AGRICULTURAL LAND AND THE SMALL PARCEL SIZE PREMIUM PARADOX

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AGRICULTURAL LAND AND THE SMALL PARCEL

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TABLE OF CONTENTS

Chapter Page

I. INTRODUCTION 1

II. THEORY 3

Equation (1): Capitalization formula 3
Equation (2): Formalized capitalization formula 3

III. DATA 7

IV. METHODS 11

Equation (3): Semi-parametric regression for average price per acre and parcel size 12
Equation (4): Change in parcel size over time 16
Equation (5): Effect of urban proximity on parcel size 17
Equation (6): Presence of small parcel premiums for urban areas 18

V. RESULTS 19

VI. SUMMARY AND CONCLUSION 22

REFERENCES 25

LIST OF TABLES

Table Page

1. Summary statistics of land parcels with improvements......................................29

2. Rural-Urban Continuum Codes 30

3. Characteristics of parcel size categories for the first and last decade of collected data 31

4. Characteristics of pasture parcels by size categories for the first and last decade of the collected data 32

5. Characteristics of cropland parcels by size categories for the first and last decade of the collected data 33

6. Estimated regression of parcel size against time 34

7. Estimated regression of parcel size changes against time for pasture and cropland separately...34

8. Estimated coefficients for determining parcel size (acres) relative to urban proximity with and without county population 35

9. Heteroskedasticity-consistent standard errors and t-values for determining parcel size (acres) relative to urban proximity with and without county population......36

10. Estimated coefficients (from least to most negative) for determining small parcel premiums...37

LIST OF FIGURES

Figure Page

1. Total number of sales and sales by land usage category 39
2. Percentage of cropland parcels sold in each size category from 1971 – 2010 ..40
3. Percentage of pasture parcels sold in each size category from 1971 – 2010 41
4. Rural-Urban Continuum Codes by county 42
5. Pasture sales, 1971 – 1980 43
6. Pasture sales, 2001 – 2010 44
7. Cropland sales, 1971 – 1980 45
8. Cropland sales, 2001 – 2010 46
9. Semi-parametric estimates of the effect of parcel size on land price 47
10. Changes in cropland parcel size over time 48
11. County parameter estimates for "Acres" 49

CHAPTER I

INTRODUCTION

The focus of this study is a greater understanding of the extent and causes of the small parcel size premium in agricultural land. Considerable research has shown that price per acre of agricultural land is inversely related to parcel size (Guiling et al., 2009b; Hepner, 1985, Jennings and Kletke 1977; Miller 2006). This small parcel premium raises the question why all agricultural land is not sold in small parcels?

Another question is whether parcel size has been decreasing over time. Studies by Koontz (2001) and Carrión-Flores et al (2009) indicate that parcel size plays a role in determining land usage. If fragmentation is increasing over time then parcels may become small enough that agricultural production is no longer a viable land use option. An additional question is how small parcel premiums vary across space? The hypothesis tested is that small parcels occur more frequently around urban areas and that a small parcel premium can be found in or near urban areas.

Breaking land up into smaller parcels is a form of fragmentation, but it is fragmentation of land ownership rather than fragmentation of land use. Considerable previous research has focused on fragmentation of land use (Brabec and Smith, 2002; Irwin and Bockstael, 2001; Kjelland et al, 2007) which is a different question. Fragmentation of ownership is a mostly new research direction.

We offer a theory to explain why price per acre decreases with parcel size. The primary theoretical argument is that returns from some uses are associated with owning a parcel and increase little with parcel size. The major policy concern associated with the fragmentation of agricultural land is agricultural productivity. From a farmer or rancher's perspective, the smaller a land parcel becomes, the more costly it may become to produce agricultural products. Indeed, should the parcel size become small enough, production would become cost prohibitive (Jabarin and Epplin, 1994).

Agricultural productivity is not the only concern. Wildlife management, soil conservation, and public road access become more of a problem as land ownership is fragmented. To examine issues related to agricultural land parcel size, a database containing information on Oklahoma land sales is used.

A semi-parametric regression is used to estimate the relationship between price per acre and parcel size. The purpose of this semi-parametric model is to determine the shape of the expected inverse relationship between price per acre and parcel size. ArcGIS[1]plotting is used to provide a visual representation of the location of small and large parcels. The expectation is that smaller parcels will be located closer to large population centers.

[1]ArcGIS is a software package that allows for geographic data to be managed and mapped. For this study, it was used to develop a series of maps.

One hypothesis tested is that parcel size decreases as urban proximity increases. Using regression, the effect of parcel size on land prices is estimated separately for each county. Finally, to determine to what extent parcel size has been changing over time, parcel size is regressed against a polynomial in time.

Buyers of land for exurban or residential land use tend to prefer smaller parcels (Sengupta and Osgood, 2003). As a parcel's size increases, so too does the likelihood that the parcel will be used for agricultural production (Carrión-Flores et al., 2009). The purchase of a parcel for exurban use does not automatically remove that parcel from agricultural production; some may purchase in the hopes to live a "rural lifestyle." Often purchasers become "hobby farmers"[2](Sengupta and Osgood, 2003). Theobald (2005) notes that there is no set point at which a parcel has become small enough to prevent agricultural production on it.

[2] Farms with less than $10,000 in yearly sales are typically considered recreational in nature.

CHAPTER II

THEORY

A theory of agricultural land parcel size needs to explain why small parcels have a higher per acre price than larger parcels. It also needs to explain why this is not always the case. Dating back to the time of classical economists, capitalization theory has been used to determine the value of land (Morton, 1970). The capitalization formula is:

(1) Agricultural Land Value = Returns/Discount Rate.

Here returns can be from agricultural use, recreational use, exurban land use, or from urban conversion. Rural residential development is a form of exurban land use (Theobald, 2005; Newburn and Berck, 2006). If the urban conversion option is chosen, it is irreversible. The returns to this option will reflect the discounted incremental return above the other returns from conversion to urban use at some point in the future (Capozza and Helsley, 1989). Since land can have multiple uses, the capitalization formula can be more formally expressed as:

(2) $$V_{pt} = \sum_k R_{kpt} / \rho_t$$

where V_{pt} is the value of the pth parcel in year t, R_{kpt} is the expected return from the kth land use (agricultural, recreational, exurban, or urban conversion), and ρ_t is the discount rate in year t. Note that a parcel can have returns from agricultural, recreational, and exurban uses, but returns from urban conversion are a one-time return and once land is converted to urban use all other returns end.

The returns from owning land are typically viewed as being realized on a per acre basis. For agricultural uses, the per acre basis clearly makes sense. However, the benefits of some uses may only require a parcel of some minimum size. For example, if the owner's main goal is land to build a house and space to keep a horse, then a few acres is sufficient. If the owner's goal is to keep a small herd of cows, then 80 to 160 acres is enough. Should the owner want a spot to build a fishing pond or produce for a farmer's market, then forty acres might be plenty. In some cases, the owner may simply want to own some land. In these cases, the returns to some uses do not increase much with parcel size beyond a specific point.

Not all parcels will have returns associated with the parcel rather than per acre. In rural areas with poor roads, little potential for deer hunting or other recreational activities, all the value will be agricultural value, which should not decrease as parcel size increases. Every county in Oklahoma has some paved roads as well as some towns. Therefore, every county in Oklahoma is expected to have some land that is more valued in small parcels.

Another factor that may play a role is the number of bidders. Land is sold both by auction and by negotiated sale. Auction theory of both private-value auctions and affiliated-value first-price auctions has shown that prices increase with the number of bidders (McAfee and McMillan, 1987). Because of capital or borrowing constraints and risk aversion, the number of bidders likely decreases with parcel size. Therefore, reduced competition may explain some of the reduced prices for larger parcels.

An issue that remains to be addressed is why more land is not sold in smaller parcels. Not all land has a small parcel premium, but there may be other reasons that sellers do not choose smaller parcel sizes. Land is not a liquid asset. Selling commissions average 5% (United States Department of Justice, 2009), legal costs such as bringing the abstract up to date can be substantial, and some portions of the proceeds are often subject to capital gains taxes. Also, the decision to sell land is typically irreversible and substitutes are imperfect. As a result, parcels are typically either offered at an estate sale or because the owner needs the money to offset a financial hardship, although some parcels will sell occasionally because someone has offered a favorable price for their land. Once a seller has committed to selling, they are still faced with a choice of how to sell their land.

For example, the owner of a 160 acre parcel can either choose to sell the parcel as a whole or divide it into two separate, 80 acre parcels. However, the choice to sell as two parcels can create a dilemma. An agricultural buyer will likely prefer the larger, 160 acre parcel and will be willing to pay more for it. If only one buyer is interested in paying a premium for an 80 acre parcel then the seller then the seller could be left with one 80-acre parcel that may be more difficult to sell. This could cause the price of the two 80 acre parcels to be less than the price of a different buyer is willing to pay for the single 160 acre parcel. Often at land auctions, a 160 acre parcel will be offered as two separate

80 acre tracts and then offered as a single 160 acre tract. The 160 acre parcel will typically receive a higher price than the combined price of the separate 80 acre parcels. Therefore there is a liquidity cost to wanting to sell more than one 80 acre parcel at a time.

Throughout the years, researchers have sought to model the supply of agricultural land. The inelasticity of farmland supply has prohibited them from developing an appropriate model (Weersink et al., 1999; Burt, 1986). Quantity supplied for agricultural parcels is fixed in any given year. Simply using the number of land sales in a year is not a suitable alternative for quantity supplied because in a given year, a parcel may be put up for sale but not sold. Here it would be part of the supply and yet would not be counted among land sales. While the amount of farmland available for sale may change over time, the amount is relatively independent of farmland prices (Burt, 1986).

CHAPTER III

DATA

The data for this research is collected by Farm Credit Service institutions in Oklahoma from 1971 to the present. This study utilizes data from 1971 to 2010. Farm sales transaction data includes land classification, parcel size, date of sale, legal description specified to the section, and county. The dataset is extensive and it is intended to provide a representation of agricultural land transactions that took place within the state with the exception that 1995 – 1996 and 2006 data are clearly lacking in the number of reported land sales. Possible explanations for the lack of data in 1995 – 1996 include data collection difficulties and the retirement of a faculty member responsible for the data set. It is unknown why there were so few sales reported in 2006. Additionally, since 2000 some Farm Credit Service offices have been subcontracting their land appraisals and therefore their data collection to other parties. There is also some variation across districts in which sales are included. Observations missing price information and duplicated observations were removed from the dataset. Observations lacking a legal description were kept in the dataset because they included all information needed for regression analysis; however, they were excluded from the maps. 1,237 observations were removed from the dataset because they were incomplete. Outliers of less than $100 and greater than $5,000 per acre were also removed; this led to removing 1,932 observations leaving 58,760 usable observations. Figure 1 shows a plot of the sales in the dataset by year; to be labeled as “Crop” the parcel consists of 85% cropland (Ag Econ Extension at OSU, 2012). Likewise, “Pasture” parcels are 85% pasture land. Other usage categories exist but were not identified separately in this graph; the “Total” category represents total number of sales in a given year and not the total of cropland and pasture sales.

