A Growth-Focused Spatial Econometric Model of Agricultural Land Development in the Northeast

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Introduction

The spatial distribution of economic activity is important for economists concerned with industrial location decisions, urban and regional growth, residential preferences, land markets, land use change, and related policies. Recent changes in spatial economic activities, accelerated through technology, income growth, investment, and in some cases government policy, have led to concerns regarding natural resource and environmental management. This paper focuses on the relationship between regional growth patterns and development of agricultural land.

Understanding development of agricultural land requires understanding the economic forces that allocate land to different uses. Since land use decisions are typically determined by households, businesses, government, and foreign trade sectors of the economy, economic forces shaping spatial patterns of economic activities have to be linked with the microeconomics of utility and profit motives, as well as government and foreign trade shocks. Whether the interactions between dynamic economic patterns and land use allocations result in an efficient and socially desirable outcome is important for land use policy. Land development in suburban and rural communities impacts economic, fiscal, environmental, and social attributes of communities with wide-ranging implications for income, employment, tax base, public services, and non-market environmental goods that have a direct impact on suburban and rural quality of life (Heimlich and Anderson 2001). For instance, studies have documented that the cost of providing public services is a function of the pattern of development (Burchell et al. 1998) and the development of agricultural lands may impose long-term costs to society (Porter 1997). The existence of these externalities suggests that land use allocation patterns might be inefficient.

Agricultural lands are multifunctional in the sense that they not only act as a factor of production in agriculture, for which competitive markets exist, but these lands also provide a source of rural livelihood, scenic beauty, and open space which are not necessarily accounted for in the market price. A number of studies have analyzed the non-market benefits of agricultural lands and how the market may fail to internalize these externalities (Plantinga and Miller 2001; Irwin and Bockstael 2001; Bowker and Didychuk 1994; Kline and Wichelns 1996; Ready et al. 1997; Rosenberger and Loomis 1999; Rosenberger and Walsh 1997). The existence of positive externalities associated with agricultural land means that market allocation of farm land may not maximize social welfare so that too little agricultural land is maintained. In addition, development of agricultural land is for all practical purposes irreversible and results in a loss of option value, which may not be taken into account by land markets (NERCRD 2002). It is this multifunctionality of land in agriculture that keeps it in the public eye and on many research agendas (Batie 2003; Abler 2003). As a result, most states have initiated some type of land use policy to slow the loss of agricultural land and its benefits (Nickerson and Hellerstein 2003).

This study focuses on the relationship between regional growth and agricultural land use by systematically bringing the agricultural land conversion problem into a regional growth framework, using an extension of growth equilibrium models that have been applied to study regional economic changes. Departing from previous studies, it applies regional equilibrium methods to agricultural land use change in a heterogeneous regional environment, including endogenous variables, such as income, land prices, and land use policies, to better explain regional land use trends and policies. This study develops a spatial simultaneous growth equilibrium model and uses econometric estimation to analyze the relationship between regional growth and agricultural land use change.

Determinants of Regional Growth and Agricultural Land Development

Several studies have modeled the interaction between economic growth and changes in rural and suburban agricultural land (Brueckner and Fansler 1983; Mieszkowski and Mills 1993). Other studies have focused on regional and local growth patterns determined by "rural renaissance" and "urban flight," a shifting economic base, and a change in employment opportunities (Dissart and Deller 2000; Power 1996; Lewis et al. 2002). Despite the level of aggregation of these studies, many agree that urban "push factors" and rural and suburban "pull factors" determine spatial patterns of development and hence agricultural land use change. Fiscal and social problems associated with central cities (high taxes, low quality public schools and other government services, crime, congestion and low environmental quality) motivate residents to migrate to suburban places (Mieszkowski and Mills, 1993).

Other factors that affect regional growth and land use change include public investment in transportation technologies and improved access to outlying areas. Studies show that investment in highways and transportation facilities increases local economic growth and productivity (Chandra and Thompson 2000; Keeler and Ying 1988; Garcia-Mila and McGuire 1992). Greater interstate highway density is also associated with higher levels of manufacturing and other sector employment (Carlino and Mills 1987). Reinforcing the urban flight (sprawl) process, the rural environment, including agricultural lands, provides scenic views, recreational opportunities, and other non-market environmental benefits that attract new development (Irwin and Bockstael 2001; Dissart and Deller 2000). These rural qualities and endowments (pull factors) affect urban migration decisions, as households are drawn to areas with higher quality of life or amenity factors (Dissart and Deller 2000). Deller et al. (2001) argue that in addition to local characteristics like taxes and income, a significant relationship between amenities, quality of life, and local economic performance exists. Other studies also indicate that amenity factors appear powerful in explaining regional growth differences (Gottlieb 1994; English et al. 2000; Roback 1988; Henry et al. 1997). Bell and Irwin (2002) found that spatial factors such as proximity to employment and other activities, natural features, surrounding land use patterns, and land use policies affect the pattern of land use change. The major causes of development of suburban and rural land can be aggregated into forces of population growth, household formation, and income and employment growth (Heimlich and Anderson 2001), which in turn are affected by the above mentioned factors.

