Valuation of Ranchette Amenities: Hedonic Price Approach

by

Sanchita Sengupta

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STATEMENT BY AUTHOR

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SIGNED: Sanchita Sen Gupta.

APPROVAL BY THESIS DIRECTOR

This thesis has been approved on the date shown below:

Daniel E. Osgood Assistant Specialist Agricultural and Resource Economics	4-11-2002 Date

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Dedication

To My Brother Rony

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Abstract

A hedonic price model has been used to ascertain the relevant characteristics that lead to the sale of rural, traditionally ranched or agricultural land parcels of 2-40 acres as "ranchettes" in Arizona. One of the characteristics of a ranchette is given by remoteness variables obtained from adjacency to open spaces and neighbors. The environmental characteristics pertaining to scenic beauty are obtained from remotely sensed satellite data through a vegetation greenness index. It was found that the greenness measure is a significant variable influencing the price of ranchettes. It was also found that those purchasing ranchettes were influenced by adjacency of the ranchette to public lands or open spaces. However, the presence of neighbors did not have any significant influence on the price of the ranchettes.

1. Introduction

One of the major changes taking place in the American West is a marked change in private land distribution patterns from traditionally large acreage ranches and farms to relatively small (2 -40 acres) residential parcels, often called "ranchettes." Ranchettes are fragmented pieces of private rural lands (often ranches) and are mainly used for hobby ranching, recreation sites or second homes. The most important difference between a ranch and a ranchette apart from the size is that the former is a business unit operated for profit maximizing purposes while the latter is mainly for utilitarian or entertainment purposes. Thus private ranch land which were formerly valued according to the cattle productivity are now increasingly being valued according to their potential as real estates (Sayre 1999). The resulting demographic change and subdivision of rural land has had significant environmental consequences. The impacts include the loss of open space, wildlife and plant community habitat fragmentation, land cover change and degradation, increased erosion and sedimentation, and heavy pressure on water quantity and quality. The redistribution of population across large, undeveloped areas has also strained rural government resources to supply public services.

Newcomers are attracted to the open space and aspire to live away from the city life. This results in the faster development of the rural areas with the most open space. Counties with the federally designated wilderness areas grew two to three times faster than all other counties in the states from the 1970s to the 1990s (Riebsame and Robb 1997). The migration of people from different states to the Western region and the subsequent increase in the demand for land are the driving forces behind land subdivision and ranchette sale.

The demand for ranchettes is affected by the consumer's demand for the rural amenities. Earlier studies of rural land took into account the productive capacities of the land. However, the owners of ranchettes gain utility from aesthetic attributes like scenery and open space. McLeod et al.(1999) employed a hedonic model to measure the impact of the presence of recreational and scenic amenities on agricultural land values in western Wyoming. Their results indicate that amenity variables like scenic view, elk habitat and fishery productivity are significant determinants of land values apart from the agricultural production attributes.

In this study a hedonic price model has been used to estimate the significance of amenity attributes of ranchette ownership including average vegetation greenness of the area, proximity to open space and distance from urban centers. Agricultural production attributes are not taken into account since these lands are assumed to be sold to households for strictly consumption purposes. The assumption is based on the premise that the "consumptive use" of agricultural land is becoming widespread(Pope and Goodwin 1984). In this study ranchettes are defined as land used strictly for consumption purposes. Hence, any agricultural profits from the land are not taken into account. The contribution of this study to hedonic pricing research lies in the hedonic estimation of environmental amenities in ranchette use, use variables derived from time series satellite imagery as a proxy for the scenic beauty of the environment and inclusion of dummy variables like presence or absence of adjacent open space and neighbors as explanatory variables.

1.1. Motivation

Some of the questions that this thesis attempts to provide answers to are, to what extent do people value living next to open spaces or public lands? For example do people prefer to have a national park next to their homes? Do potential owners of ranchettes prefer living near other ranchette owners over being alone in the wilderness? Also, what premium are the ranchette owners willing to pay to have a home site in a scenic place and how far away from the cities are they willing to move? In other words, what attracts the ranchette owners?

The answers to these questions are obtained by estimating a hedonic pricing model, where ranchette sales depend on civic and scenic amenities and the value of remoteness to the ranchette owners. A comprehensive dataset is developed using Geographical Information System (GIS) which helps in organizing and analyzing spatially explicit data. GIS provides a practical accounting of the spatial relationships (proximity and remoteness) and variability (how green is the vegetation here?) of variables designed to capture the ameniy value of a ranchette.

This study is innovative in two ways. First, it addresses the particular attributes of ranchette land valuation that are different from typical urban real estate or production agricultural land valuation. Second,the study attempts to use GIS to provide simple proxies for ranchette attributes like remoteness and scenic beauty.

It is the first attempt to estimate the value of land used as ranchettes using a hedonic pricing approach. The ranchette use is not similar to agricultural use because the latter is mainly for productive purposes. Also, ranchettes are different from urban real estates in terms of the amenities. Rural studies of the farmland valuation have addressed the productive capacities of the land. Some of these studies have been used to value environmental amenities like open space, wetlands, watersheds and scenic views (Schultz 2001; Acharya and Lynne Lewis 2001; Mohan, Polasky and Adams 2000). However, no hedonic estimations have been done on ranchettes which are located in rural areas but are used by urbanites for consumption or recreational purposes. The study of ranchette properties is new in hedonic estimations and so are the proposed methods to capture the amenities/disamenities of ranchettes. The study includes explicit neighborhood characteristics and allows for the study of remoteness proxies.

Secondly, the study attempts to simplify the estimation procedure by following parsimony and efficiency in the use of the variables. For example, in most hedonic studies on urban amenities, housing details are used to separate the effect of structural variables from the environmental variables on the price of the house (Mohan, Polasky and Adams 2000). Here, the use of official County Assessor's office estimations of the improvements on ranchette land is used as a proxy for all those variables. In terms of the efficiency of the use of the variables, scenic beauty is defined by a vegetation greenness index called the Normalised Difference Vegetaiton Index (NDVI) from the NOAA Advanced Very High Resolution Radiometer (AVHRR). This NDVI product is widely available and used to monitor landcover and landuse change across large areas over time.

1.2. Organization

This thesis includes an assessment of the problem and its context, theory, methods, results and conclusions. The second chapter describes the policies and the economic incentives that led to the formation and sale of ranchettes and the motivations that led to this study. The third chapter provides the theoretical model of hedonic estimations and the literature review. Chapter Four gives an extensive description of the study area and the data. Chapter Five discusses the empirical model and the methodology that has been followed. The sixth chapter presents empirical results. The final chapter interprets the results and provides conclusions.

2. Background Information on Ranchette

The Taylor Grazing Act of 1934 recognised that rangeland in Western United States was too dry for rainfed agriculture. As a result rangelands have been primarily used for livestock grazing or managed for wildlife. Today these lands once considered to be of low utility are being considered as ideal locations for living in open space with a reasonable drive to urban centers. This has led to an increase in their value due to their potential as residential real estate. This shift in land valuation cause environmental changes as well as changes in demographic and land tenure trends. For example, in 1990, the median home value in Pitkin County (Colorado) reached over $450,000, second in the United States only to New York city (Riebsame and Robb 1997).

Once the ranches subdivide, they are packaged as retirement homes by the realtors on the open rangeland to be bought by potential ranchette owners. The primary difference between the use of land as ranchettes and ranch are in the consumptive versus the productive use. Since most of the ranchettes are retirement homes or second homes of people living in cities, there are hardly ever any production activities undertaken in these ranchettes. Some ranchettes have a few cattle-heads or a few horses but most of them are involved in hobby ranching. The other major difference between ranches and ranchettes are the kind of owners of these lands. The ranches are mostly owned by family operating units who are typically long time settlers in this region. They are also professionals in ranch management and their prime source of income is from the agricultural and livestock production in the land. In contrast the ranchette owners are mainly hobby agriculturists and are often newcomers to the region. They are mainly dependent on off-farm income for their livelihood. For example, the ranchette owners who are retired depend on their savings and social securities etc., while the second home owners have non-agricultural income (Hoppe 2001). Because of this good land management techniques are often not followed by ranchette owners since the land is not their main source of income. Also, ranchette owners are attracted to the ranching lifestyles of the West. Horses are a main attraction. Direct expenditure in the Arizona recreational horse industry were eighty million dollars more than all of the cattle sales in the state in 2000 (Beattie, et al. 2001). Thus the recreational use of land is replacing the traditional ranching industry.

One of the main concerns of this demographic change is the haphazard development that results in a fragmented landscape. There is rarely any long term land use planning; as a result ranchettes often lack the natural management practices necessary to protect the resource base from degradation. A large portion of the semi-arid zones in the western United States are covered with rangeland. According to the Natural Resources Inventory of the USDA Natural Resources Conservation Services more than 99% of the Nation's rangeland is west of the Mississippi River. In Arizona, almost 76% of the land are non-federal land, more than half of which are rangeland. These zones are heavily impacted by human activities. The increasing population in the western states have increased the demand for land to be developed as residential real estate, creating increasing pressure on the ecology and the environment. Some of the general environmental concerns are the loss of open spaces and increased urbanization. Other greater concerns are overgrazing, shortage of water and loss of animal and plant species due to fragmentation of wildlife habitat. Apart from owning large tracts of land (hundreds of acres), ranch owners have leases with government owned land for grazing purposes. Good rangeland practices can be undertaken to prevent severe damage to the environment. However, the ranchette owners do not lease adjacent public lands. Futher they own small herds of cattle or horses for hobby purposes which leads to intensive grazing in the small ranchette lands. The overgrazing on these lands leads to soil erosion and depletion. Water is also a very controversial issue in the West. Increased population leads to further scarcity of water. Apart from these, the newcomers to the region might bring in some socio-economic values which might conflict with those of the long time settlers in these regions.

