ESTIMATING TRACT VALUE RELATIONSHIPS IN THE NORTH LOUISIANA TIMBERLAND MARKET

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ABSTRACT

Hedonic modeling techniques were combined with geographic information systems (GIS) procedures to examine factors hypothesized to influence per acre values in the timberland market. Econometric procedures were used to develop a hedonic timberland value model for northern Louisiana. Model predictions were then used to develop GIS-generated land value contours, which visually illustrate the impacts of location and tract development potential on timberland values. Results indicated that location and tract development potential play an important role in determining timberland value. Procedures used demonstrate the potential for integrating GIS with econometric techniques in developing models that explore relationships in timberland markets.

INTRODUCTION

Environmental concerns, regulatory burdens, shifts in timber availability, and other factors have contributed to a realignment of the United States forest economy from the Northwest to the South. The forest economy has continued to change as corporations merge, reorganize, and respond to fluctuating market and policy conditions. Pressures on the land resource in the South have grown as a result of these and other changes, such as increased economic development activity. Identifying and measuring major influences that determine timberland value are of particular importance because, in contrast to the Northwest, the majority of timberland in the South is owned by private nonindustrial landowners.

From a productivity standpoint, the commonly accepted theory of land valuation is that the value of timberland is determined by estimating the future net cash flows (economic rent) that a particular tract can generate from timber production and discounting these net cash flows to a present value. The bare land value of the tract (excluding future timber production) is also estimated and combined with the present value of projected future earnings to form an estimation of current tract value. Buyers and sellers of timberland have often relied on this approach because information on timber prices, harvesting costs, taxes, and replanting expenditures are usually available to both parties (Healy and Bergquist 1994). The actual market value of land, however, can be affected by several factors other than the present value of expected future income from production. For example, the present value approach to timberland valuation does not explain increasing timberland values during periods of declining or stagnant stumpage prices (Sendack and McEnvoy 1989, Armstrong 1987).

Empirical research has shown that location, accessibility, and economic development are also important factors in timberland and other rural land markets. In a study examining factors that influence Vermont forestland prices, Turner et al. (1991) substantiated the contribution of nontimber factors, such as recreational development and esthetic quality, in the demand for forestland. Roos (1996) demonstrated that population density relative to the amount of land in a county displayed a positive relationship with forestland prices in Sweden. Chicoine (1981) found that the soil=s productivity influence on farmland prices in the urban fringe market appeared to be overshadowed by the locational attributes of parcels. Similarly, Adrian and Cannon (1992) found that land values in the urban fringe segment were almost three times the values in the rural segment.

With rural land being converted to non production uses at the urban fringe, buyers, sellers, planners, appraisers, tax assessors and others are expected to have an increasing need for information related to the effect of location and economic development potential on timberland values. Important questions relate to the magnitude of these influences and to the spatial extent of these influences in timberland markets. The objective of this paper is to illustrate how geographic information systems (GIS) and spatial econometric procedures can be combined to develop improved estimates of factors that influence timberland values. Spatial econometric procedures (Anselin 1995) are used to develop a hedonic timberland value model in northern Louisiana. Model predictions are then used to develop land value contours, which visually illustrate the impacts of location and tract development potential on per acre timberland values.

LAND VALUATION THEORY

Location theory was introduced into economics by Heinrich von Thunen in his book *The Isolated State* (1826). Von Thunen's model considered the controlling factor in determining agricultural or rural land use to be economic rent and the primary factor which influences economic rent to be transportation cost. This model has been modified to explain the spatial organization of land use (Dicken and Lloyd 1990). In its simplest form, a location-rent model, illustrated in Figure 1, allocates land use around a market center. Diagonal lines in Figure 1 represent rents for different land uses. Downward sloping lines indicate decreasing economic rent as distance from market and transportation cost increase. Through competitive bidding, steeper rent curves produce higher rents and result in locations closer to the center of the city. For example, commercial and industrial uses are typically bid higher than residential and agricultural uses because of proximity to the market center. It follows that land closer to markets (or amenity centers) receive higher rents and higher capitalized values than areas located at larger distances. Thus, differential rents form the basis for concentric land uses with differing radiuses from the center of the city.

