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Spatial Analysis of Rezoning Approval Decisions

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Introduction

New land development typically requires the approval of a rezoning petition because most new development occurs where land is originally zoned as undevelopable (Green 2004; Hulse, Gregory, and Baker 2002). Approval of rezoning petitions has major implications on spatial patterns of development since the decisions to permit rezoning from undevelopable land classifications (e.g., agricultural/forestry uses) to developable land classifications (e.g., residential/commercial uses) accumulate over space, affecting changes in spatial patterns of development. While the land development decision is mainly driven by demand for development, local governments typically possess authority to intervene in development through approval or denial of rezoning petitions.

Despite the zoning authority of local governments to intervene in land development decisions, many local communities struggle to manage efficient spatial patterns of development. For example, communities committed to smart growth, which is an urban planning and transportation strategy that encourages efficient and compact development patterns, continue to struggle with policy implementation (Brueckner 2001, Cho and Roberts 2007, among many others). The struggle of local communities for better management of spatial patterns of development, in spite of their zoning authority, raises questions about how local governments make rezoning decisions and the consequences of those decisions on spatial patterns of development.

In theory, a local government makes rezoning decisions for the benefit of the entire community by maximizing the welfare of the community's total population. In the process of rezoning decisions for achieving the goal, local governments consider the physical and economic situations of their communities and also compatibilities with existing land use plans. The

compatibility with the land use plan plays an important role in dictating spatial patterns of the future development because the land use plan lays out a local government's preference for future development patterns and acts as a guide for rezoning approval decisions. Typically, a land use plan lays out areas suitable for different types of future land uses. Knox County, Tennessee, has 20 different types of land uses under its land use plan and, for each land use, the County's plan stipulates the permitted zoning classifications and the density levels consistent with the county's growth plan.¹

The objectives of this research are to examine how compatibility with a land use plan affects rezoning approval decisions and to understand the consequences of such decisions on a community's spatial pattern of development. To implement the objective, it is hypothesized that rezoning approvals from undevelopable land classifications to developable land classifications are affected by compatibility with the land use plan. An empirical model of binary decisions for rezoning approvals at the parcel scale (referred to as "rezoning approval model") is developed based on a simple theoretical framework to test the aforementioned hypothesis. Using the estimated relationship, we compare the spatial pattern of rezoning approvals under the status quo land use plan (referred to as "baseline plan") and *ex ante* simulations under hypothetical land use plans that induce more restrictive development by expanding areas designated for agricultural-rural residential use (referred to as "hypothetical plans").

The reason for the focus on agricultural-rural residential use is to evaluate more restrictive land-use plans that allow the expansion and preservation of areas for open space, agricultural and planned residential development, and prohibit residential development at a

¹ The 20 different types of land use are agricultural and rural residential, business park, commercial, neighborhood commercial, light industrial, heavy industrial, low density residential, low-medium density residential, medium density residential, high density residential, medium density residential and office, mixed use, office, park and open space, public institute, slope protection area, stream protection area, technology park, transportation, and other open space.

density exceeding 1 dwelling unit per acre and to protect natural, historic and scenic resources from commercial and industrial development and sprawling residential development (MPC 2008). Thus, a land use plan that expands areas for agricultural-rural residential use is assumed to increase restrictions on the amounts of land available for residential and commercial uses.

The impact of the compatibility with the land use plan on rezoning approval decisions is captured in a rezoning approval model by a dummy variable that indicates whether the rezoning request is consistent with the land use plan. To simulate rezoning approvals under the hypothetical plans, we establish hypothetical land use plans that expand areas designated for agricultural-rural residential use by 0.5, 1.0 and 1.5 miles toward the urban core area. Under the hypothetical plans, the dummy variable for consistent approvals with the plan is adjusted to the new zoning boundaries. The probabilities of rezoning approvals from the hypothetical plans are then predicted and compared with the probabilities of rezoning approval under the baseline plan. To investigate changes in spatial patterns of rezoning approvals, we divided our study area, i.e., Knox County, Tennessee, into five sections: the area currently designated for agricultural-rural residential use, the areas included in the three previously mentioned buffers of 0 to 0.5 miles, 0.5 to 1 mile and 1 to 1.5 miles toward the urban core from the inner boundary of the agricultural-rural residential areas, and the area inside of the inner boundary of the buffer of 1 to 1.5 miles (see Figure 1). The predicted rezoning approvals from the baseline plan and hypothetical plans occurring in each section were counted to examine how the numbers of approvals differed spatially.