It can be argued that although there are environment concerns, the increased population in these regions lead to increased development in terms of economic and social infrastructures. The Western states have mainly attracted extractive industries which produce goods from the natural environment like the agricultural and forest mineral and mineral products. These extractive industries have traditionally been viewed as "the economic engine energizing the local economy and making on-going settlement of that area possible" (Power 1996). By contrast, those who are moving on to small farms and ranchettes derive the majority of their income from the off-farm activities often from Social Security and investments (Hoppe 2001). Further according to Power (1996), this income tends to be spent in the local economy through the creation of demand for local services, leading to increased opportunities for local businesses and pressure on local government for supplying better services.

Thus there are varied perspectives on land use, that is, open space and environmental protection versus conversion of open space into exurban residential areas. It is important to apprehend that the land conversion itself is not the degrading action.

What potentially results in land degradation is the change from a landscape managed for its ecological value and livestock production value to smaller parcels that, in practise, tend to be "hobby" farms and ranchettes where no particular management or planning is employed. The result, as discussed above, is too many cows or horses in too few acres, or, wildlife unfriendly fencing every 5,10, or 40 acres, or, introduction of invasive species either through uninformed landscaping or misidentification of plants that arrive in response to the disturbance of the soil when structures (house, fence, water, electricity, etc.) are put in place.

Arizona has a lot of open space. Data from the U.S. Department of the Interior, Bureau of Land Management shows that Arizona has 47.2% of public lands. Most of the public lands range (almost 24%) is made up of thousands of acres of federally owned land which are not likely to be developed. However a federal grazing permittee has a ranch base property i.e. a few acres near the public grazing allotment which is most vulnerable to sale by their owners and development. Development of these ranch base properties leads to loss or fragmentation of wildlife habitat.

Livestock production is a major agricultural industry in Arizona, consisting of 25% of Arizona's entire agricultural output[1]. However, there has been a steady fall in land base use farming in most of the counties. Figure 2.1 shows the percentage decrease in the land in farms (in acres) for Yavapai county and Arizona since 1982.

[1]Arizona Rangelands: http://ag.arizona.edu/agnic/az/index.html 2002

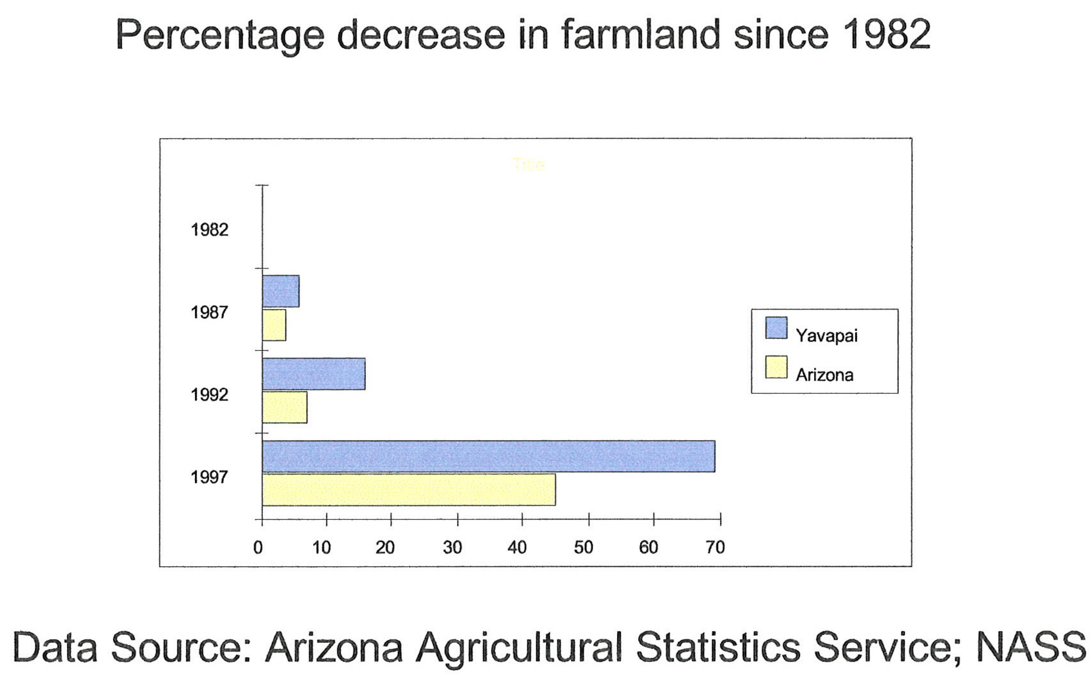

FIGURE 2.1. Percentage change in farmland

2.1. Ranchette Formation

A major reason for the subdivision of the ranches is the difference in the value of land that is used for grazing and the land that is used for real estate development. In 1930, the taxable per-acre value of grazing lands in Pima County was $2.57, while the value of suburban and irrigated lands was $57.38 and $52.24, respectively (Sayre 1999). This difference is due to the fact that the value of land used for grazing is determined by the carrying capacity of land and the market price of beef, while the land value for suburban development depends on the supply and demand for housing. This disparity of land values might be one of the reasons behind land subdivisions since the benefits from subdividing and selling the land can be more lucrative to the ranch owner in the short run than the profits accruing from the ranch.

Often, various kinds of tax incentives act as incentives for ranch owners to subdivide their land. For example, an inheritance tax might be incurred when a large property such as a ranch is transferred. According, to the Arizona State Legistature, lower taxes are paid on the smaller properties. Often the ranch is subdivided and passed on to the various heirs so that on the whole lower taxes are paid. Thus, land fragmentation might occur in some cases as a result of evasion of high inheritance taxes. Traditionally managed rangeland has been sold to subdivision developers often as a result of tax disincentives (Ladd 1998). Arizona has neither an inheritance tax nor a gift tax. However, there is a federal estate tax. Heirs are not taxed by the state on proceeds from the estate unless the proceeds qualify for federal taxation. Only estates valued at $6,250,000 or more (in 1999) are subject to federal estate taxes. Subdivisions of large estates is one of the ways to avoid the high federal estate taxes. Higher inheritance taxes in other states induce elderly tax payers to move into Arizona. For example the number of elderly people who in-migrated from Arizona to Iowa was 558, from 1985 through 1990, while the out migration from Iowa to Arizona was 2257 during the same period (Iowa Legislative Fiscal Bureau 1997). This might be attributed to the difference in the tax structure apart from the more significant factors such as weather, income etc.

2.2. Ranchette Sale

Some of the Western states had high percentage of second homes which have increased in number over the past decade. In certain counties of Arizona, New Mexico, Utah, Colorado etc., there are about 25-76% of second homes (Riebsame and Robb 1997). They describe the main attractions of the Western region as the ski zones in the Rocky mountains and the deserts and canyon lands of Utah and Arizona. People visiting these places often settle down in these parts of the country. In Yavapai County, almost 13% of the home sales in the last decade consists of ranchette sales (Yavapai County, Management Information Systems).

This influx of people wanting to buy a ranchette could be attributed to the love for the countryside and for horses. People from the neighboring states, which are comparatively more urbanized and wealthier, might seek out this kind of a lifestyle and venture to buy a second house or a retirement place in these areas. Nelson and Dueker (1990), called the phenomenon of population deconcentration in the United States as exurbanization. They found that there is a steady trend of urban deconcentration and some of the main reasons behind the locational behaviour of the exurban households are the federal programs and policies that stimulate and guide development and home ownership; the desire for space and access to environmental resources; the desire to escape from negative attributes of urban living; and developments in transportation, communication, and employment that enable the relocation. Improved communication and rising affluence has given additional impetus to the ranchette sales. For example, California continues to be the prime source of American migrants to Arizona. Also, Arizona ranked third after Florida and North Carolina with the highest net migration rate of more than 12%. Arizona has one of the highest growth rates in the country. From 1990-1994 the population growth rate for Arizona was 11.2%, the third fastest growing state after Nevada (21.2%) and Idaho(12.5%). All the above fact show that a large number of people migrated and bought homes in the West. Given, the high population growth rate together with loss of farmland in Arizona it can be conjectured that most of the people seemed to have settled in the private rural lands.

3. Theoretical Review on Hedonic Price Model

3.1. Literature Review

Earlier studies on estimation of the farmland values, can be categorized into two groups. The first group tries to estimate the land characteristics like soil, carrying capacity of land (Gardner and Barrows 1985; Miranowski and Hammes 1984) where the farmer maximizes farm profits. The second group focuses on the effects of urbanization on farmland values like studying recreational and urban pressure on agricultural land (Rowan and Workman 1992; Spahr and Sunderman 1995; LeGoffe 2000; Egan and Luloff 2000). In the study by Sunderman and Spahr (1995) on Wyoming ranch sales it was observed that the ranch prices were based on productivity during the period of political uncertainty but stable prices. However, ranch value determining attributes changed to speculative potentials in the periods of political stability and rising prices. Egan and Luloff (2000), studied the effects of sudden population changes on forestry.

Some of the recent studies have addressed amenities like oceanic views, proximity to wetlands, scenic beauty. There are no markets for amenities like the prettiness of an area ,open spaces and neighbors. There is the market for land which harbors these amenities and thus hedonic estimations on the market values of land can be used to estimate the values of these amenities. Spahr and Sunderman (1995) used Wyoming ranch sales data to model the contribution of scenic and recreational quality to land price. The three dummy variables for very little, average and substantial scenic beauty were based on values assigned by appraisers from the Farm Credit Services. They found that scenery was significant in explaining the land values. In other wetland studies (Mahan 1997), a classification system designed by Doss and Taff (1996) was used. Doss and Taff aggregated the Cowardin system of classification (used by the U.S. Fish and Wildlife Service's National Wetlands Inventory in Oregon) into six major types of wetland scenery which were expected to influence home prices. The major category included forested, scrub-shrub, emergent vegetation, open water, lakes and rivers.

GIS techniques are now used in many hedonic pricing estimations in providing proxies for views and sceneries. In a recent paper by Lake et al.(2000) building area, garden and land use polygons were obtained from Ordnance Survey and complex Digital Elevation Models for visibility studies were developed in order to be employed in property valuation studies. In yet another paper by Benson et al.(1998) it was found that the value of oceanic view was found to vary inversely with distance from the water which was calculated using GIS.