The data set has limitations. First, it is unknown what percent of total sales are included in the data set. A Farm Credit Services officer estimated that 25% to 50% of total sales were included for his regional office. Appraisers at that office attempt to write up every “arms-length” agricultural transaction. Second, another Farm Credit Services office currently does not typically include sales of less than 40 acres. It is unknown whether or not similar practices occur at other offices. Third, appraisers at each office choose which information is included in the observations. This could result in variation across offices. Clearly, the data does not include the population of all agricultural land transactions at the time of sale.

Appraisers use a variety of descriptors to classify land. We reduced the classifications to cropland, pasture, timber, water, waste/roads, home site and other uses. For example, “native pasture” and “improved pasture” classifications are both included under the more general term “pasture”. Land in the Conservation Reserve Program (CRP) was classified as “other”. CRP is a voluntary program where farmers can receive annual rental payments and other benefits in exchange for allowing resource conserving cover on eligible farmland (USDA, 2011).

In all, there were 8,252 observations with improvements (Table 1). The average improvement contribution value was $51,085 with an average price per acre of $1,543. The value of the improvements and the acres associated with the improvements were not included in the calculation of price per acre.

Figures 2 and 3 show the percent of land sold within certain size categories for cropland and pasture land. The purpose of these figures was to determine whether or not any distinct patterns over time for size categories. Trend lines are included for the 0 – 40, 41 – 160, and 161 – 640 acre categories. Little to no change was found in the larger size categories for which there were relatively few observations so no trend line was included for those categories. While most size categories exhibit little trend, the smallest size category for cropland parcels shows a strong downward trend.

To distinguish between rural and urban areas, Rural-Urban Continuum Codes were developed by the United States Department of Agriculture Economic Research Service. These codes classify metropolitan and nonmetropolitan areas of the United States based on factors such as population size, degrees of urbanization, and adjacency to metropolitan areas. The codes are available at the county level (Figure 4). A Rural-Urban Continuum Code of 1 indicates the most metropolitan county, with a population of 1 million or more. In contrast, a county with a 9 is a completely rural county, not adjacent to a metropolitan area, and has a population of less than 2,500. Table 2 lists a complete description of Rural-Urban Continuum Codes (USDA Economic Research Service, 2004) as well as the number of counties in each classification.

Table 3 shows the descriptive statistics for a variety of variables used in the study by size category (0 – 40, 41 – 160, 161 – 320, 321 – 640, and 641+ acres). The upper portion of the table shows the information for 1971 – 1980 while the lower portion of the table shows information for 2001 – 2010. The 2001 – 2010 time period contains relatively more small parcels (0 – 40 acres) and very large parcels (larger than 640 acres). In the three larger size categories, average number of acres for that size category increased over time. As anticipated, price per acre decreased as parcel size increased for both time periods. Also of note, Rural-Urban Continuum Codes were essentially unchanged over time. Large parcels are typically located in counties with lower populations. Note that the smallest and largest parcel size categories typically have less cropland than medium sized parcels. The pasture, crop, and irrigation land use percentages will not sum to 100% because some parcels had a significant number of acres in the “timber”, “site”, “waste”, and “other” land usage categories.

CHAPTER IV

METHODS

The first hypothesis is concerned with parcel size. It is expected that average per acre price will decrease as parcel size decreases. To test for the presence of this decrease, a semi-parametric model is used with price per acre as the dependent variable and the size of the parcel as the primary explanatory variable. The semi-parametric regression function imposes no functional form for the relationship between price and parcel size. Other explanatory variables are included parametrically. Conversely, semi-parametric estimators are typically less efficient than a correctly specified parametric model (Powell, 1994). Using the PROC GAM procedure in SAS along with a LOESS smoothing effect, will utilize a local regression rather than thin-plate smoothing splines. With a local regression, the regression function is locally estimated with the local function being parametric. No changes were made from the default settings and no form of weighting was used in the model. The model is:

$$\ln(PerAcre_i) = \beta_0 + f(Acres_i) + \beta_1 Year_1 + \beta_2 Year_i^2 + \varepsilon_i \quad (3)$$

where $PerAcre_i$ is the price per acre received when the parcel was sold, i represents the individual parcel, $f(Acres_i)$ is the non-parametric functional form used to express the

$Acres_i$ in the parcel, $Year_i$ is the year the parcel was sold minus 1970 or 2000 to account for scaling issues and ε_i is an error term with a Gaussian distribution.

The data used in the model was separated into four different categories; the model was then run individually for each. The first division was for two time periods: 1971 – 1980 and 2001 – 2010. Parcels with a Rural-Urban Continuum Code of 1 – 5 were considered metropolitan for the purposes of this model; the remainder as non-metropolitan. Based on the definitions for these codes, it seemed probable that they contained parcels that would fall under the category of “exurban development.” See Table 2 for exact definitions. The purpose of this change allows a test for whether or not large parcels in rural counties have value derived only from their agricultural potential.

Equation (3) was estimated separately using only sales data from 1971 to 1980 and 2001 to 2010 to evaluate changes over time. It is expected that the natural log of price per acre will decrease as parcel size increases but at some point will become relatively flat in rural counties as land becomes valued mostly for agriculture.

The next question addressed is, “Where does land ownership fragmentation occur?” Maps were used to provide a visual answer to this question. Since the legal description of the parcels is specific down to the section, the latitude and longitude for each parcel is taken from the center point of the section. Also included on the map is the location of the fourteen cities in Oklahoma as defined by the 2010 Census (U.S. Census Bureau). Census information states a place with a population of 25,000 or larger is classified as a city (U.S. Census Bureau). Cities were added to provide relevant landmarks and identify the location of urban areas.

Figure 5 shows the location of pasture sales by parcel size from 1971 to 1980 while Figure 6 shows the same information from 2001 to 2010. Large areas of white space indicate no sales took place in the area. Large ranches are typical in Osage county northwest of Tulsa which accounts for a lack of markers there. Similarly, large tracts of land are owned by timber companies in southeastern Oklahoma and the land changes hand infrequently. A large military base near Lawton, Oklahoma and the Wichita Mountains Wildlife Refuge account for the large amount of white space in Comanche County. Areas with few sales can represent public land, urban areas, land held by Indian tribes, or an area of little interest to the Farm Credit Services appraiser. Other possible explanations include an appraiser who chose not to report sales in an area or simply an area where land changes hands infrequently.

Figure 5 shows a considerable number of large parcels located in the eastern half of the state. A band of mostly small to medium parcels is located to the west and north of the Oklahoma City metropolitan area. This band then gives way to a cluster of larger parcels in the northwest corner of the state.

In Figure 6, a cluster of larger parcels can be seen to the south and east of the Oklahoma City metropolitan area, along the western edge of the state, and between Ponca City and Bartlesville in north central Oklahoma. The rest of the state shows a mix of small and medium parcels scattered throughout. Table 4 compares average statistics for the beginning and end of the analysis period for pasture parcels. From the first time period to the last time period, average pasture parcel sized decreased by 45.21 acres while price per acre increased from $662 to $1,649 per acre.

Similar maps and tables were made to illustrate crop sales (Figures 7 and 8, Table 5) also using 1971 – 1980 and 2001 – 2010 time frames, respectively, with the location of cities. Figure 7 shows the majority of the parcels to be between 0 and 160 acres for 1971 – 1980. Most parcels between 41 and 160 acres are in the western half of the state. Larger parcels tend to be located either along the southern border of the state or in the Panhandle.

Figure 8 also shows few large parcels for 2001 – 2010. In the data, the largest concentration of large parcels is located in the Panhandle with some scattered throughout the state, particularly in the western half. The eastern half of the state is mostly given over to parcels smaller than 40 acres while the western half holds most parcels between 41 and 160 acres. Land settlement patterns may explain some of these differences. Also, the western half of the state contains more cropland.

In Oklahoma, all land is surveyed from the Initial Point in Murray County with the exception of land located in the Panhandle. Rather than using the Indian Baseline and Meridian, land in the Panhandle is surveyed from the Cimarron Baseline and Meridian. The Initial Point, establishing the Indian Baseline and Meridian, was set in 1870. It is from this point that land was laid out in townships and ranges with each township and range being 6 miles with a total land area of 36 square miles (Oklahoma Society of Land Surveyors, 2010). The sections are further subdivided into quarter sections or 160 acres which is often found throughout Oklahoma (National Atlas, 2011). Oklahoma, or Indian Territory, as it was known at the time it was resurveyed in 1890 to include land belonging to the Choctaw, Chickasaw, Cherokee, Muscogee, and Seminole Indian Tribes. The western half of the state was settled between 1889 and 1901 in either land rushes or a land lottery. Prior to a land rush or lottery, a tribe would allot each man, woman, and child 160 acres of land. The surplus land was then sold to the United States to be used in land runs or lotteries (Oklahoma Historical Society, 2007b). Quarter sections and town lots were available to settlers (Bohannon and Coelho, 1998) with the exception of Osage County. Unlike other Indian tribal lands in Oklahoma, Osage lands which comprise Osage County, never came under the Homestead Act of 1862. The Homestead Act would eventually lead to land runs and land lotteries but the Osage had previously purchased their land and owned it in fee simple. They allotted their land to tribe members from 1906 – 1907. This allotment provided a headright holder, one who could receive an equal share of the tribe's mineral interests, an allotment of land slightly larger than 640 acres in Osage County. This division left the Osage with no surplus land (Oklahoma Historical Society, 2007a). Tribal land accounts for 2.5% of the land in Oklahoma (Bureau of Indian Affairs, 1990.)These settlement patterns may account for some of the differences in parcel sizes across the state.