Economic development potential also exerts a positive influence on rural land values. An increasing need for land for industrial purposes, housing, transportation, wholesale and retail trade, health care, recreation, and other service activities increases the demand for tracts of rural land with desirable access characteristics. These forces may result in zones of transition which contain a mixture of land uses. Commerce and other service activities move into this zone of transition as rural land is converted to suburban and other uses. The result is a rural-urban fringe where the influence of the market center extends beyond its political boundaries. The price of accessible tracts of rural land in these areas is bid-up by speculators, investors, or developers who anticipate future economic growth.

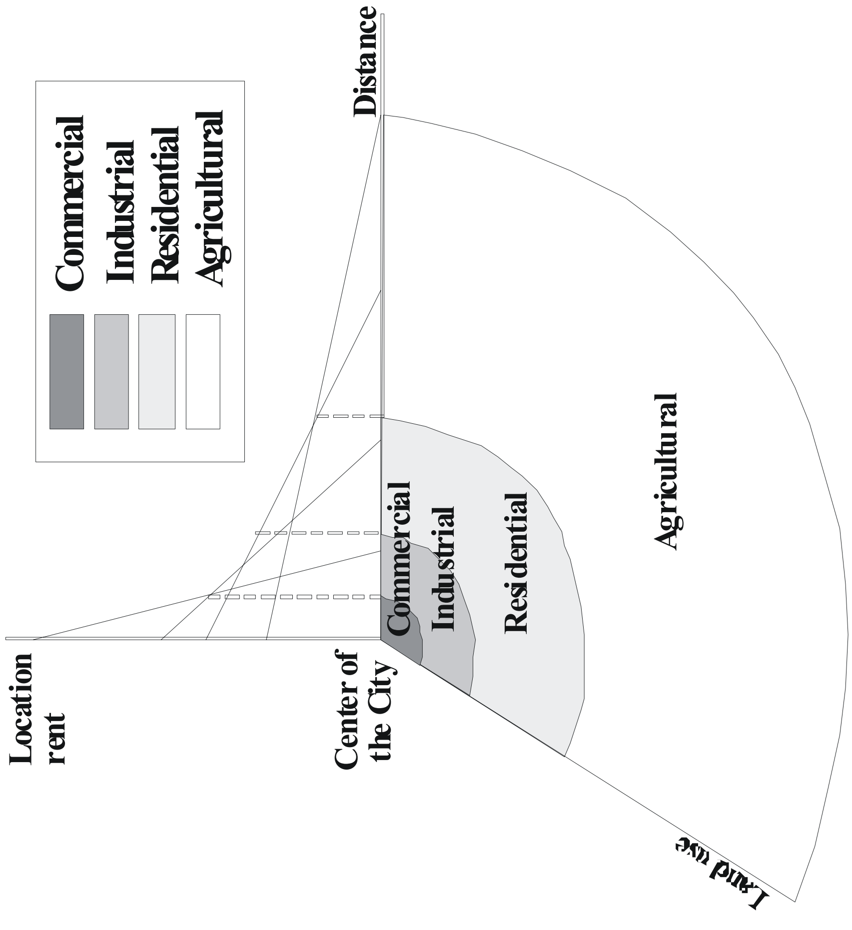

Figure 1. Theoretical Relationship Between Location, Rent, and Spatial Organization of Land Use

A combination of theories including marginal productivity, location, and economic development theories are generally necessary to explain valuation in rural land markets. The concept of comparative advantage offers a useful way of integrating these theories. Barlowe (1986) points out that in practice, comparative advantage not only comes from the natural resource endowment but also comes from favorable combinations of production inputs, favorable location and transportation costs, favorable policies, and desired amenity factors. This suggests that not only site characteristics, but locational and economic development factors are expected to influence land use and affect highest and best use of the land. Multiple uses of land and the selection of highest and best use of land are expected to increase bidding activity in rural land markets and hence influence land values in affected areas.

MODEL DEVELOPMENT

This study uses hedonic price analysis to identify and to measure the effect of hypothesized characteristics and factors on per acre timberland values. Hedonic modeling applications in timberland markets have been limited (Roos 1996). The effect of the characteristics of timberland on house prices was examined by Willis and Garrod (1992) using a hedonic model. Similarly, Roos (1995) used the hedonic methodology to examine markets containing agricultural land, timberland and houses. Roos (1996) and Turner et al. (1991) also used hedonic models to estimate the relationship between tract characteristics and timberland prices in Sweden and Vermont, respectively. While some of these studies have included both the physical and locational characteristics of timberland, none have incorporated GIS in a detailed spatial analysis of timblerland markets.