In this study the scenery also plays an important characteristic for ranchette values. However, the scenery is determined by the remote sensing data or the vegetation index that are publicly available. In earlier studies GIS data has been used by McLeod et al. to characterize scenic beauty. Although in landscape literature there are various methods and estimations for incorporating aesthetic beauty of a place[1], these are not common in economic studies.

Earlier hedonic studies recognized that what surrounded a property had a major influence on its price. Hedonic estimations attempted to incorporate characteristics

[1] Review of Existing Methods of Landscape Assessment and Evaluation: http://www.mluri.sari.ac.uk/ccw/task-two/evaluate.html, 2002

based on income levels, crime statistics and other census based data which reduced spatial considerations to unidimensional measures. In a significant study by Geoghegan, Waigner and Bockstael (1997) GIS was extensively used to calculate the percentage diversity in land use and percentage land fragmentation in the neighborhood of each property. Significance of open spaces in property valuation was an important aspect of this study.

3.2. The Hedonic Model

The value of environmental goods like open space and the prettiness of an area to the residents is difficult to measure since these variables are not traded in the market. However, behaviors in the market are sometimes related to the environment quality and hence the demand for the environment goods can be inferred. There are several valuation techniques to estimate the value of the unpriced good. For example, Household Production Framework, Contingent Valuation Methods, Choice modelling etc., are some techniques commonly used in environmental economics. The hedonic method is appropriately used in this study since it is based on the realization that some goods are not homogeneous and can differ in numerous characteristics, environment quality being one of them. Hedonic models are reduced form statistical models that specifies the equilibrium transaction property prices as a function of its characteristics.

Most hedonic studies valuating the environmental goods are based on the theoretical model of Sherwin Rosen (1974). Hedonic studies have been quite successful in explaining the influence of amenities or non-market goods on housing prices. The main idea behind hedonic pricing is that houses consist of differentiated characteristics that are not sold individually in the market. The market price of the house incorporates all these characteristics and hence the market price can be evaluated as a function of these characteristics.

The general form of the hedonic model can be represented as

$$P = P(C_1, \ldots, C_n) \tag{3.1}$$

where, P represents the per acre sale price of a differentiated product, ranchettes, in this case and $C = (C_1, ..., C_n)$ represents a vector of characteristics of the parcel that affect sales price. The equilibrium hedonic price schedule is determined by the interactions of the buyers and sellers of the property.

The theoretical aspects of hedonic property pricing as explained by Mahan, Polasky and Adams (2000) is presented here. It can be assumed that each individual's utility function has arguments, X, a composite commodity representing all goods other than a ranchette, and S, a vector of structural, environmental and neighborhood characterisitics of the individuals residence. The utility function u(X,S) is assumed to be weakly separable in housing characteristics and other goods, which allows the demand for housing characteristics to be independent of the prices of other goods.

The main assumptions of the model are that, the individuals are optimizing their choices based on the prices of alternative land parcels, which implies that the market is in equilibrium. Thus, the hedonic equation is an equilibrium that results from the interactions of the supply and demand. Also, the prices are assumed to be market-clearing, given the choice of land and their characteristics. Another assumption that helps in formulating the model is that the range of product choices are continuous.

Given, the assumptions, the housing price is assumed to be a function of the house characteristics as shown above. Since, each individual maximises utility subject to a budget constraint given by $M - P_h - X = 0$, where M is income and P_h is the price of the house. The price of X is scaled to \$1. The first order condition that maximizes the utility subject to a variable j in the vector S is given by:

$$\frac{\partial u/q_j}{\partial u/\partial X} = \frac{\partial P_h}{\partial q_j} \tag{3.2}$$

The left-hand side of equation 3.2 represents the marginal rate of substitution between the environmental attribute and the composite good or the marginal willingness to pay for the environmental attribute. The right hand side of the equation is the partial derivative of the hedonic price function with respect to any characteristic yielding its marginal implicit price, the additional amount to be paid(received) to get one more unit of the characteristic.

3.3. Functional Form for the Hedonic Equation

In hedonic estimation methods there are no theoretical reasons behind choosing a particular functional form. The exception being that if the product characteristic can be costlessly repackaged then a nonlinear price schedule would be a better fit (Palmquist 1991). Some of the most common hedonic model specifications are: linear, semilog, log-linear. Theory only suggests that the first derivative of the hedonic price function with respect to a particular characteristic be positive or negative according to whether the characteristic is an amenity or a dis-amenity. No properties of the second derivative can be deduced from the model (Freeman 1993).

Many authors experiment with various functional forms and select the one that gives the best fit. For example, Mieszkowski and Saper (1978) estimate linear and semilog models, while Graves et al. (1988) use a semilog functional form. Cropper, Deck and McConnell (1988) examined the question on selection of functional form using a housing market data for Baltimore, MD. Their result showed that , in models with omitted or proxy variables, the simpler forms (linear, semi-log, log-log) and the more complex linear Box-Cox functions perform better compared to quadratic and Box-Cox quadratic forms. Box-Cox performed well with correctly specified or the perfect information models.

Linear, log-linear and log-log models are special cases of the Box-Cox functional form. Box-Cox functional form uses the data to determine the appropriate functional form and therefore it is more flexible. Palmquist (1991) has argued that the Box-Cox procedures are unsuitable for estimating implicit attribute prices since the coefficient estimates are difficult to interpret. According to Cassel and Mendelsohn (1985) the Box-Cox model may not be the best option when the goal is to get the best estimates rather than provide a best fit. This study estimates the linear and the log-linear models. The log-log model cannot be used because of the presence of the zero explanatory variables.

4. Study Area and Data

4.1. Study Area

The study area for this thesis is Yavapai county in central Arizona. Yavapai County is the second largest county in Arizona, encompassing 8,122 square miles of area, about the size of the state of New Jersey. According to the 1990 census the county's population was 107,714. In 2000, the population grew to 167,517. The growth rate for this period was 5.5%. Of the 5.2 million acres of land, about 26 percent is in private hands (individuals or corporations)[1].

Yavapai County has an abundance of open spaces or public lands. About thirty-eight percent of the land is administered by the U.S. Forest Service, nine percent by the U.S. Bureau of Land Management, 27 percent by the State of Arizona, and less than 0.5 percent is held in trust as Indian reservations. Most of the ranchette formations have occurred in the rural ares in northern parts of the county. There is a "checkerboard" pattern of land ownership in this area, alternating between private and State owned land every other square mile. This unique pattern developed in Yavapai County in the nineteenth century as a result of the transfer of land to the private owners in order to provide incentives to build railroads. A checkered landscape embodies a high fragmentation of the land, which in turn implies high risk of losing plant and animal spacies (Pickett and White 1985). Most of the subdivisions have occured on private lands that offer the potential buyers the possibility of owning land adjacent to public land. For example, one of the largest subdivisions is the

[1] Yavapai County: http://www.infozona.com/County/yavapai/main.asp, 2002

Juniperwood Ranch Unit 2, an area of 20,716 acres of which 1390 acres were sold between 1991 and 2000. Only ranchette sales among all home sales are included in the study. (include percentage of ranchettes sold to defend the study area)

Figure 4.1 shows the important roads, rivers and towns in Yavapai County. The principal data source for this figure is the Environmental System Research Institute (ESRI). Cities in and around Yavapai, like Prescott, Sedona, Chino Valley, Flagstaff etc. are small western towns that are important tourist attractions and portray a ranching lifestyle. The abundant open spaces with urban amenities present attractive areas for people to build second or retirement homes.

4.2. Data

The principle data sources for this study were the sales data and parcel data, both of which were obtained from the Assessor's Office and MIS, Yavapai County. The complete data set has 68,749 observations on all the property sales that occured between 1991 to 2000. The dataset has extensive information on all parcels that sold, the sale price, buyers, sellers, sale date, assessed value of the land, among other variables.

The usage classification for ranchettes in this data set was inappropriate for the objectives of this study; therefore ranchettes identified on the basis of their size. Only those parcels ranging from 2 to 40 acres were taken into account since a general survey of the area and indicated that the ranchette size varied within this range. There were 10,287 parcels in this size range. Of these, 1536 observations were missing geographic coordinates and/or sales price. This study therefore included the analysis of 8,751

