MONTANA AGRICULTURAL LAND PRICES:

AN EVALUATION OF RECREATIONAL AMENITIES

AND PRODUCTION CHARACTERISTICS

by

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ABSTRACT

A hedonic price regression model is used to estimate the contributions of amenities to agricultural land values. The model was applied to a sample of agricultural land sales in Montana between 1999 and 2009. Statistically and economically significant effects are estimated for certain amenity variables that pertain to wildlife habitat and location.

CHAPTER 1

INTRODUCTION

Traditionally, the value of agricultural land has been modeled as a function of the discounted expected present value of profits obtained from the sale of agricultural products produced on the land. Nonetheless, numerous studies find that agricultural land often exchanged at prices that exceed its ability to produce output (Bastain et al. 2002; Torell et al. 2005). What accounts for the discrepancy between traditional and observed measures of value? Researchers have determined that agricultural land values are influenced by factors that do not directly contribute to a revenue stream of a residual claimant. These aspects may provide utility to a residual claimant or may possibly be developed into a revenue stream that is outside the paradigm of traditional production agriculture.

Both anecdotal and empirical evidence exist to support the thesis that amenities contribute to agricultural land values. For example, when agricultural land is offered for sale, advertisements often include a description of production capabilities, capital improvements, and a proclamation of aspects that are tied to the property but are not tied to any direct form of income generation. These amenities often include “great views,” “healthy populations of trophy white-tailed deer,” “provision of outstanding opportunities for a private day of fly-fishing for mountain trout,” etc. If advertisements present these factors, then it is likely that amenities contribute to the sale value of land parcels. This thesis builds upon the small but growing body of economic literature that moves beyond anecdotal evidence to examine empirical evidence of these phenomena.

This research examines observed sale values of a cross section of land sales that are (or at one time were) employed in production agriculture in Montana between the years 1999 and 2009. The goal of this research is to improve our understanding of the contribution of amenities to Montana agricultural land values. This research builds upon previous literature by examining a unique region. It also includes a greater number of amenity variables than found in previous studies. Quantifying amenity contribution to land value allows individual agricultural producers to make sound, economic land management decisions. It also provides policy makers and analysts with information for making policy decisions that directly or indirectly affect amenities.

Montana is primarily an agricultural state and encompasses 94 million acres of land. According to the 2007 United States Department of Agriculture's Census of Agriculture, Montana had 61.4 million acres of farmland; 29.7 percent of that land was cropland and 67.3 percent was pastureland or rangeland. In Montana, 3.6 million acres were enrolled in conservation or wetlands reserve programs. There were over twenty-nine thousand farms in Montana. The average size of these farms was over two thousand acres. The average estimated value of land and buildings was $1.6 million.

An understanding of the contribution of amenities to land value is important for Montana, because it represents the largest percentage of the State's land mass. Agricultural land is important to the region's agricultural producers because it comprises a majority of their assets. Montana real estate accounted for 86 percent of farm asset values and 51 percent of farm debt in 2007 (USDA Economic Research Service 2009).

The remainder of this thesis is organized as follows. Chapter 2 presents a review of the literature of agricultural land valuation, amenity pricing, and spatial dependence issues in hedonic property models. Chapter 3 provides a description of the theoretical model that is employed and a review of the hedonic approach. Chapter 4 provides descriptions and summary statistics of the data used in the analysis. Chapter 5 discusses the empirical methods used and the results obtained from the analysis. Chapter 6 offers a summary and conclusions to the research contained herein.

CHAPTER 2

LITERATURE REVIEW

The literature related to hedonic models and land price valuation is discussed in this chapter with special focus on the literature related to amenity contributions to agricultural land. The literature associated with spatial autocorrelation is also discussed with special focus on the literature related to spatial autocorrelation in hedonic models.

When agricultural land is viewed solely as an income-producing asset, a net present value model is typically used to describe value. Burt (1986) describes this model and uses it as the basis for quantifying the value of agricultural land in Illinois. Burt states that under competition and certainty the price of agricultural land is determined by the classical capitalization formula (shown here with a constant real interest rate):

(1) $P_0 = \Sigma^{\infty}_{t=0} R_t / (1 + r)^t$

where P_0 is agricultural land price at time zero, R_t is net land rent at time t, and r is the real discount rate. Net rents are comprised of many factors that are difficult to forecast (such as output and input prices in future time periods) from which two dynamic behaviors emerge. Market participants form expectations of future rent, and a dynamic adjustment process occurs as expected prices move between equilibria after market perturbations. Burt assumes that these behaviors are confounded and, therefore, uses a robust distributed lag specification to approximate the composite effects.

Burt applies the following model to Illinois agricultural land prices:

(2) $ln\ P_t = \delta + \gamma_0\ ln\ R_t + \gamma_1\ ln\ R_{t-1} + \lambda_1 E(ln\ P_{t-1}) + \lambda_2 E(ln\ P_{t-2}) + ln\ u_t$

where *ln* represents natural logarithums, $E(\ln P_t) = (\ln P_t + \ln u_t)$ is the expectation operator, and $\delta = (1 - \lambda_1 - \lambda_2) \ln \alpha$, where α is the reciprocal of the constant capitalization rate. Burt assumes that Illinois agricultural land did not contain substantial non-agricultural value during the time period considered, and that cash rents were the driving source of value.

Burt suggests that the net present value model is most appropriate when non-agricultural factors do not contribute to land value. Thus, the net present value approach to land valuation may be an incomplete model when land contains valued recreational amenities. A recreational amenity is defined as any tangible or intangible property characteristic that provides utility but may not be related to the production of a good or service. A hedonic model is often used to account for non-agricultural factors (Bastian et al. 2002; Taylor and Brester 2003; Torell et al. 2005).

A hedonic model assumes that goods are valued for their utility-bearing characteristics (Rosen 1974). Rosen defines hedonic prices as "the implicit prices of attributes" and states that they are revealed "from observed prices of differentiated products and the specific amounts of characteristics associated with them." A hedonic model describes an equilibrium outcome under perfect competition. Each good (*z*) is differentiated by *n* characteristics such that:

(3) $z = (z_1, z_2, \ldots, z_n)$

where z_i measures the amount of the *i*th characteristic contained in *z*. Each product is completely described by characteristics, and different distinct goods are described by different bundles of characteristics.

For each good (*z*) there is a price (*p*) such that:

(4) $p(z) = p(z_1, z_2, \ldots, z_n)$.

Under perfect competition, buyers and sellers treat the prices as exogenous to their decisions (Rosen 1974). Equation (4) indicates that hedonic prices are determined by the intersection of quantity supplied and quantity demanded at each point *z*. Both the quantity demanded and supplied decisions are based on utility and profit maximizing behavior for buyers and sellers, respectively, with no restrictions on the composition of good (*z*).

Bastian, McLeod, Germino, Reiners, and Blasko (2002) apply a hedonic model to land price valuation in Wyoming and estimate recreational and scenic amenity impacts on agricultural land prices. They argue that agricultural land may provide opportunities for development and may contain many recreational amenities (including wildlife habitat, scenic views, and recreational opportunities).

Their basic model is:

(5) $P(\mathbf{Z_i}) = P(z_{ag1}, z_{ag2}, \ldots, z_{agn}, z_{am1}, z_{am2}, \ldots, z_{amk})$

where $P(\mathbf{Z_i})$ is the price of parcel *i* with a vector $\mathbf{Z_i}$ comprised of agricultural attributes (z_{agn}) and amenity attributes (z_{amk}). This is a reduced form model of supply and demand associated with agricultural production, non-agricultural rent-generating possibilities, and demand factors for residential living. Several functional forms were evaluated using goodness-of-fit statistics.

The authors generate a random sample of Wyoming agricultural land sales. The data consist of per acre sales prices, production, and amenity characteristics. The data were obtained from appraisals and amenity data were collected and measured using Geographic Information Systems (GIS) technologies. They presume that GIS provides a better means of measuring amenities than qualitative measures or indicator variables. The amenities of interest include stream length, fish productivity, elk habitat acreage, and a measure of the view composition for each parcel selected. Productivity ratings are measured in Animal Unit Months (AUMs) and are used to control for agricultural productivity contributions to each parcel's value. Bastian et al. (2002) find that amenities contribute to the value of agricultural land.

Torell, Rimby, Ramirez, and McCollum (2005) use a truncated nonlinear hedonic model to evaluate factors contributing to agricultural land values in New Mexico. Their model is truncated to preclude negative predictions of the dependent variable. Agricultural productivity is accounted for using appraised estimates of annual crop and livestock income. Wildlife income and potential rental income of facilities and housing are also considered using gross income generated from hunting and wildlife-related activities and the appraised real property value, respectively. Elevation measures and a dummy variable for each observation's location with respect to one of five major land resource areas serve as proxy variables for amenities.[1] Torell et al. conclude that while agricultural income is important in determining the price of agricultural land, certain amenity packages also contribute to value.

Hedonic models of land valuation may suffer from spatial autocorrelation. Spatial autocorrelation can be defined as the "coincidence of value similarity with locational

[1]. The resource areas are designated by the Natural Resource Conservation Service (NRCS).

similarity." This can take the form of relative values of a random variable tending to be spatially grouped or very dissimilar may values border each other. Such situations are known as positive and negative spatial autocorrelation, respectively (Anselin and Bera 1998). Spatial error dependence and spatial lag dependence are two forms of spatial autocorrelation. Spatial error dependence is the correlation of error terms across neighboring observations, while spatial lag dependence is the correlation of dependent variables across neighboring observations.

Bastian et al. (2002) find no spatial correlation for observations within 400 miles of each other; however, they question this result due to the presence of heteroskedasticity. A joint remedy for spatial correlation and heteroskedasticity of an unknown nature was not available to them. Therefore, they decided that a heteroskedasticity correction was more important than possible efficiency losses caused by spatial correlation. Torell et al. (2005) also acknowledge potential spatial complications inherent in land data, but were unable to account for this because of the complexity their model.

Patton and McErlean (2003) test for spatial effects in a hedonic model of agricultural land prices in Northern Ireland using a standard Lagrange Multiplier test. Their spatial weights matrix consists of elements that are functions of the distances between observations. They maintain that hedonic models that fail to account for spatial correlation may produce biased and inefficient estimates. They find spatial lag dependence to be present in their data which could lead to biased parameter estimates. They conclude, however, that spatial lag dependence is attributable to the circularity of price setting caused by appraisers valuing land based on observed values of similar parcels within a reasonable proximity (i.e., comparable sales).

Mueller and Loomis (2008) address spatial correlation issues with respect to hedonic property valuation models. They try three different specifications for their spatial weights matrix; four nearest neighbors, eight nearest neighbors, and an inverse-distance function. They consider the issue of spatial dependence and conclude that, in their particular application, ignoring spatial correlation does not undermine economic interpretations of hedonic results. Their data are spatially correlated for all three spatial weights matrices specifications, and they compare OLS regression results to a spatially-correlated correction model. They determine that correcting for spatial correlation generates improved statistical estimates. The improvement in the estimates, however, is deemed to not be economically significant. The bias and inefficiency under OLS is not enough to undermine the policy implications of the results. Thus, hedonic property models that do not correct for spatial correlation may still be relevant.

In summary, the classical capitalization formula as described by Burt (1986) may not be sufficient to model land values in cases where recreational amenities are present. Instead Rosen (1974) proposes a hedonic model that is generally applied. Bastian et al. (2002) provide a direct example of the use of the hedonic model with respect to estimating amenity contributions to land value. Torell et al. (2005) also provide an example of using a truncated nonlinear hedonic model with respect to estimating amenity contributions. Spatial autocorrelation: spatial lag dependence and spatial error dependence can be issues when considering land prices. Spatial error dependence can arise from an omitted variable and leads to inefficient estimates. Patton and McErlean (2003) find that spatial lag dependence can arise when land prices are in part determined by the land price of neighboring parcels. This can lead to biased estimates. The model used by Bastian et al. (2002) allows for the use of tests that detect for both forms of spatial autocorrelation, while the model used by Torell et al. (2005) does not. A model following the example set by Bastian et al. (2002) is used in this thesis. Spatial autocorrelation is tested for and when found special estimation techniques are used to correct for any inefficiencies or biases in the estimates. The special estimation techniques will be discussed in Chapter 3.