Methodology

It is assumed that firms and households adjust to disequilibrium over time to maximize profits and utility across space. In a general equilibrium framework, population, employment, and income are affected not only by each other, but also by a variety of other variables that affect number of jobs consistent with competitive profits, number of people consistent with equalized utility levels among places, and an array of factors influencing income growth. In principle, many such variables are likely to be simultaneously determined in such a general equilibrium model, along with population and employment (Carlino and Mills 1987). Growth equilibrium models were developed to simultaneously explain employment and population changes for a region. In their early applications, these models were used to resolve the debate over whether people follow jobs or jobs follow people (Carlino and Mills 1987). To capture the impact of inter-temporal employment density, population density, and income changes on agricultural land, a growth equilibrium modeling is introduced here.

Assuming a simultaneous relationship between growth factors, county per capita income, agricultural land prices, and the stock of agricultural land at a particular time the model can be expressed as the following.

(1) $P^* = f [E, I, P_L | \Omega^P]$

(2) $E^* = f [P, I, P_L | \Omega^E]$

(3) $I^* = f [P, E, P_L | \Omega^I]$

(4) $P_L^* = f [P, E, I, AgL | \Omega^P{}_L]$

(5) $AgL^* = f [P, E, I, P_L | \Omega^{AgL}]$

where P^*, E^*, I^*, P_L^*, and AgL^* refer to equilibrium levels of population, employment, per capita income, agricultural land value, and agricultural land stocks, respectively, and Ω^P, Ω^E, Ω^I, $\Omega^P{}_L$, and Ω^{AgL} refer to a vector of other exogenous variables having a direct or indirect influence on population, employment, per capita income, agricultural land value, and agricultural land stocks.

Population and employment are likely to adjust to their equilibrium values with substantial lags (Mills and Price 1984). Similarly, regional income levels, agricultural land, and its value are assumed to adjust to their equilibrium values. The rate and level of agricultural land conversion in the base year is likely to influence agricultural land conversion in the current year, or conversely, equilibrium levels of agricultural land adjust to previous period conversion patterns. Thus, a distributed lag adjustment equation can be introduced.

(6) $P_t = P_{t-1} + \lambda_P[P^* - P_{t-1}]$

(7) $E_t = E_{t-1} + \lambda_E[E^* - E_{t-1}]$

(8) $I_t = I_{t-1} + \lambda_I[I^* - I_{t-1}]$

(9) $P_{Lt} = P_{Lt-1} + \lambda_{PL}[P_L^* - P_{Lt-1}]$

(10) $AgL_t = AgL_{t-1} + \lambda_{AgL}[AgL^* - AgL_{t-1}]$

where λ_P, λ_E, λ_I, λ_{PL}, and λ_{AgL} are speed-of-adjustment coefficients, $0 \leq \lambda_P, \lambda_E, \lambda_I, \lambda_{PL}, \lambda_{AgL} \leq 1$, and t-1 is a one period lag. Thus, current population, employment, income, land prices, and the stock of agricultural land are dependent on their one period lagged levels and on the adjusted change between equilibrium values and one lagged period values. Rearranging terms:

(11) $\Delta P = P_t - P_{t-1} = \lambda_P[P^* - P_{t-1}]$

(12) $\Delta E = E_t - E_{t-1} = \lambda_E[E^* - E_{t-1}]$

(13) $\Delta I = I_t - I_{t-1} = \lambda_I[I^* - I_{t-1}]$

(14) $\Delta P_L = P_{Lt} - P_{Lt-1} = \lambda_{PL}[P_L^* - P_{Lt-1}]$

(15) $\Delta AgL = AgL_t - AgL_{t-1} = \lambda_{AgL}[AgL^* - AgL_{t-1}]$.