The differences in location of smaller versus larger parcels may be caused by a variety of reasons. Geography may come into play because the eastern half of the state is more covered with hills and trees while the western half of the state is a flat or rolling plain with considerably less tree cover. These differences lead to a difference in production practices. The eastern half of the state tends to focus on cattle over major crop production and the western half is typically in wheat production. Table 5 presents a comparison of average statistics for the beginning and end of the analysis period for cropland parcels. When comparing Tables 4 and 5, one can see that average cropland parcel size is smaller than average pasture parcel size for both time periods.

It is easier to divide a parcel into smaller parcels than it is to consolidate parcels. Thus, the second hypothesis tested in this study is that parcel size has been decreasing over time. To see how size has changed over time, parcel size is regressed against a polynomial in time using the following model:

$$(4) \qquad A_{it} = \beta_0 + \beta_1 Y_t + \beta_2 Y_t^2 + \varepsilon_{it}$$

where A_{it}, the dependent variable, is acres (parcel size), i represents the individual parcel, t represents the time period, and Y_t is the year the parcel was sold minus 1970 to reduce scaling problems.

This model was estimated using all the data and then on cropland parcels and pasture parcels separately. The observations were classified as a cropland parcel if 85% or more of the parcel was devoted to crop activities. The same rule was applied to the classification of pasture parcels. The 85% threshold was used to align with previous research (Ag Econ Extension at OSU, 2012) and the land values database on the Oklahoma Agricultural Land Values website.

The third hypothesis determines the relationship between a parcel's size and its proximity to urban areas. It is hypothesized that the closer a parcel is to an urban area, the smaller the parcel will be. Keeping the original regression for parcel size against a polynomial in time in equation (4), other variables are added to take into account the parcel's closeness to an urban area, county population, and three land usage variables. The model used to test this hypothesis is:

$$(5) \quad A_{it} = \beta_0 + \beta_1 Y_t + \beta_2 Y_t^2 + \beta_3 R2_{it} + \beta_4 R3_{it} + \beta_5 R4_{it} + \beta_6 R5_{it} + \beta_7 R6_{it} + \beta_8 R7_{it} + \beta_9 R8_{it} + \beta_{10} R9_{it} + \beta_{11} POP_{it} + \beta_{12} PAST_{it} + \beta_{13} CROP_{it} + \beta_{14} TIMBER_{it} + \varepsilon_{it}$$

where the dependent variable A_{it} is the number of acres, i is the individual parcel, Y_i is the year the parcel sold minus 1970 to account for scaling issues, $R2_i$ through $R9_i$ are variables representing the Rural-Urban Continuum Code for the county in which the parcel is located, POP_i is the population of the county in which the parcel is located, $PAST_{it}$ represents the percent of the parcel that is classified as pasture land, $CROP_{it}$ is a usage variable representing the percent of the parcel devoted to cropping activities, $TIMBER_{it}$ is the percent of the parcel classified as timber, and ε_{it} is an error term. A variable representing Rural-Urban Continuum Code 1, the most urban classification, is left out of the model to avoid perfect collinearity.

Rural-Urban Continuum Codes take into account a county's population when classifying counties and this may affect results when the County Population variable is included in the equation. The model is run with and without the County Population variable included to assess its effect on the regression results.

For the final hypothesis tested in this study, it is expected that parcel premiums will vary with location. Capozza and Helsley (1989) argue that the closer a parcel is located near an urban boundary, the higher the price it will achieve. This reflects the value of future increases in rent that can be realized after the land has been converted to urban use. A small parcel premium is expected to occur for similar reasons since small parcels are fine for many urban uses.

The sixth model seeks to determine if there is a greater premium for smaller parcels located closer to urban areas. This is tested by regressing price per acre against parcel size and other hedonic variables. To determine whether or not parcel premiums vary by location, the model is regressed individually for each county in Oklahoma. It is expected that parcel premiums will vary from county to county with more urban counties having a higher premium than those located in more rural settings. The model used is:

$$\ln P_{it} = \beta_0 + \beta_1 Y_t + \beta_2 A_{it} + \beta_3 C_{it} + \beta_4 T_{it} + \varepsilon_{it} \qquad (6)$$

where the dependent variable P_{it} is the price per acre for parcel i, Y_t is the year parcel i was sold, A_{it} is the number of acres in parcel i, C_{it} is the percentage of the parcel that is cropland, and T_{it} is the percentage of the parcel that is timber. ε_{it} is the error term. For this equation, the primary focus is on the β_2 coefficient which will be plotted as part of the results.

CHAPTER V

RESULTS

The semi-parametric regression function for Equation (3) yielded the expected results. For all four categories, parcel size has an inverse relationship with price per acre. The bulk of this relationship is expected to be explained by nonagricultural uses that do not increase with parcel size. But, the less competition for large parcels may be a partial explanation as three of the graphs indicate price per acre does not completely flatten out as parcel size increases but rather gradually declines (Figure 9). The graph for non-metropolitan parcels in the last decade does flatten out. The kinks that can be seen in some of the line graphs may be attributed to a large number of observations clustered around a certain parcel size, e.g. a large number of observations around 160 acres.

The analysis for parcel size over time, Equation (4), ultimately showed little change in parcel size over the time period presented in the dataset. Over the 40-year period, the change in parcel size, based on this model, is only one acre (Table 6). However, when the regression was run separately for cropland and pasture land the results differed (Table 7). For pasture parcels, the regression showed no significant trend.

For cropland, the results show a significant increase in parcel size (Figure 10). The decrease in small cropland parcels maybe attributed to larger machinery making small cropland parcels less economical as well as changes in farm programs that provided greater planting flexibility.

In the third model (Equation 5), which sought to test the hypothesis that parcel size decreases as urban proximity increases, parcel size is regressed against a variety of variables. These variables included information on the year the parcel sold, proximity to urban areas as expressed by Rural-Urban Continuum Codes, and land usage variables. Regression results supported the hypothesis that parcel size decreased as urbanization increased. Generally, as the Rural-Urban Continuum Code increased, indicating the parcel is in a more rural county, parcel size increased (Tables 3 – 5). The coefficients for Rural-Urban Continuum Codes 3, 4, and 6 were insignificant (Table 8); however, their effect on parcel size was not explained by the inclusion of the County Population variable (POP). The remaining code variables were significant and positive. The variable for County Population, when included, was significant and negative and as a county's population increases, parcel size decreases. Of the usage variables included, the crop variable was significant and negative (-12.19), which reflects the very largest tracts being pasture or timber.

Both versions of the model, with county population included and county population removed, were tested for heteroskedasticity using a White test (White, 1980). Both models were found to be heteroskedastic, the presence of which could render significance tests biased and lead to wrong inferences. Heteroskedasticity-consistent standard errors are included in Table 9. Tests on the coefficients for the Rural-Urban Continuum Codes still found codes 3, 4, and 6 to be insignificant.

For Equation (6), the log of price per acre was regressed against parcel size, year sold, and other variables describing land use (Table 10, Figure 11). Of most interest to this study is the parameter estimates for Acres. Since the regression was run separately for the 77 counties in Oklahoma, it provided an opportunity to determine the existence of a difference in sales price due to a parcel's location.

The sign for the "Acres" coefficient is negative for all 77 counties. A smaller, less negative coefficient for the variable "Acres" means there is a larger price per acre premium for smaller parcels while a larger number means little or no premiums exists in that county. Counties with lighter shading receive larger per acre price premiums for smaller parcels. Of the ten counties with the greatest small parcel premiums, nine of those either are metro areas or are adjacent to metro areas (Rural-Urban Continuum Codes 1 – 3). To test whether or not there were statistically significant differences between Rural-Urban Continuum Codes, the coefficient for Acres was regressed against them. An examination of the test for fixed effects shows the differences between the codes are statistically significant with a calculated F-value of 22.53 and a critical F-value of 3.965 allowing the null hypothesis of no differences to be rejected. At some distance from an urban area a parcel may be valued solely for its agricultural use. Thus, these results can help explain why most land is not sold in small parcels. Other issues such as distance to cities, road access, water, and utilities are important and may affect the presence of a premium as well.

CHAPTER V

SUMMARY AND CONCLUSION

The focus of this study was to provide a better understanding of the small parcel size premium for agricultural land. The data used were collected by Farm Credit Services on land sales across the state of Oklahoma. Research methods included the use of descriptive statistics, ArcGIS mapping, and regression analysis.

As expected, parcel size and price per acre have an inverse relationship. A semi-parametric regression was used to avoid the restrictions imposed by a parametric model. The resulting graphs show price per acre decreases sharply as parcel size increases. The discount for large parcels slows at about 160 acres, but only flattens out for the rural counties in the last decade.

While it was hypothesized that parcel size was decreasing over time, this was not the case when the regression was run for the entire data set. The hypothesis was tested using the data set as a whole and then cropland and pasture parcels separately. Parcel size was found to only have decreased by one acre for the aggregate data. However, cropland parcel size has recently risen. The effect of time on pasture parcels was insignificant. Note that the finding of little change in parcel size over time is only indicative of the parcel size in the Farm Credit Services database. Land that is converted to urban or exurban uses and deemed too small to be agricultural would not be included in the database. A third model tested the hypothesis that parcel size decreases as proximity to urban areas increases. The results of the regression analysis supported the hypothesis. Parcels located in more rural and less populated counties tend to be larger than parcels in more urban counties.

The fourth hypothesis tested is that the small parcel premium would be greater in or near urban areas. Separate regressions were estimated for each of the 77 Oklahoma counties. A small parcel premium was found in all 77 counties. A location premium exists for smaller parcels with parcels in urban counties more likely to receive a premium than those located in more rural counties.

The results of this study show small parcels received a premium. The findings support the theory offered that benefits from some forms of land use do not increase much with parcel size. Regarding the issues of why all land is not sold in small parcels, the study provides a partial explanation. The small parcel premium is stronger in urban counties. Some parcel locations may preclude them from receiving the premium.

Overall, parcel size did not increase over time. This may be the result of regressing Equation 4 on the entire data set. Suggestions for future research include running the model on each county to determine if parcel size is increasing in some counties but not others. The finding of urban proximity to be negatively correlated with parcel size indicates this could be a worthy pursuit.

Suggestions for further research include determining how a parcel’s distance from a paved road or state highway may affect its value. Similarly, a parcel’s distance from a town with a population greater than 1,000 people should also be considered. Another possible avenue to explore would be to investigate what effect, if any, agricultural policy has had on either parcel size or land values.