CHAPTER 3

EMPIRICAL MODELS

The empirical analysis uses two different hedonic models to explain variations in total land sales price: one with total acres used as one of the independent variables and a second in which acres enter as independent variables based on land use. Also included in this chapter is a description of the models that are used to account for spatial autocorrelation.

Parameter estimates of hedonic price models are interpreted as the marginal effects of characteristics on product price. Because a hedonic model describes an equilibrium outcome under perfect competition (see Chapter 2), hedonic price models do not necessarily define supply or demand functions. Rather, a hedonic model is used in this research to determine the marginal impact of recreational amenities on agricultural land.

The hedonic land price literature provides little direction as to whether price per acre or total sales price should be used as a dependent variable. Bastian et al (2002), Taylor and Brester (2003), Patton and McErlean (2003) and Torell et al. (2005) use per acre prices of parcels as dependent variables, while Spahr and Sunderman (1995) and Egan and Watts (1998) use total price of land parcels as dependent variables. Spahr and Sunderman (1995) chose the total price model over a per acre price model based on explanatory power. Torell et al. (2005) reject the use of a total price model because estimated coefficients measure average effects of independent variables across all parcel sizes. They maintain that responses are expected to differ across parcel size. Price per acre, however, may be less relevant than the total price of a parcel to both buyers and sellers. Therefore, total price of land parcels are used as dependent variables in this research.

Total Acres Model

The first model (Model 1) to be estimated uses total prices of land parcels as a function of other factors. Model 1 is a modification of the specification used by Bastian et al. (2002). The hedonic model is specified as:

(6) $P_T = f$ *(production characteristics, recreational opportunities, wildlife habitat, view characteristics, development opportunities),*

where P_T is the total price of agricultural land parcels in Montana, *production characteristics* are those attributes that contribute to agricultural land productivity, *recreational opportunities* are recreational amenities that contribute to land value, *wildlife habitat* measures existence of native wildlife, *view characteristics* represents different land types and possible land use, and *development opportunities* are those attributes that influence residential development.

Production characteristics include measures of agricultural productivity. As the productivity of land increases, then the value of that property is also expected to increase. The size and topographical diversity of parcels also affect agricultural land values. Sandrey et al. (1982) suggest that the decreasing marginal benefits of size are due to higher demand for smaller parcels associated with “hobby farmers.” Pope (1985) argues that economies of size exist as farm size increases. This would cause the total value of a parcel to increase at an increasing rate with size. This may not hold, however, over all parcel sizes. Research shows that the values of land parcels increase with size but at a decreasing rate (Sandrey, Arthur, Oliveira, and Wilson 1982; Bastian et al. 2002; Taylor and Brester 2003; Huang et al. 2006). Taylor and Brester (2003) include size and its square in their model and find that per acre prices decline at a decreasing rate with size. In this model size will be captured by the total acres of a parcel. This model and all subsequent models will try different functional forms to examine the possible non-linearity of the size affects.

Recreational opportunities and viewscapes generate utility, and are predicted to be reflected in property values. A proxy for recreational and urban opportunities is measured by distances to towns and recreational areas. The effect of distances to towns on land values is ambiguous and research results are mixed. Towns may provide recreation opportunities and services, but may reduce the value of seclusion. Patton and McErlean (2002), Torell et al. (2005), and Huang et al. (2006) find a negative relationship with distance, while Bastian et al. (2002) find a positive relationship. A negative relationship suggests that travel costs to towns overwhelm seclusion value.

Unhindered viewscapes probably positively contribute to the value of land parcels. Bastian et al. (2001) conclude that a diversified view contributes positively to land values and Torell et al. (2005) conclude that an increase in value due to a parcel's location in a mountainous region is, in part, due to desirable viewscapes.

Wildlife habitat can provide recreational opportunities or a source of income (e.g., through hunting leases). Conversely, wildlife may hinder agricultural production and, consequently, reduce land value. Bastian et al. (2002) find a negative effect of elk habitat on agricultural land values. Pope (1985) finds a positive relationship between the number of deer harvested and agricultural land value. Torrell et al. (2005) find that wildlife income contributed more to land values than agricultural income. Henderson and Moore (2006) find that hunting leases and recreational income associated with wildlife are capitalized into Texas agricultural land values.

Development opportunities are expected to have a positive relationship with agricultural land values because they reflect value of converting land from agricultural production to residential property. These opportunities are generally greater the closer a parcel is to population centers. For example, negative relationships between land value and distances from population centers have been found by some research (Pope 1985; Patton and McErlean 2003; Torell et al. 2005; Huang et al. 2006). In addition, other research finds positive relationships between population density and land value (Taylor and Brester 2003; Torell et al. 2005; Henderson and Moore 2006; Huang et al. 2006).

Development opportunities are reduced if conservation easements are attached to land parcels. A conservation easement is a legally binding perpetual agreement between a land owner and a second party that restricts real estate development on a parcel to specific levels. A second party may purchase a conservation easement as a means to guarantee the maintenance of certain characteristics. These amenities may contribute positively to the value of land, but may be offset because of decreased usage opportunities. The net effect is most likely negative, because some form of compensation is generally required for a land owner to enter into such an agreement.

Acreage Components Model

The second model (Model 2) to be estimated uses total prices of land parcels as a function of total acres and other factors. Thus, Model 2 estimates the marginal impacts of land usage on the price of land parcels. Land usage components are measured in terms of the number of CRP acres, dryland crop acres, irrigate crop acres, pasture acres, improved pasture acres, site acres, and unclassified acres that exist in each land parcel. An acre of irrigated land is expected to contribute more to the total price of a parcel than an acre of dryland due to productivity differences. The remaining independent variables in Model 2 are identical to those of Model 1. The effects of the various production and amenity characteristics discussed above are expected to be similar among the two models.

Spatial Autocorrelation

Ordinary Least Squares estimates of hedonic models are inefficient and inconsistent in the presence of autocorrelation. Spatial autocorrelation can take on two forms that have different consequences for OLS estimation. Spatial error dependence leads to inefficient estimates of hedonic prices. Inefficiency occurs because of an omission of otherwise non-essential variable(s) that are spatially correlated with independent variables in the regression. An example would be vegetation that increases wildlife habitat, but has no direct effect on a parcels value. If there is no controlling variable in the model for vegetation, but wildlife habitat is an independent variable then it would be likely that model would exhibit spatial error dependence. Anselin and Bera (1998) define spatial error dependence as:

(7) $$y = X\beta + \varepsilon$$

(8) $$\varepsilon = \lambda W\varepsilon + \xi$$

where y is a $n \times 1$ vector of observations on the dependent variable, X is a $n \times k$ matrix of explanatory variables, β is a $k \times 1$ vector of regression coefficients, ε is a $n \times 1$ vector of error terms, λ is the spatial autoregressive coefficient, $W\varepsilon$ is the spatial lag for error terms and, ξ is a uncorrelated and homoskedastic error term.

Spatial lag dependence violates the OLS assumption of an independently distributed error term due to simultaneity of the spatially lagged dependent variables. Maximum likelihood estimation can be used to obtain consistent and efficient estimates of the hedonic prices in the presence of either types of spatial dependence. Such models can be estimated using instrumental variables combined with Generalized Method Moments to account for complex error structures (Anselin and Bera 1998).

Anselin and Bera (1998) define spatial lag dependence as:

(9) $$y = \rho Wy + X\beta + \varepsilon$$

where y is a $n \times 1$ vector of dependent observations, ρ is the spatial autoregressive parameter, Wy is the spatially lagged dependent variable, X is a $n \times k$ matrix of explanatory variables, β is a $k \times 1$ vector of regression coefficients, ε is an error term. An example of spatial lag dependence would occur if the sales price of a parcel is directly influenced by the sales price of a neighboring parcel. If sellers, buyers, appraisers, and real estate agents use the price of parcel X when trying to determine the value of parcel Y because the parcels are in the same area, then it is likely that model would exhibit spatial lag dependence.

The matrix W represents a spatial weights matrix. The matrix is used to create spatially lagged variables and in Lagrange multiplier tests for spatial dependence. It is important for calculating Jacobian determinants used in maximum likelihood estimation (Anselin and Hudak 1992). The spatial weights matrix is comprised of elements that describe an observation's "neighborhood." The matrix is of dimension n by n and is symmetric. The locations that are deemed to be in an observation's neighborhood are represented by non-zero elements, and those locations outside of the neighborhood are represented by elements that are equal to zero. Convention calls for the non-zero elements for an observation to sum to one and the diagonal elements to be set to zero. An observation's neighborhood (which determines the non-zero elements) is somewhat arbitrary (Anselin and Bera 1998).

Lagrange multiplier (LM) tests for spatial error autocorrelation and spatial lag dependence are convenient and offer the best performance over other tests (Anselin and Bera 1998). Anselin and Hudak (1992) describe the tests for spatial autocorrelation. The LM tests are performed under their respective null hypotheses. The null hypothesis of the LM test for spatial error autocorrelation is $H_0: \lambda = 0$. The null hypothesis of the LM test for spatial lag dependence is $H_0: \rho = 0$. They are distributed as a chi-squared with one degree of freedom. The LM test for spatial error autocorrelation (LM_λ) takes the form:

(10) $LM_\lambda = [e'We/(e'e/n)^2]^2 / \text{transpose } [W'W+W^2]$

where e is a $n \times 1$ vector of the OLS residuals. The LM test for spatial lag dependence (LM_ρ) takes the form:

(11) $LM_\rho = [e'Wy/(e'e/n)^2]^2 / \{[(WXb)'MWb/(e'e/n)^2] + \text{transpose } [W'W+W^2]\}$

where $M = I-X(X'X)^{-1}X'$, b are the OLS estimates of β, e is a $n \times 1$ vector of the OLS residuals, and the rest of the notation is the same as described above. It is possible to get a false positive result as both LM_λ and LM_ρ have some power against each other. However, they have the most power for their own designations. Thus, the test with the lower p-value should be used to identify the true form of spatial autocorrelation (Anselin and Bera 1998).

Anselin and Hudak (1992) derive the log-likelihood functions used in maximum likelihood estimation for both types of spatial dependence. For the spatial error model the log-likelihood function is defined as:

(12) $L = \Sigma_i \ln (1 - \lambda\omega_i) - (n/2) \ln (2\pi) - (n/2) \ln (\sigma^2)$

$- (y - \lambda Wy - X\beta + \lambda W X\beta)' (y - \lambda Wy - X\beta + \lambda W X\beta)/2\sigma^2$.

The spatial lag model's log-likelihood function takes the form:

(13) $L = \Sigma_i \ln (1 - \rho\omega_i) - (n/2) \ln (2\pi) - (n/2) \ln (\sigma^2)$

$- (y - \rho Wy - X\beta)' (y - \rho Wy - X\beta)/2\sigma^2$

where y is a $n \times 1$ vector of dependent observations, X is a $n \times k$ matrix of explanatory variables, β is a $k \times 1$ vector of regression coefficients, λ is the autoregressive coefficient, ρ is the spatial autoregressive parameter, Wy is the spatially lagged dependent variable, n is the number of observations, and σ^2 is the variance . The assumption of normality is important for both functions, and both contain a Jacobian term, $|I - \lambda W|$ for the spatial error model and $|I - \rho W|$ for the spatial lag model. The Jacobians are expressed as functions of the Eigen values of the weights matrix W, ω_i.

Spatial autocorrelation issues will be examined during the estimation process. Ordinary least squares is used to estimate both models, unless Lagrange multiplier tests indicate spatial autocorrelation. If tests indicate the presence of spatial dependence, the models will be estimated by Maximum Likelihood.

