American Journal of Agricultural Economics Advance Access published November 20, 2014

FARMLAND PROTECTION AND AGRICULTURAL LAND VALUES AT THE URBAN-RURAL FRINGE: BRITISH COLUMBIA'S AGRICULTURAL LAND RESERVE

ALISON J. EAGLE, DAVID E. EAGLE, TRACY E. STOBBE, AND G. CORNELIS VAN KOOTEN

Farmland conservation policies typically use zoning and differentiated taxes to prevent urban development of farmland, but little is known about the effectiveness of these policies. This study adds to current knowledge by examining the impact of British Columbia's Agricultural Land Reserve (ALR), established in 1973, which severely restricts subdivision and nonagricultural uses for more than 4.7 million hectares of farmland. To determine the extent to which the ALR preserves farmland by reducing or removing the development option, a multilevel hedonic pricing model is used to estimate the impact of land use, geographic, and zoning characteristics on farmland value near the capital city of Victoria on Vancouver Island. Using sales data from 1974 through 2008, the model demonstrates a changing ALR impact over time that varies considerably by improved and unimproved land types. In 2008, landowners paid 19% less for the typical improved farmland parcel within the ALR versus that outside it. This suggests that would-be developers expect permanency in the zoning law, and prefer non-ALR zoned land. However, ALR land that is unimproved has a premium of 55%, suggesting that this land is more valuable for agriculture than for development. Farmland located closer to the city or the commuting highway commands a premium if it has a residence on it, with a residence also explaining why smaller agricultural properties sell at higher prices. However, it appears that zoning by itself is insufficient to protect farmland; other policies likely need to be implemented in conjunction with zoning to protect agricultural land.

Key words: Agricultural land reserve zoning, farmland protection, small-scale farming, spatial econometrics, urban-rural fringe.

JEL codes: Q28, Q15, R14.

Concerns about permanent conversion of agricultural land to other uses have prompted the adoption of farmland conservation policies across the United States and Canada (Duke and Lynch 2006; Deaton and Vyn 2010; Kline and Wichelns 1996). In 1974, Oregon established one of the earliest and best-known land-use planning systems, protecting agricultural and forest land and establishing state-wide urban growth boundaries outside of which development was restricted (see Jaeger, Plantinga, and Grout 2012). At the same time, similar legislation in British Columbia (BC) led to the formation of the Agricultural Land Reserve (ALR). The ALR strictly limits subdivision and nonfarm activities and, at the time of inception, included all agriculturally zoned land parcels larger than 0.8 ha (2 acres).

This research aims to examine the effectiveness of the ALR in preventing urban development and preserving active farmland. Existing research on preservation schemes in other jurisdictions demonstrates a complex set of interacting factors. In a study of 89 Wisconsin farmland parcels with little development potential, but high agricultural

Alison J. Eagle is a Research Analyst in the Department of Sociology and the Nicholas Institute for Environmental Policy at Duke University; David E. Eagle is a PhD Candidate in the Department of Sociology at Duke University; Tracy E. Stobbe is an Associate Professor in the School of Business at Trinity Western University; G. Cornelis van Kooten is a Professor and Canada Research Chair in the Department of Economics at the University of Victoria.

This research was funded by Agriculture and Agri-Food Canada through the Farm Level Policy Network. Additional support came from Canada's Social Sciences and Humanities Research Program (SSHRC) via a graduate research award for David Eagle and from SSHRC's Canada Research Chairs program for G. Cornelis van Kooten.

Corresponding author: Alison Eagle, Department of Sociology, Duke University, Box 90088, Durham, NC 27708-0088; alison.eagle@duke.edu.

Amer. J. Agr. Econ. 1–17; doi: 10.1093/ajae/aau098

potential, Henneberry and Barrows (1990) demonstrated that farmland conservation policies boosted prices for properties within the protected zone. In this case, farmland preservation adds value by removing uncertainty and reducing negative interactions with nonagricultural uses.

Other studies in peri-urban jurisdictions with exclusive agricultural zoning have shown that land under development pressure is priced *lower* if it is within an agricultural protection zone. Farmland near Montreal, Quebec, lost 15% to 30% of its value following protection in 1978 (Vaillancourt and Monty 1985) and 2004 legislation reduced value of protected land near Toronto, Ontario by 24% (Deaton and Vyn 2010). Even voluntary programs or those with less widely applied zoning have experienced some decline in land value for preserved farmland. This has been shown, for example, in conservation easements in Wisconsin (Anderson and Weinhold 2008) and purchase of development rights programs in Maryland (Lynch, Gray, and Geoghegan 2007). Price response may vary by actual land use. In Maryland, one study has shown that land in active agriculture or forest management retained its value, but nonresource parcels lost 20% to 50% of their value in localized down-zoning programs (Liu and Lynch 2011).

