land	-0.2853	-0.1395	-0.0299	-0.0474	0.9322
hunters	-0.1587	-0.15	-0.0211	-0.0305	0.994
booncrocktrophy	-0.2987	-0.1524	-0.0095	-0.0266	0.9537
income	-0.3515	-0.25	0.0234	-0.0314	0.4952
buckssqmile	0.409	0.1184	-0.0419	-0.0256	-0.3156
crime05fitted	0.3241	0.2291	0.0052	0.0372	-0.7349

	pop distance	pop distance sq	hunters	Booncrock trophy	income
pop distance	1				
pop distance sq	0.9616	1			
public land	0.5454	0.4047			
hunters	0.2448	0.0896	1		
booncrocktrophy	0.4972	0.3913	0.9276	1	
income	0.746	0.7181	0.4565	0.5949	1
buckssqmile	-0.8449	-0.8438	-0.2584	-0.49	-0.7283
crime05fitted	-0.6518	-0.5834	-0.6913	-0.8104	-0.8379

	buckssqmile	crime05fitted
buckssqmile	1	
crime05fitted	0.5763	1