CHAPTER 4

DATA

The data used in the empirical analyses are presented in this chapter. Land sales are not publicly disclosed in Montana; therefore, data for this research are obtained from appraisals undertaken at the time of sale and maintained by an agricultural lending firm. These appraisals are not exclusively associated with parcels financed by the lending firm as they are obtained independently of its financing division. This ensures a more representative sample of the agricultural land sales in Montana. Data are collected from Uniform Agricultural Appraisal Report sheets supplied by the agricultural lender. Data on production characteristics, recreational opportunities, wildlife habitat, view characteristics, and development opportunities are collected from the Montana Cadastral Mapping Project, Montana Natural Resource Information System, and from the Montana Fish Wildlife and Parks.

Certain variables are obtained, in part, through Geographic Information System (GIS) analysis done by a third party. The GIS analysis consists of mapping each of the observations and comparing those maps with existing maps of towns, airports, ski resorts, waterways, wildlife habit, topography, precipitation, publicly owned land, and land types. Measurements are then constructed from this data.

The data consist of 401 land sales (each exceeding 40 acres) between the years of 1999 and 2009. Because repeat appraisals did not occur, the data are a cross section of agricultural land sales in Montana. Annual dummy variables are included to account for time factors. Table 1 provides descriptive statistics. Table 10 in Appendix A provides pairwise correlations for all major variables. The observations represent 33 counties in Montana. Carbon County has the most observations with 82, while five counties have only one observation. The average number of observations per county is 12. Table 2 lists the frequency of observations in each county.

Table 1. Descriptive Statistics.

Total Sample Size n = 401				
Variable	**Mean**	**Standard Deviation**	**Min Value**	**Max Value**
Total Price (2009 dollars)	$742,793	$1,177,218	$13,492	$10,419,768
Year (1999=1)	6.08	1.51	1	11
Total Acres	1,103	2,759	40	28,501
Building Value (2009 dollars)	$100,249	$344,285	$0	$4,694,171
CRP Acres	61.1	337.4	0.0	4,487.1
Dryland Crop Acres	98.3	311.2	0.0	2,893
Irrigated Crop Acres	24.4	78.9	0.0	786
Pasture Acres	650.2	1807.5	0.0	20,692
Improved Pasture Acres	32.6	200.8	0.0	3398
Site Acres	129.4	373.0	0.0	3,266
Unclassified Acres	107.2	1207.0	0.0	16,775
Town (Distance in Miles)	32.4	38.2	0.6	135.5
Airport (Distance in Miles)	45.8	27.8	0.6	133.7
Ski Resort (Distance in Miles)	79.6	76.7	2.0	279.7
Waterway (Proportion)	1,575.2	5,165.3	0.0	95,230.4
BRTrout Stream (Proportion)	59.7	447.3	0.0	5,325.1
Mule Deer (Percentage)	90.652	24.290	0.0	100.0
Whitetail Deer (Percentage)	50.927	47.500	0.0	100.0
Antelope (Percentage)	44.005	46.693	0.0	100.0
Elk (Percentage)	26.365	41.884	0.0	100.0
Pheasant (Percentage)	21.455	38.257	0.0	100.0
Blue Grouse (Percentage)	12.663	32.309	0.0	100.0
Ruffed Grouse (Percentage)	8.597	27.542	0.0	100.0
Sharp Grouse (Percentage)	72.740	42.044	0.0	100.0
Spruce Grouse (Percentage)	1.373	11.326	0.0	100.0
Precipitation (Zone in Inches)	16	11	7	34

Table 1. Descriptive Statistics (continued).

Total Sample Size n = 401				
Variable	**Mean**	**Standard Deviation**	**Min Value**	**Max Value**
Elevation (Average in Feet)	3,910	979	2,122	8,489
Topographic Diversity (Feet)	275	295	7	3,589
Conservation Easement (Binary)	0.06	NA	0	1
State Land (Binary)	0.28	NA	0	1
Federal Land (Binary)	0.23	NA	0	1
View Diversity Index	22.08	7.47	9.09	45.45

Total sales price is reported as *Total Price*. *Total Price* is deflated using the Bureau of Economic Analysis's Gross Domestic Product Implicit Price Deflator. The values are reported in 2009 dollars. The values range from $13,492 to $10,419,768 with an average of $742,793. Park County has the highest average total sales price at $3,470,023 and Carter County has the lowest at $41,311. Figure 1 and Table 2 present real total price statistics by county.

Table 2. Total Price by County.

County Name	Mean	Standard Deviation	Frequency
Beaverhead	$1,015,834.80	$916,680.58	5
Big Horn	$397,254.74	$379,724.12	42
Blaine	$754,026.41	$646,864.13	4
Broadwater	$835,633.41	$961,286.96	10
Carbon	$644,993.71	$792,472.43	82
Carter	$41,311.65	$0.00	1
Custer	$145,821.67	$101,243.57	5
Dawson	$122,389.48	$67,278.46	9
Deer Lodge	$126,150.44	$0.00	1
Fallon	$182,647.90	$203,172.64	20
Fergus	$1,813,006.30	$1,626,153.10	11
Gallatin	$3,219,023.50	$2,494,382.70	8
Garfield	$200,446.13	$90,962.15	5
Golden Valley	$744,814.11	$737,011.10	18

Table 2. Total Price by County (continued).

County Name	Mean	Standard Deviation	Frequency
Granite	$1,238,264.60	$1,277,803.60	3
Hill	$152,979.92	$0.00	1
Judith Basin	$281,427.66	$22,397.61	2
Lewis & Clark	$323,310.26	$241,142.31	3
Liberty	$409,777.87	$406,409.01	2
Madison	$636,236.98	$199,574.45	4
McCone	$239,595.40	$199,257.15	15
Meagher	$621,120.11	$599,403.65	4
Musselshell	$451,863.85	$261,213.46	13
Park	$3,470,023.90	$4,161,552.70	6
Petroleum	$853,467.13	$738,999.72	10
Powder River	$188,913.08	$132,760.94	4
Powell	$1,607,621.40	$0.00	1
Richland	$559,557.94	$0.00	1
Rosebud	$444,141.07	$628,507.79	6
Stillwater	$705,128.98	$950,852.23	60
Sweet Grass	$1,476,715.10	$1,405,963.30	25
Wibaux	$139,992.40	$204,555.96	13
Yellowstone	$1,339,024.80	$2,782,695.40	7

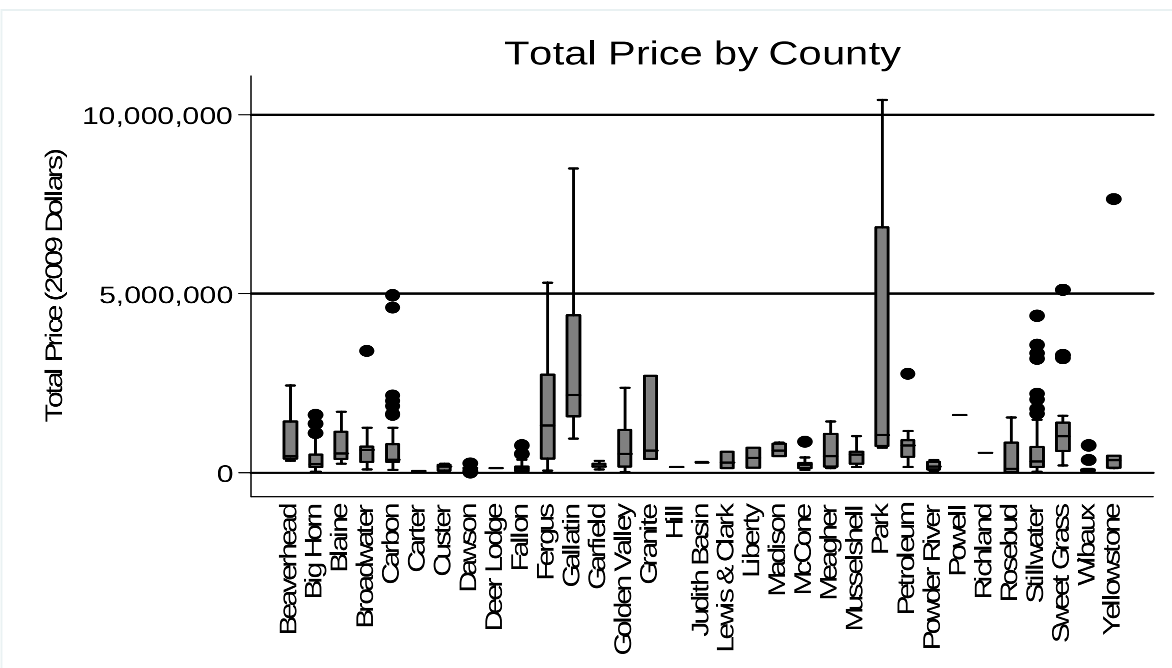

Figure 1. Box Plot of Total Price by County.

The independent variables that measure production characteristics include Acres, CRP Acres, Dryland Crop Acres, Irrigated Crop Acres, Pasture Acres, Improved Pasture Acres, Precipitation, and Topographic Diversity. The acreages are reported on appraisal sheets for each parcel. Total Acres is the total deeded acres of a parcel and is expected to have a positive relationship with Total Price. The parcels range in size from 40 acres to 28,501 acres. Total Acres is the sum of CRP Acres, Dryland Crop Acres, Irrigated Crop Acres, Pasture Acres, Improved Pasture Acres, Site Acres, and Unclassified Acres. When included in the model in place of Total Acres, these are each expected to have a positive relationship with Total Price and have different magnitudes reflecting productivity values.

Precipitation is measured in inches and is the average annual precipitation for each parcel. This variable is constructed using GIS analysis. A parcel may have different levels of precipitation across it, thus it is necessary to average the values of the zones to obtain a single number. The data source lists eight different levels for the amount of precipitation. The levels (in inches) are: 6-12, 12-14, 14-16, 16-22, 22-34, 34-60, 60-85, and 85+. The maps of these levels are compared to the map of each parcel and the value in inches that represents the average of the zones was chosen. Increased precipitation is expected to increase the total price of a parcel.

Topographic Diversity is measured as the difference between maximum and minimum elevations in feet of each parcel. This variable is constructed using GIS analysis. The topography of each parcel was obtained to determine the highest and lowest elevations. *Topographic Diversity* is expected to have a negative impact on *Total*

Price if the increase on production costs is greater than the value associated with better views obtained on more "rugged" parcels.

A non-production related variable that is also predicted to impact the value of land is *Building Value*. The appraised value of buildings is reported on the appraisal sheets for each parcel. *Building Value* is transformed into 2009 dollars and is predicted to have a coefficient estimate equal to one.

Recreation opportunities including *Town, Airport,* and *Ski Resort* may also affect land price. Each is collected using GIS analysis of information provided by the Montana Cadastral Mapping Project and is measured as distance (miles) a parcel is from its respective item. For the purposes of this study, a town of over 500 people is considered a population center. The a priori effect of *Town* is ambiguous. Greater distances from population centers may negatively affect demand because of travel costs. Conversely, the desire for "solitude" may lead to a positive relationship between *Town* and dependent variable in both models. Airports are defined as regional commercial airports. An increase in distance from an airport is predicted to have a negative effect on the price of parcels because of increased time to access the parcel for out-of-state owners. Skiing is a popular recreation activity in Montana. Therefore, parcels that are relatively closer to a ski resort are expected to have a larger sales prices than similar parcels that are further away. Nine ski resorts are considered with over one-half of the observations being closest to Red Lodge Mountain near Red Lodge, MT.

State Land and *Federal Land* also measure recreational opportunities associated with a parcel and/or a prohibition on nearby development. Their presences are determined using GIS analysis of information from the Montana Cadastral Mapping Project and are measured with binary variables. The maps of the parcels and maps of public land are overlaid and a visual analysis is used to determine a common borders between the items. A “1” indicates that the parcel borders that type of publically-owned land and a “0” indicates that it does not. Twenty-eight percent of parcels bordered State Land and 23 percent bordered Federal Land. It is expected that a price premium exists for bordering public land.