The next section includes a theoretical framework of rezoning for development from a local government's perspective. It is followed by a presentation of the empirical rezoning

approval model. A description of the study area and data is then presented. The analytical results are presented and discussed and conclusions are drawn.

Theoretical Framework

Assume a local government makes rezoning decisions for the benefit of the entire community by maximizing the welfare of the community's total population (hereafter referred to as "social welfare maximization"). For social welfare maximization, assume that (1) the petitioning landowner and local government have perfect knowledge, (2) the land market is competitive, and (3) the rezoning petition from undevelopable to developable land is for conversion from non-timber forest land to residential or commercial land and the land is developed if rezoning approval is granted. Extending the model by Capozza and Helsley (1989; 1990), the social welfare (SW) of a petitioned parcel is expressed as the integral over τ :

$$(1) \quad SW = \int_t^{t^*} \{Q(\tau) + F(\tau)\Gamma(\tau)\}e^{-r(\tau-t)}d\tau + \int_{t^*}^{\infty} R(\tau)\{1 + \Gamma(\tau)\}e^{-r(\tau-t)}d\tau - C_t(t^*)e^{-r(t^*-t)},$$

where Q represents the environmental benefits of the parcel as forest land, F is forest land value, R is rent from residential or commercial development if the parcel is successfully rezoned, C is the cost of converting the parcel from forest to residential or commercial use, Γ is the tax rate on forest land and residential or commercial land, r is the discount rate, t is time, and t^* is the time of land converted from forest to residential or commercial use by granting the rezoning petition.

In the first integral of equation (1), the first term is the present value of the environmental benefits of the forest-land parcel received by the entire community and the second term is the property tax revenue received by the local government from the value of the forest land. The first term in the second integral is the present value of rent from residential or commercial development received by developers, the second term is the present value of additional property

tax revenues from the rent of residential or commercial development, and third term is the construction cost paid by the builder.

The local government approves the rezoning request by choosing t^* to maximize the present value given in equation (1). Using Liebnitz' rule (Flanders 1973), the first-order necessary condition for a maximum of SW with respect to t^* is:

$$(2) \quad R(t^*)\Gamma(t^*) = Q(t^*) + F(t^*)\Gamma(t^*) + rC_t(t^*).$$

The local government's decision making for approval of rezoning from forest use to residential use y is simplified as:

$$(3) \quad y \equiv f\{R(F), Q(L)\},$$

In addition to the factors that affect the local government's rezoning approval decision through the social welfare maximization assumption, other site-specific and neighborhood factors, including the factor that indicates whether the rezoning request is consistent with land use plan, may influence the rezoning approval decision. To accommodate these additional factors Z , the local government's decision to approve rezoning petitions from non-timber forest use to residential or commercial use is expressed as:

$$(4) \quad y \equiv f(F, L, Z; \beta),$$

where F includes assessed land value and total square footage of the parcel being petitioned for rezoning, L consists of location and physical attribute variables that determine environmental benefits of the petitioned parcel (i.e., distances to central business district, railroad, major road park, and water bodies, slope and elevation), and Z includes other site-specific and neighborhood attributes (e.g., neighborhood income level, access to public sewer, jurisdictional dummy variables, dummy variables indicating whether the rezoning petition is consistent with existing

neighborhood zoning classifications and the land use plan, and whether the petition is for commercial or residential development) and $\hat{\beta}$ is a vector of parameter estimates.

Empirical Model

Two potential econometrics issues need to be addressed in estimating the equation (4). The first issue is the potential endogeneity of assessed land value, which is included in F . Because assessed land value is largely determined by forces in the housing market that affect the rezoning decision, which in turn is a function of assessed land value, a system of simultaneous equations to represent the relationship between assessed land value and rezoning approval decisions may be needed. The Durbin-Wu-Hausman test (Baum, Schaffer, and Stillman 2007) was conducted to test the hypothesis that assessed land value is statistically exogenous. Failure to reject the null hypothesis at the 5% level suggested that assessed land value is statistically exogenous. Thus we consider it exogenous in the rezoning approval model.