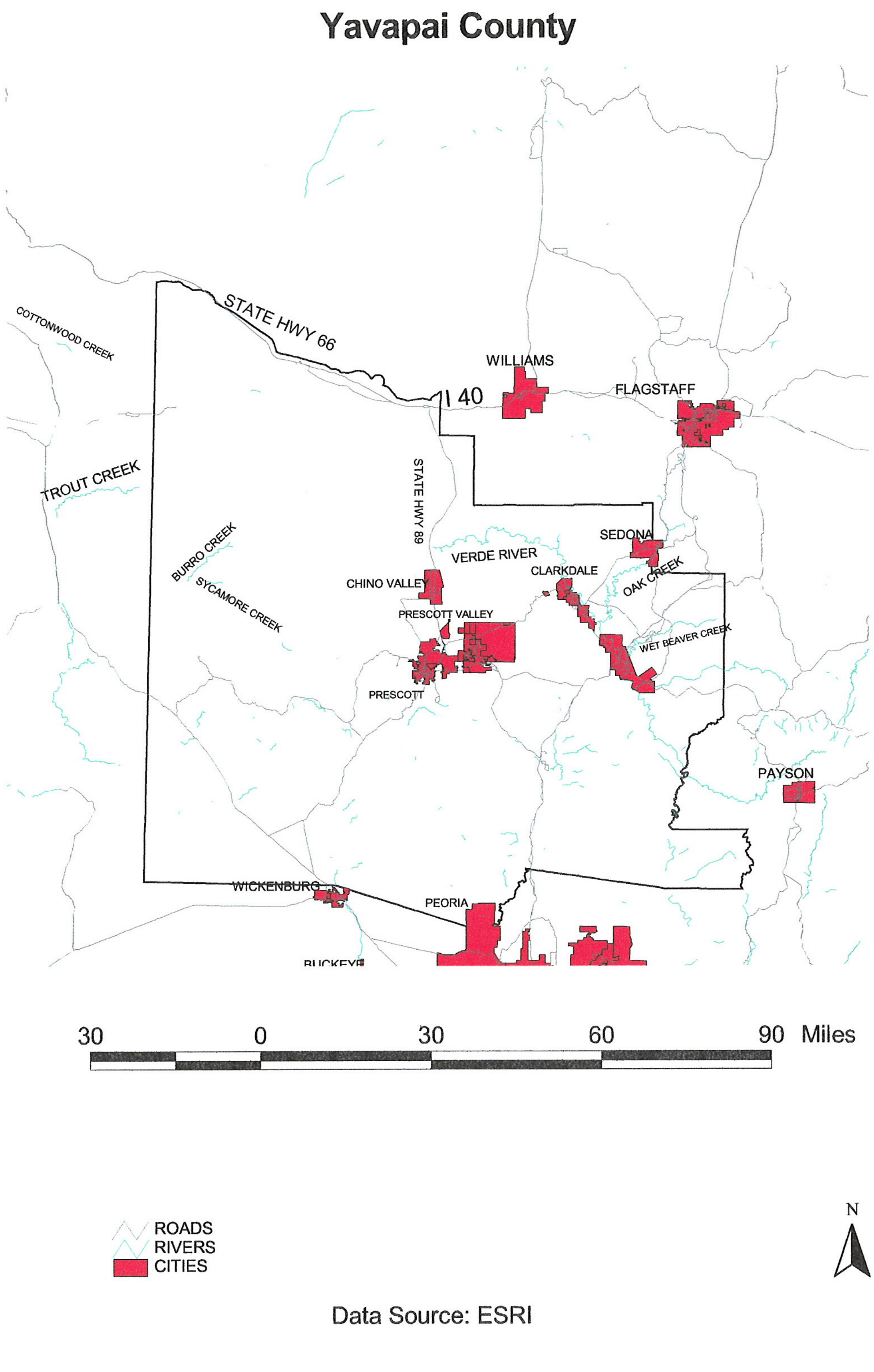

FIGURE 4.1. Feature map of Yavapai County

parcels ranging in size from 2 to 40 acres that were sold between 1991 and 2000. Fig 4.2 shows a selected portion of the Yavapai County where the majority of the ranchette sales occurred. These sales data have been obtained from the Yavapai County, Management Information System (MIS).

The dependent variable selected for the hedonic price function was the per acre sales price of the ranchette. The sales price were adjusted by an yearly average price index to account for the inflation over the 10 years under analysis. The consumer price indices used for the correction of inflationary pressures is given in Appendix B. The sales price was divided by the size of the lot obtained from the assessor's dataset. The deflated price per acre was used as the dependent variable for the study. The average sale price after adjusting for inflation $15,393.00 per acre.

For each observation of a ranchette sale there is a set of associated explanatory variables that can be used to explain statistically the sales price. Many hedonic studies group all the variables into categories depending on environmental, structural and neighborhood characteristics. This categorization is an artificial method used for the ease of understanding the explanatory power of each variable in the model. In this study the independent variables are categorized into three main groups comprising the environmental characteristics, the site specific characteristics, and the remoteness proxies.

4.2.1. Remoteness Proxies

The remoteness proxies comprise both adjacency and proximity to natural amenities or disamenities. The distance variables are a form of the proximity measures and they include distances to features like nearest city or town and roads. This spatial

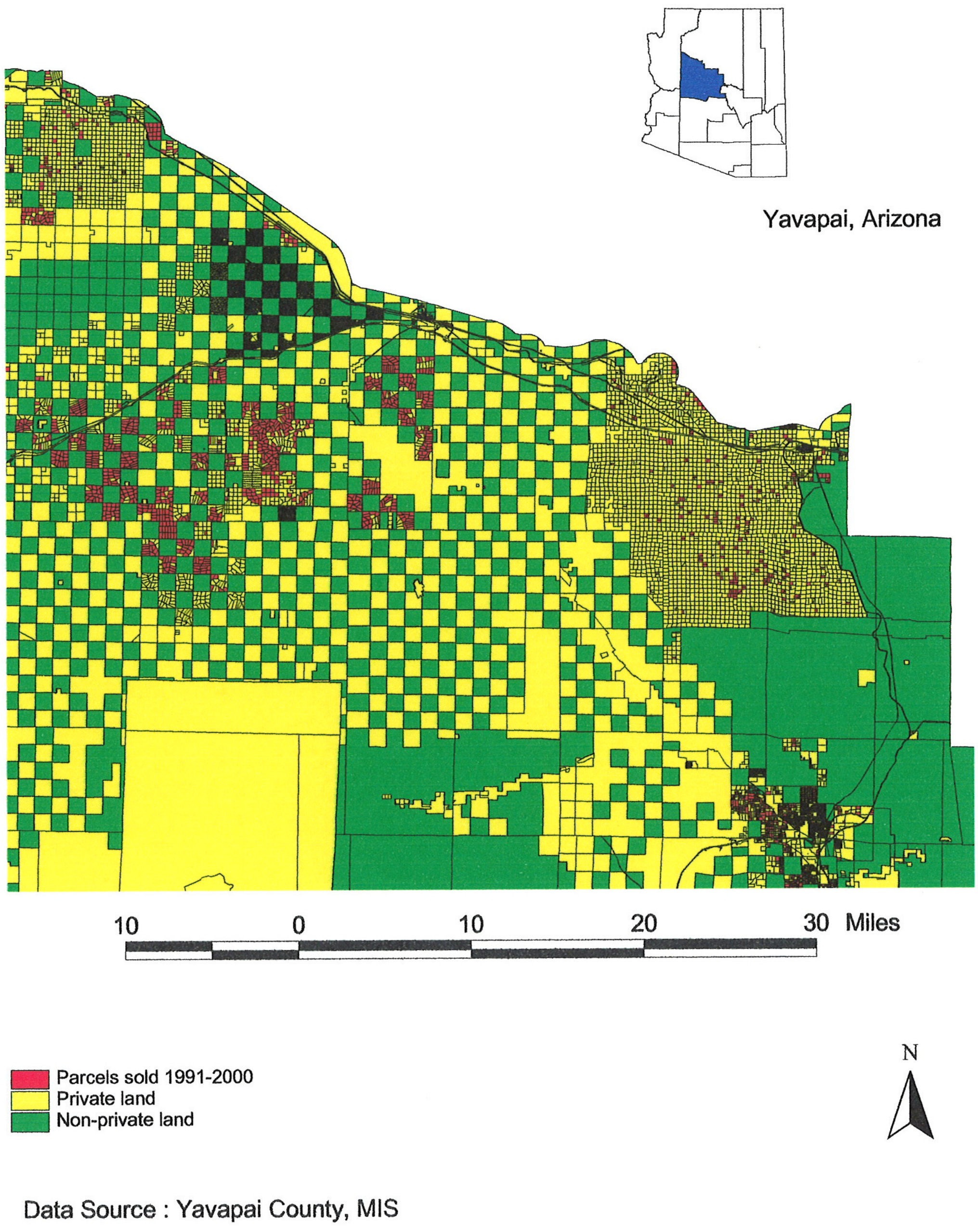

FIGURE 4.2. Ranchette sales in Yavapai County

data layers were in 2001 obtained from ESRI in digital form. ESRI created these data layers from 1:24,000 USGS topographic maps. All these layers were converted to the Universal Transverse Mercator (UTM) projection (zone 12) and a point coverage was created linking each parcel to the features. Euclidean distance from the centroid of each parcel to the edge of the nearest feature was then calculated. If the closest feature was in another county, the distance to that feature was used.

Property prices are often determined by the characteristics of the neighborhood. In sparsely populated rural settings, the neighborhood characteristics would be less varied as compared to an urban setting. Among the different types of neighbors that a ranchette might have, two particlar types were considered for valuation in this study, public lands and other ranchettes. Two types of adjacency variables were created. One accounted for the adjacency to the permanent open space or the public lands. The other accounted for the adjacency to neighboring ranches. Two dummy variables (OPENSPACE and NGBS) that characterizes the neighborhood of the ranchette were created using GIS.

If a ranchette was adjacent to a non-private land, then the variable OPENSPACE was allocated the value 1, otherwise 0. Because public land generally is neither sold to private ownership nor developed, these areas were assumed to represent permanent open space. All non-private lands were considered public lands in this study and no classification were made according to different, non-private types of land. Figure 4.3 shows the parcels which are adjacent to the public lands. The parcels were selected if they were sold and were adjacent to the open spaces. The selection of these parcels were done using GIS in ARCVIEW.