The speed-of-adjustment coefficient (λ) is embedded in the linear coefficient parameters α, β, and δ (Deller et al. 2001), hence, equations (11) through (15) can be rearranged and linearly expressed as:

(16) $\Delta P = \alpha_{0P} + \beta_{1P}P_{t-1} + \beta_{2P}\Delta E + \beta_{3P}\Delta I + \beta_{4P}\Delta P_L + \sum\delta_{iP}\Omega^P + \varepsilon_i$

(17) $\Delta E = \alpha_{0E} + \beta_{1E}E_{t-1} + \beta_{2E}\Delta P + \beta_{3E}\Delta I + \beta_{4E}\Delta P_L + \sum\delta_{iE}\Omega^E + \varepsilon_i$

(18) $\Delta I = \alpha_{0I} + \beta_{1I}I_{t-1} + \beta_{2I}\Delta P + \beta_{3I}\Delta E + \beta_{4I}\Delta P_L + \sum\delta_{iI}\Omega^E + \varepsilon_i$

(19) $\Delta P_L = \alpha_{0PL} + \beta_{1PL}P_{Lt-1} + \beta_{2PL}\Delta P + \beta_{3PL}\Delta E + \beta_{4PL}\Delta I + \beta_{5PL}\Delta AgL + \sum\delta_{iPL}\Omega_{PL} + \varepsilon_i$

(20) $\Delta AgL = \alpha_{0AgL} + \beta_{1AgL}AgL_{t-1} + \beta_{2AgL}\Delta P + \beta_{3AgL}\Delta E + \beta_{4Agl}\Delta I + \beta_{5Agl}\Delta P_L + \sum\delta_{iAgL}\Omega_{AgL} + \varepsilon_i$.

Because land exists in space, there can be significant spatial correlation in land use models. Spatial autocorrelation exists when the error term or the specified dependent variable at one location is correlated with observations of other error terms or observations for the dependent variable at other locations (Anselin 1995). If this is the case, the expected value of the error terms, or the correlation of errors across space is different from zero and standard econometric estimations may lead to inefficient and biased estimates. A number of tests can be used to discover whether the model should be a spatial lag or spatial error model. In this study, appropriate spatial econometric tests and estimations are conducted on the reduced form equations of the simultaneous system.

County level data for West Virginia, Maryland, and Pennsylvania for 1987, 1999, and 2002 are used to estimate the econometric models. The source for population, employment, per capita income, and unemployment rate data is the Regional Economic Information Service (REIS). Data on agricultural land value, agricultural land acreage, government financial assistance to farmers, land conservation programs (CRP), proportion of total lands in farms, agricultural income per farm and farm employment are generated from the U.S. Agricultural Census. Per capita taxes, property taxes, government expenditures per capita, median housing value, crime rate, number of physicians and education levels are from the County and City Data Book. Growth variables and spatial data were computed from the above mentioned data sets.

Results and Discussion

Two empirical models are estimated in this study. The first uses a three-stage-least-squares approach to simultaneously identify the impact of growth on agricultural lands. The second model investigates possible spatial dependence in the data. Due to the complexity of estimating such a simultaneous spatial econometric system, we identify reduced form equations for the simultaneous system and estimate each equation using spatial lags to test for spatial dependence. A complete list of variables and their definitions is provided in Table 1.

Estimation results from the first system of simultaneous equations are presented in Table 2. Population growth (ΔP) is positively and significantly related with employment expansion (ΔE), asserting that in our study area people follow jobs. The relationship between population growth and per capita income growth (ΔPCI) is negative, suggesting that population growth is higher in rural and suburban communities where income growth is slower. The significant and negative relationship between population growth and agricultural land prices (*ΔAgLP*) may be due to high per acre land values discouraging housing development, and/or high farmland values reflecting high productivity and less interest by farmers in selling their land for development. Fiscal factors, local tax burden ($PCTAX_{t-1}$) and property taxes ($TAXPPRO_{t-1}$), have the expected negative effect on local population growth, as evidenced by estimated coefficients that are negative and significant. This result is consistent with the theoretical expectation that people are mobile across space to optimize tax burdens. A positive relationship between the crime rate ($CRIM100k_{t-1}$) and population growth was not expected, however, the effect of crime may have been overshadowed by other local attributes that encourage population growth.

Employment growth (*ΔE*) is positively and significantly related with population growth (*ΔP*), per capita income expansion (*ΔPCI*), and land prices (*ΔAgLP*). The expansion of employment following population growth has been supported in previous studies. A growing population provides the markets and labor pool that attract new businesses and employment. Employment opportunities also expand in counties with growing per capita income and purchasing power. The expansion of employment demands land that may come from farmland development. If this pressure is significant, farmland prices would be expected to rise. These results indicate that employment growth is higher in counties that are experiencing growth in farmland prices. Mining is an important economic activity in our study area, and its contribution to local employment and hence employment growth is significant. Our results show that there is a significant contribution by the service sector to job growth ($SERVEMP_{t-1}$), but construction employment ($CONSTEMP_{t-1}$) is negatively related to job growth. This could be a reflection of slower overall employment growth in counties with high employment in construction jobs. Fiscal characteristics of communities can be an important determinant of employment growth. Property taxes ($TAXPPR_{t-1}$), used to proxy the impact of taxes on job creation in the study area, are significantly and negatively related with job growth, meeting prior expectations. Differences in human capital endowments are hypothesized to lead to different job growth patterns. In our study area, education levels (proportion of county 25 and above with high school or higher, $PERHIGDA_{t-1}$) are positively and significantly related to employment growth.