Following the approach used by Chicoine (1981), Shonkwiler and Reynolds (1986), and Turner et al. (1991), using similar data and variables, value in a rural land submarket (y) is specified by the following transcendental function:

$$y = ß_0 Z_1^{ß_1} \exp\left[\sum_{i=1}^{m} \alpha_i X_i + \sum_{j=1}^{n} \gamma_j D_j + \varepsilon \right], \quad (1)$$

where y is the per acre selling price of land, Z_1 is the size of tract in acres, m is the number of additional continuous variables (X_i), n is the number of discrete (dummy) variables (D_j), and ε is a random disturbance term. Taking the natural logarithm of both sides of equation (1) gives:

$$\ln y = \ln \beta_0 + \beta_1 \ln Z_1 + \sum_{i=1}^{m} \alpha_i X_i + \sum_{j=1}^{n} \gamma_j D_j + \varepsilon. \quad (2)$$

This model is formulated to include non linearities because the price of land is hypothesized to decline as the size of tract (Z_1) increases. This results in a negative relationship between per acre value and size of tract.

The implicit marginal price of each characteristic is an estimate of the amount by which the per acre land price changes, given a unit change in the characteristic. For all except the discrete variables in equation (1), the implicit marginal prices (i.e., the partial derivatives) are given by the following:

$$My_t / MZ_{1,t} = IMPSIZE_{1,t} = (\beta_1 / Z_{1,t})(y_t)$$
$$My_t / MX_i = IMPX_{i,t} = \alpha_i \, (y_t).(3)$$

The subscript, t, implies there are implicit marginal prices associated with each land transaction. An estimate of the implicit marginal price at the mean price and mean level of characteristic over all observations is obtained by substituting mean values of each variable in equation (3).

The derivation of implicit marginal prices for discrete variables (D_j) in semilogarithmic equations is not as straightforward. Kennedy (1981) suggests the following estimation procedure where the variance of the coefficient of the discrete variable is taken into account:

$$IMPD_j = (\exp\,[c_j - 2\,V(c_j)] - 1)(\text{Mean Price}), \quad (4)$$

where $IMPD_j$ is the implicit marginal price of the discrete variable, c_j is the estimated coefficient of the discrete variable parameter, γ_j; $V(c_j)$ is the variance of the estimated coefficient, c_j; and Mean Price is the mean price per acre over all observations used in the model.

STUDY AREA, DATA, AND VARIABLES

The study area used in this analysis is limited to a timber production region in the northern part of Louisiana. The area, illustrated in Figure 2 as the North Central Area, was delineated by Kennedy et al. (1997) using multivariate statistical procedures. The Coastal Plain general soils make the North Central Area a major softwood timber production area in Louisiana. Smaller amounts of hardwood are grown in this region, primarily in the Gulfcoast Flatwoods and Minor Floodplains general soil areas.

Data for the study consists of 133 tracts of timberland in the North Central Area that sold between January 1, 1993 and June 30, 1998. Tracts included in the study consisted of largely pre-merchantable and merchantable soft and hardwood timber. The data were collected using the annual Louisiana Rural Land Market Survey and a statewide listing of individuals with knowledge of Louisiana rural land markets. The listing included 501 individuals who were: state certified appraisers; officers in commercials banks; personnel of the Farm Service Agency, Federal Land Bank, and Production Credit Association; and members of the Louisiana Chapter of the American Society of Farm Managers and Rural Appraisers and Louisiana Realtors Land Institute. Tracts used in this study had at least 50 percent timber production by area, were located outside city limits, included no houses or buildings, were 10 acres or more in size, and sold only once during the study period. The locations of the 133 tracts of timberland were geo-referenced in GIS. In Figure 2, each symbol represents the location of each tract included in this study. The size of each symbol corresponds with the value of the per acre selling price for each observation.