Wildlife habitat is measured by *Mule Deer*, *Whitetail Deer*, *Antelope*, *Elk*, *Pheasant*, *Blue Grouse*, *Ruffed Grouse*, *Sharp Tail Grouse*, *Waterway*, and *BR Trout Stream*. The data are collected using GIS analysis of information from the Montana Fish Wildlife and Parks. Maps of land parcels were overlaid with maps of wildlife habitats to determine the amount of habitat that lies within the boundaries of each parcel. It is important to note that different types of wildlife habitat often occur simultaneously on land parcels (e.g. *Mule Deer* and *Whitetail Deer*). The wildlife habitat variables are measured as a percentage of the size of each parcel multiplied by 100 to avoid multicollinearity of wildlife habitat acreages and *Total Acres*. The percentage is calculated by dividing each habitat acreage by the size of the parcel (*Total Acres*). The percentage transformation is preferred over measuring the wildlife habitat variables as simply the number of acres of each type of habit per parcel. See Tables 3 and 4 for correlations between wildlife habitat variables and Total Acres. The average proportion of a parcel with wildlife habitat varies across county and by species. Mule deer habitat is the most widely and evenly distributed as it exists on over 90% of parcels. Spruce grouse habitat is the least widely and most unevenly distributed with only six observations occurring in four counties. Tables 5 and 6 present information on the average proportion of wildlife habitat by species and county to illustrate the distribution of wildlife habitat across counties. The expected effects of wildlife habitat are ambiguous. Wildlife may have a positive effect on the price of a parcel due to increased recreational opportunities involved in hunting (and its possible commercial development) or because of viewing enjoyment. Negative effects could occur, however, if wildlife are a nuisance to agricultural production. This is much more likely if ungulates are present rather than birds.

Table 3. Correlations: Wildlife Habitat and Acres.

	Waterway	*BR Trout Stream*	*Mule Deer*	*Whitetail Deer*	*Antelope*	*Elk*
Waterway	1.00					
BR Trout Stream	0.10	1.00				
Mule Deer	0.89	0.03	1.00			
Whitetail Deer	0.53	0.11	0.40	1.00		
Antelope	0.84	-0.03	0.96	0.34	1.00	
Elk	0.75	0.08	0.77	0.35	0.67	1.00
Pheasant	0.12	-0.03	0.15	0.44	0.18	0.01
Blue Grouse	0.49	0.16	0.22	0.58	0.13	0.39
Ruffed Grouse	0.17	0.48	0.05	0.20	-0.04	0.17
Sharp Grouse	0.88	-0.02	0.99	0.37	0.96	0.75
Spruce Grouse	-0.01	-0.01	0.00	0.05	-0.02	0.04
Total Acres	0.86	0.02	0.98	0.35	0.95	0.79

Table 3. Correlations: Wildlife Habitat and Acres. (continued).

	Pheasant	*Blue Grouse*	*Ruffed Grouse*	*Sharp Grouse*	*Spruce Grouse*	*Total Acres*
Pheasant	1.00					
Blue Grouse	0.03	1.00				
Ruffed Grouse	-0.07	0.46	1.00			
Sharp Grouse	0.14	0.20	-0.04	1.00		
Spruce Grouse	-0.03	0.10	0.23	-0.04	1.00	
Total Acres	0.12	0.19	0.04	0.97	0.00	1.00

Table 4. Correlations: Wildlife Habitat (Measured as Percentage) and Acres.

	Waterway	*BR Trout Stream*	*Mule Deer*	*Whitetail Deer*	*Antelope*	*Elk*
Waterway	1.00					
BR Trout Stream	0.07	1.00				
Mule Deer	0.04	0.05	1.00			
Whitetail Deer	0.08	0.12	0.28	1.00		
Antelope	0.06	-0.03	0.27	-0.01	1.00	
Elk	-0.02	0.00	0.13	-0.02	-0.21	1.00
Pheasant	0.12	0.01	0.13	0.40	0.07	-0.17
Blue Grouse	0.01	0.05	-0.15	-0.04	-0.25	0.34
Ruffed Grouse	-0.01	0.09	0.04	0.08	-0.22	0.42
Sharp Grouse	0.03	-0.17	0.08	-0.03	0.25	-0.27
Spruce Grouse	0.00	-0.02	0.02	0.07	-0.10	0.20
Total Acres	-0.04	-0.04	-0.02	-0.16	0.15	0.07
Pheasant	1.00					

Table 4. Correlations: Wildlife Habitat (Measured as Percentage) and Acres (continued).

	Waterway	*BR Trout Stream*	*Mule Deer*	*Whitetail Deer*	*Antelope*	*Elk*
Blue Grouse	-0.13	1.00				
Ruffed Grouse	-0.17	0.62	1.00			
Sharp Grouse	0.25	-0.42	-0.41	1.00		
Spruce Grouse	-0.07	0.23	0.27	-0.16	1.00	
Total Acres	-0.14	-0.04	-0.06	0.07	-0.02	1.00

Table 5. Wildlife Habitat Average Proportion By County (Species Group 1).

County	**Obs.**	**Mule Deer**	**White Tail Deer**	**Antelope**	**Elk**	**Pheasant**
Beaverhead	5	0.955	0.400	0.368	0.600	0.200
Big Horn	42	0.569	0.294	0.222	0.087	0.179
Blaine	4	1.000	0.750	1.000	0.000	0.737
Broadwater	10	0.941	0.301	0.443	0.452	0.153
Carbon	82	0.929	0.590	0.112	0.131	0.274
Carter	1	1.000	1.000	1.000	0.000	0.000
Custer	5	0.953	0.216	0.100	0.000	0.067
Dawson	9	0.981	0.981	0.981	0.000	0.580
Deer Lodge	1	1.000	1.000	1.000	0.742	0.000
Fallon	20	0.963	0.530	0.961	0.000	0.032
Fergus	11	0.888	0.662	0.492	0.436	0.340
Gallatin	8	0.997	0.877	0.012	0.250	0.431
Garfield	5	0.996	0.396	0.397	0.200	0.000
Golden	18	0.959	0.120	0.734	0.056	0.076
Granite	3	0.996	0.996	0.000	0.716	0.000
Hill	1	1.000	1.000	1.000	0.000	0.000
Judith Basin	2	1.000	1.000	1.000	0.000	1.000
Lewis &	3	0.997	0.665	0.663	0.333	0.331
Liberty	2	0.982	0.982	0.982	0.500	0.982
Madison	4	0.999	0.237	0.999	0.999	0.000
McCone	15	0.991	0.924	0.924	0.000	0.291
Meagher	4	0.831	0.593	0.315	0.593	0.000
Musselshell	13	0.973	0.792	0.479	0.810	0.478
Park	6	0.976	0.809	0.251	0.227	0.000
Petroleum	10	0.969	0.266	0.620	0.772	0.138

Table 5. Wildlife Habitat Average Proportion by County (Species Group 1) (continued).

County	Obs.	Mule Deer	White Tail Deer	Antelope	Elk	Pheasant
Powder	4	0.987	0.500	0.895	0.500	0.000
Powell	1	0.943	0.943	0.000	0.943	0.000
Richland	1	1.000	1.000	0.009	0.000	0.408
Rosebud	6	0.913	0.000	0.601	0.072	0.000
Stillwater	60	0.966	0.340	0.427	0.437	0.074
Sweet Grass	25	0.876	0.466	0.323	0.572	0.148
Wibaux	13	0.991	0.961	0.991	0.000	0.690
Yellowstone	7	0.716	0.152	0.376	0.037	0.202
Total	401	0.907	0.509	0.440	0.264	0.215

Table 6. Wildlife Habitat Average Proportion By County (Species Group 2).

County Name	Obs.	Blue Grouse	Ruffed Grouse	Sharp Grouse	Spruce Grouse
Beaverhead	5	0.559	0.200	0.000	0.400
Big Horn	42	0.145	0.024	0.875	0.000
Blaine	4	0.000	0.000	0.500	0.000
Broadwater	10	0.190	0.452	0.667	0.000
Carbon	82	0.112	0.110	0.520	0.000
Carter	1	0.000	0.000	1.000	0.000
Custer	5	0.000	0.000	0.953	0.000
Dawson	9	0.000	0.000	0.981	0.000
Deer Lodge	1	1.000	0.307	0.000	0.000
Fallon	20	0.000	0.000	0.961	0.000
Fergus	11	0.180	0.001	0.812	0.000
Gallatin	8	0.622	0.250	0.750	0.000
Garfield	5	0.000	0.000	0.996	0.000
Golden Valley	18	0.000	0.000	0.959	0.000
Granite	3	0.996	0.996	0.000	0.667
Hill	1	0.000	0.000	1.000	0.000
Judith Basin	2	0.000	0.000	1.000	0.000
Lewis & Clark	3	0.000	0.347	0.459	0.000
Liberty	2	0.000	0.000	0.982	0.000
Madison	4	0.999	0.000	0.250	0.000
McCone	15	0.000	0.000	0.991	0.000
Meagher	4	0.629	0.355	0.000	0.141
Musselshell	13	0.000	0.077	0.973	0.000
Park	6	0.258	0.000	0.809	0.000
Petroleum	10	0.000	0.000	0.969	0.000
Powder River	4	0.000	0.000	0.987	0.000
Powell	1	0.000	0.943	0.943	0.943

Table 6. Wildlife Habitat Average Proportion By County (Species Group 2) (continued).

County Name	Obs.	Blue Grouse	Ruffed Grouse	Sharp Grouse	Spruce Grouse
Richland	1	0.000	0.000	1.000	0.000
Rosebud	6	0.000	0.000	0.913	0.000
Stillwater	60	0.081	0.083	0.686	0.000
Sweet Grass	25	0.159	0.169	0.435	0.000
Wibaux	13	0.000	0.000	0.991	0.000
Yellowstone	7	0.422	0.000	0.988	0.000
Total	401	0.127	0.086	0.727	0.014

Waterway and *BR Trout Stream* are measured in linear feet divided by *Total Acres*, with *BR Trout Stream* being a specific measure of high quality "blue ribbon" trout habitat. The values for these variables are obtained from GIS analysis. Maps of each parcel were overlaid with maps of these variables, and the lengths of waterways in each parcel were obtained. The average parcel has over 11,000 linear feet of waterway access. Only 13 observations in four counties (Beaverhead, Carbon, Stillwater, and Sweet Grass), however, have Blue Ribbon Trout Stream access. The average length of access for those observations is 5,909 linear feet. These variables are expected to increase the value of parcels.

The data on viewshed are collected using GIS analysis of information from the Montana Natural Resource Information System. The viewshed of each parcel is approximated by a series of binary variables indicating if a particular land type exists within a five mile radius around the border of a parcel. *View Diversity* was created by dividing the number of land types that lie within the viewshed of a parcel by the total number of land types. The quotient was then multiplied by 100. Land types considered are "mostly cropland," "cropland with grazing land," "irrigated land," "woodland and forest with some cropland and pasture," "forest and woodland mostly grazed," "forest and woodland mostly ungrazed," "subhumid grassland and semiarid grazing land," "open woodland grazed (juniper, aspen, brush)," "desert shrubland grazed," "urban areas," and "open water." The average *View Diversity* was 22.08. Increased view diversity should have a positive impact on the price of a parcel. It should be noted that the construction of this variable means that a *View Diversity* value of 20.0 is twice as good as a value of 10.0. This may or may not accurately measure the "quality" of viewsheds.

Elevation may also impact the view characteristics of a property. It may capture the ability to see a greater area from a parcel due to its height above its surroundings. If so, we would expect an increase in elevation would increase *Total Price*. However, a greater elevation may negatively affect the production characteristics of a parcel and, thus, decrease its value.