The variable NGBS represents the presence or the absence of neighbors. A value

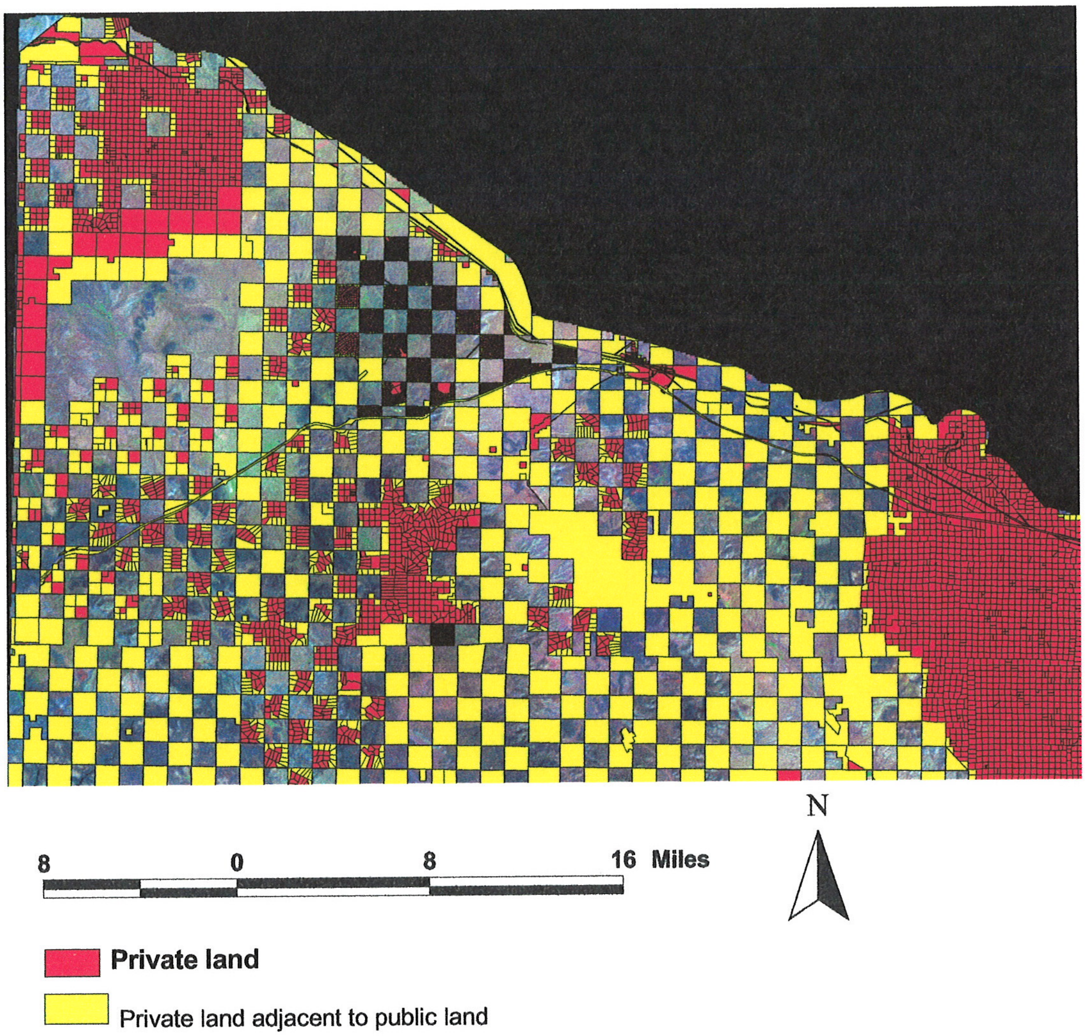

FIGURE 4.3. Open spaces adjacent to the ranchettes

of 1 was assumed if there was an adjacent ranchette at the time of the sale of the particular ranchette, otherwise it took on the value 0. The variable NGBS basically represents the fact that people may or may not like having ranchettes as neighbors. This variable may also take into account the spatial autocorrelation that arises due to neighborhoods having similar characteristics and locational amenities. The neighborhood variable can also represent people's desire for a ranching lifestyle.

4.2.2. Environmental Characteristics

In many of the earlier hedonic studies on the importance of view as an amenity, the environmental variables in question are categorized according to the type of environmental amenity. For example Doss and Taff (1996) categorize the environment according to classes, including forested, scrub, emergent vegetation, lakes, oceans etc. In this study the environment is not classified into any categories. Instead a greenness index for each square kilometer area was obtained. Hence the proxy used for the environment measurement was assumed to be continuous over space.

The variable Normalised Difference Vegetation Index (NDVI) was used in this study as a proxy designed to capture the environmental characteristics of a particular parcel. NDVI is a spectral algorithm used in satellite imagery analysis to distinguish the "greenness" of vegetation. It is a measure of the vegetation abundance and vigor. A NOAA satellite sensor called the Advanced Very High Resolution Radiometer (AVHRR) collects the relevant spectral bands used to calculate NDVI at 1km resolution everyday. In order to reduce cloud interference these observations are composited over 10-14 periods or biweekly. NDVI values are based on the interaction of chlorophyll with the electromagnetic spectrum, specifically the red and the near infra red wavelengths. High NDVI values indicate high amounts of green vegetation (Tucker 1979). NDVI values used in this study were based on an 8 bit "brightness" scale, where the highest NDVI possible would be 255 and the lowest 0. The NDVI data for this study were downloaded from Arizona Regional Image Archive(ARIA 2002)[2]. The yearly average of the NDVI images were computed with the software package ERDAS Imagine 8.3.

[2] http://aria.arizona.edu/

In order to understand what the NDVI implies, the average NDVI for the year 1998, that is the year preceding the maximum number of ranchette sales are considered as an example. The NDVI for the whole of the Yavapai County ranged from 106 to 150. For the northern region where the ranchettes have sold the NDVI ranged from 106 to 132. When it snows, green vegetation tends to get covered with snow, resulting in very low NDVI. Hence the NDVI for the northern part of Yavapai County (high elevation) has a low mean annual NDVI due to snow cover. However, because most of the ranchette sales have occurred in the snow covered area, variability in NDVI due to snow coverage can be assumed to be the same across the ranchettes.

Despite the biweekly compositing effort, cloud cover can also impact NDVI levels. The NDVI is averaged over a period of one year in order to account for variations due to cloud cover. The NDVI images on ARIA are georegistered and thus could be used with other mapping data in the spatial analysis. NDVI value at the centroid of the parcel was taken to be the NDVI value for the parcel. The NDVI average for the year preceding the sale of the ranchette is used as a proxy for the environment condition at the time of the sale of the ranchette.

Another variable explaining the environmental characteristic, is elevation. The terrain for the Yavapai county varies in elevation from 1600 feet to a little bit less than 8000 feet. Most of the ranchette sales have occured in the mountainous regions. Figure 4.4 shows the NDVI for Yavapai county for a particular year, 1998 and the elevation for the county in meters. The data source for the figures are ARIA for the NDVI image and ESRI for the elevation.

Distance to rivers or other water bodies, like creeks etc., were considered in the environmental variables, both as a proxy for green environment and scenic view. This

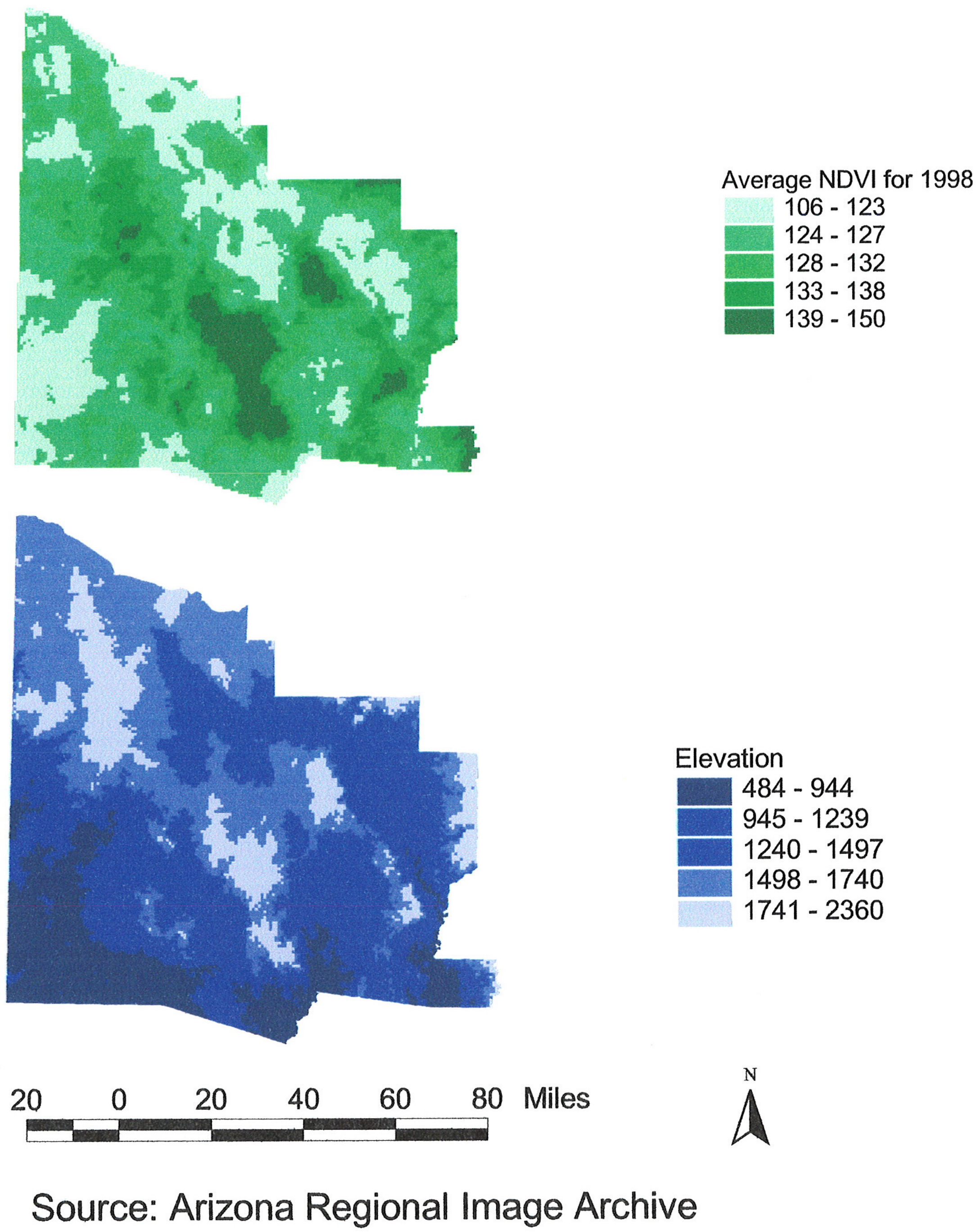

FIGURE 4.4. Maps showing elevation and greenness for Yavapai County

distance measure was calculated the same way as the other distances.