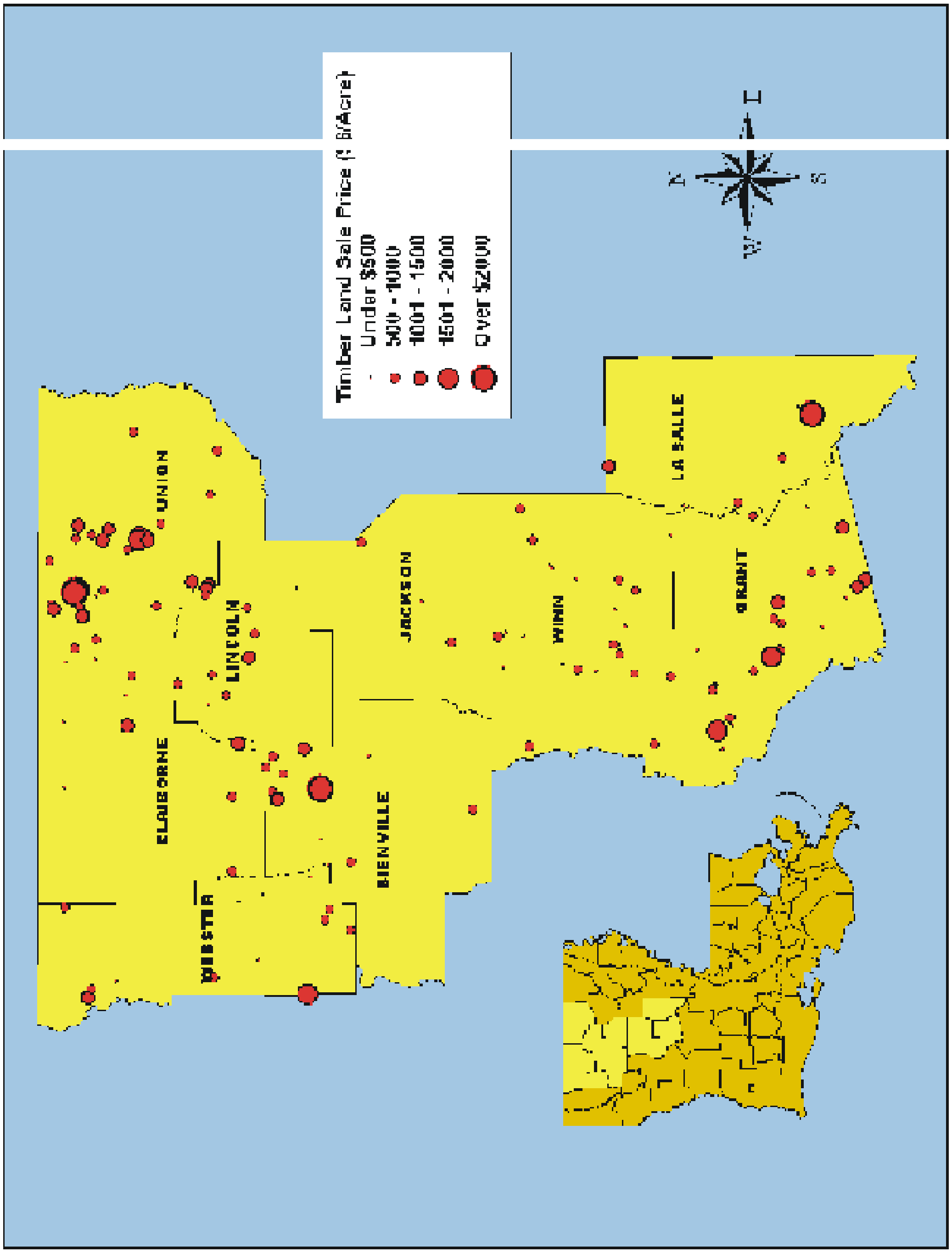

Figure 2. Geo-referenced Location of Timberland Sales

Variables selected for inclusion in the hedonic model are presented in Table 1. The per acre nominal selling price of timblerland (PRICE) is the dependent variable and includes the value of growing or merchantable timber. Independent variables expected to have an inverse relationship with per acre selling price include the size of tract (SIZE) and distance to nearest metropolitan city (DNC). Generally, there is an expected negative relationship between size of tract and per acre selling price because fewer buyers compete for larger tracts, whereas, many buyers typically compete for smaller tracts. As previously discussed, location theory suggests an inverse relationship between distance to major markets (cities) and per acre selling prices. Size of tract ranged from 10 acres to 842 acres, with a mean of 91.5 acres; distance to nearest metropolitan city (Alexandria, Monroe, or Shreveport) ranged from 9.6 to 58.8 miles, with a mean of 35.5 miles.