Restrictions on development opportunities are captured in *Conservation Easement*. Restrictions on land use and/or development in the form of a conservation easement would negatively affect the value of a parcel. It is measured by a binary variable with "1" indicating that the characteristic exists and "0" indicating that it does not. Six percent of parcels had a conservation easement.

It is reasonable to suspect that there may be regional time constant factors that affect *Total Price*. These time constant factors may be related to production characteristics associated with a region. For example, the production characteristics of Yellowstone County (where there is a relatively larger focus on irrigated crops) differ from the production characteristics of Park County (where there is a relatively larger focus on livestock production). In addition, regional land development issues may differ by county. For example, parcels located in Gallatin County might sell for a premium because the city of Bozeman is a popular community because of its educational and recreational attributes. Or, parcels in Park County might sell for a premium based upon the scenery of the Paradise Valley. The inclusion of county fixed coefficients is used to capture these regional affects. Gallatin County will be the base county.

CHAPTER 5

ESTIMATION AND ANALYSIS

This chapter presents the empirical analysis of the impacts of production attributes and recreation amenities on land prices. Two models and several functional forms are estimated. Model 1 uses *Total Price* of each parcel as the dependent variable and uses total size of parcels (measured as *Total Acres*) along with *Precipitation* and *Topographic Diversity* to capture production characteristics. The second model replaces *Total Acres* with separate variables for each of its components (i.e., *Dryland Crop Acres, Irrigated Crop Acres, Pasture Acres, Improved Pasture Acres, Site Acres,* and *Unclassified Acres*). Several functional forms are estimated for each of the models including linear, quadratic (the inclusion of the square of *Total Acres* in the level-level functional form for Model 1 and the square of each of the subcategory acreage variables for Model 2), semi-log, and semi-log quadratic. Log-Log and Box-Cox transformations of the independent variables functional forms were considered but not estimated because several explanatory variables have zero values. All models and specifications are estimated with Ordinary Least Squares (OLS) except when spatial autocorrelation is detected. Maximum Likelihood Estimation (MLE) that corrects for specific forms of spatial autocorrelation is used in those cases.

Model 1: Total Acres

A Breusch-Pagan (1979) / Cook-Weisberg (1983) test for heteroskedasticity indicated the presence of heteroskedasticity in the linear and the quadratic functional forms but not in either of the semi-log functional forms. Lagrange multiplier tests for spatial autocorrelation reject the null hypothesis of spatial lag independence in the semi-log and semi-log quadratic functional forms when using distance bands of 60 miles or less. This suggests that *LnTotal Price* of a parcel is not independent of *LnTotal Price* of another parcel when those parcels are within 60 miles of each other, but that they are independent when the parcels are more than 60 miles apart. Spatial lag dependence is also indicated in the semi-log functional forms with a greater p-value than that of the spatial error dependence. Tests with lower p-values levels should be used to identify the true form of spatial autocorrelation (Anselin and Berra 1998). Neither spatial error nor spatial lag dependence are indicated in either the linear or the quadratic functional forms. The linear and quadratic forms are estimated using OLS. They are reported as Specifications 1 and 2 in Table 7 with robust t-statistics generated from Huber (1967) and White (1980, 1982) robust standard errors. The semi-log and semi-log quadratic functional forms are estimated using Maximum Likelihood Estimation (MLE) to correct for spatial lag dependence for parcels within 60 miles of each other. The estimates of the spatial lag component (*Rho*) are statistically different than zero at the 5 percent level for both the semi-log and semi-log quadratic functional forms indicating that the MLE estimates are superior to their respective OLS counterparts. The semi-log and semi-log quadratic estimates are also reported in Table 7.

Table 7. OLS and MLE Regression Results for Model 1.

	Specification			
	(1)	(2)	(3)	(4)
	Linear	Quadratic	Semi-Log	Semi-Log Quadratic
	OLS	*OLS*	*MLE*	*MLE*
Variables	*Total Price*	*Total Price*	*LnTotal Price*	*LnTotal Price*
Total Acres	179.4***	412.1***	0.000127***	0.000502***
	(46.07)	(69.84)	(1.83e-05)	(4.24e-05)
Total Acres^2		-0.00953***		-1.53e-08***
		(0.00280)		(1.59e-09)
Building Value	0.750**	0.763**	3.61e-07***	3.84e-07***
	(0.332)	(0.349)	(1.19e-07)	(1.08e-07)
Town	-1879	1991	0.00291	0.00887*
	(4360)	(4066)	(0.00509)	(0.00464)
Airport	252.0	2599	-0.00573*	-0.00194
	(3054)	(2989)	(0.00338)	(0.00308)
Ski Resort	361.1	-3437	-0.00953**	-0.0154***
	(3534)	(3244)	(0.00392)	(0.00359)
Waterway	-7.791*	-1.784	-1.44e-05*	-4.77e-06
	(4.044)	(3.985)	(7.56e-06)	(6.89e-06)
BR Trout Stream	33.45	43.40	3.25e-05	4.75e-05
	(97.56)	(99.89)	(9.26e-05)	(8.35e-05)
Mule Deer	-1451	-1086	0.00416**	0.00478***
	(1784)	(1777)	(0.00200)	(0.00181)
Whitetail Deer	3140***	2934***	0.00372***	0.00341***
	(1100)	(1039)	(0.00108)	(0.000972)
Antelope	-1302	-2541**	-0.000468	-0.00249**
	(1257)	(1238)	(0.00126)	(0.00116)
Elk	-1520	-938.0	-0.000847	9.49e-05
	(1298)	(1235)	(0.00139)	(0.00126)
Pheasant	1921	2051	0.00114	0.00134
	(1733)	(1688)	(0.00141)	(0.00128)
Blue Grouse	-6494*	-6601*	-0.00336	-0.00353*
	(3652)	(3529)	(0.00223)	(0.00201)
Ruffed Grouse	921.6	2405	-0.00532**	-0.00291
	(3301)	(3200)	(0.00228)	(0.00208)
Sharp Tail Grouse	-1450	-1610	-0.00269*	-0.00298**
	(1374)	(1307)	(0.00138)	(0.00125)
Spruce Grouse	3423	966.4	0.00267	-0.00122
	(7160)	(6321)	(0.00553)	(0.00501)

Table 7. OLS and MLE Regression Results for Model 1 (continued).

	Specification			
	(1)	(2)	(3)	(4)
	Linear	Quadratic	Semi-Log	Semi-Log Quadratic
	OLS	*OLS*	*MLE*	*MLE*
Variables	*Total Price*	*Total Price*	*LnTotal Price*	*LnTotal Price*
Conservation	267426	169890	0.232	0.0746
	(270868)	(257102)	(0.185)	(0.168)
State Land	163085	49085	0.447***	0.263***
	(108396)	(109563)	(0.103)	(0.0949)
Federal Land	64079	-469.0	0.276**	0.172
	(119773)	(120116)	(0.120)	(0.108)
Elevation	62.88	27.52	6.74e-05	1.16e-05
	(150.3)	(143.3)	(0.000141)	(0.000127)
Topographic	947.1***	507.2**	0.000613***	-9.37e-05
	(306.5)	(246.3)	(0.000196)	(0.000192)
View Diversity	7929	5583	-0.000315	-0.00419
	(6400)	(6463)	(0.00621)	(0.00561)
Precipitation	12836	7441	0.0415*	0.0326*
	(26928)	(25152)	(0.0215)	(0.0194)
Constant	2.072e+06**	2.361e+06**	23.49***	23.35***
	(941190)	(929222)	(2.931)	(2.784)
Rho			-0.740***	-0.694***
			(0.204)	(0.195)
Observations	401	401	401	401
R-squared	0.640	0.667	0.656	0.720
Adjusted R-	0.572	0.6030		
Log likelihood			-434.74	-392.85

Robust standard errors in parentheses for Specification 1 and Specification 2
*** p<0.01, ** p<0.05, * p<0.1

The linear functional form (Specification 1) indicates *Acres* and *Topographic Diversity* are statistically significant. The year dummy variables are jointly significant and the dummy for the year 2007 is significant and positive while the rest are not statistically different than zero. The dummy variables for year are not reported in Table 7. The estimated coefficient for *Building Value* is statistically different than zero, and the predicted magnitude lies with in the standard error of the estimated coefficient. There is no estimated effect for *Town, Airport,* or *Ski Resort* and they are not jointly significant. *Waterway* and *Blue Grouse* is estimated to have a negative effect on the dependent variable, while *Whitetail Deer* is estimated to have a positive effect. All county dummy variables are statistically significant and negative with the exception of *Park* which is not statistically different than zero. This indicates that parcels not located in Gallatin or Park counties receive price discounts. Coefficient estimates for county dummy variables are omitted from Table 7.

The estimates of the quadratic functional form (Specification 2) are similar to the estimates of the linear functional form with a few exceptions. Specification 2 indicates that *Acres* and $Acres^2$ are statistically significant. *Topographic Diversity* is statistically significant and signed the same as in Specification 1. The year dummy variable for 2007 is statistically significant and positive. *Building Value* is positive and significant. There is no estimated effect for *Town, Airport,* or *Ski Resort* and they are not jointly significant. *Whitetail Deer, Antelope,* and *Blue Grouse* are estimated to be statistically different than zero. *Waterway* and *BR Trout Stream* are neither singularly or jointly significant. As in Specification 1, all county dummy variables are statistically significant and negative with the exception of *Park*. The significance of *Acres* and $Acres^2$ suggests that the quadratic functional form is preferred to the linear functional form.

The Maximum Likelihood Estimates (MLE) of the semi-log functional form correcting for spatial lag dependence are reported as Specification 3 in Table 7. *Total Acres* is estimated to be significant. Both *Precipitation* and *Topographic Diversity* are positive and statistically significant. The year dummy variables are jointly significant. An increase in the distance from a Ski Resort or Airport as measured by *Ski Resort* and *Airport* are estimated to decrease *Total Price*. The coefficients for *Waterway, Mule Deer, Whitetail Deer, Ruffed Grouse,* and *Sharp Tail Grouse* are each statistically different from zero. A premium is received for parcels bordering State Land and/or Federal Land. All county dummies are statistically significant and negative with the exceptions of *Powell* and *Richland*.

A simple comparison of R-squared coefficients between the semi-log functional form and the linear functional form is not appropriate because the two specifications have different dependent variables. Box and Cox (1964) outline a process by which to compare the linear and semi-log functional forms. The process compares the sum of squared residuals (SSRs) between:

(14) $y^* = X\beta + \varepsilon$

(15) $\ln y^* = X\delta + \varepsilon$

where

(16) $y^* = y(\exp(-(\Sigma \ln y)/ N)))$.

The regression with the smaller sum of squared residuals indicates the preferred functional form. A test statistic is offered to determine if the difference in SSRs is significant. It is defined as:

(17) $d = (N/2) \mid \log (SSR_1/SSR_2) \mid$

where SSR_1 and SSR_2 are from equations (14) and (15) respectively. The null hypothesis is that the two functional forms are equivalent. The *d* statistic follows a chi-squared distribution with one degree of freedom. *Total Price* is transformed into *Total Price* and LnTotal Price** and regressed onto the same variables as in Specifications 1 and 2. The process described by Box and Cox (1964) suggest that the semi-log functional form is preferred over linear functional form. The sum of squared residuals for the *Total Price** and the *LnTotal Price** regressions are 1.8478e+17 and 210.03, respectively. The *d*-statistic (6,899.37) rejects the null hypothesis that the two functional forms are empirically equivalent, and the smaller SSR of the semi-log functional form suggests that Specification 3 is preferred over Specification 1.