Per capita income growth (ΔPCI) is significantly and negatively affected by population growth (ΔP), indicating for our study area that areas with lower population density experienced larger income growth than dense population centers. This result confirms the decentralization of jobs to suburbs and rural areas where population concentration is comparatively low. Income growth is positively and significantly related with employment growth. Fiscal burdens, like per capita income ($PCTAX_{t-1}$) and property taxes ($TAXPPRO_{t-1}$) were expected to slow down income growth, however, both variables were positively related to income growth. This may be due to reinvestment of high tax revenues by counties through the provision of better public goods that may partially offset the negative impacts of taxes. The effect of poverty on income growth, as expected, indicates that counties with a high proportion of income levels below poverty ($PPOINCBP_{t-1}$) experienced slower income growth. Counties with high poverty rates are less likely to attract new jobs and investment, consequently per capita income growth may be hampered.

Increases in agricultural land prices ($\Delta AgLP$) not only affect the rate of agricultural land development but also the distribution of population and employment growth (ΔE) across space. Our results show that higher agricultural land prices have a negative impact on population and per capita income growth. The agricultural land price is significantly and positively influenced by employment growth, indicating that growth in employment puts upward pressure on agricultural land prices. However, the expectation that growth in population and income lead to higher farmland prices is not supported by our analysis. Counties with higher farmland prices at the beginning of the study period experienced positive growth in farmland prices as indicated by a positive and significant coefficient on the initial period agricultural land prices ($AgLP_{t-1}$). The initial density of cropland ($DCROPL_{t-1}$) has a negative coefficient, as expected, indicating that an initial high endowment of cropland is associated with lower farmland prices. In other words, increasing scarcity of farmland over time is likely to lead to higher farmland prices. Agricultural land prices are also influenced by farmland productivity as measured by agricultural income per farm ($AGINCPFA_{t-1}$). For our study area, the results suggest that for every $1 increase in farm income, the average value of farmland increases by $0.038 cents per acre. Thus, income support to farmers is capitalized into higher farmland values, which in turn discourage population and income growth in suburban and rural areas. A positive and significant relationship is found between the amount of land in the Conservation Reserve Program (CRP) ($LICONSRP_{t-1}$) and farmland prices since land enrolled in the CRP is at least temporarily unavailable for development.

Looking at agricultural land density, we find that high growth in population density (ΔP) is associated with high farmland losses (ΔAgL) as agricultural land is developed. There is also a positive relationship between farmland price growth (*AgLP*) and farmland development. With development pressure, the value of farmland increases partly due to speculation. Thus, high growth in farmland prices may indicate the extent of development pressure on farmland, after accounting for its increase in the value due to productivity of the farm sector. Employment and per capita income growth did not have a significant impact on agricultural land density. The initial cropland density variable ($DCROPL_{t-1}$) has a significant positive impact on agricultural land levels, indicating that a large concentration of crop farming activity tends to reduce development. This may be due to the nature of economic activities where concentrated large scale farming brings economies of scale in input and output markets. More dense farming activity is likely to challenge development compared to fragmented farmland due to collective advantages and economies of scale. This may indicate that there could be a threshold of farmland density below which farming activity becomes sensitive to development. Finally, government financial assistance to farmers ($GVPYPFAR_{t-1}$) was significant in slowing down farmland development. In the presence of many positive externalities to society from the agricultural sector, the public may interfere in terms of policy support or direct financial assistance. These results indicate that such government assistance programs have a significant impact in terms of reducing farmland development.

Spatial dependence of data in regional land use change analysis is a common phenomenon. To test for the existence of spatial correlation in the data, exploratory Moran's I test and econometric spatial dependence significant tests were performed. The test results indicate existence of spatial dependence in the employment growth, agricultural land price, and agricultural land change reduced form equations, however, no significant spatial dependence was found for the population and per capita income growth equations. A spatial lag model is used for the reduced form equations that exhibited significant spatial dependence to generate unbiased coefficient estimates. These estimation results are reported in Table 3.