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Table 1. Summary statistics of land parcels with improvements

	No. of observations	Avg. no. of acres	Avg. no. improved acres	Avg. price per acre	Avg. improvement contribution	Percent with houses	RU continuum code	County population
0-40 Acres	3,723	24.65	1.86	$1,827	$47,256	4%	5	50,652
41-160 Acres	2,614	103.49	0	$1,574	$48,850	0%	5	33,211
161-320 Acres	1,261	208.77	0	$973	$43,126	0%	6	27,185
321-640 Acres	359	460.87	0	$948	$64,127	0%	6	27,564
641+ Acres	295	2,282.05	0	$852	$137,375	0%	6	25,056
Weighted Average	8,252[a]	177.43	0.84	$1,543	$51,085	1.8%	5	39,621

[a]Total

Table 2. Rural-Urban Continuum Codes

Code	Description	No. of Oklahoma counties
Metropolitan Counties		
1	Counties in metro areas of 1 million population or more	7
2	Counties in metro areas of 250,000 to 1 million population	9
3	Counties in metro areas of fewer than 250,000 population	1
Nonmetropolitan Counties		
4	Urban population of 20,000 or more, adjacent to a metro area	5
5	Urban population of 20,000 or more, not adjacent to a metro area	5
6	Urban population of 2,500 to 19,999, adjacent to a metro area	20
7	Urban population of 2,500 to 19,999, not adjacent to a metro area	16
8	Completely rural or less than 2,500 urban population, adjacent to a metro area	1
9	Completely rural or less than 2,500 urban population, not adjacent to a metro area	13

Table 3. Characteristics of parcel size categories for the first and last decade of collected data

Time/Size	No. of observations	Avg. no. of acres	Avg. price per acre	% Pasture	% Crop	RU continuum code	County population
1971 - 1980							
0-40 Acres	1,240	33.33	$1,150	80%	18%	5	59,508
41-160 Acres	7,058	122.47	$618	54%	44%	5	37,121
161-320 Acres	1,508	251.05	$473	62%	36%	6	31,867
321-640 Acres	603	460.52	$389	74%	24%	6	32,064
641+ Acres	301	1,710.03	$341	86%	13%	6	26,032
Weighted Average	10,710[a]	193.90	$638	60%	37	5	38,376
2001 - 2010							
0-40 Acres	2,033	29.99	$2,087	40%	5%	5	42,311
41-160 Acres	8,168	118.03	$1,094	35%	25%	6	30,528
161-320 Acres	2,037	253.13	$877	37%	20%	6	26,228
321-640 Acres	856	462.78	$782	38%	12%	7	21,214
641+ Acres	511	2,161.35	$750	40%	6%	6	22,933
Weighted Average	13,605[a]	223.54	$1,177	36%	19%	6	30,773

[a]Total

Table 4. Characteristics of pasture parcels by size categories for the first and last decade of the collected data

	No. of observations	Avg. no. of acres	Avg. price per acre	% Pasture	RU continuum code	County population
1971 - 1980						
0-40 Acres	944	32.35	$1,267	98%	4	64,510
41-160 Acres	2,614	108.03	$575	98%	5	48,654
161-320 Acres	611	242.97	$402	98%	5	37,162
321-640 Acres	319	461.10	$360	98%	6	36,271
641+ Acres	240	1,892.52	$285	98%	6	27,564
Weighted Average	4,728[a]	224.76	$662	98%	5	48,429
2001 – 2010						
0-40 Acres	1,220	25.25	$2,188	99%	5	42,003
41-160 Acres	1,709	107.71	$1,555	98%	6	34,023
161-320 Acres	405	245.74	$1,057	98%	6	26,464
321-640 Acres	188	465.48	$935	98%	6	21,439
641+ Acres	139	1,837.55	$777	97%	6	22,316
Weighted Average	3,661[a]	179.55	$1,649	98%	6	34,755

[a]Total

Table 5. Characteristics of cropland parcel by size categories for the first and last decade of the collected data

	No. of observations	Avg. no. of acres	Avg. price per acre	% Cropland	RU continuum code	County population
1971 - 1980						
0-40 Acres	159	35.88	$1003	96%	5	44,429
41-160 Acres	1,548	125.45	$1,548	95%	6	24,703
161-320 Acres	197	262.42	$604	95%	7	19,438
321-640 Acres	42	464.66	$591	95%	6	23,891
641+ Acres	13	1050.00	$546	95%	7	20,393
Weighted Average	1,959[a]	145.36	$1,381	95%	6	25,728
2001 – 2010						
0-40 Acres	71	34.43	$1,638	98%	5	37,659
41-160 Acres	1,166	128.46	$925	96%	7	20,865
161-320 Acres	187	266.38	$782	96%	7	18,105
321-640 Acres	38	488.67	$725	95%	7	13,565
641+ Acres	10	1,084.50	$1,151	97%	6	27,141
Weighted Average	1,472[a]	157.24	$937	96%	7	21,178

[a]Total

Table 6. Estimated regression of parcel size against time

Variable		Coefficient	t- value
Intercept	(β_0)	207.85	23.94
Year	(β_1)	-1.05	-1.18
Year^2	(β_2)	0.02	1.18

Table 7. Estimated regression of parcel size changes against time for pasture and cropland separately

Variable		Coefficient	t- value
Pasture			
Intercept	(β_0)	246.00	15.35
Year	(β_1)	-1.55	-0.95
Year^2	(β_2)	-0.01	-0.24
Crop			
Intercept	(β_0)	115.10	42.89
Year	(β_1)	--3.60	-12.24
Year^2	(β_2)	0.12672	17.91

Table 8. Estimated coefficients for determining parcel size (acres) relative to urban proximity with and without county population

		With county population			Without county population		
Variable		Coefficient	Standard error	t-value	Coefficient	Standard error	t-value
Intercept	(β_0)	166.64	12.12	13.75	151.12	11.62	11.62
Year	(β_1)	-0.36	0.96	-0.37	-0.34	0.96	0.96
Year^2	(β_2)	0.01	0.02	0.23	0.00	0.02	0.02
RU2	(β_3)	51.79	10.18	5.09	54.03	10.17	10.17
RU3	(β_4)	0.92	21.91	0.04	-4.49	21.88	21.88
RU4	(β_5)	-10.69	11.59	-0.92	-6.60	11.56	11.56
RU5	(β_6)	58.59	10.77	5.44	65.54	10.66	6.15
RU6	(β_7)	13.09	9.00	1.45	24.62	8.62	2.86
RU7	(β_8)	81.25	9.55	8.51	93.26	9.17	10.18
RU8	(β_9)	246.56	31.39	7.85	260.68	31.24	8.34
RU9	(β_{10})	115.58	10.15	11.39	129.90	9.64	13.48
POP	(β_{11})	$1.8\text{x}10^{-4}$	$4.0\text{x}10^{-5}$	-4.49	--	--	--
PAST	(β_{12})	-0.27	0.26	-1.05	-0.27	0.26	-1.05
CROP	(β_{13})	-12.19	2.17	-5.62	-12.01	2.17	-5.54
TIMBER	(β_{14})	-0.34	0.35	-0.97	-0.34	0.35	-0.97

Table 9. Heteroskedasticity-consistent standard errors and t-values for determining parcel size (acres) relative to urban proximity with and without county population

		With county population		Without county population	
Variable		Standard error	t-value	Standard error	t-value
Intercept	(β_0)	8.26	20.18	8.17	18.49
Year	(β_1)	0.86	-0.41	0.86	-0.40
Year^2	(β_2)	0.02	0.24	0.02	0.23
RU2	(β_3)	9.43	5.49	9.52	5.67
RU3	(β_4)	6.25	0.15	6.25	-0.72
RU4	(β_5)	4.62	-2.31	4.60	-1.44
RU5	(β_6)	12.32	4.75	12.34	5.31
RU6	(β_7)	4.08	3.20	4.02	6.12
RU7	(β_8)	5.33	15.23	5.23	17.83
RU8	(β_9)	48.34	5.10	48.33	5.39
RU9	(β_{10})	7.63	15.15	7.53	17.25
POP	(β_{11})	1.3×10^{-5}	-13.77	--	--
PAST	(β_{12})	0.08	-3.41	0.08	-3.41
CROP	(β_{13})	5.59	-2.18	5.51	-2.18
TIMBER	(β_{14})	0.20	-1.72	0.20	-1.72

Table 10. Estimated coefficient (from least to most negative) for determining small parcel premiums

County	Acres coefficient	t-statistic	p-value	R-U Code	County population
Payne	-0.001930	-9.27	<.0001	4	68,190
Logan	-0.001850	-7.66	<.0001	1	33,924
Canadian	-0.001710	-8.76	<.0001	1	87,697
Garfield	-0.001680	-9.11	<.0001	5	57,813
Pawnee	-0.001650	-8.91	<.0001	2	16,612
Oklahoma	-0.001610	-2.83	0.0051	1	660,448
Kingfisher	-0.001550	-8.50	<.0001	6	13,926
Tulsa	-0.001440	-5.64	<.0001	2	563,299
Lincoln	-0.001410	-9.69	<.0001	1	32,080
Pottawatomie	-0.001410	-9.03	<.0001	4	65,521
Caddo	-0.001300	-6.74	<.0001	6	30,150
Adair	-0.001270	-6.30	<.0001	6	21,038
Washita	-0.001150	-6.71	<.0001	7	11,508
Wagoner	-0.001080	-6.57	<.0001	2	57,491
Garvin	-0.001070	-9.60	<.0001	6	27,210
Cherokee	-0.000979	-8.93	<.0001	6	42,521
Major	-0.000939	-6.52	<.0001	9	7,545
Grady	-0.000861	-8.83	<.0001	1	45,516
Jackson	-0.000851	-6.40	<.0001	5	28,439
Noble	-0.000806	-7.93	<.0001	6	11,411
Custer	-0.000802	-6.97	<.0001	7	26,142
Comanche	-0.000719	-7.20	<.0001	3	114,996
Alfalfa	-0.000698	-3.23	0.0013	9	6,105
Rogers	-0.000692	-7.42	<.0001	2	70,641
McCurtain	-0.000596	-6.32	<.0001	7	34,402
Love	-0.000585	-5.86	<.0001	9	8,831
Seminole	-0.000582	-4.36	<.0001	7	24,894
Haskell	-0.000581	-5.44	<.0001	6	11,792
Cleveland	-0.000568	-4.05	<.0001	1	208,016
McClain	-0.000566	-8.04	<.0001	1	27,740
Mayes	-0.000510	-8.54	<.0001	6	38,369
Blaine	-0.000510	-3.69	0.0002	6	11,976
Washington	-0.000480	-5.41	<.0001	4	48,996
Sequoyah	-0.000476	-6.85	<.0001	2	38,972
Delaware	-0.000472	-5.89	<.0001	6	37,077
Beckham	-0.000467	-7.84	<.0001	7	19,799
Tillman	-0.000431	-3.30	0.001	6	9,287