The MLE estimates of the semi-log quadratic functional form that correct for spatial lag dependence are reported as Specification 4 in Table 7. *Acres* and $Acres^2$ are significant and indicate that *LnTotal Price* increases with size at a decreasing rate until *Total Acres* is equal to 32,810.46. *Precipitation* is statistically significant and positive. *Topographic Diversity* has no effect. The time dummy variables are jointly significant. An increase in *Building Value* is estimated to increase *Total Price*. An increase in *Ski Resort* is estimated to decrease *Total Price*, while an increase in *Town* is estimated to increase *Total Price*. *Mule Deer* and *Whitetail Deer* are estimated to have positive effects while *Antelope, Blue Grouse* and *Sharp Grouse* are each estimated to negatively impact the price of a parcel. All of the county dummies are statistically significant and negative with the exceptions of *Powder River*, *Powell*, *Richland*, and *Wibaux* which are not statistically significant. This indicates that parcels not located within Gallatin County receive a price discount (with the exception of those parcels in Powder River, Powell, Richland, and Wibaux counties). *Total Acres*^{2} is highly significant (t-stat of -9.62) suggesting that Specification 4 is better than Specification 3.

Log likelihoods should be used to compare spatial models estimated by MLE (Anselin and Bera, 1998). Specification 3 is a restricted form of Specification 4. The likelihood ratio statistic is twice the difference of the log likelihoods, and it is approximately distributed as chi-squared with q degrees of freedom. The null hypothesis is that the difference in log likelihoods is not significant (Wooldridge, 2006). The likelihood ratio statistic between Specification 4 and Specification 3 is 83.78, and is greater than the critical value of 6.63 needed for a 0.01 significance level for the Chi-Square distribution with one degree of freedom. This suggests a preference of the semi-log quadratic functional form over the semi-log functional form. The sum of squared residuals for the *Total Price** and the *LnTotal Price** regressions are 1.7106e+17 and 170.12, respectively. The *d*-statistic (6926.13) rejects the null hypothesis that the two functional forms are empirically equivalent, and the smaller SSR for the semi-log quadratic functional form suggests the preference of Specification 4 over Specification 2. This makes the semi-log quadratic the preferred functional form for Model 1.

Model 2: Acreage Components

OLS is used to estimate Model 2 with *Total Price* as the dependent variable and *Total Acres* replaced with its subcategory components. A Breusch-Pagan (1979) / Cook-Weisberg (1983) test for heteroskedasticity indicates the presence of heteroskedasticity in the linear and the quadratic functional forms, but not in either of the semi-log functional forms. Lagrange multiplier tests for spatial autocorrelation reject the null hypothesis of spatial lag independence in the semi-log and semi-log quadratic functional forms when using distance bands of 60 miles or less. Neither spatial error nor spatial lag dependence were indicated in either the linear or the quadratic functional forms.

Estimates for the linear and quadratic forms are reported as Specifications 5 and 6 in Table 8 with robust t-statistics generated from Huber (1967) and White (1980, 1982) robust standard errors. The semi-log and semi-log quadratic functional forms are estimated using Maximum Likelihood Estimation (MLE) to correct for spatial lag dependence for parcels within 60 miles of each other. The estimates of the spatial lag component (*Rho*) are statistically different than zero at the 5 percent level for both the semi-log and semi-log quadratic functional forms indicating that the MLE estimates are superior over their OLS counterparts. The semi-log and semi-log quadratic estimates are also reported in Table 8 as Specification 7 and 8, respectively.

Table 8. OLS and MLE Regression Results for Model 2.

	Specification			
	(5)	(6)	(7)	(8)
Variables	Linear *OLS* *Total Price*	Quadratic *OLS* *Total Price*	Semi-Log *MLE* *LnTotal Price*	Semi-Log Quadratic *MLE* *LnTotal Price*
CRP Acres	118.7	454.8**	0.000137	0.00136***
	(124.0)	(195.2)	(0.000148)	(0.000274)
CRP Acres^2		-0.0693		-3.05e-07***
		(0.128)		(9.73e-08)
Dryland Crop Acres	180.2*	389.5	0.000632***	0.00179***
	(106.9)	(340.8)	(0.000123)	(0.000288)
Dryland Crop Acres^2		-0.0932		-6.45e-07***
		(0.143)		(1.37e-07)

Table 8. OLS and MLE Regression Results for Model 2 (continued).

	Specification			
	(5)	(6)	(7)	(8)
Variables	Linear *OLS* *Total Price*	Quadratic *OLS* *Total Price*	Semi-Log *MLE* *LnTotal Price*	Semi-Log Quadratic *MLE* *LnTotal Price*
Irrigated Crop Acres	865.0	2672**	0.00173***	0.00535***
	(650.0)	(1340)	(0.000517)	(0.00114)
Irrigated Crop Acres^2		-3.770		-7.91e-06***
		(4.483)		(2.81e-06)
Pasture Acres	341.9***	326.1***	0.000214***	0.000542***
	(43.63)	(81.73)	(2.82e-05)	(5.16e-05)
Pasture Acres^2		0.00177		-2.21e-08***
		(0.00370)		(3.09e-09)
Improved Pasture Acres	286.6**	708.0	0.000440**	0.00158***
	(118.3)	(466.4)	(0.000178)	(0.000456)
Improved Pasture Acres^2		-0.134		-3.31e-07**
		(0.135)		(1.46e-07)
Site Acres	1076***	1746***	0.000788***	0.00226***
	(130.2)	(499.3)	(0.000107)	(0.000252)
Site Acres^2		-0.246		-4.83e-07***
		(0.155)		(8.46e-08)
Unclassified Acres	0.347	-6.305	-2.42e-05	0.000255
	(64.75)	(156.7)	(3.97e-05)	(0.000196)
Unclassified Acres^2		-0.00190		-2.51e-08**
		(0.0107)		(1.21e-08)
Building Value	0.732**	0.705**	3.26e-07***	3.37e-07***
	(0.340)	(0.338)	(1.10e-07)	(9.82e-08)
Town	784.5	1847	0.00622	0.00767*
	(3746)	(4046)	(0.00475)	(0.00433)
Airport	949.3	1500	-0.00419	-0.000931
	(2526)	(2541)	(0.00314)	(0.00278)
Ski Resort	-2579	-2118	-0.0121***	-0.0109***
	(2855)	(2780)	(0.00371)	(0.00329)
Waterway	-1.628	-0.0277	-7.43e-06	8.02e-07
	(3.399)	(3.371)	(6.96e-06)	(6.16e-06)

Table 8. OLS and MLE Regression Results for Model 2 (continued).

	Specification			
	(5)	(6)	(7)	(8)
Variables	Linear *OLS* *Total Price*	Quadratic *OLS* *Total Price*	Semi-Log *MLE* *LnTotal Price*	Semi-Log Quadratic *MLE* *LnTotal Price*
BR Trout Stream	54.18	61.48	7.15e-05	7.64e-05
	(98.50)	(96.68)	(8.48e-05)	(7.44e-05)
Mule Deer	-2025	-2371	0.00392**	0.00381**
	(1597)	(1606)	(0.00184)	(0.00162)
Whitetail Deer	2370**	1990**	0.00273***	0.00213**
	(972.5)	(946.3)	(0.000994)	(0.000884)
Antelope	-1644	-1983	-0.00121	-0.00281***
	(1119)	(1209)	(0.00117)	(0.00104)
Elk	-1325	-1301	0.000245	0.000209
	(1154)	(1195)	(0.00129)	(0.00113)
Pheasant	1508	1491	0.000925	0.00166
	(1589)	(1552)	(0.00129)	(0.00114)
Blue Grouse	-4918	-4987	-0.00296	-0.00374**
	(3241)	(3193)	(0.00206)	(0.00181)
Ruffed Grouse	2032	1748	-0.00403*	-0.00258
	(3033)	(3104)	(0.00210)	(0.00187)
Sharp Tail Grouse	-904.9	-458.4	-0.00228*	-0.00218*
	(1204)	(1277)	(0.00126)	(0.00112)
Spruce Grouse	2394	749.2	-0.000305	-0.00378
	(6370)	(6047)	(0.00513)	(0.00459)
Conservation Easement	-18004	-15096	-0.0193	0.00820
	(271697)	(292597)	(0.176)	(0.157)
State Land	90942	106517	0.326***	0.233***
	(94738)	(95021)	(0.0956)	(0.0870)
Federal Land	35060	37068	0.188*	0.149
	(106457)	(104760)	(0.111)	(0.0979)
Elevation	93.52	88.23	7.33e-05	4.24e-05
	(139.5)	(134.9)	(0.000130)	(0.000115)
Topographic Diversity	235.4	189.0	0.000128	-0.000241
	(216.8)	(223.4)	(0.000196)	(0.000177)

Table 8. OLS and MLE Regression Results for Model 2 (continued).

	Specification			
	(5)	(6)	(7)	(8)
Variables	Linear *OLS* *Total Price*	Quadratic *OLS* *Total Price*	Semi-Log *MLE* *LnTotal Price*	Semi-Log Quadratic *MLE* *LnTotal Price*
View Diversity	2523	2928	-0.00676	-0.000851
	(6130)	(5890)	(0.00577)	(0.00509)
Precipitation	-3668	5244	0.0338*	0.0431**
	(24340)	(24998)	(0.0199)	(0.0176)
Constant	2.449e+06***	2.302e+06**	24.23***	22.62***
	(882315)	(893300)	(2.770)	(2.618)
Rho			-0.774***	-0.672***
			(0.194)	(0.184)
Observations	401	401	401	401
R-squared	0.721	0.730	0.704	0.780
Adjusted R-squared	0.664	0.667		
Log likelihood			-398.42	-344.66

Robust standard errors in parentheses for Specification 5 and Specification 6
*** p<0.01, ** p<0.05, * p<0.1

The linear functional form (Specification 5 in Table 8) includes CRP Acres, Dryland Crop Acres, Irrigated Crop Acres, Pasture Acres, Improved Pasture Acres, Site Acres, and Unclassified Acres. The estimated coefficients for Dryland Crop Acres, Pasture Acres, Improved Pasture Acres, and Site Acres are positive with Site Acres having the largest impact on Total Price. None of the time dummy variables are individually significant, nor are they jointly significant. The estimated coefficient for Building Value is statistically significant. The estimated coefficients for Town, Airport, or Ski Resort are not statistically significant (either jointly or individually). Whitetail Deer habitat is estimated to have a positive effect on the total sales price of a parcel. None of the other wildlife habitat variables are significant. F-tests do not indicate joint significance for the water variables, bird habitat variables, ungulate habitat variables (excluding Whitetail Deer), nor all wildlife habitat variables. All of the estimated effects of the county dummy variables are significant and negative, with the exception of effect of Park County which is not statistically different than zero.

The quadratic functional form (Specification 6) has somewhat different estimated coefficients than Specification 5. *Irrigated Crop Acres* is significant while *Dryland Crop Acres* is not and *CRP Acres* is significant while *Improved Pasture Acres* is not. *Pasture Acres* and *Site Acres* are significant. None of the time dummy variables are significant, nor are they jointly significant. The estimated coefficient on *Building Value* is still significant. The estimated effects for a parcel's distance from a *Town*, *Ski Resort*, or *Airport* are not jointly significant. The estimated effects of *Whitetail Deer* are significant. The results of the F-test indicating joint significance of the quadratic terms suggests the preference of the quadratic functional form over the linear functional form.

The MLE estimates of the semi-log functional form that corrects for spatial lag dependence are reported as Specification 7. All the acreage variables are significant with the exceptions of *CRP Acres* and *Unclassified Acres*. The acreage variable coefficients are positive as predicted with *Irrigate Crop Acres* estimated to increase *LnTotal Price* the most. *Precipitation* is significant and positive while *Topographic Diversity* is not significant. The estimated effects of the time dummy variables are not significant (singularly or jointly). *Ski Resort* is estimated to have a negative impact while *Town* and *Airport* have no impacts on the dependent variable (nor are they jointly significant). The estimated effects of increases in *Mule Deer* and *Whitetail Deer* are statistically significant and positive, while the estimated effects of increases in *Ruffed Grouse* and *Sharp Tail Grouse* are statistically significant and negative. There are estimated positive effects for both of the public land variables. The estimated effects of the county dummy variables are all statistically significant and negative with the exceptions of *Powell* and *Richland* which are not statistically significant.