In the employment growth equation, the spatial lag variable ($W\Delta E$) is negative and significant, indicating that employment growth in neighboring counties reduces job expansion in the county in question. This may be due to the biased spatial distribution of jobs across counties, where counties with high employment growth attract commuters form neighboring counties, creating further incentives for job creation at that destination. Similar to the conclusion reached in the non-spatial system of equations model, this result indicates that employment growth is positively related with population endowment and the initial income level of counties, along with the level of human capital formation, while taxes, land conservation efforts, the crime rate, a higher unemployment rate, and high housing values may slow employment growth.

The agricultural land price spatial lag variable ($W\Delta AgLP$) is positive and significant, indicating that high farmland prices in neighboring counties put pressure on local farmland prices due to increasing development pressure that is increasing speculation regarding future development. After correcting for spatial correlation, farmland price growth is positively related with initial population density, initial per capita income, and construction employment, which may be due to an increased demand for land to accommodate a growing population base. A positive relationship with higher farm income, on the other hand, means that a better return on farmland is being translated into high farmland prices following Ricardian land rent theory. Taxes and the crime rate are significantly and negatively related with farmland price growth. Higher taxes and higher crime rates discourage population and employment relocation to these locations resulting in lower demand for land and hence lower farmland prices.

Finally, the agricultural land change spatial lag variable ($WAgL$) has a positive and significant relationship with change in agricultural land. This indicates that counties whose neighbors are experiencing high levels of farmland development may also see development of their farmlands as well. This suggests a sprawling pattern of development of farmland. The performance of the spatial model is weak compared to the non-spatial system, however, the results indicate that local externalities in terms of higher property values and unemployment are related to lower farmland losses. Places with weaker employment performance and high property values as well as those with higher crime rates or higher taxes may discourage migration of population and employment creation, hence limiting the pressure on farmland developments.

Conclusion

This study provides a theoretical and empirical modeling approach to understanding agricultural land development from a regional growth perspective. A simultaneous equilibrium model is developed to estimate the interaction of endogenous variables of growth in population, employment, per capita income, and agricultural land prices with agricultural land development. Empirical three-stage-least-square estimation and spatial econometric estimation of reduced form equations are undertaken.

The results suggest that while there is an array of factors that influence population growth, from a farmland development perspective, population growth is negatively related with increasing agricultural land prices. This may indicate that policies that increase farmland values are likely to reduce population growth and pressure on farmland development. Employment growth is also affected by a number of socio-economic conditions, however, from a farmland development perspective, higher farmland prices were associated with employment growth, suggesting that an increase in farmland prices may not reduce employment growth and pressure on farmland development. Per capita income growth may indicate the level of economic activity in a county and is positively related to employment growth. A negative relationship with farmland prices indicates that counties with high farmland prices experienced lower per capita income growth. From a policy perspective, government transfer programs that increase the value of farmland may slow development and income growth. Agricultural land prices are positively affected by employment growth, higher farm incomes, and land conservation. However, a higher county endowment of agricultural lands tends to reduce the land market value of farmland. This study also concludes that farmland stocks are negatively related to pressure from population growth, however, no significant pressure on farmland stocks is found for employment and income growth. High density farming activity and government farm financial assistance are found to lessen pressure on farmland development. This may be due to economies of scale associated with agglomerated farming activity and due to more net return in farming with government assistance motivating farmers to keep their land in agriculture.

A spatial econometric approach is also used to correct for spatial correlation. Though population and income growth have no significant spatial pattern, employment, farmland price, and agricultural land change showed significant spatial dependence. While high employment growth in neighboring counties slows employment growth in the local county, high farmland prices and agricultural land development in neighboring counties results in higher farmland prices and development in the local county. Understanding this spatial dependence in regional growth and land use change is relevant for spatially explicit land use policies and management.

References

Abler, D. "Multifunctionality, Agricultural Policy, and Environmental Policy." Paper presented at the annual meeting of the Northeastern Agricultural and Resource Economics Association, Portsmouth, NH, June 10, 2003.

Anselin, L. *SpaceStat Version 1.80 User's Guide*. Regional Research Institute, West Virginia University, 1995.

Batie, S.S. "The Multifunctional Attributes of Northeast Agriculture: A Research Agenda." *Agricultural and Resource Economics Review.* 32(2003):1-8.

Bell, K.P., and E.G. Irwin. "Spatially Explicit Micro-level Modeling of Land Use Change at the Rural-urban Interface." *Agricultural Economics*. 27(2002):217-232.

Bowker, J.M., and D.D. Didychuk. "Estimation of the Nonmarket Benefits of Agricultural Land Retention in Eastern Canada." *Agricultural and Resource Economics Review.* 23(1994):218-225.