Marshall	-0.000422	-5.12	<.0001	6	13,184
Stephens	-0.000420	-6.06	<.0001	4	43,182
Bryan	-0.000383	-8.69	<.0001	6	36,534
Kiowa	-0.000379	-3.52	0.0004	6	10,227
Okmulgee	-0.000352	-5.43	<.0001	2	39,685
Ellis	-0.000348	-3.83	0.0001	9	4,075
Ottawa	-0.000332	-4.44	<.0001	6	33,194
Cotton	-0.000321	-1.81	0.0711	6	6,614
Muskogee	-0.000315	-5.77	<.0001	4	69,451
McIntosh	-0.000276	-6.76	<.0001	6	19,456
Hughes	-0.000265	-5.57	<.0001	7	14,154
Creek	-0.000255	-5.46	<.0001	2	67,367
Craig	-0.000247	-7.61	<.0001	6	14,950
Woods	-0.000236	-4.89	<.0001	7	9,089
Choctaw	-0.000230	-4.72	<.0001	7	15,342
Latimer	-0.000225	-4.55	<.0001	7	10,692
Greer	-0.000212	-3.58	0.0004	7	6,061
Okfuskee	-0.000211	-2.93	0.0036	6	11,814
Atoka	-0.000210	-5.83	<.0001	7	13,879
Pontotoc	-0.000193	-6.41	<.0001	7	35,143
Woodward	-0.000169	-6.21	<.0001	7	18,486
Kay	-0.000163	-5.26	<.0001	5	48,080
Nowata	-0.000162	-5.48	<.0001	6	10,569
Coal	-0.000160	-5.76	<.0001	9	6,031
Johnston	-0.000158	-4.78	<.0001	7	10,513
Harper	-0.000157	-4.39	<.0001	9	3,562
Harmon	-0.000140	-2.35	0.0192	9	3,283
LeFlore	-0.000127	-4.31	<.0001	2	48,109
Grant	-0.000108	-1.06	0.2912	9	5,144
Murray	-0.000104	-3.03	0.0027	7	12,623
Carter	-0.000102	-3.39	0.0007	5	45,621
Texas	-0.000100	-2.50	0.0126	7	20,107
Jefferson	-0.000099	-3.47	0.0006	8	6,818
Roger Mills	-0.000092	-2.58	0.0102	9	3,436
Pushmataha	-0.000090	-3.70	0.0003	9	11,667
Dewey	-0.000078	-3.48	0.0005	9	4,743
Pittsburg	-0.000071	-5.86	<.0001	5	43,953
Osage	-0.000057	-4.48	<.0001	2	44,437
Cimarron	-0.000045	-2.58	0.01	9	3,148
Beaver	-0.000038	-2.39	0.0171	9	5,857

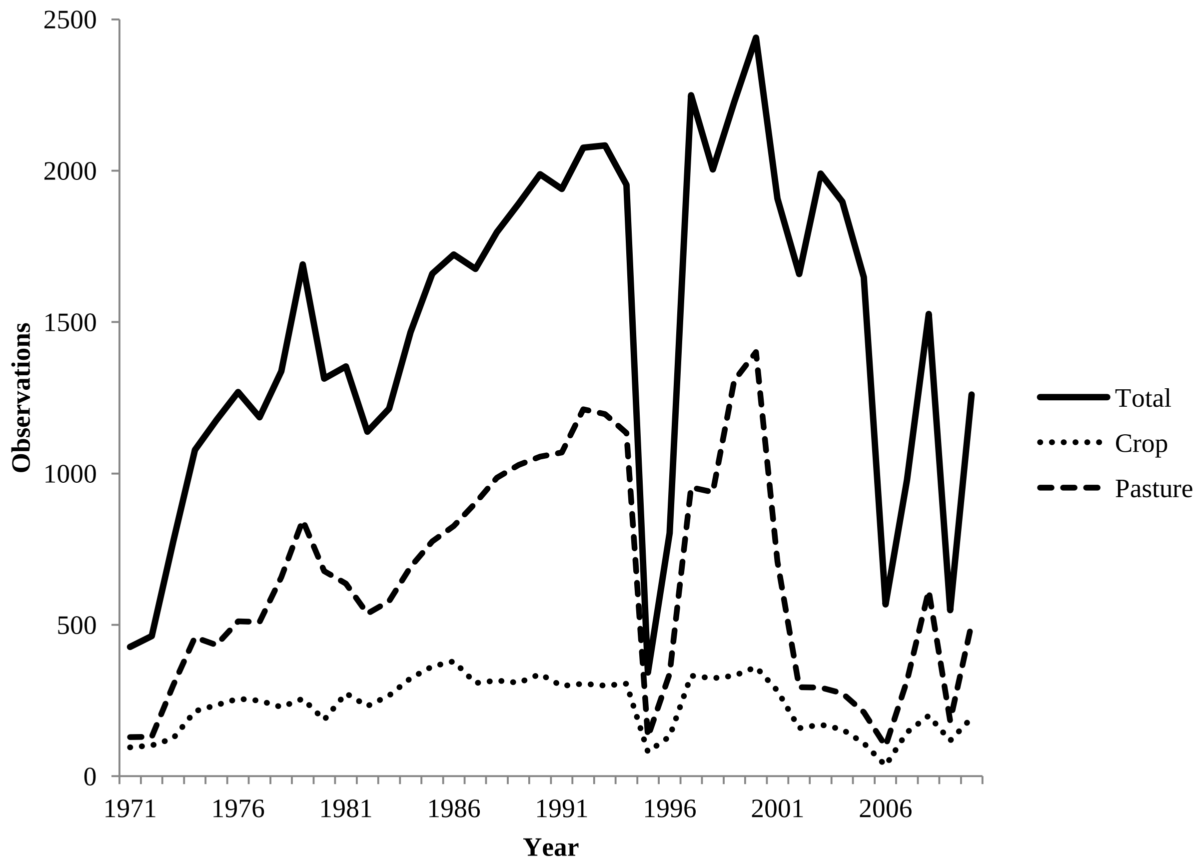

Figure 1. Total number of sales and sales by land usage category

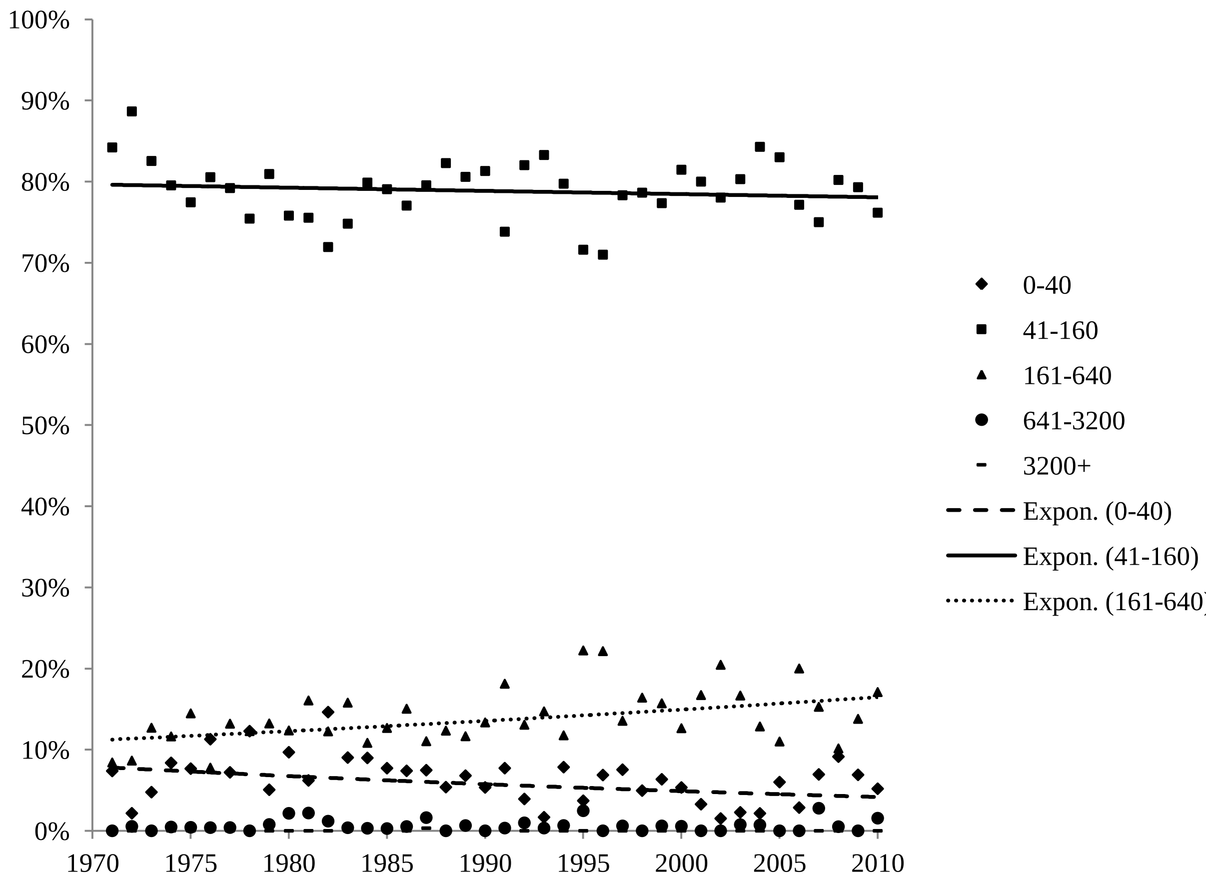

Figure 2. Percentage of cropland parcels sold in each size category from 1971 – 2010