The second issue is the potential spatial structure of rezoning petitions and approval decisions that may be codetermined through neighborhood spillover effects because rezoning approval decisions may be codetermined. A spatial-probit model commonly used for the modeling of spatial qualitative-dependent variables is estimated (Autant-Bernard 2006; Beron, Murdoch, and Vijverberg 2003; Garrett, Wagner, and Wheelock 2005; Holloway, Shankar, and Rahman 2002; Mukherjee and Singer 2008; Murdoch, Sandler, and Vijverberg 2003; Rathbun and Fei 2006; Schofield, Miller, and Martin 2003). Among the possible estimation techniques, such as the general linear model for limited dependent variables (LDV's) (Rasmussen 2004; Schabenberger and Gotway 2005), conditional autoregressive specifications of LDV's (Schabenberger and Pierce 2002) and general moment approaches (Klier and McMillen 2008;

Pinkse and Slade 1998), the Bayesian strategy of Markov Chain Monte Carlo (MCMC) introduced by LeSage (2000) is used to estimate the spatial-probit model.

$$(5) \quad \begin{aligned} \mathbf{y}^* &= \rho \mathbf{W} \mathbf{y}^* + \mathbf{X} \boldsymbol{\beta} + \mathbf{u} \\ \mathbf{u} &\sim N(0, \sigma^2 \mathbf{V}) \\ \mathbf{V} &= \text{diag}(v_1, v_2, \dots, v_N) \end{aligned}$$

where $\mathbf{y}^*$ is $N \times 1$ vector of dependent variable; ρ is the spatial lag, which is associated with the non-negative row-standardized exogenous $N \times N$ weight matrix $\mathbf{W}$; $\mathbf{X}$ is $N \times K$ matrix of explanatory variables; and $\boldsymbol{\beta}$ is $K \times 1$ vector of coefficients. The variance ($\mathbf{V}$) of the error terms ($\mathbf{u}$) is a set of variance scalars ($v_1, v_2, \dots, v_N$) to account for potential spatial heterogeneity and outliers. The conditional posterior distribution of the spatial lag is derived as:

$$(6) \quad p(\rho | \boldsymbol{\beta}, \mathbf{V}, \mathbf{y}^*) \propto |I_N - \rho \mathbf{W}| e^{(\frac{1}{2}\sigma^2)(\mathbf{u}'\mathbf{V}^{-1}\mathbf{u})},$$

where $p(\rho | \boldsymbol{\beta}, \mathbf{V}, \mathbf{y}^*)$ is proportional up to a constant to $|I_N - \rho \mathbf{W}| e^{(\frac{1}{2}\sigma^2)(\mathbf{u}'\mathbf{V}^{-1}\mathbf{u})}$. Since the prior of the spatial lag cannot be generated from a standard normal distribution, the Markov Chain Monte Carlo (MCMC) method should be used to obtain a sequence of random samples from a probability distribution for which direct sampling is difficult.

The MCMC method is used because of its ability to use prior information and to directly answer specific scientific questions that can be easily understood (Berry 2006). The MCMC method is a simulation technique that generates a sample from the target distribution by specifying the transition probability of a Markov process (Vieira, Theys, and Alengrin 1998). The Markov chain is then iterated a large number of times in computer-generated Monte Carlo simulation (Chib and Greenberg 1995). It is useful because the joint distribution of the spatial-probit model is not expressible directly and sufficiently complex to prohibit direct sampling. The Gibbs sampler, introduced by Geman and Geman (1984), is used in this analysis. It is possibly

the MCMC sampling technique used most frequently (Gelfand 2000; Verdinelli and Wasserman 1991).

Study Area and Data

The rezoning approval model was estimated using rezoning request information between January 1997 and December 2006 in Knox County, Tennessee that was collected from the Knoxville, Knox County Metropolitan Planning Commission (MPC 2008). The rezoning information includes date of the denial or approval decision, parcel location and size, access to public sewer, existing zoning classification, requested zoning change, and whether the requested rezoning change is consistent with the existing neighbor zoning classifications and land use plan. The shape file for the map of Knox County's land use plan was obtained from MPC. Boundary data, including the boundary of the City of Knoxville and the Town of Farragut were obtained from Knoxville Utilities Board Geographic Information System (KGIS 2006).