Table 1
Symbols and Descriptive Statistics for Hedonic Model Variables

Symbol[a]	Variable	Mean	Minimum	Maximum	Std. Dev.
PRICE	Per acre price of land ($)	788.2	350.0	3714.0	593.9
SIZE (-)	Size of tract (acres)	91.5	10.0	842.0	124.6
RT (+)	Paved road access (1,0)	0.5	0.0	1.0	N/A
ROAD (+)	Road frontage (feet)	427.2	0.0	5350.0	928.3
DNC (-)	Distance to nearest metro. city (mi.)	35.5	9.6	58.8	10.1
VALUE (+)	Value of improvements ($)	11477.3	0.0	460000.0	46493.9
TIME (+)	Month of sale (01/01/93 = 1)	27.6	1.0	72.0	20.7

[a] Parentheses indicate expected effect of variables on selling price per acre.

Value of improvements (VALUE) is a dollar value measure of any improvements made on, or to, the tract and is predominantly the estimated value of growing timber. The average value of improvements was $11,477 per tract, ranging from a minimum of zero to a maximum of $460,000. Other independent variables expected to have a positive influence on per acre selling price included the presence of paved road access (RT), the amount of road frontage (ROAD), and the month of sale (TIME). RT entered the model as a discrete variable (RT = 1 if tract included paved road access; RT = 0, otherwise). For the study period, rural land values had been trending upward, hence TIME was included to account for the trend of the dependent variable (per acre selling price) and was expected to have a positive influence on per acre selling prices.

MODEL RESULTS

Hedonic model estimation and diagnostic tests results presented in Table 2 were conducted using the SpaceStat algorithm (Anselin 1995). Results from the ordinary least squares (OLS) model indicated that SIZE, RT, VALUE, and TIME were all statistically significant at the 1% level of significance. ROAD and DNC were statistically significant at the 10% level of significance. All variables exhibited the expected coefficient sign. The Breusch-Pagan test was not statistically significant at the 1% level, suggesting that heteroskedasticity was not a serious problem. The statistical insignificance of the Lagrange multiplier tests (lag and error) indicated that spatial autocorrelation, or spatial interdependence in the data, was not present[1]. The presence of spatial autocorrelation can result in inefficient and biased estimates (Vandeveer et al. 1998).

Table 2
Estimated Hedonic OLS Model, Marginal Implicit Prices, and Specification Diagnostics

Independent variable	Estimated coefficient[a]	Standard error	Marginal implicit price ($/acre)[b]
ln SIZE	-0.286276**	0.052125	-2.47
RT	0.309857**	0.095535	281.42
ROAD	0.000091*	0.000055	0.07
DNC	-0.007678*	0.004280	-6.05
VALUE	0.000006**	0.000001	5.20[c]
TIME	0.008078**	0.002056	6.37
Intercept	7.432630**	0.250396	
Measures of fit	Value		
Maximized log likelihood (LIK)	-88.412		
Akaike information criteria (AIC)	190.825		
Schwartz Criteria (SC)	211.057		
R^2	0.468		
F-test	18.463		
Specification diagnostics	Value	Statistical significance	
Breusch-Pagan test	13.804	0.040	
Lagrange multiplier (error)	0.050	0.823	
Lagrange multiplier (lag)	0.665	0.415	
Number of observations: 133			

[a] ** denotes significance at the 1% level; * denotes significance at the 10% level.
[b] Estimated in dollars per acre at the mean value for each variable.
[c] Estimated per $000 increase in value of improvements (i.e., $1,000 worth of improvements adds an estimated $5.20 per acre to the selling price, other factors held constant.)