4.2.3. Site Specific Characteristics

The variable IMPPERACRE is the value of the capital improvements per acre, capitalized in the sale price. This variable is an assessment by the appraisers at the Yavapai County Assessor Office; it represents the asset value of all the constructions undertaken in the parcel. It is the assessed value of all parcel improvements normalized by the lot size. Though this estimate may not necessarily be equal to the implicit market value, a coefficient greater than one on this variable indicates that the market values are greater than assessed values, and a coefficient less than one indicates that the market values are less than the assessed values.

The county assessor data also included the variable LANDSIZE, the area of the sold parcels in acres. The size of the parcel is included to allow for the diminishing marginal utility with respect to land.

The variable DIFFYR was included to estimate the appreciation or the depreciation of the value of land over the ten year period. DIFFYR is a number ranging from 1 to 9, where 1 represents those parcels that were sold in 2000 and 9 represents those sold in 1991.

4.2.4. Other Variables

The census data were available for inclusion in the study to explain demographic variables like population density, age distribution of population etc. However, census data were not suitable for inclusion in the estimation. The census data are for each census tract and the size of each census tract is determined by the density of population of the area. The densely populated urban areas have small census tract giving substantial variation in the demographic feature. However, census tract data are not very useful in localized studies of rural areas because there is not much variation within one census tract which are large in rural areas. For this study the demographic variables were not incorporated, although these would be important in studies which consider ranchette formations across different states. There are various hedonic studies which use census tract data, when individual units belong to different census tracts. For example, urban housing studies like that of Kahn (1995) and Jensen and Leven (1997) use census tract data for population density, but in urban areas the census tract data cover very small areas unlike the rural areas.

All the parcel sales used in this study, occurred from 1991 to 2000. Although there is some time-series component in the data, the large number of cross-sectional observations are not repeated over the years in order to qualify for a panel data. 74% of the sales occurred only once, 21% occurred twice, 4% three times and about a percent of the repeat sales occurred four or more times. The dataset was therefore assumed to be cross-sectional.

The variable names and their units used in the study are explained in Table 4.1.In order to get reliable estimates, there should be substantial variation in perceived environmental quality. The range and variation across each variables is shown in Table 4.2.

TABLE 4.1. Variable description

Variable names	Decription
DIST2ROAD	Distances in meters to the nearest highways
DIST2CITY	Distances in meters to the nearest cities
DIST2RIVER	Distances in meters to the nearest water body
NGBS	Adjacent to neighbors(Dummy Variable)
OPENSPACE	Adjacent to permanent open space(Dummy Variable)
NDVI	Normalised Difference Vegetation Index
ELEVATION	Elevation in meters
DIFFYR	Property appreciation over the years
IMPPERACRE	Improvement per acre(Dollars per acre)

TABLE 4.2. Descriptive statistics of the variables

Variable names	**Mean**	**Std devs**	**Minimum**	**Maximum**
Dependent variable				
SALEPRICE(per acre)	15393.27	82994.06	0.0231246	7160853.22
Independent variables				
Remoteness Proxies				
DIST2ROAD	3383.47	572886.47	0.092	29870.23
DIST2CITY	14007.27	20560.29	0.244000	77747.85
OPENSPACE	0.2437	0.4293	0	1
NGBS	0.5168	.4997	0	1
Environmental variables				
NDVI	122.857	10.805	0	151
DIST2RIVER	7981.4	6966.26	1.15	37581.68
ELEVATION	1436.29	289.74	0	2355
Site Specific Characteristics				
IMPPERACRE	6290.22	21114.89	0	552564.04
LAND_SIZE	10.142	11.735	1.91	39.99
DIFFYR	3.9	2.4	1	10

4.2.5. Georeference

The range of datasets discussed above were integrated into a form in which each parcels sold was associated with the appropriate observation on the parcel. A geographical integration was performed in which attribute variables were linked to the sold parcels. The number of sold parcels is the number of observations in the study.

5. Methodology

5.1. The Empirical Specification

Following, the categorization of the independent variable in the earlier chapter, E, is defined as a vector of environmental characteristics including NDVI and distance to river, S, a vector of site-specific characteristic consisting of lot-size and assessed improvements and R, distance variables from the road and cities, and other site-specific remoteness characteristics like the openspace and neighbors. The difference between the year of sale and the current year is taken into account as variable T, to control for the appreciation of the property price over the period of time.

Assuming that the housing market is in equilibrium and prices are market clearing, the price of a ranchette can be described as a function of the environmental, site-specific and remoteness characteristics:

$$P_i = P(E_1, S_i, R_i, T_i) \tag{5.1}$$

5.1.1. Specification of the Functional Form

Most of the housing studies have successfully used linear or semi-log approaches. For this particular study, a semi-log model has been used, where the logarithm of per acre price is the dependent variable. The regression coefficient for this model indicates how a unit change in the independent variable affects the rate of change of ranchette price as opposed to the ranchette price in case of a linear model.

A semi-log model with no intercept is developed in this study. A non-zero intercept term implies that the sale price is non-zero even though all the explanatory variables, including land-size is zero. Therefore, the intercept is forced through zero because a ranchette with zero acres would have no sale price. The dependent variable in the estimation is the market sales price per acre which is adjusted for inflation. The market sales price are obtained by an interplay of supply and demand mechanisms and hence reflect an equilibrium price as opposed to assessed or appraised prices of the property and land.

The econometric model that is estimated is given by;

$$\begin{aligned} ln(P_i) &= \beta_1 DIST2ROAD_i + \beta_2 DIST2CITY_i + \beta_3 DIST2RIVER_i \\ &\quad + \beta_4 NGBS_i + \beta_5 NDVI_i + \beta_6 OPENSPACE_i \\ &\quad + \beta_7 DIFFYR_i + \beta_8 IMPPERACRE_i + \beta_9 LAND\_SIZE_i + \epsilon_i. \end{aligned}$$

or more compactly

$$ln(P_i) = \beta(E_1, S_i, R_i, T_i) + \epsilon_i \tag{5.2}$$

The marginal implicit prices for different variables, in case of a semilog model is given by the product of the coefficients times the mean sales price. This derivation is shown in Appendix C.

The Ordinary Least Squares was used to estimate the above model. The regression results are listed in table 6.1 in the next chapter.

5.2. The Statistical Specification

5.2.1. Multicollinearity and Specification Bias

Problems of collinearity and specification bias might arise in hedonic estimations. In the presence of high collinearity or high correlation between two or more explanatory variables, the variance or imprecision of the coefficient estimates are increased. But, if the relevant variables are left out of the regression to reduce collinearity problems, then the coefficient estimates would be biased. Thus there is a bias-variance tradeoff in the selection of the appropriate variables.

The collinearity is most common if there exits cluster of housing and several distance variables. For example in the housing study done by Powe et al (1995), dummy variables indicating proximity to a Metro station, school, college, major road, large open space and woodland were all significant and were giving rise to the collinearity problems. In this thesis, the study area is approximately one-third , the size of the Yavapai County which occupies an area of 8,125 square miles. And, the distance variables used in this study are the distances to the nearest cities, the nearest highway and the nearest river, which are not likely to be collinear given the vastness of the area. The model was checked for collinearity using both the rule of thumb, that is a high R^2 and low t-ratios, and a more rigorous method using condition indices.

Specification bias occurs due to omission of relevant variables or inclusion of irrelevant variables. The hedonic theory does not provide answers to the question as to which variables should be included in the model. In order to reduce any specification bias a stepwise regression procedure was conducted. This procedure evaluates the significance of each variable in the model and adds or deletes variables sequentially to the model according to the highest F-value of the variable.

5.2.2. Heteroscedasticity

Heteroscedasticity is a frequent problem in cross-section data. Heteroscedasticity arises when the error terms are not constant across the observations. The presence of heteroscedasticity can be hypothesized to be due to serial correlation which might occur since the sales price of a ranchette might depend on the sale prices of ranchettes that have been sold in the past.

5.2.3. Market Segmentation

In many studies, especially on urban housing, markets consisted of several submarkets. In the rural areas the market segmentation is not a severe issue and hence the hedonic price function is estimated for rural market as a whole.

5.2.4. Spatial Analysis

Spatial autocorrelation in urban housing studies have been analyzed extensively (Mingchi and Brown 1980; Schnare and Struyk 1976; Dubin 1992; and Pace and Gilley 1997). There are two main reasons for spatial autocorrelation (Basu and Thibodeau 1998). First, neighborhoods developed simultaneously would tend to have similar structural characteristics. Secondly, local amenities are shared among neighborhood residential properties. If the dependent variables are such that they do not explain the neighborhood and the locational characteristics of the housing unit, then the residuals obtained from the regression would be spatially autocorrelated. The two reasons for the presence of spatial autocorrelation are not valid for this study. First, this is a localized study of an area where ranchettes have developed and hence further localization is irrelevant. Secondly, rural housing prices are not dependent on the presence of local amenities like hospitals or schools as much as the urban housing prices are. But, rural house prices are dependent on the distances from the cities and highways which are the centers of such amenities. The distance variables are taken into account in this study and should explain much of the spatial autocorrelation in the data.

Moran's I (Moran 1948) statistic was used to test for the existence of spatial error processes. The statistic is explained in detail in the Appendix A. One of the requirements of the statistic is to generate a weight matrix. An inverse squared distance measure computed from the x and y coordinates of the centroid of the parcels was used as the weighting matrix. SAS was unable to compute the inverse of the weight matrix because of the large number of observations. Matlab code was used to compute the Moran's I using sparse matrices.

6. Empirical Results

The results from the ordinary Least Squares regression are given in Table 6.1. The statistical analysis was done using SAS procedures. All the variables are statistically significant beyond one-tenth of a percent level. Exception to the significance test is the dummy variable, NGBS, for adjacent neighbors. It was hypothesized that people would value open space, but the coefficient for this dummy variable is negative. However, the low t-statistics indicate that this variable has little influence on the sale price of ranchette and also it is not significant in explaining the model.