The individual parcel data including market assessed land value and parcel size were collected from Knox County Tax Assessor's Office. The Knox County Tax Assessor's Office conducts assessment of the structure and land separately once every four years and the data we obtained were for 2006. The reason for the use of market assessed land value instead of reported sale price of land is that transaction prices for the lots petitioned for rezoning during the study period were only available for the total value of both structure and land.

The original zoning shape file that was last updated on December 2004 was used to identify zoning classifications consistent with the petitioned zoning changes in the surrounding area of each petitioned parcel at the time of rezoning considered between 1997 and 2006. The zoning map during the period of 1997-2006 was recreated using the original zoning shape file

and rezoning shape file. The percentages of zoning classification consistent with the requested rezoning within a 0.2-mile radius buffer around the petitioned parcel were estimated. The size of buffer, 0.2-mile radius was determined based on a series of interviews with planners in the area. The percentage estimation was done by superimposing a 0.2-mile radius buffer around each petitioned parcel during the period of 1997-2006 using the Patch Analyst (v3.12) extension for ArcView 3.3 (Rempel 2011).

The rezoning committee composed of Knoxville City Council, Knox County Commission, and Farragut Municipal Planning Commission approved 651 of 724 parcels petitioned from undevelopable land classifications (e. g., agricultural and open space zonings) to residential and commercial during the 1997-2006 period in Knox County. Among the petitions, 530 were petitions for the residential classification and 194 were for the commercial classification. These 724 cases were the focus of this study.

The shape files for railroads, major roads, parks, greenways and water bodies that were used to create distance variables were acquired from KGIS (2006) and Environmental Systems Research Institute Data and Maps 2004 (Environmental Systems Research Institute 2004). The timing of the land-feature data (2004) and the rezoning information (1997-2006) did not match. Because land features, such as railroads, major road, parks, greenways and water bodies, were not expected to change appreciably, the distances in 2004 were used as proxies for the distance variables during the 1997-2006 period.

The slope and elevation were obtained from U.S. Geological Survey (U.S. Geological Survey 2009) and were calculated at a resolution of 1/3 arc-second (approximately 100 square meters). This scale is sufficiently small to account for the smallest rezoning occurrence (600 square meters). Additional information not available from the parcel data, i.e., per capita income,

was collected at the census-block group level from the 2000 US census long-form dataset. The study area consists of 234 census-block groups. All the petitioned parcels within the boundaries of a census-block group were assigned the per capita income for that census-block group. Although the timing of the census and rezoning did not match, given the timing of census taking, per capita income in 2000 was used as a proxy in the rezoning approval equation. A statistical summary of the variables used in the rezoning equation is presented in Table 1.

Empirical Results

The Akaike Information Criterion (AIC) for MCMC spatial-probit model was -1.23. The percentage of correct predictions of rezoning decisions was 92%. The parameter estimates and elasticities calculated based on the parameter estimates are presented in Table 2. Hereafter, elasticities are considered statistically significant if their p-values are ≤ 0.05 . Only statistically significant elasticities are discussed in the remainder of this section.

The probability of rezoning approval for development increases by 0.43% given a 1% increase in assessed land value. A 1% increase in lot size increases the probability of rezoning approval for development by 0.43%. A 1% decrease in distance to the CBD increases the probability of rezoning approval for development by 1.84%. Petitions for rezoning inside of the city boundary are 0.35% less likely to be approved for development than petitions parcels outside the boundary. The findings indicate that rezoning petitions for development are more likely approved if the petitioned parcels are more highly valued, larger, closer to the CBD, and outside of the city boundary.

A rezoning petition that is consistent with the current land use plan is 23.13% more likely to be approved for development than a petition that is not consistent with the land use plan. A 1%

increase in the ratio of zoning classifications that are consistent with the type of rezoning request increases the probability of rezoning approval for development by 2.41%. This result implies that the efforts made by local government to sustain spatially consistent land use patterns to reduce incompatibility with neighborhood areas have been largely successful. These findings of land use plan and surrounding land use variables imply that the land use plan plays a significant role in the rezoning approval decision.

The rezoning approval rates under both the current land use plan and the three hypothetical land use plan scenarios are reported in Table 3. Under the current land use plan, 77% of rezoning petitions (or 59 of 77 cases) were predicted to be approved in the area currently designated for agricultural-rural residential use. In contrast, 94% of rezoning petitions (or 610 of 647 cases) was predicted to be approved in areas outside of the current area designated for agricultural-rural residential use (see Table 3). The considerably lower approval rate in the area currently designated for agricultural-rural residential use implies that zoning for agricultural-rural residential use contributes substantially to confining rezoning attempts for development.