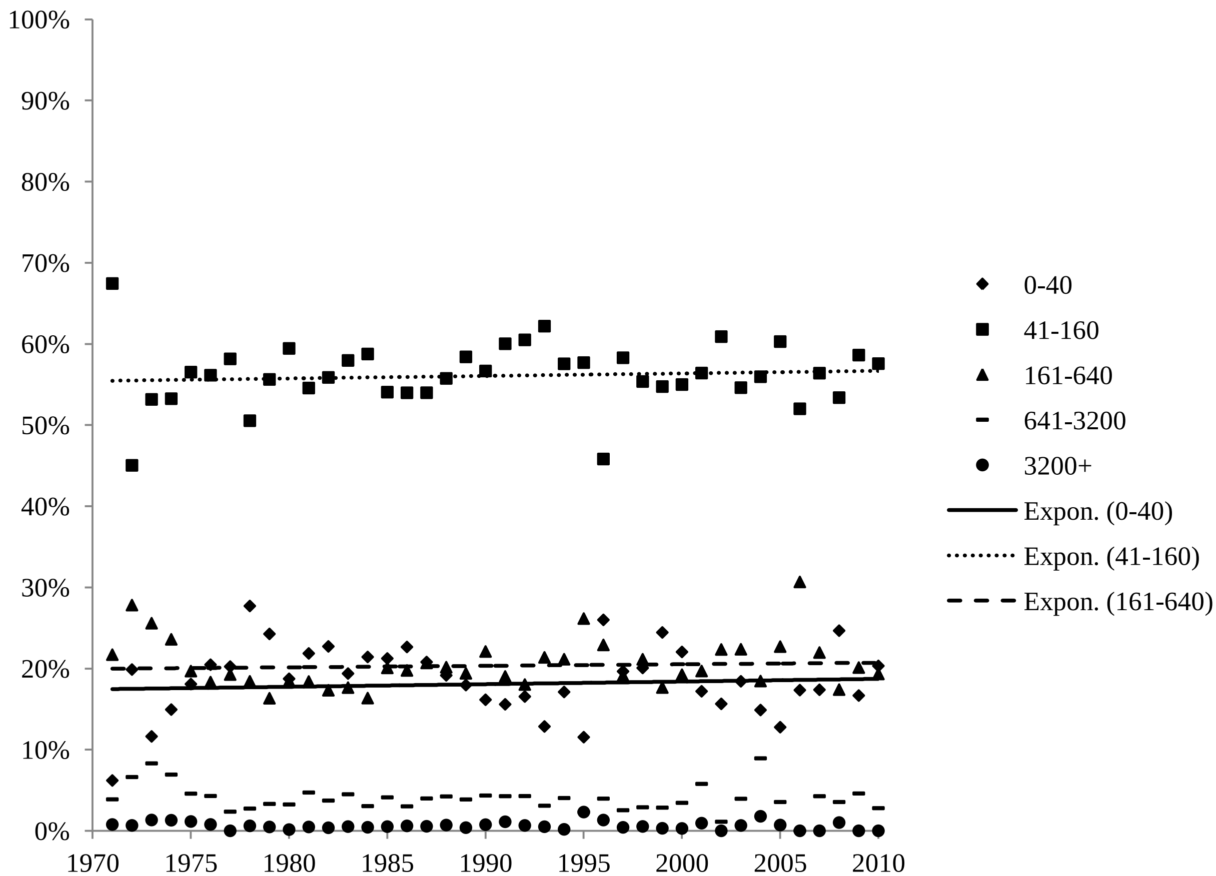

Figure 3. Percentage of pasture parcels sold in each size category from 1971 – 2010