The Box and Cox (1964) procedure suggests that the semi-log functional form is preferred over linear functional form. The sum of squared residuals for the *Total Price** and the *LnTotal Price** regressions are 1.4282e+17 and 176.47, respectively. The *d*-statistic (6882.61) rejects the null hypothesis that the two functional forms are empirically equivalent, and the smaller SSR for the semi-log functional form suggests the preference of Specification 7 over Specification 5.

The MLE estimates of the semi-log quadratic functional form that corrects for spatial lag dependence are reported as Specification 8. All the coefficients for the acreage variables are significant with the exception of *Unclassified Acres*. *Precipitation* is estimated to have a positive effect. The estimates suggest that the log of land prices increases at a decreasing rate with increases in size. *Topographic Diversity* is estimated to have no effect. There is no estimated effect for the time dummy variables (either jointly or singularly). An increase equal to one standard deviation in *Building Value* is estimated to increase *Total Price* by approximately 11.6 percent which is similar to the result in Specification 7. *Ski Resort* is estimated to decrease *Total Price* by approximately 1.09 percent per mile which is slightly less than the result in Specification 7. *Town* is estimated to increase *Total Price* by approximately 0.77 percent per mile.

Airport is estimated to have no effect on *LnTotal Price*. *Mule Deer,* and *Whitetail Deer,* are estimated to have positive effects, while *Antelope, Blue Grouse,* and *Sharp Grouse* are estimated to negatively impact *Total Price*. A premium equal to 26.23 percent is estimated for parcels bordering State Land.[2] *Powell* and *Madison* are the only county dummy variables whose estimated effect is not statistically significant.

The likelihood ratio statistic between Specification 7 and Specification 8 is 108 which is greater than the critical value of 6.63 needed for a 0.01 significance level for the Chi-Square distribution with one degree of freedom. This suggests the semi-log quadratic functional form is preferred over the semi-log functional form. Also, an F-test rejects that the joint insignificance of the squared acreage variables. The sum of squared residuals for the *Total Price** and the *LnTotal Price** regressions are 1.3845e+17 and 136.46, respectively. The *d*-statistic (6,927.93) rejects of the null hypothesis that the two functional forms are empirically equivalent, and the smaller SSR for the semi-log quadratic functional form suggests the preference of Specification 8 over Specification 6. Specification 8 is also preferred over Specification 4 from Model 1 based on F-tests that reject the null hypothesis that effects of the acreage variables are equivalent and that their squares are equivalent (both with p-values of less than 0.005) to the estimated values of *Total Acres* and *Total Acres*^{2}. Also the likelihood ratio statistic between Specification 8 and its restricted model Specification 4 is equal to 96.38 which is greater than the critical value of 29.14 needed for a 0.01 significance level for the Chi-Square distribution with 14 degrees of freedom.

[2.] The transformation of the estimated coefficient of a dummy variable upon the dependent variable follows from Halvorsen and Palmquist (1980).

Summary

Specification 8 is the preferred model based upon goodness of fit factors. It provides estimates of the acreage variables that are statistically different from each other. It found statistically significant effects for several amenity variables. Some of these effects were estimated to be positive, while some were estimated to be negative. The economical significance of the amenity variables is shown in Table 9.

Table 9. Economic Significance of Select Variables from Specification 8.

Variable	**Standard Dev.**	**Coefficient**	**Economic Effect**
Town	38.2 Miles	9.82e-08	0.000375%
Ski Resort	76.7 Miles	-0.0109	-83.6%
Mule Deer	24.29%	0.00381	9.3%
Whitetail Deer	47.50%	0.00213	10.1%
Antelope	46.69%	-0.00281	-13.1%
Blue Grouse	32.31%	-0.00374	-12.1%
Sharp Tail Grouse	42.04%	-0.00218	-9.2%
State Land	NA	0.233	26.2%

The economic significance is determined by multiplying the standard deviation of the variable by the estimated coefficient from Specification 8. The resulting product can be interpreted as the approximate percentage change in the sales price of a parcel given a change (of a likely magnitude) in one of the amenity variables. The distance a parcel is from a ski resort is the most economically significant.

The average parcel is less than eighty miles away from a ski resort, the closest is two miles, and the furthest is 280 miles away. An increase in one standard deviation of the distance a parcel is from a ski resort (equal to 76.7 miles) is estimated to decrease the sale price by 83.6 percent, all else equal. This is a large effect, and likely reflects the greater demand for parcels that are located in mountainous regions and the amenities that they provide.

The distance a parcel is from a town is not economically significant. An increase in the distance a parcel is from town (equal to one standard deviation) has a miniscule effect on the sales price. This suggests that the seclusion value offered by being further away from town is just greater than the increased costs to travel to town.

The economic effect of a parcel bordering state land is relatively great. Twenty-eight percent of the parcels in the sample bordered state land; those parcels received a premium of over 26 percent for other parcels, when controlling other factors. This likely represents the increased recreational opportunities associated with being able to access public land.

The economic effects of changes in wildlife habitat are non-trivial. A ten percent change in the average parcel's sale price is equal to roughly $74,000. This suggests that wildlife habitat (of certain species) is important in determining a parcel's value.

It is possible that the negative values of the estimated coefficients for *Antelope*, *Blue Grouse*, and *Sharp Tail Grouse* variables are due to the limited number of observations for some counties. Counties that have few observations and little variation in the amount of habitat of different species may cause some of the wildlife habitat variables to reflect the effect of the county and not the true effect of the habitat. To test this hypothesis, a regression that drops observations that lie within counties with fewer than ten observations is estimated. There are no changes in the directional effects of the variables, and only slight changes in the magnitudes and standard deviations of the estimated coefficients. Thus, the negative values of the habitat variables in Specification 8 are not due to the limited amount of observations in some counties.

The estimated negative impacts in Specification 8 does not necessarily mean that all wildlife are a nuisance to agricultural production and, thus, decrease a parcels sale price. It is possible that wildlife habitat is correlated with land that is poorly suited to agricultural production. Sharp tail grouse and antelope may prefer habitat that is populated with sagebrush. Land covered in sagebrush is relatively less productive than grassland. Since there is no control variable available for sagebrush, *Antelope* and *Sharp Tail Grouse* may be acting as proxies. The same argument may be made for *Blue Grouse* with respect to heavily wooded land.

The amenity variables that are statistically significant are also economically significant (with the exception of *Town*). The location of a parcel with respect to a ski resort appears to have the most effect of the amenity variables. The wildlife habitat variables are also important, but may not necessarily estimate the true effects of wildlife. The estimated amenity effects are relatively stable across both models and all specifications. A semi-log quadratic, however, is deemed to provide the best fit.

CHAPTER 6

SUMMARY AND CONCLUSIONS

Summary

The research presented in this thesis expanded on efforts by Bastian et al. (2002). Bastian et al. examines agricultural land sales within Wyoming, while this thesis examines agricultural land sales within Montana. Both studies address the contributions of amenities to the value of agricultural land parcels. Bastian et al. focuses on elk habitat, fishing, and view amenities, while this thesis considers a broader array of amenities. Bastian et al. selects linear and semi-log hedonic specifications over quadratic specifications, while this research finds that a semi-log quadratic specification is preferred.

Bastian et al. uses price per acre as the dependent variable, while this thesis total price of land parcels is the dependent variable. The total price of a parcel probably affects decisions by buyers and sellers more directly than associated per acre prices. Also, the use of price per acre as a dependent variable a introduces a common trend between the dependent and independent variables as the dependent variable and some of the independent variables are being divided by the measure (acres).

Bastian et al. finds that elk habitat increases a parcel's value as does view diversity, fish habitat, and distance from a town. In the present study elk habitat, fish habitat, and view diversity are not statistically significant. However, distance from a town, distance from a ski resort, deer habitat, bird habitat, and borders with public land are all statistically significant.

Conclusions

The analysis presented in this thesis suggests that types, quantities, and quality of recreational amenities are important for Montana agricultural land values. The total sale price of a parcel of agriculture land is influenced by wildlife habitat, distances from recreation opportunities, topographic features, and location. The purpose of this study is to quantify the effects of these amenities on total sales price. Quantifying these effects is important to agricultural producers who must make decisions that may affect the quantity and quality of certain amenities. It is also important to policy makers and policy analysts who may offer policies that affect (either directly or indirectly) amenities. An important example is policy that expands or contracts the range of certain species of wildlife such as changes in hunting regulations. A direct application of this study is to create an appraisal tool for land owners, buyers, and financial institutions.

Data for this study are supplied by an agricultural lending organization and obtained from the Montana Cadastral Mapping Project, Montana Natural Resource Information System, and from the Montana Fish Wildlife and Parks. The data consisted of information about a land parcel's production characteristics and amenities at the time of sale.

Two hedonic land price models are estimated. The total price of each parcel is used as a dependent variable for both models. Production characteristics included total acres in one model and its subcategory components in the other. Four functional forms are estimated for each model to examine possible non-linear relationships between independent variables and the dependent variable. The preferred model allowed for the interpretation of the individual acreage effects. A semi-log quadratic functional form is found to best fit the data for both models. Spatial autocorrelation is considered a possible problem for this study. Tests indicated the presence of spatial lag dependence in both models in the logarithmic functional forms. Maximum likelihood estimation techniques are used to correct for bias created by spatial lag dependence.

Correcting for spatial lag dependence has little consequence for the results. Table 11 in Appendix B provides a table comparing the OLS and MLE estimation results for the preferred specification. The two estimation techniques provide similar estimated results. The two techniques share the same statistically significant estimated coefficients except for the impact of distance from town. The estimated magnitudes of the statistically significant coefficients do not vary much between the two techniques.

The results for the preferred specification indicate that the value of a parcel is decreased by being further away from a ski resort, but increased by being further away from a town. Mule deer habitat and whitetail deer habitat are found to increase property values while antelope, sharp tail grouse habit, and blue grouse habitat are found to decrease property values. Parcels are found to be worth more if they border State Land.

There may be a problem separating out the contributions of production characteristics and amenities to land value. This may be due to the inexact nature of the production characteristic variables employed in the model. Animal Unit Months and crop yields may be a better option for controlling for production characteristics rather than broad usage categories. Also, the wildlife habitat variables may not be specific enough to capture the actual wildlife/human interaction that may take place on an individual parcel. The available data describe a broad range of specific species habitat, but may not be detailed enough to capture the actual habitat that is available on any one parcel. There may also be problems with certain species of wildlife habitat being correlated with production characteristics that are not represented in the data. For example, antelope habitat may not actually decrease a parcels sale price, but may be correlated with relatively unproductive land.

The results from this study can be used to create an appraisal tool that accounts for wildlife habitat and other location factors of land parcels when estimating its market value. The preferred model can be used as a predictive equation. The differences between the OLS and MLE estimates for Specification 8 are not economically significant enough to merit the greater difficulty in obtaining predictions while controlling for spatial lag dependence. A simple computer application could be written that prompts usesr to enter values for amenities considered in this thesis. Those values would then be used to predict the log of the estimated total value. That log then can be transformed into estimated total value by taking its anti-log and multiplying by 0.74384. [3]

Future research with respect to amenity contributions to agricultural land value should focus on detailed production characteristic variables and detailed wildlife habitat

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[3.] This number was obtained by regressing Total Price on the anti-log of the fitted values obtained from the OLS estimates of the preferred specification (Wooldridge, 2006).

variables. The inclusion of more detailed production characteristics may increase the importance of wildlife habitat variables.

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APPENDICES

APPENDIX A

PAIRWISE CORRELATIONS OF PRIMARY VARIABLES

Table 10. Pairwise Correlations of Primary Variables.