The predicted approval rate for development within the 0–0.5 mile buffer drops from 91% (or 165 of 182 cases) under the current land use plan to 62% (or 113 of 182 cases) under the hypothetical land use scenario with 0.5 mile expansion of area zoned for agricultural-rural residential use. The predicted approval rate for development within 0.5 – 1 mile buffer drops from 96% (or 96 of 100 cases) under the current land use plan to 80% (or 80 of 100 cases) under the hypothetical land use scenario with 1 mile expansion of agricultural-rural residential use. The predicted approval rate for development within 1–1.5 mile buffer drops from 97% (or 103 of 106 cases) under the current land use plan to 81% (or 86 of 106 cases) under the hypothetical land use scenario with 1.5 mile expansion of the area zoned for agricultural-rural residential use. The

hypothetical expansions of the areas for agricultural-rural residential use increase the frequency of denials of rezoning petitions for development by 52, 16, and 17 cases within the areas of 0 – 0.5 mile, 0.5 – 1 mile, and 1 – 1.5 mile buffers, respectively.

Conclusions

The objective of this study was to examine how the compatibility with the land use plan affects rezoning approval decisions and to understand the consequences of such decisions on a community's spatial pattern of development. The results show that the predicted approval rates for rezoning for development drop under hypothetical land use scenarios with expanded areas zoned for agricultural-rural residential use compared with the baseline plan. The decreases in predicted approval rates result from decreases in the approval rates in the expanded areas designated for agricultural-rural residential use. These results indicate that manipulating the area designated for agricultural-rural residential use can restrict the expansion of residential sprawl and commercial development.

This research is unique in that rezoning approval for development is modeled to examine whether the government land use plan affects spatial patterns of development. The changes in spatial patterns of rezoning approval predicted in this research provide guidance for local governments to improve their land use plans. This finding can be directly applied to local communities that struggle for better management of spatial patterns of development. For example, land planners in Knox County, Tennessee can influence rezoning approval rates for residential and commercial development around the urban core by adjusting the area zoned for agricultural-rural residential use. This finding provides important information to community leaders and local government officials because different spatial patterns of rezoning approvals

lead to divergent spatial pattern of land development, which in turn could have dissimilar consequences on landscape characteristics, depending on infrastructure and environmental quality.

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Table1. Statistical summary of the variables used in the rezoning approval equation

Variables	Description	Unit	Mean (St. Dev)
<i>Endogenous Variables</i>			
Rezoning	1 if land petitioned for rezoning was approved between 1997 and 2006; 0 otherwise		0.90 (0.30)
<i>Parcel Variables</i>			
Assessed Land value	Average of assessed land value per acre of parcels within land for rezoning	\$	23,213.34 (38,009.11)
Lot size	Total square footage of land for rezoning	feet ²	710,387.50 (1,490,030.00)
Sewer	Access to public sewer		0.82 (0.39)
<i>Census Variables</i>			
Income	Per capita income in 2000 census	feet ²	24,036.10 (9,045.72)
<i>Distance Variables</i>			
Dist. CBD	Euclidean distance from the centroid of a parcel to the centroid of the central business district	feet	52,251.77 (17,024.13)
Dist. railroad	Euclidean distance from the centroid of a parcel to the nearest railroad	feet	9,262.97 (6,839.38)
Dist. Major road	Euclidean distance from the centroid of a parcel to the nearest major road	feet	1,849.91 (2,398.44)
Dist. park	Euclidean distance from the centroid of a parcel to the centroid of the nearest park	feet	11,913.74 (6,593.89)
Dist. water body	Euclidean distance from the centroid of a parcel to the nearest stream, lake, river, or other water body	feet	10,288.03 (6694.06)
<i>Boundary Variables</i>			
Knoxville	1 if within Knoxville, 0 otherwise		0.10 (0.30)
Farragut	1 if within the Town of Farragut, 0 otherwise		0.02
<i>Plan variables</i>			
land use plan	1 if rezoning request is consistent with land use plan in the Sector Plan		0.76 (0.43)
Surrounding land use	Ratio of zoning classification consistent with the type of rezoning request within a 0.2-mile radius buffer around the petitioned parcel	ratio	0.22 (0.21)
<i>Geographical variables</i>			
Slope	Average slope of land for rezoning	%	6.13 (3.17)