Brueckner, J.K., and D.A. Fansler. "The Economics of Urban Sprawl: Theory and Evidence on the Spatial Sizes of Cities." *The Review of Economics and Statistics.* 65(1983):479–482.

Burchell, R.W., and N.A. Shad. *The Costs of Sprawl – Revisited*. Transportation Research Board, National Research Council. National Academy Press, Washington, D.C., 1998.

Carlino, G.A., and E.S. Mills. "The Determinants of County Growth*." Journal of Regional Science.* 27(1987):39-54.

Chandra, A., and E. Thompson. "Does Public Infrastructure Affect Economic Activity? Evidence from the Rural Interstate Highway System." *Regional Science and Urban Economics.* 30(2000):457-490.

Deller, S.C., T.-H. Tsai, D.W. Marcouiller, and D.B.K. English. "The Role of Amenities and Quality of Life in Rural Economic Growth." *American Journal of Agricultural Economics.* 83(2001):352-365.

Dissart, J.C., and S.C. Deller. "Quality of Life in the Planning Literature." *Journal of Planning Literature.* 15(2000):135-161.

English, D.B.K, D.W. Marcouiller, and H.K. Cordell. "Linking Local Amenities with Rural Tourism Incidence: Estimates and Effects." *Natural Resources*. 13(2000):185-202.

Garcia-Mila, T. and T.J. McGuire. "The Contribution of Publicly Provided Inputs to States' Economies." *Regional Science and Urban Economics.* 22(1992):229-241.

Gottlieb, P.D. "Amenities as an Economic Development Tool: Is there Enough Evidence?" *Econ. Dev. Quart*. 8(1994):270-85.

Heimlich, R.E., and W.D. Anderson. *Development at the Urban Fringe and Beyond: Impacts on Agriculture and Rural Land*. Economic Research Service, U.S. Department of Agriculture. Agricultural Economic Report No. 803, 2001.

Henry, M.S., D.L. Barkley, and S. Bao "The Hinterland's Stake in Metropolitan Growth: Evidence from Selected Southern Regions." *Jour. of Reg. Sci*. 37(1997):479-501.

Irwin, E.G., and N.E. Bockstael. "Interacting Agents, Spatial Externalities, and the Endogenous Evolution of Residential Land Use Patterns." Ohio State University, Department of Agricultural, Environmental, and Development Economics, Working Paper AEDE-WP-0010-01, 2001.

Keeler, J.E., and J.S. Ying. "Measuring the Benefit of a Large Public Investment: the Case of the US Federal-aid Highway System." *Jour. of Pub. Econ.* 36(1988):69-85.

Kline, J., and D. Wichelns. "Public Preferences Regarding the Goals of Farmland Preservation Programs." *Land Econ.* 72(1996):538-49.

Lewis, D.J., G.L. Hunt, and A.J. Plantinga. "Public Conservation Land and Employment Growth in the Northern Forest Region." *Land Econ.* 78(2002):245-259.

Mieszkowski, P., and E.S. Mills. "The Causes of Metropolitan Suburbanization." *The Journal of Economic Perspectives.* 7(1993):135-147.

Mills, E.S., and R. Price. "Metropolitan Suburbanization and Central City Problems." *Journal of Urban Economics.* 15(1984):1-17.

Nickerson, C.J., and D. Hellerstein. "Protecting Rural Amenities through Farmland Preservation Programs." *Agricultural and Resource Economics Review*. 32(2003):129-144.

Northeast Regional Center for Rural Development (NERCRD). *Land Use Problems and Conflicts in the U.S.*, Research Workshop on Land Use Problems and Conflicts, Orlando, FL., Feb. 21-22, 2002.

Plantinga, A.J., and D.J. Miller. "Agricultural Land Values and the Value of Rights to Future Land Development." *Land Econ.* 77(2001):56-67.

Porter, D. *Managing Growth in America's Communities*. Island Press, Washington, D.C., 1997.

Power, T.M. *Lost Landscapes and Failed Economies: The Search for a Value of Place*. Island Press. Washington, D.C., 1996.

Ready, R.C., M.C. Berger, and G.C. Blomquist. 1997. Measuring Amenity Benefits from Farmland: Hedonic Pricing vs. Contingent Valuation. *Growth and Change.* 28:438-458.

Roback, J. "Wages, Rents, and Amenities: Differences Among Workers and Regions." *Economic Inquiry*. 26(1988):23-41.

Rosenberger, R.S., and J.B. Loomis. "The Value of Ranch Open Space to Tourists: Combining Contingent and Observed Behavior Data." *Growth and Change.* 30(1999):366-383.