Marginal implicit prices were used to observe the magnitude and direction of influence of various model factors on per acre land values. Marginal implicit prices presented in Table 2 were calculated using equations (3) and (4). A positive marginal implicit price indicates that an increase in that characteristic, or variable, results in an increase in the per acre selling price of timberland. For example the presence of a paved access road (RT) added $281 per acre to the tract selling price, holding other factors constant. The presence of each linear foot of road frontage added $0.07 per acre to the selling price (440 feet of road frontage would add about $31 per acre). The marginal implicit price for the value of existing or growing timber (VALUE) indicates that each $1,000 increase in VALUE would add $5.20 to the bare land value of timberland. Similarly, each additional month added approximately $6.37 per acre to the value of each tract.

Negative marginal implicit prices, resulting from a negative model coefficient, have a depressing effect on per acre timberland values. The marginal implicit price for ln SIZE indicated that an increase in tract size of one acre reduced per acre timberland value by $2.47, other factors held constant. As distance to the nearest metropolitan city increased by one mile, the marginal implicit price associated with DNC suggests that per acre timberland values decreased by $6.05.

TIMBERLAND VALUE CONTOURS

Holding other variables constant at mean levels, location and tract accessibility variables (RT, ROAD, and DNC) were allowed to vary in developing predicted land values from the hedonic model. Predicted timberland values, along with GIS procedures, were then used to estimate timberland value contours. A timberland value contour is an iso-price line that geographically represents areas that have approximately equal prices. The method used to estimate timberland value contours was the triangulated irregular network (TIN) available within the ARC/INFO data model. The TIN method is a terrain model that uses a sheet of continuous, connected triangular facets based on a Delaunay triangulation of irregularly spaced nodes or observation points (Burrough 1987). The TIN procedure provided an efficient method for estimating detailed land value contours without requiring a huge amount of data.

Timberland value contours from predictions of the hedonic model are illustrated in Figure 3. Each contour line is drawn as a continuous line identifying timberland values at $200 price intervals. Isolines located close together indicate steep price gradients in short distances, and isolines located further apart indicate much smaller price gradients. The location of timberland value contours relative to major highways, towns, and lakes suggest that economic development potential is a major factor influencing land values in the study area. The well-developed contours illustrated in Figure 3 are consistent with location theory=s concentric circles illustrated in Figure 1. Such contours are evident around the areas of Catahoula Lake, Iatt Lake, and Darbonne Lake. Well-developed contours are also evident along U.S. Highway 167 in the vicinity of the towns of Winnfield and Jonesboro. Similarly, along Interstate Highway 20, well-developed contours are illustrated northeast of Ruston and in the vicinity of Minden. In more remote areas within the study region, timberland value contours are less developed.

CONCLUDING REMARKS

The general objective of this paper was to demonstrate how spatial econometric modeling and GIS procedures can be integrated to improve information from timberland market research. Marginal implicit prices estimated from the hedonic model indicated that location and tract development variables are important in explaining per acre timberland values. Holding all explanatory variables constant at mean characteristic levels, location and tract development potential variables (distance to nearest metropolitan city, paved road access, and amount of road frontage) accounted for approximately 30% of predicted timberland value from the hedonic model. Physical characteristics (size of tract and value of improvements) and time of sale accounted for the remainder of predicted timberland value.