Elevation	Average elevation of land for rezoning	ft	1,020.80 (100.39)
<i>Rezoning type Variables</i>			
To Residential	1 if rezoning to residential uses, 0 otherwise		0.62 (0.49)
To Commercial	1 if rezoning to commercial uses, 0 otherwise		0.27 (0.44)

Table 2. Estimated coefficients and elasticities of the rezoning approval model

Variables	Coefficient (Std. Err)	Variables	Elasticity (Std. Err)
Intercept	6.257 (8.227)		
ln (Assessed Land value)	0.165* (0.088)	Assessed Land value	0.433* (0.231)
ln (Lot size)	0.149* (0.079)	Lot size	0.433* (0.230)
ln (Income)	-0.555 (0.332)	Income	-1.623 (0.971)
ln (Dist. CBD)	-0.628* (0.276)	Dist. CBD	-1.840* (0.809)
ln (Dist. Railroad)	0.113 (0.094)	Dist. Railroad	0.325 (0.270)
ln (Dist. Major road)	-0.120 (0.094)	Dist. Major road	-0.003 (0.254)
ln (Dist. Park)	0.016 (0.141)	Dist. Park	0.000 (0.000)
ln (Dist. Water body)	-0.008 (0.095)	Dist. Water body	0.000 (0.000)
Slope	-0.026 (0.026)	Slope	-0.664 (0.664)
ln (Elevation)	0.410 (1.210)	Elevation	1.190 (3.513)
Sewer	-0.047 (0.232)	Sewer	-0.088 (0.436)
Knoxville	-0.649* (0.319)	Knoxville	-0.353* (0.174)
Farragut	-0.101 (0.707)	Farragut	-0.006 (0.043)
Land use plan	2.315* (0.262)	Land use plan	23.133* (2.618)
Surrounding land use	3.766* (0.619)	Surrounding land use	2.413* (0.397)
To Residential	-0.546 (0.348)	To Residential	-0.871 (0.555)
To Commercial	-0.262 (0.279)	To Commercial	-0.232 (0.247)
ρ	-0.006 (0.086)		
N		724	
Overall % of correct prediction		90.94	

* = .05 level (5%)

Table 3. Changes in the spatial pattern of rezoning approval rates under the hypothetical land use plan scenarios compared with the current land use plan

	Number of rezoning predicted to be approved / Total number of rezoning petition (Rezoning approval rates)			
	Current land use plan	Hypothetical land use plan scenarios of expansions of agricultural-rural residential uses		
		0.5 mile expansion	1 mile expansion	1.5 mile expansion
Current agri-resid use [*]	59/77 (76.6%)	59/77 (76.6%)	59/77 (76.6%)	59/77 (76.6%)
Outside of current agri-resid use ^{**}				
0.0–0.5 mile buffer	165/182 (90.7%)	113/182 (62.1%)	113/182 (62.1%)	113/182 (62.1%)
0.5–1.0 mile buffer	96/100 (96.0%)	96/100 (96.0%)	80/100 (80.0%)	80/100 (80.0%)
1.0–1.5 mile buffer	103/106 (97.2%)	103/106 (97.2%)	103/106 (97.2%)	86/106 (81.1%)
Inside of inner boundary ^{***}	246/259 (95.0%)	246/259 (95.0%)	246/259 (95.0%)	246/259 (95.0%)
The entire area ^{****}	669/724 (92.4%)	617/724 (85.2%)	601/724 (83.0%)	584/724 (80.7%)

^{*}Area currently designated for agricultural-rural residential use.

^{**}Areas outside of the current area designated for agricultural-rural residential use (i.e., 0.0–0.5 mile buffer, 0.5–1.0 mile buffer, 1.0–1.5 mile buffer, and Inside of inner boundary).

^{***}Area inside of the inner boundary of the buffer of 1 to 1.5 miles.

^{****}Sum of area currently designated for agricultural-rural residential use and areas outside of the current area designated for agricultural-rural residential use.

Figure 1. Five sections under hypothetical land use plan scenarios