Ordinary Least Squares were conducted on both semi-log and linear forms of model. The Ordinary Least Squares estimation results on the linear model is shown in table 6.2.

Table 6.1. Ordinary least squares estimation of semilog model

Variable names	Parameter Estimate	t-value	$Pr < \|t\|$	Mean value
INTERCEPT	8.72652	67.12	$< .0001$	
DIST2ROAD	-0.00004430	-13.77	$< .0001$	3383.47
DIST2CITY	-0.00002336	-28.87	$< .0001$	14007.24
DIST2RIVER	-0.00003540	-20.86	$< .0001$	7981.81
OPENSPACE	0.11877	4.62	$< .0001$	
NGBS	-0.03495	-1.58	0.1148	
NDVI	0.00942	9.39	$< .0001$	122.857
DIFFYR	-0.06376	-13.91	$< .0001$	
LAND_SIZE	-0.03880	-27.27	$< .0001$	10.142
IMPPERACRE	0.00001921	38.10	$< .0001$	6290.22

$R^2 = 0.6238$

TABLE 6.2. Ordinary least squares of the linear model

Variable names	Parameter Estimate	t-value	$Pr < \|t\|$
INTERCEPT	-2249.47881	-0.21	0.8316
DIST2ROAD	-0.52933	-2.02	0.0431
DIST2CITY	-0.10406	-1.58	0.1139
DIST2RIVER	-0.00040900	-0.00	0.9976
OPENSPACE	706.29440	0.34	0.7354
NGBS	-2700.2166	-1.50	0.1341
NDVI	129.43958	1.59	0.1128
DIFFYR	-47.25202	-0.13	0.8992
LAND_SIZE	-85.24272	-0.74	0.4613
IMPPERACRE	1.15535	28.17	$< .0001$

$R^2 = 0.0945$

The results from semi-log and the linear model show that the semi-log model provides a better estimation than the linear model. Almost all the coefficients are significant in the semi-log model unlike the linear model. According to the standard goodness of fit criteria, $R^2 = 0.6238$ shows a good fit for the semi-log model. The R^2 in this model without intercept was computed as $1 - \Sigma(p - \hat{p})^2/\Sigma(p - \bar{p})^2$ (Kvalseth 1985). Also all the coefficient estimates in the semilog model are of expected signs. Hence the semi-log model is taken to be the benchmark model in this study and all the coefficient estimates are based on this model.

6.1. Diagnostics

In order to reduce any specification bias a stepwise regression procedure was conducted. It was found that all the variables entered into the model and had a significant effect on the price of the ranchettes. Also, in the presence of specification bias due to the omission of relevant variables the estimates are biased. However, biasedness of the error terms were not detected.

Another modeling concern was the presence of multicollinearity. Obvious indicators of multicollinearity, a high R^2 combined with low t-ratio is not evident. More rigorous multicollinearity tests using condition indices were also conducted. Condition indices ranging from 20 to 40 pose a multicollinearity problem. The maximum condition index obtained was 3.30. It was therefore concluded that multicollinearity was not a problem.

Further diagnostics were performed to check for the robustness of the fit. Regression was performed on half of the data selected randomly and the coefficient estimates were used to compute the mean squared error of the other half of the data. The mean squared error for the regression predictions for the in-sample data was 0.986, while for the out of sample prediction the mean squared error was 0.991.

There was no systematic relationship in the plot of squared residuals against the predicted values. However, both the Breusch-Pagan and the White's test have been used to test for heteroscedasticity. Both these tests are based on the residuals of the estimation. For the Breusch-Pagan test it was assumed that the error variance varied with all the explanatory variables and the square of the variables except the dummy variables. The Breusch-Pagan test statistic and its correction is explained in the Appendix D. The test statistic for White's test is 431.8 and for Breusch-Pagan, it is 155.8. In both instances the test statistic were significant at 1% level[1], establishing the presence of heteroscedasticity.

Since the exact form of heteroscedasticity is not known, a full information maxi-

[1]The critical value of the test statistic at the 1% level of significance is 13.28

mum likelihood (FIML) estimation was performed using GLS estimation of the covariance matrix to correct for the heteroscedasticity. The results of the model after correcting for heteroscedasticity is shown in table 6.3. The results indicate that although there is a substantial drop in R^2, the parameter estimation and their significance are almost the same as in the semi-log model.

TABLE 6.3. Full Information Maximum Likelihood Estimations

Variable names	Parameter Estimate	t-value	$Pr < \|t\|$
INTERCEPT	8.726515	89.87	$< .0001$
DIST2ROAD	-0.00004	-12.84	$< .0001$
DIST2CITY	-0.00002	-25.99	$< .0001$
DIST2RIVER	-0.00004	-19.63	$< .0001$
OPENSPACE	0.118768	4.60	$< .0001$
NGBS	-0.03495	-1.60	0.1098
NDVI	0.009418	12.73	$< .0001$
DIFFYR	-0.06376	-13.46	$< .0001$
LAND_SIZE	-0.0388	-30.30	$< .0001$
IMPPERACRE	0.000019	145.45	$< .0001$

R-Square for FIML estimation is 0.6238

The data was tested for the presence of any spatial autocorrelation in the residuals. The Moran's I estimate of 0.2501 was not significant with a P value of 0.6504 indicating the absence of spatial correlation in the residuals. The implication of this result is that the dependent variables explained much of the spatial processes and hence an estimation correcting the spatial autocorrelation was not required.

6.2. Discussion

The primary focus of this hedonic estimation is on the role and significance of the remoteness proxies and the greenness indices. Both the environmental variables, distance to rivers and the NDVI, were found significant. A higher value of average annual vegetation greenness for a parcel in the year preceding the sale of the ranchette increased its market value. Also proximity to the rivers and creeks increased the sales value of the ranchette.

The NDVI proved to be a significant variable in explaining the sales value of the ranchette. The marginal implicit price of increasing the greenness index by one unit, evaluated at the mean sale price of $15,393, produces an increase in the land value of $144.97 per acre, which is quite a significant increase. It can be conjectured that greenness increases the value of the any rural land, including those involved in agricultural productivity since greenness might be correlated to higher soil fertility. In Arizona, the main farm activity is livestock production. Forage for livestock in Arizona tends to be green for only 1-2 months in the year, but even the more yellow senescent biomass has production value. Senescent biomass tends to have a lower NDVI, hence greenness measure can be taken to be a proxy for the scenic beauty of a place. It can be inferred that NDVI provides a good proxy for ranchette amenities even though it fails to measure 100% of the forage value of vegetation for livestock in semiarid Arizona.

The NDVI takes into account the intra-annual temporal variations and the spatial variations 1 kilometer pixels or one square kilometer area. NDVI serves an indirect proxy to rainfall. Rainfall varies with elevation, among other factors. Due to a possible correlation between the two variables, elevation and NDVI, separate OLS regressions including and excluding the elevation coverage were done to test for the significance of elevation in the presence of NDVI. It was found that elevation was a significant variable in the regression which did not include the NDVI with a marginal drop in the R^2 from 0.6238 to 0.6210. However, elevation was not significant when estimated along with NDVI, the t value being 1.05. NDVI remained significant even when elevation was included. Hence the benchmark regrssion was done without taking into account the variable elevation.

Depending on whether or not ranchette owners like living next to open spaces, the coefficient estimate for this dummy variable would be positive or negative. Most of the hedonic literature have shown that open space is a positive amenity although these studies were conducted for the urban properties. The treatement of the open space variables and the neighborhood variables are different in a rural setting from those in an urban setting. For example, since ranchette owners are mainly urbanites who have migrated from different parts of the country, they might not like as much to live in remote wilderness as the traditional residents of these places. Also, proximity to open spaces are more plausible in rural areas then in urban areas and hence might not be valued as much as in the urban areas. Due to the uncertainty in how the ranchette owners value neighbors and public lands, no conjectures were made on the possible sign of the coefficients for the proximity to the open spaces or the public lands and the neighbors.

The regression results showed that the variable open space was significant and had a positive sign. This could be interpreted as ranchette owners valuing adjacency to public lands. If there is an adjacent public land bordering a particular ranchette then on an average the sale value of that ranchette would increase by almost $1830.00. This is quite a significant increase in the sale value of the ranchettes. This could attributed not only to the desirability of open spaces, but also the possibility of grazing on the nearby public lands if a ranchette can acquire a grazing lease.

Another important set of variables that help in valuing ranchettes are the remoteness proxies. The variables, distance to cities and roads have a negative coefficient and are significant. This implies that the more farther away the ranchettes are from the cities and the highways, the lower is their value. The marginal implicit price of the ranchette for being one meter closer to a city is \$0.31 and to the roads, it is \$0.61. That is, if a ranchette is closer to the cities by one mile then its sale value would increase by \$5,240 and if a major road or a highway is within one kilometer of the ranchette then the value of the ranchette would increase by \$6100. This implies that people value accessibility and enjoy the benefits of being closer to small towns.

This study is different from the earlier hedonic studies in its attempt to include neighbors as an explanatory variable. A ranchette owner has the option of not being next to neighbors as opposed to the home owners in more densely populated urban areas. Thus, the presence or the absence of the neighbors are incorporated in the study. Spatial autocorrelation present in housing studies are due to similar neighborhood or simultaneous development of neighborhoods. The variable NGBS tries to capture the presence or absence of neighbors at the time of sale of the ranchette and hence may explain much of the spatial autocorrelation. The inclusion of this variable is important in answering the question,"How does the neighborhood affect the price of the ranchettes?" Do people like the Western lifestyle and have desires to own houses on the ranches or they like remoteness and have desires to build their houses away from neighbors.

Estimation results show that this variable has a negative coefficient with pvalue equal to 0.1148, indicating that people may not like having neighbors. The price of a ranchette decreases by almost \$500 per acre if there are neighbors. The ranchette owners are not willing to pay a higher value for the ranchettes if the adjacent parcels are already sold. This strengthens the desire of the ranchette owners to be near open spaces as opposed to having neighbors. It might be conjectured that, the presence of neighbors is a good factor since that might reduce the implicit cost of infrastructure maintenance. However, since the people are moving into a new region for settlement presence of neighbors might not be a desirable factor for these people.