Rosenberger, R.S., and R.G. Walsh. "Nonmarket Value of Western Valley Ranch Land Using Contingent Valuation." *Journal of Agricultural and Resource Economics.* 22(1997):296-309.

Table 1. Variable Definitions.

ΔP	Population density change (1987-1999)
ΔE	Employment density change (1987-1999)
ΔAgL	Agricultural land density change (1987-2002)
ΔPCI	Change in per capita income (1987-1999)
$\Delta AgLP$	Change in agricultural land price (1987-2002)
$DPOP_{t-1}$	Population density 1987
$DEMP_{t-1}$	Employment density 1987
$DAgL_{t-1}$	Agricultural land density 1987
PCI_{t-1}	Per capita income 1987
$AgLP_{t-1}$	Value of farmland per acre 1987
$DCROPL_{t-1}$	Cropland density 1987
$FARMEMP_{t-1}$	Farm employment 1987
$SERVEMP_{t-1}$	Service employment 1987
$MINEMP_{t-1}$	Mining employment 1987
$CONSTEMP_{t-1}$	Construction employment 1987
$PCTAX_{t-1}$	Per capita tax 1987
$TAXPPRO_{t-1}$	Percentage property tax 1987
$AGINCPFA_{t-1}$	Agricultural income per farm 1987
$GVPYPFAR_{t-1}$	Government payments per farm 1987
$OWNOCCH_{t-1}$	Owner occupied housing (percent of total) 1990
$MEDHVAL_{t-1}$	Median housing value 1990
$UNEMPRT_{t-1}$	Unemployment rate 1990
$PASTACR_{t-1}$	Pastureland acres 1987
$PTLNDIFR_{t-1}$	Percentage of total land in farming 1987
$LICONSRP_{t-1}$	Land in the Conservation Reserve Program 1987
$CRIM100k_{t-1}$	Crime rate per 100,000 population 1990
$PHYP100k_{t-1}$	Physicians per 100,000 population 1990
$PERHIGDA_{t-1}$	Percentage of population with high school education and above 1990
$PPOINCBP_{t-1}$	Percentage of population with income below poverty line 1990
$GVEXPCAP_{t-1}$	Government expenditures per capita 1987
$W\Delta E$	Spatial lag of employment growth (1987-1999)
$W\Delta AgLP$	Spatial lag of agricultural land price growth (1987-2002)
$W\Delta AgL$	Spatial lag of agricultural land change (1987-2002)

Table 2. First Equation System Econometric Results

VARIABLE	ΔP Equation		ΔE Equation		ΔPCI Equation		ΔAgLP Equation		ΔAgL Equation	
	Coef.	p-value	Coef.	p-value	Coef.	p-value	Coef.	p-value	Coef.	p-value
Endogenous Variables										
ΔP	-	-	0.64*	0.00	-13.64*	0.00	-3.64	0.53	0.11§	0.07
ΔE	1.28*	0.00	-	-	26.72*	0.00	26.16*	0.00	-0.104	0.36
ΔPCI	-0.02*	0.00	0.01*	0.01	-	-	-0.47§	0.09	-0.002	0.36
ΔAgLP	-0.01*	0.00	0.02*	0.00	-0.25†	0.04	-	-	0.01†	0.03
ΔAgL	-	-	-	-	-	-	-6.07	0.78	-	-
Initial Condition Variables										
DPOP$_{t-1}$	-0.05*	0.00	-	-	-	-	-	-	-	-
DEMP$_{t-1}$	-	-	-0.01	0.70	-	-	-	-	-	-
PCI$_{t-1}$	-	-	-	-	-0.29†	0.04	-	-	0.001	0.77
AgLP$_{t-1}$	-	-	-	-	-	-	1.27*	0.00	-	-
DAgL$_{t-1}$	-	-	-	-	-	-	-	-	0.59§	0.05
DCROPL$_{t-1}$	-	-	-	-	-	-	-48.63†	0.05	-0.69§	0.07
Exogenous Variables										
FARMEMP$_{t-1}$	-	-			-	-	-	-	0.01	0.12
SERVEMP$_{t-1}$	-	-	0.01†	0.05	-	-	-	-	-	-
MINEMP$_{t-1}$	-	-	0.02§	0.09	-	-	-	-	-	-
CONSTEMP$_{t-1}$	-	-	-0.01§	0.07	-	-	-	-	-	-
PCTAX$_{t-1}$	-0.06*	0.02	-	-	5.92†	0.01	-	-	-	-
TAXPPRO$_{t-1}$	-0.59	0.17	-1.18	0.01	48.96*	0.00	-	-	-0.31	0.31
AGINCPFA$_{t-1}$	-	-	-	-	-	-	0.04†	0.02	0.001	0.77
GVPYPFAR$_{t-1}$	-	-	-	-	-	-	-	-	-0.01†	0.02
OWNOCCH$_{t-1}$	5.48†	0.04	-	-	-	-	-	-	-	-
MEDHVAL$_{t-1}$	0.001*	0.00	-	-	-	-	-	-	-	-
UNEMPRT$_{t-1}$	-	-	-11.27†	0.02	463.7*	0.00	-	-	-	-
PASTACR$_{t-1}$	-	-	-	-	-	-	-	-	-0.001†	0.05
PTLNDIFR$_{t-1}$	-	-	-	-	-	-	141.19§	0.09	-	-
LICONSRP$_{t-1}$	-	-	-	-	-	-	5.50§	0.05	-	-
CRIM100k$_{t-1}$	0.01†	0.05	-	-	-	-	-	-	-	-
PHYP100k$_{t-1}$	-0.10*	0.01	-	-	-	-	-	-	-	-
PERHIGDA$_{t-1}$	-	-	1.47§	0.10	-	-	-	-	-	-
PPOINCBP$_{t-1}$	-	-	9.54*	0.01	-399.1*	0.00	-	-	-	-
GVEXPCAP$_{t-1}$	-	-	-	-	-3743.4*	0.00	-	-	-	-
Constant	-349.12	0.04	-137.46	0.06	8474.1	0.001	116.68	0.89	31.87	0.31