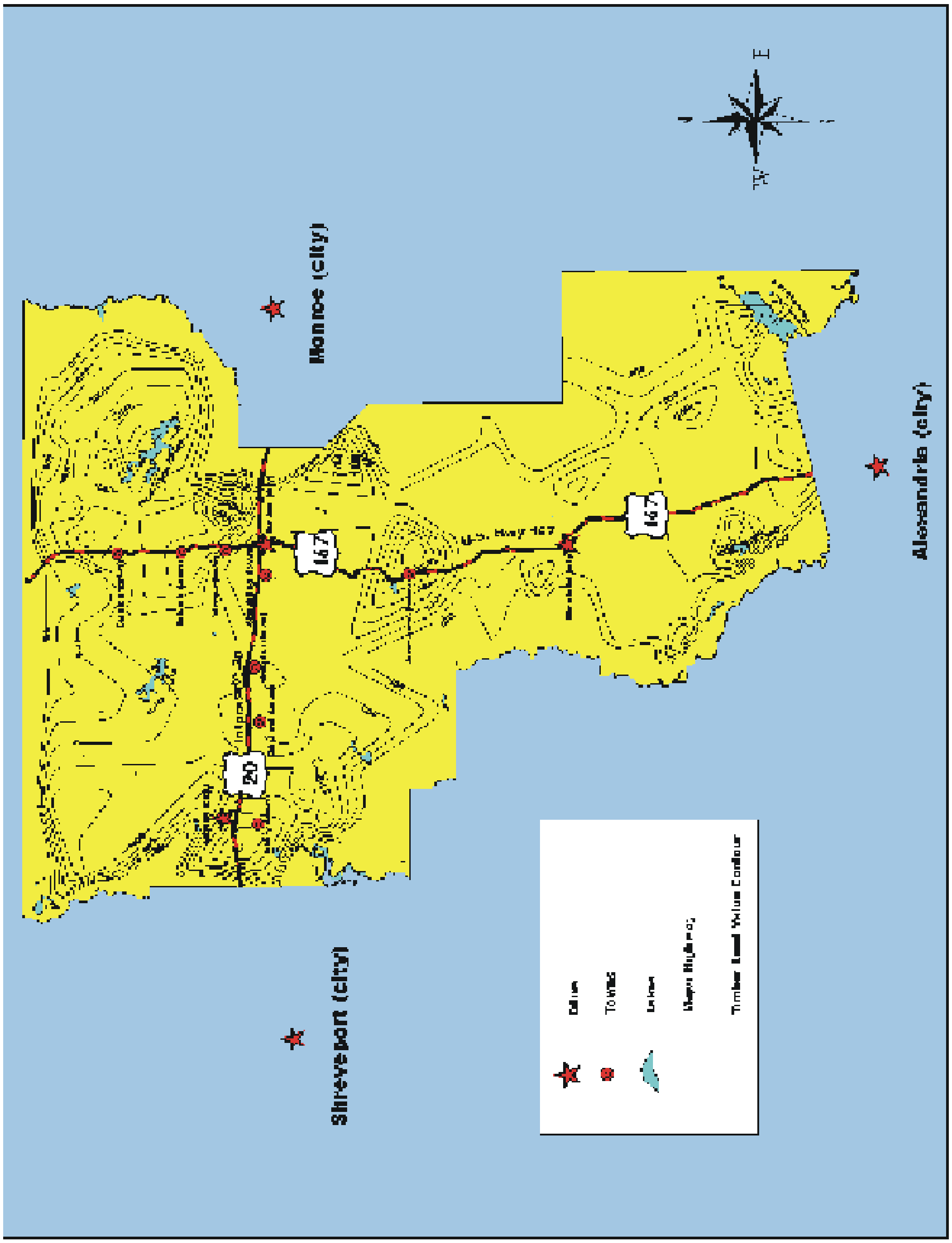

Figure 3. Timberland Value Contours as Determined by Tract Location and Accessibility

GIS-generated timberland value contours provided an illustration of the effects of location and tract accessibility on per acre timberland values. This allowed a visual examination of the geographic influence of these variables on per acre timberland values. Results of the GIS component of this project suggest that modeling efforts may be improved by examining alternative distance and amenity variables, such as distance to the nearest lake. Empirical timberland value contours estimated in this analysis are largely consistent with location theory models of concentric circles of land value around market or amenity centers.

Spatial econometric modeling combined with GIS procedures offer an effective method of developing improved timberland value models and information. Because spatial autocorrelation can result in inefficient and biased econometric results, it is important to include diagnostic tests for the presence of spatial dependence in the data. Additional research to improve timberland value estimation includes estimation of second-stage bid functions that incorporate non tract-specific variables such as population density and income, exploration of alternative model functional forms, alternative amenity variables, and development of additional variables and methods to improve the measurement of location and tract development impacts on timberland value.

ENDNOTES

For this analysis, Lagrange multiplier (LM) tests were used to test for spatial dependence. The joint use of LM error and LM lag tests can help determine the type of spatial autocorrelation that is present and can indicate if the use of a corrective spatial model is appropriate. A complete description of the tests for spatial dependence and the use of spatial models can be found in *SpaceStat Version 1.80 User=s Guide* by Luc Anselin, West Virginia State University Regional Research Institute, 1995.

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