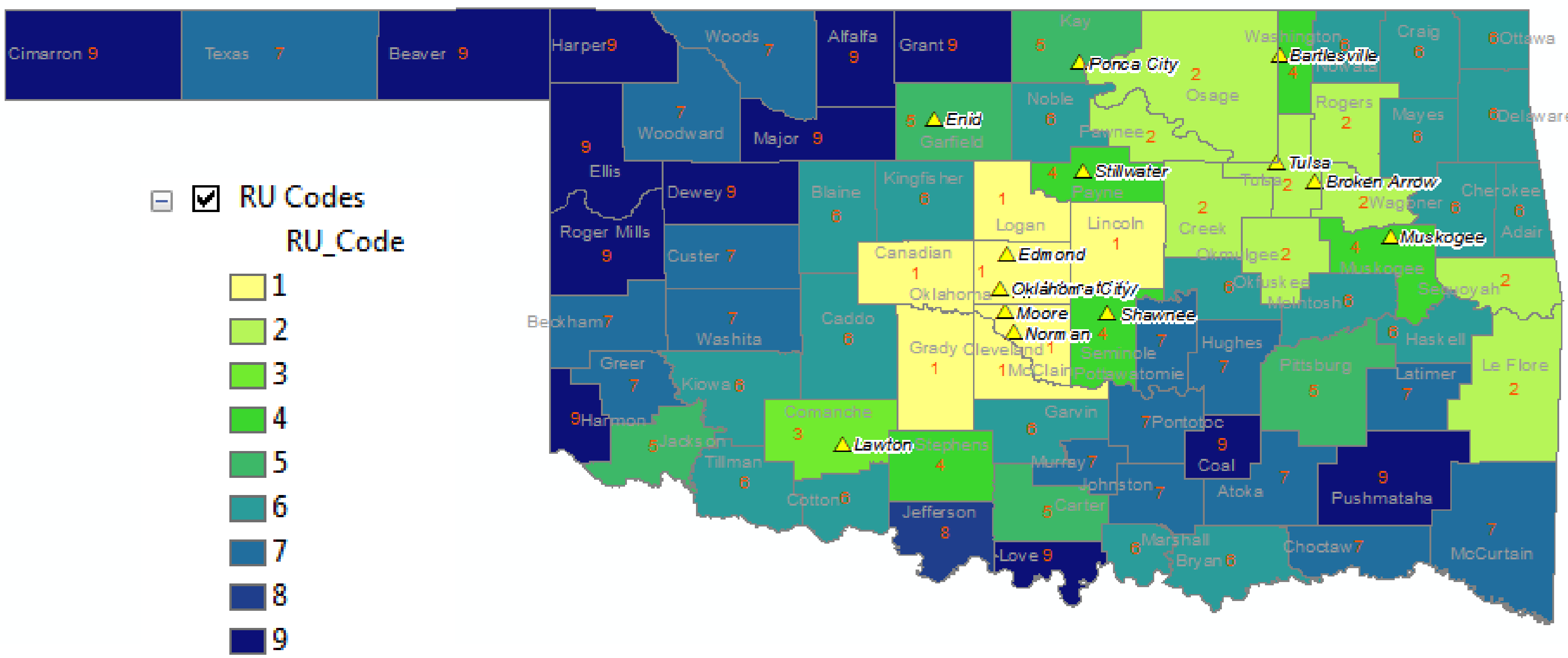

Figure 4. Rural-Urban Continuum Codes by county

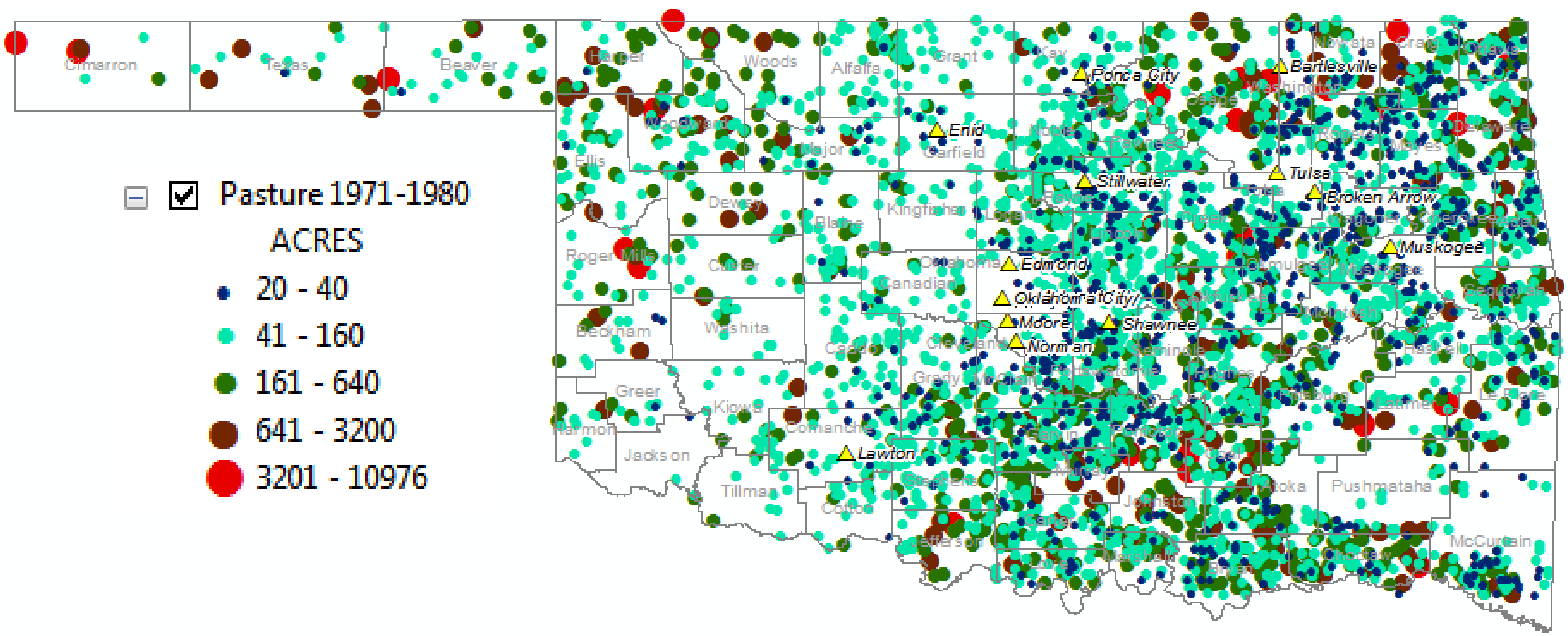

Figure 5. Pasture sales, 1971 – 1980

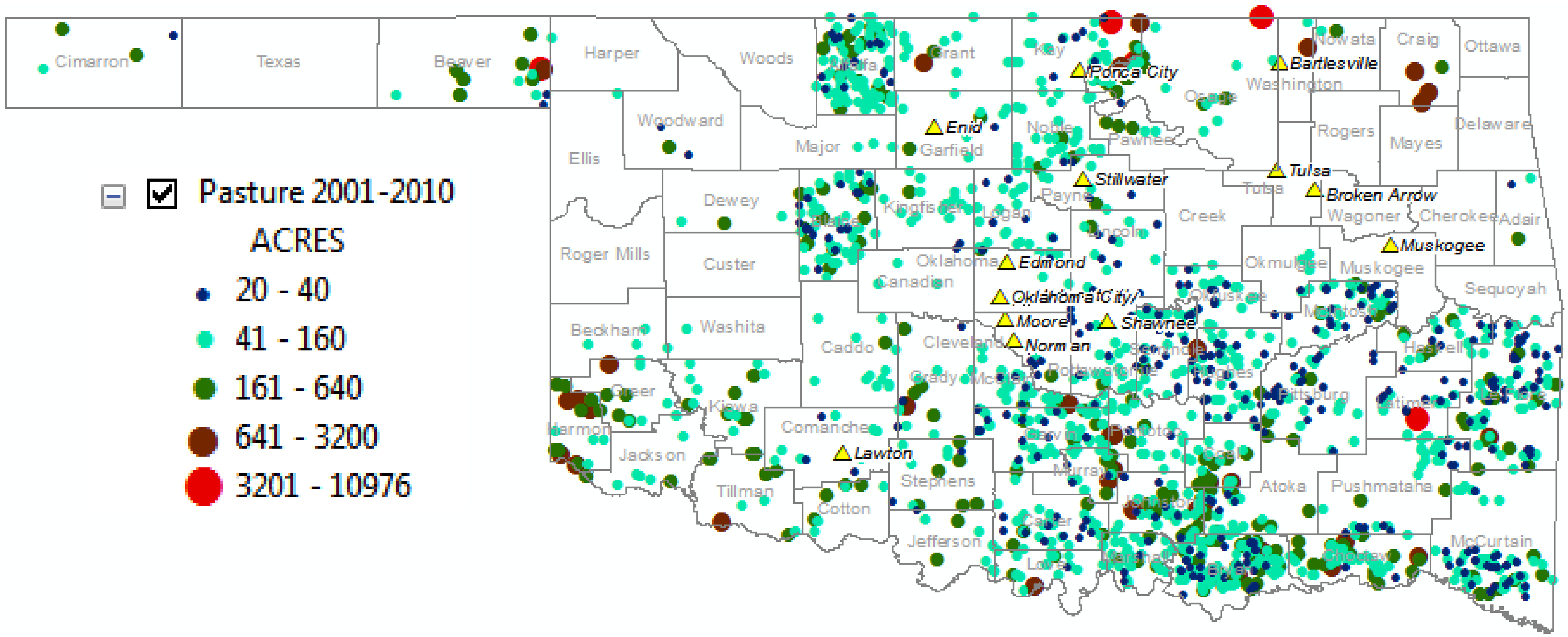

Figure 6. Pasture sales, 2001 – 2010

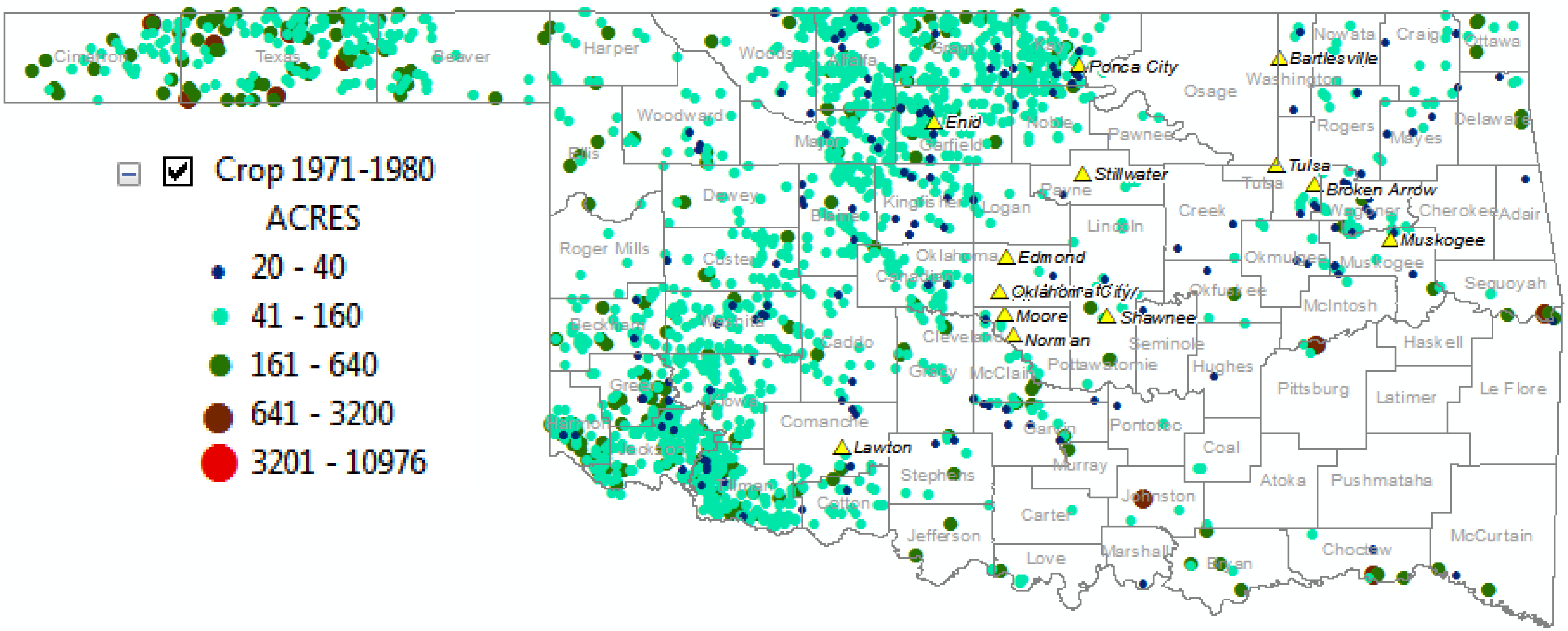

Figure 7. Cropland sales, 1971 – 1980

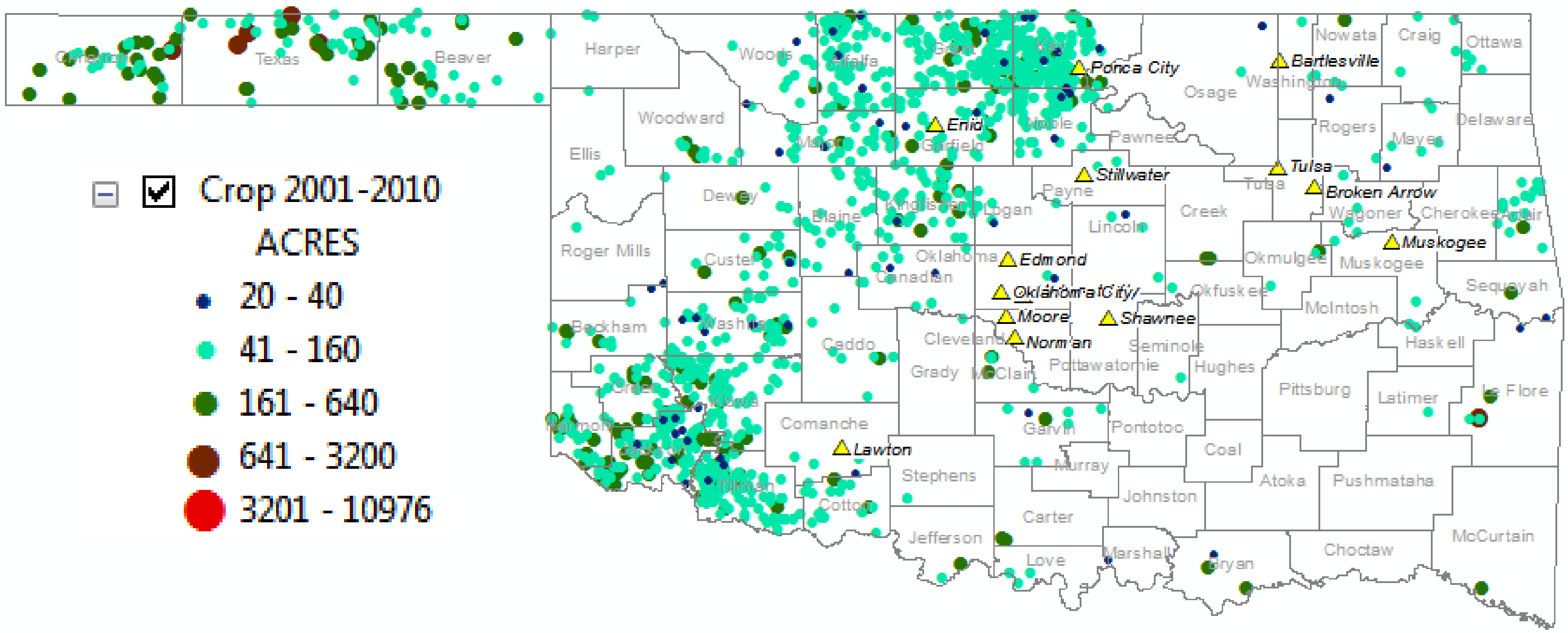

Figure 8. Cropland sales, 2001 – 2010

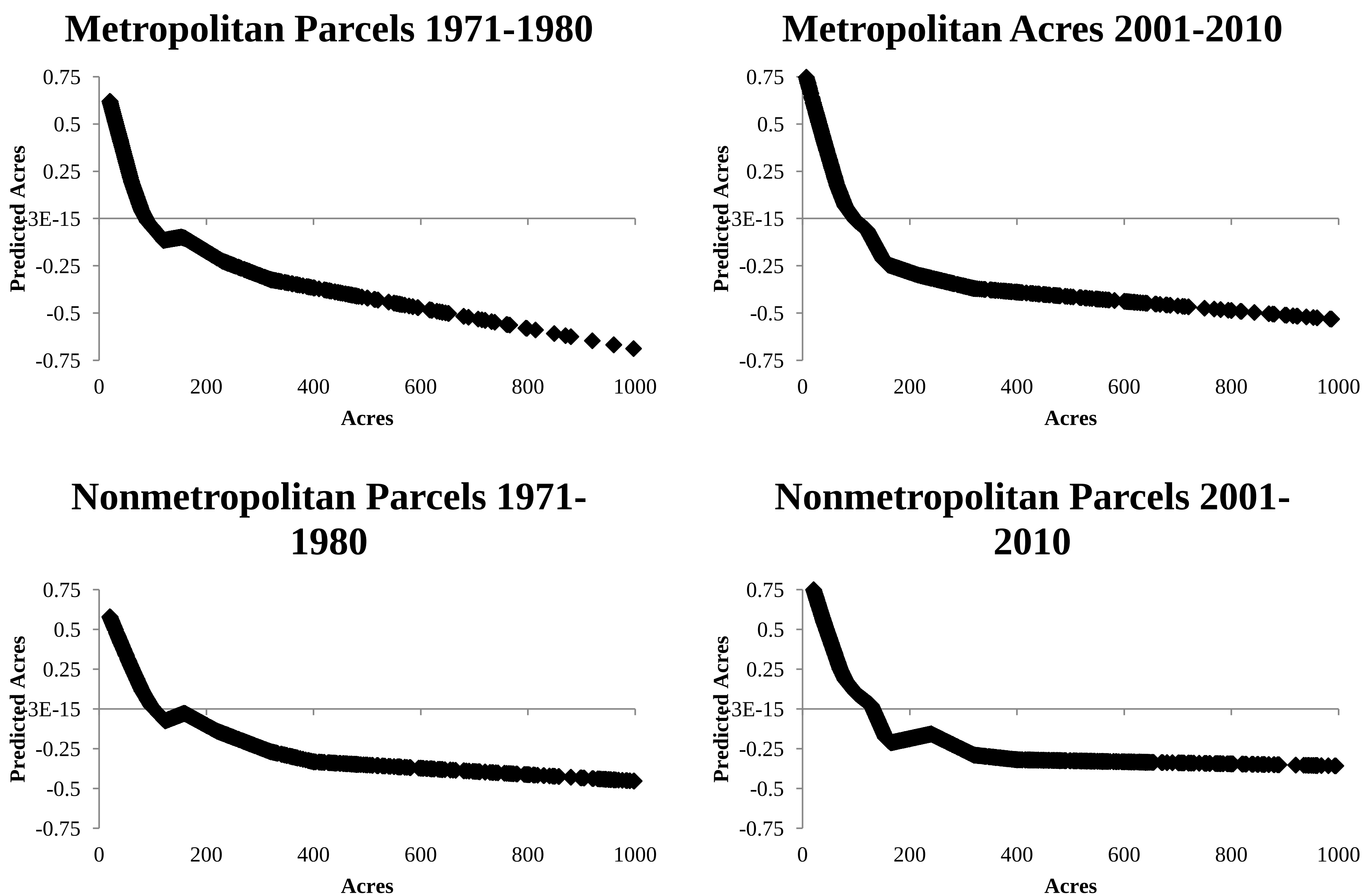

Figure 9. Semi-parametric estimates of the effect of parcel size on land price

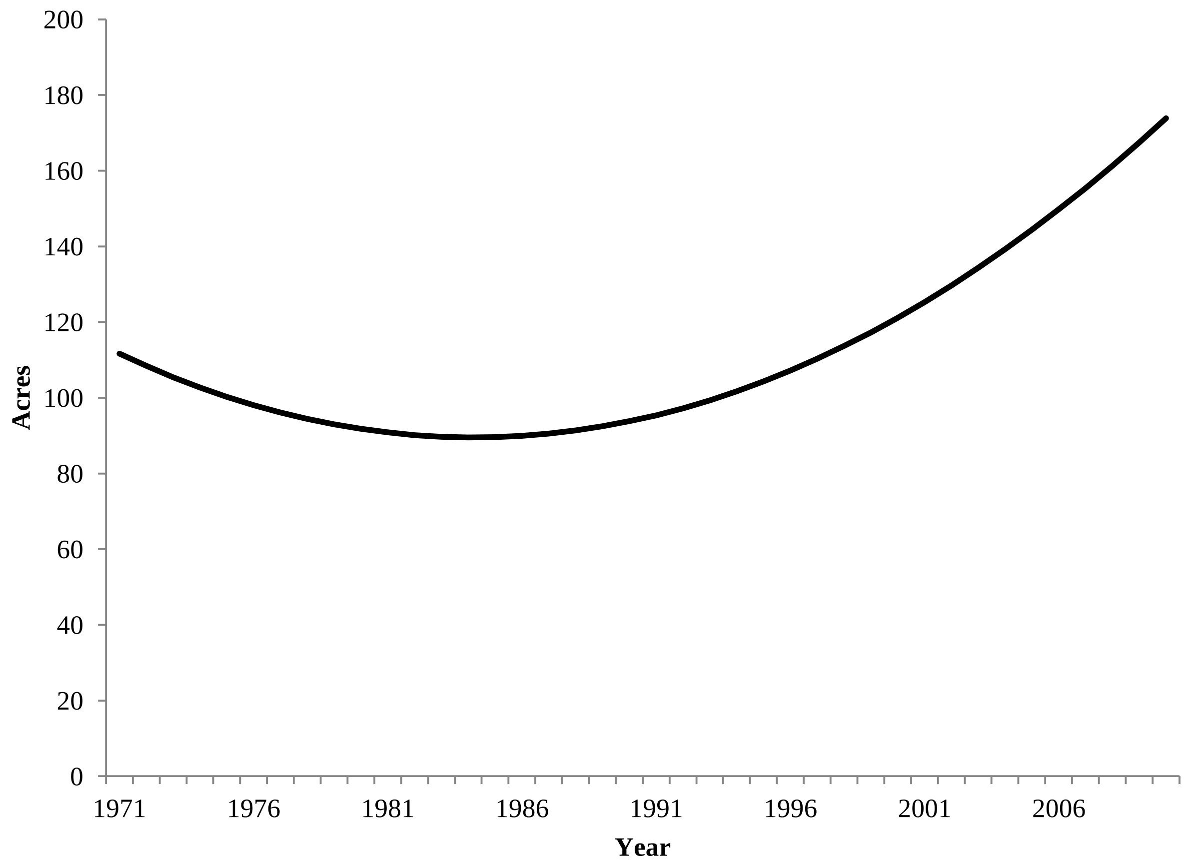

Figure 10. Changes in cropland parcel size over time

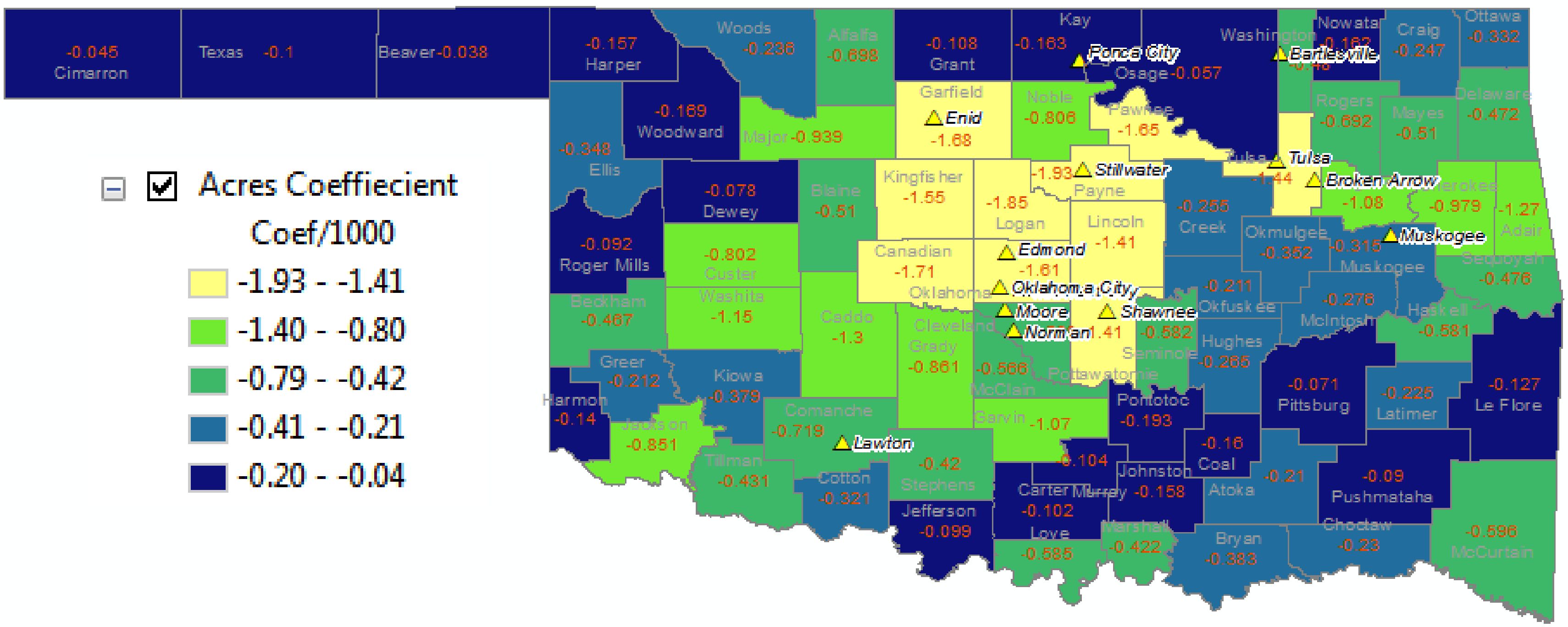

Figure 11. County parameter estimates for "Acres"

VITA

Kalyn Beth Neal

Candidate for the Degree of

Master of Science

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Scope and Method of Study: The focus of this study is a greater understanding of the small parcel size premium in agricultural land. While this is a mostly new research direction, to the extent that land ownership is related to land use, the research is related to policy concerns about fragmentation of land use. Price per acre is inversely related to parcel size but all agricultural land is not sold in smaller parcels. One concern is whether parcel size has been increasing over time. If parcel size is increasing over time then parcels may become small enough that agricultural production is no longer a viable land use option. Additionally, where do small parcels occur? The hypothesis tested is that small parcels are more common around urban areas and that a small parcel premium can be found in or near urban areas. A semi-parametric regression is used to estimate the relationship between price per acre and parcel size. One hypothesis tested is that parcel size decreases as urban proximity increases. Also tested is whether or not parcel size is negatively correlated with proximity to an urban area.

Findings and Conclusions: The semi-parametric regression function yielded the expected results; parcel size has an inverse relationship with price per acre. Although there was little change in parcel size over the time period presented in the dataset,for cropland, the results show a significant increase in parcel size. Parcels located in more rural and less populated counties tend to be larger than parcels in more urban counties. A location premium exists for smaller parcels with parcels in urban counties receiving a larger premium than those located in more rural counties. The findings support the theory offered that benefits from some forms of land use do not increasemuch with parcel size. Regarding the issues of why all land is not sold in small parcels, the study provides a partial explanation. The small parcel premium is stronger in urban counties. Some parcel locations may preclude them from receiving the premium. Overall, parcel size did not increase over time.

ADVISER’S APPROVAL: Dr. Damona Doye