Note: § indicates statistical significance at the 10% level, † indicates significance at 5%, and * indicates significant at the 1% level.

Table 3. Spatial Equation System Econometric Results

VARIABLE	ΔE Equation		ΔAglP Equation		ΔAgl Equation	
	Coefficient	p -Value	Coefficient	p -Value	Coefficient	p -Value
Spatial-lag Variables						
WΔE	-0.1341†	0.045	-	-	-	-
WΔAgLP	-	-	0.642*	0.000	-	-
WAgL	-	-	-	-	0.363*	0.0002
Initial Condition Variables						
$DPOP_{t-1}$	0.051	0.122	4.712*	0.000	0.031	0.284
$DEMP_{t-1}$	-0.295*	0.000	-8.896*	0.000	0.048	0.328
PCI_{t-1}	0.010*	0.000	0.100	0.187	-0.0003	0.901
$AgLP_{t-1}$	0.031*	0.000	0.473§	0.077	0.006	0.432
$DAgL_{t-1}$	0.908*	0.000	5.908	0.375	-0.629*	0.0005
$DCROPL_{t-1}$	-0.315*	0.000	-4.155	0.157	-0.036	0.655
Exogenous Variables						
$FARMEMP_{t-1}$	-0.011*	0.000	-0.242†	0.004	0.001	0.596
$SERVEMP_{t-1}$	0.0001	0.382	-0.018†	0.013	-0.0002	0.383
$CONSTEMP_{t-1}$	0.006*	0.000	0.178*	0.000	0.001	0.431
$PCTAX_{t-1}$	-0.035§	0.087	-1.831*	0.004	0.037†	0.037
$AGINCPFA_{t-1}$	0.00004	0.959	0.011*	0.000	-0.00007	0.292
$OWNOCCH_{t-1}$	-0.394	0.765	24.316	0.228	0.042	0.939
$MEDHVAL_{t-1}$	-0.0001	0.452	-0.009	0.165	-0.0004†	0.017
$UNEMPRT_{t-1}$	-0.394	0.765	-47.674	0.253	-2.129§	0.062
$PTLNDIFR_{t-1}$	-4.349*	0.0001	-30.774	0.465	4.232*	0.0002
$LICONSRP_{t-1}$	-0.014†	0.014	0.052	0.777	-0.00009	0.984
$CRIM100k_{t-1}$	-0.002	0.328	-0.146§	0.062	-0.0005	0.814
$PHYP100k_{t-1}$	0.013	0.301	0.616	0.118	-0.013	0.218
$PERHIGDA_{t-1}$	1.102†	0.038	31.265§	0.063	0.181	0.697
$PPOINCBP_{t-1}$	2.614*	0.004	50.090§	0.074	0.941	0.225
Constant	-211.099	0.007	-4620.803	0.062	4.729	0.0002
Likelihood Ratio	Value = 3.471		Value = 42.131		Value = 12.253	
	p-Value = 0.062		p-Value = 0.000		p-Value = 0.0004	

Note: the sign § indicates statistical significance at 10%, † indicates significance at 5%, and * indicates significant at 1% level.