The structural variables were also significant and of the expected sign. The lot size had a negative coefficient which implies there are diminishing returns to lot size, that is, larger parcels have lower value per acre. The decrease in price for a increase in the lot size by an acre was \$600.

The assessed improvements in the lots were also significant and had a positive coefficient. The inverse log of the estimated coefficient was close to one, indicating that the accuracy of the assessors estimates. Improvements in the land increased the per acre value of the land by almost 29 cents.

The coefficient of the variable DIFFYR gives the rate of depreciation or appreciation of the particular parcel. As can be seen from the results there is an appreciation of the value of land at the rate of 3.23% per year ($\beta \exp \beta$). The marginal implicit prices for each independent variable are summarized in table 6.4. These values are obtained from the coefficient estaimates in table 3, after correcting for heteroscedasticity.

TABLE 6.4. Marginal implicit prices and elasticities

Variable names	Parameter Estimate	MIP	Elasticity
DIST2ROAD	-0.00004	-0.61572	-0.1353388
DIST2CITY	-0.00002	-0.30786	-0.2801454
DIST2RIVER	-0.00004	-0.61572	-0.319256
OPENSPACE	0.118768	1828.19	
NGBS	-0.03495	-537.985	
NDVI	0.009418	144.97	1.157
DIFFYR	-0.06376	-981.457	-0.248664
LAND_SIZE	-0.0388	-597.248	-0.3935096
IMPPERACRE	0.000019	0.292467	0.11951418

7. Conclusions

Land transition issues are important in understanding the social and economic changes that are taking place in the United States. Subdivision of rural land and a shift in the demand from agricultural to recreational use of the land goes a long way to usher in an era of change. Land use is related to the characteristics of the land. Rural lands provide open spaces, recreation and aesthetics all of which are collective good characteristics. Because these characteristics are not represented in the market, hedonic property pricing approach is an appropriate apporach to explain the demand for the land's amenities/disamenities.

This study estimated the value of scenic beauty and remoteness to ranchette owners in Yavapai County, Arizona. The analysis used an Ordinary Least Squares regression on a semi-log model. Because of the large number of observations a good fit and precise estimates of the statistics were obtained. All the variables with the exception of open space were found to be significant. The price of land increased with the decrease in the distance to the roads and cities, implying that people prefer accessibility to transportation and proximity to the urban centers. Their preference for a house in the rural areas is also reflected on the premium they are willing to pay in order to be located next to the open spaces represented by the public lands. The results also show that the remote sensing data has substantial predictive power on ranchette value.

There are several contributions of this study to the hedonic pricing literature. Firstly, this study addresses the use of rural land solely for consumption or recreational purposes using a hedonic estimation technique and the response of those who buy second homes in rural areas to the land attributes in terms of placing an implicit value on the ranchette. Secondly, this study provides a good proxy for a scenic beauty variable with remote sensing data which are easily accessible. The temporal and the spatial nature of the data provides a better measure of the scenic beauty than a measure obtained from the assessors or general survey of the study area. Thirdly, several variables have been created which are a new GIS addition to hedonic modelling. The remoteness proxies include adjacency to open spaces as opposed to distance from the open spaces. Also the variable, adjacency to the neighbors provide a convenient way of understanding the preferences on the lifestyles of the ranchette owners.

7.1. Future Research

Opportunities for further research related to this study would involve identifying areas which have the potential to subdivide and form ranchettes and extrapolating the model on other locations. Ranchette formation pressures could be studied at the county or the state level by including demographic variables like population, in-state migration, age distribution of population, etc. Estimation of the probability of ranchette sale could also be done to explicitly quantify ranchette formation pressures.

A. APPENDIX: MORAN'S I

The Moran statistic gives a measure of the spatial autocorrelation. The numerator measures the extent to which adjacent points have similar deviations about the mean of the data, and the denominator standardizes that quantity to reflect the scale or variability of the variable being examined.[1] The Moran statistic is given by

$$I = (\frac{n}{\sum_{i=1}^{n}\sum_{j=1}^{n} w_{ij}})(\frac{\sum_{i=1}^{n}\sum_{j=1}^{n} w_{ij}(x_i - \overline{x})(x_j - \overline{x})}{\sum_{i=1} n(x_i - \overline{x})^2}) \tag{A.1}$$

where, n= the number of points or spatial units x= the variable of interest (residuals) $\overline{x}$ = the mean of x w_{ij} = the spatial weight describing the adjacency or distance between the i-th and the j-th points. The significance of Moran's I can be judged by calculating the following statistic and comparing it to the standard normal distribution

$$Z = \frac{I - E(I)}{var(I)} \tag{A.2}$$

The expected value of Moran's I that would be obtained when there is no spatial autocorrelation is $E(I) = 1/(n-1)$.

The variance of the Moran's I is given:

$$var(I) = \frac{nS_4 - S_3S_4}{(n-1)(n-2)(n-3)(\sum_{i=1} n \sum j = 1nw_{ij})} \tag{A.3}$$

where,

$$S_1 = (\sum_{i=1}^{n}\sum_{j=1}^{n}(w_{ij} + w_{ji})^2)/2 \tag{A.4}$$

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[1]University of Oregon: http://geography.uoregon.edu/courses/geog414f01/images/moran.gif, 2002

$$S_2 = \sum_{i=1}^{n}[\sum_{j=1}^{n} w_{ij} + \sum_{j=1}^{n} w_{ji}]^2 \tag{A.5}$$

$$S_3 = \frac{n^{-1}\sum_{i=1}^{n}(x_i - \overline{x})^4}{(n^{-1}\sum_{i=1}^{n}(x_i - \overline{x}))^2} \tag{A.6}$$

$$S_4 = (n^2 - 3n + 3)S_1 - nS_2 + 3(\sum_{i=1}^{n}\sum_{j=1}^{n} w_{ij})^2 \tag{A.7}$$

$$S_5 = S_1 - 2nS_1 = 6[\sum_{i=1}^{n}\sum_{j=1}^{n} w_{ij}]^2 \tag{A.8}$$

For values of $Z \geq 2.0$ or $Z \leq -2.0$ (p values ≤ 0.05) indicate significant spatial autocorrelation.

B. APPENDIX: SALES PRICE ADJUSTED FOR PRICE INFLATION

TABLE B.1. Average price deflator

Year	Average Price Index
1991	136.2
1992	140.3
1993	144.5
1994	148.2
1995	152.4
1996	156.9
1997	160.5
1998	163
1999	166.6
2000	172.2

The consumer price indices were obtained from the US Department of Labor Bureau of Labor Statistics.[1]

The following procedure was followed to compute the deflated prices. To eliminate the effect of inflation, first the price deflator for each were divided by 100 and then joined to the data using Arcview with the year being the join variable. Next, each year's sale price was divided by the deflator for that year. Thus the sale prices adjusted for inflation were obtained.

[1]Consumer Price Indices: http://www.bls.gov/cpi/, 2002

C. APPENDIX: Derivation of the Marginal Implicit Prices and Elasticities

The appendix shows the derivation of the marginal implicit prices from the semilog model.

$$
\begin{aligned}
lnP &= \sum_{k=1}^{K} X_k \beta_k + \epsilon \\
\frac{\partial lnP}{\partial X_k} &= \beta_k \\
\frac{\partial P}{\partial X_k} &= \beta_k P
\end{aligned}
$$

where, P is given by the average sale price and β_k is the coefficient estimate of an independent variable. The elasticity of the price of a ranchette with respect to an amenity is given by:

$$\epsilon_k = \frac{\partial p}{\partial x}\frac{x}{p} = \beta \overline{x_k} \qquad \text{(C.1)}$$

D. APPENDIX: TEST AND CORRECTION FOR HETEROSCEDASTICITY

A modified Breusch-Pagan (BP) test was conducted using SAS. The null hypothesis of the BP test is

$$H_0 : \sigma_i^2 = \sigma^2(\alpha^{`} z_i) \tag{D.1}$$

where σ_i^2 is the error variance for the ith observation, α are vector of regression coefficients.

The test-statistic for the BP test is

$$bp = \frac{1}{v}(u - \overline{u_i})^{`} z(z^{`}z)^{-1} z^{`}(u - \overline{u_i}) \tag{D.2}$$

where $u = (e_1^2, e_2^2, ..., e_n^2)$, i is a (nx1) vector of ones, and

$$v = \frac{1}{n}\sum_{i=1} n(e_i^2 - \frac{e^{`}e}{n})^2 \tag{D.3}$$

z is the matrix containing the values of the set of regressors which are used in explaining the heteroscedasticity. This modified version of the BP test is differenr from the orinigan1 test where normality is assumed.

Full Information Maximum Likelihood Estimation: FIML

Consider the general non-linear model:

$$\epsilon_t = q(y_t, x_t, \theta) \tag{D.4}$$

$$z_t = Z(x_t) \tag{D.5}$$

where, ϵ_t is an unobservable disturbance vector with the following properties:

$$E(\epsilon_t) = 0 \tag{D.6}$$

$$E(\epsilon_t \epsilon_t^{`}) = \Sigma \tag{D.7}$$

FIML estimation method minimizes the following objective function:

$$I_n(\theta, \sigma) = \tfrac{n}{2} ln(2\pi) - \sigma_{i=1}^{n} ln(|\tfrac{\partial q(y_t, x_t, \theta)}{\partial y_t'}|)$$

$$+\frac{n}{2} ln(|\Sigma(\sigma)|) + \frac{1}{2} tr(\Sigma(\sigma)^{-1} \sigma_{i=1}^{n} q(y_t, x_t, \theta) q`(y_t, x_t, \theta))$$

The estimate of the variance covariance of θ for FIML is given by the generalised least squares estimator of the covariance matrix.

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