	Total Price	*Total Acres*	*Building Value*	*CRP Acres*	*Dryland Crop Acres*	*Irrigated Crop Acres*	*Pasture Acres*
Total Price	1.00						
Total Acres	0.53	1.00					
Building Value	0.31	0.06	1.00				
CRP Acres	0.17	0.57	-0.02	1.00			
Dryland Crop Acres	0.11	0.35	0.03	0.27	1.00		
Irrigated Crop Acres	0.12	0.15	0.07	0.30	-0.02	1.00	
Pasture Acres	0.55	0.84	0.06	0.23	0.18	0.14	1.00
Improved Pasture Acres	0.12	0.21	-0.01	0.12	0.08	0.12	0.16
Site Acres	0.32	0.02	0.09	-0.06	-0.10	-0.10	-0.12
Unclassified Acres	0.20	0.73	0.01	0.58	0.21	0.00	0.31
Town	-0.20	-0.02	-0.14	0.05	0.18	-0.14	-0.04
Airport	-0.07	0.16	-0.05	0.18	0.16	-0.02	0.07
Ski Resort	-0.25	-0.03	-0.14	0.06	0.14	-0.07	-0.01
Waterway	-0.01	-0.04	0.05	-0.03	-0.04	-0.01	-0.03
BRTrout Stream	0.08	-0.04	0.19	-0.02	-0.04	-0.04	-0.05
Mule Deer	0.06	-0.02	0.06	-0.02	0.02	-0.03	-0.02
Whitetail Deer	0.07	-0.16	0.05	-0.02	-0.02	0.10	-0.18
Antelope	-0.09	0.15	-0.06	0.12	0.25	-0.04	0.16
Elk	0.15	0.07	0.05	-0.05	-0.15	0.02	0.09
Pheasant	-0.09	-0.14	-0.07	-0.03	-0.01	0.07	-0.15
Blue Grouse	0.09	-0.04	0.01	-0.05	-0.07	-0.02	-0.01
Ruffed Grouse	0.06	-0.06	0.00	-0.06	-0.10	-0.06	-0.06
Sharp Grouse	-0.09	0.07	-0.01	0.07	0.13	0.06	0.09
Spruce Grouse	0.04	-0.02	-0.01	-0.02	-0.04	-0.04	-0.02
Precipitation	0.07	0.02	-0.01	-0.02	-0.01	-0.04	0.02
Elevation	0.26	-0.04	0.08	-0.11	-0.16	-0.07	-0.01
Topographic Diversity	0.48	0.45	0.14	0.09	0.05	0.12	0.52
Conservation Easement	0.20	0.04	0.17	0.10	-0.05	0.05	0.03
State Land	0.18	0.34	-0.04	0.18	0.24	0.08	0.35
Federal Land	0.18	0.27	0.07	0.14	0.06	0.13	0.26
View Diversity Index	0.14	0.03	-0.01	0.01	0.01	0.09	0.05

Table 10. Pairwise Correlations of Primary Variables (continued).

	Improved Pasture Acres	*Site Acres*	*Unclassified Acres*	*Town*	*Airport*	*Ski Resort*	*Waterway*
Improved Pasture Acres	1.00						
Site Acres	-0.05	1.00					
Unclassified Acres	0.02	-0.03	1.00				
Town	0.01	-0.19	0.02	1.00			
Airport	0.06	-0.04	0.16	0.51	1.00		
Ski Resort	-0.03	-0.20	-0.03	0.83	0.52	1.00	
Waterway	-0.02	-0.00	-0.02	-0.05	-0.01	-0.04	1.00
BRTrout Stream	0.01	0.06	-0.01	-0.06	-0.02	-0.11	0.07
Mule Deer	0.04	0.08	-0.05	0.16	0.04	0.04	0.04
Whitetail Deer	-0.05	0.02	-0.09	0.23	0.01	0.13	0.08
Antelope	0.12	-0.16	0.04	0.51	0.33	0.49	0.06
Elk	0.01	0.21	0.02	-0.17	0.06	-0.24	-0.02
Pheasant	-0.04	-0.09	-0.05	0.13	-0.10	0.10	0.12
Blue Grouse	-0.02	0.02	-0.03	-0.08	-0.10	-0.25	0.01
Ruffed Grouse	0.01	0.09	-0.03	-0.06	-0.08	-0.21	-0.01
Sharp Grouse	0.04	-0.18	0.01	0.19	0.12	0.41	0.03
Spruce Grouse	0.12	-0.04	-0.01	0.14	0.06	-0.09	0.00
Precipitation	-0.01	0.14	-0.01	0.00	0.00	-0.02	-0.01
Elevation	0.03	0.17	-0.06	-0.44	-0.39	-0.67	0.02
Topographic Diversity	0.12	0.23	0.12	-0.14	0.00	-0.24	0.02
Conservation Easement	0.00	0.15	-0.02	-0.06	0.00	-0.10	0.04
State Land	0.16	-0.05	0.13	0.18	0.22	0.18	0.05
Federal Land	0.05	0.08	0.14	0.07	0.22	-0.02	-0.03
View Diversity Index	-0.01	0.08	-0.05	-0.12	-0.17	-0.16	0.06

Table 10. Pairwise Correlations of Primary Variables (continued).

	BR Trout Stream	*Mule Deer*	*Whitetail Deer*	*Antelope*	*Elk*	*Pheasant*	*Blue Grouse*
BR Trout Stream	1.00						
Mule Deer	0.05	1.00					
Whitetail Deer	0.12	0.28	1.00				
Antelope	-0.03	0.27	-0.01	1.00			
Elk	0.00	0.13	-0.02	-0.21	1.00		
Pheasant	0.01	0.13	0.40	0.07	-0.17	1.00	
Blue Grouse	0.05	-0.15	-0.04	-0.25	0.34	-0.13	1.00
Ruffed Grouse	0.09	0.04	0.08	-0.22	0.42	-0.17	0.62
Sharp Grouse	-0.17	0.08	-0.03	0.25	-0.27	0.25	-0.42
Spruce Grouse	-0.02	0.02	0.07	-0.10	0.20	-0.07	0.23
Precipitation	0.05	-0.03	-0.05	-0.02	0.06	-0.07	0.14
Elevation	0.15	0.01	-0.12	-0.32	0.37	-0.30	0.58
Topographic Diversity	-0.03	0.06	-0.11	-0.06	0.43	-0.27	0.33
Conservation Easement	0.12	0.04	0.08	-0.08	0.23	-0.07	0.25
State Land	0.01	0.15	-0.02	0.34	-0.02	-0.04	-0.04
Federal Land	0.03	0.03	-0.09	-0.07	0.35	-0.18	0.26
View Diversity Index	0.10	0.16	0.21	-0.16	0.15	-0.03	0.09

Table 10. Pairwise Correlations of Primary Variables (continued).

	Ruffed Grouse	*Sharp Grouse*	*Spruce Grouse*	*Precipitation*	*Elevation*	*Topographic Diversity*
Ruffed Grouse	1.00					
Sharp Grouse	-0.41	1.00				
Spruce Grouse	0.27	-0.16	1.00			
Precipitation	0.11	-0.13	0.05	1.00		
Elevation	0.44	-0.61	0.28	0.18	1.00	
Topographic Diversity	0.27	-0.20	0.09	0.13	0.39	1.00
Conservation Easement	0.27	-0.08	0.15	0.18	0.20	0.14
State Land	-0.02	0.06	0.02	-0.06	-0.08	0.24
Federal Land	0.32	-0.17	0.07	0.10	0.15	0.40
View Diversity Index	0.13	-0.11	0.02	0.03	0.09	0.16

Table 10. Pairwise Correlations of Primary Variables (continued).

	Conservation Easement	*State Land*	*Federal Land*	*View Diversity Index*
Conservation Easement	1.00			
State Land	-0.01	1.00		
Federal Land	0.07	0.09	1.00	
View Diversity Index	0.11	-0.02	-0.03	1.00

APPENDIX B

COMPARISON OF OLS AND MLE ESTIMATIONS FOR SPECIFICATION 8

Table 11. OLS and MLE Regression Results for Specification 8.

	Specification 8	
	OLS	**MLE**
	Semi-Log Quadratic	**Semi-Log Quadratic**
Variables	***LnTotal Price***	***LnTotal Price***
CRP Acres	0.00138***	0.00136***
	(0.000311)	(0.000274)
CRP Acres^2	-2.94e-07***	-3.05e-07***
	(1.11e-07)	(9.73e-08)
Dryland Crop Acres	0.00178***	0.00179***
	(0.000328)	(0.000288)
Dryland Crop Acres^2	-6.44e-07***	-6.45e-07***
	(1.56e-07)	(1.37e-07)
Irrigated Crop Acres	0.00557***	0.00535***
	(0.00129)	(0.00114)
Irrigated Crop Acres^2	-8.63e-06***	-7.91e-06***
	(3.19e-06)	(2.81e-06)
Pasture Acres	0.000565***	0.000542***
	(5.82e-05)	(5.16e-05)
Pasture Acres^2	-2.30e-08***	-2.21e-08***
	(3.51e-09)	(3.09e-09)
Improved Pasture Acres	0.00165***	0.00158***
	(0.000519)	(0.000456)
Improved Pasture Acres^2	-3.49e-07**	-3.31e-07**
	(1.66e-07)	(1.46e-07)
Site Acres	0.00234***	0.00226***
	(0.000286)	(0.000252)
Site Acres^2	-5.04e-07***	-4.83e-07***
	(9.60e-08)	(8.46e-08)
Unclassified Acres	0.000273	0.000255
	(0.000223)	(0.000196)
Unclassified Acres^2	-2.66e-08*	-2.51e-08**
	(1.37e-08)	(1.21e-08)
Building Value	3.72e-07***	3.37e-07***
	(1.11e-07)	(9.82e-08)
Town	0.00372	0.00767*
	(0.00477)	(0.00433)
Airport	-0.000628	-0.000931
	(0.00316)	(0.00278)
Ski Resort	-0.00799**	-0.0109***
	(0.00363)	(0.00329)

Table 11. OLS and MLE Regression Results for Specification 8 (continued).

	Specification 8	
	OLS	**MLE**
	Semi-Log Quadratic	**Semi-Log Quadratic**
Variables	***LnTotal Price***	***LnTotal Price***
Waterway	1.14e-06	8.02e-07
	(7.00e-06)	(6.16e-06)
BR Trout Stream	6.21e-05	7.64e-05
	(8.44e-05)	(7.44e-05)
Mule Deer	0.00425**	0.00381**
	(0.00184)	(0.00162)
Whitetail Deer	0.00241**	0.00213**
	(0.00100)	(0.000884)
Antelope	-0.00323***	-0.00281***
	(0.00118)	(0.00104)
Elk	0.000271	0.000209
	(0.00129)	(0.00113)
Pheasant	0.00156	0.00166
	(0.00130)	(0.00114)
Blue Grouse	-0.00373*	-0.00374**
	(0.00206)	(0.00181)
Ruffed Grouse	-0.00223	-0.00258
	(0.00212)	(0.00187)
Sharp Tail Grouse	-0.00277**	-0.00218*
	(0.00126)	(0.00112)
Spruce Grouse	-0.00295	-0.00378
	(0.00522)	(0.00459)
Conservation Easement	0.000339	0.00820
	(0.178)	(0.157)
State Land	0.230**	0.233***
	(0.0989)	(0.0870)
Federal Land	0.144	0.149
	(0.111)	(0.0979)
Elevation	6.13e-05	4.24e-05
	(0.000130)	(0.000115)
Topographic Diversity	-0.000236	-0.000241
	(0.000201)	(0.000177)
View Diversity	-0.00212	-0.000851
	(0.00578)	(0.00509)
Precipitation	0.0411**	0.0431**
	(0.0200)	(0.0176)

Table 11. OLS and MLE Regression Results for Specification 8 (continued).

	Specification 8	
	OLS	**MLE**
	Semi-Log Quadratic	**Semi-Log Quadratic**
Variables	***LnTotal Price***	***LnTotal Price***
Constant	13.62***	22.62***
	(0.995)	(2.618)
Rho		-0.672***
		(0.184)
Observations	401	401
R-squared	0.770	0.780
Log likelihood		-344.66

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1