Farmland preservation programs without a land-price response may face little real development pressure, as was found by (Jaeger, Plantinga, and Grout 2012), who note a relatively large amount of undeveloped, unrestricted land remaining within the urban growth boundaries near Portland, Oregon. Price impacts of preservation programs may also be lower when there is little expectation of permanence, as in the case where residual development options are retained on some New Jersey farmland with conservation easements (Schilling, Sullivan, and Duke 2013).

In the current research, we employ a hedonic regression model (Rosen 1974), adapted to a Bayesian multilevel hierarchical linear modeling framework (Gelfand et al. 1998; Kruschke 2011), to investigate farmland prices near the capital city of Victoria, British Columbia, an expanding urban center. Conditional on property characteristics and spatial and land-use factors, we compare farmland zoned as ALR with that outside the reserve in order to assess the existence and scope of development option values and related urban-to-rural and rural-to-urban externalities. This research adds to previous empirical studies by adding a land-use component to the zoning status, including both vacant and residential properties, and examining the long-term trend of actual transactions of both protected and unprotected properties. This study covers farmland sales over the first 35 years of the ALR. The empirical results also evaluate the ability of the ALR to provide stability—that is, expected permanence for farmland protection—in a region that experiences significant development pressure.

Since the region in and around Victoria has experienced a great deal of development pressure over the past 35 years, we began this study with the suspicion that legally protected farmland will be less valuable than similar, but unprotected, farmland. Our findings indicate that this may not necessarily be the case. Unimproved farmland outside the ALR transacts at prices that are 55% lower than similar properties in the ALR, *ceteris paribus*. This reflects the residual demand for dedicated farmland, and the greater security that an agricultural producer in the ALR has that her land will not be lost to development at some future date. In contrast, the price of improved farmland, which usually includes a significant residence, is worth only four-fifths as much as a similar property outside the ALR. This is likely due to the high transaction costs associated with attempts to remove land from the ALR, and possibly (for those who wish to use an agricultural property for a purely residential purpose) the potential of negative impacts from externalities related to neighboring agricultural operations (Cotteleer and van Kooten 2012).

The Agricultural Land Reserve and BC Agriculture

British Columbia's total land base is 94.65 million hectares (ha) of which 93.8% is considered provincial Crown land (owned by the provincial government), 1.1% is federal Crown land, and 0.2% is First Nations' treaty settlement land, leaving only 4.9% (4.6 million ha) as private land. Public ownership of land in British Columbia exceeds that of any US state, including Alaska and Nevada, for which 89% and 70%, respectively, of total land is publicly owned (BC Ministry of Forests, Lands and Resource Operations 2011). Less than 3% of British Columbia's land area is capable of growing a reasonable range of crops and only 0.6% is classed as prime agricultural soil (Runka 2006). Further, prime farmland is concentrated near the large population centers of Metro Vancouver, the capital city of Victoria on Vancouver Island, and the city of Kelowna in the interior.

Few jurisdictions have such a long history of public control over development and subdivision of agricultural land. In December 1972, the province became one of the first jurisdictions in North America to implement agricultural land zoning on a large scale. This began with a short-term moratorium on farmland subdivision and/or development, followed by the initiation of the ALR through the *Land Commission Act* of April, 1973. By placing all farm-zoned land within the reserve, restricting development and nonagricultural uses, and requiring any applications for removal to prove no harm to local agriculture, the ALR protects much of the private land in the province (Agricultural Land Commission 2005).

In British Columbia, there has been widespread support for government restrictions on urban development to protect farmers and farmland (Quayle 1998), with province-wide public willingness to pay for maintaining the ALR estimated at over $90 million per year (Androkovich et al. 2008). This public sentiment stems from a desire to secure local food production, maintain the local agricultural economy, and protect the environment. Environmental groups expend significant effort encouraging the government and the general public to increase protection of agricultural land (Campbell 2006; SmartGrowthBC 2005). In contrast to this general support for agriculture, urban concerns about agricultural emissions, noise, or landscape views have led to a concomitant backlash against livestock operations and greenhouse developments at the urban-rural fringe. Such issues led to the passage of the *Farm Practices Protection (Right to Farm) Act* in 1996 (Government of British Columbia 1996), which protects normal farm activity from liability and assists in managing complaints.

Despite a population growth rate higher than the rest of Canada, a cursory look at agricultural census data from 1971 to 2006 suggests that British Columbia has succeeded in preserving productive farmland. Both the numbers of farms and total farmland area have grown since 1971 (see table 1), opposite the trend elsewhere in the country. The conversion rate of prime farmland in British Columbia to nonfarm developed uses declined from 6,000 ha/yr in the early 1970s to 500 ha/yr as of 2006 (Agricultural Land Commission 2006). Productivity also increased to a greater extent in British Columbia than elsewhere in Canada: Farm receipts doubled over 35 years, compared to an increase of only one and a half times for the country as a whole. However, because BC's agricultural sector is small compared to those of the three Prairie Provinces, Ontario, and Quebec, small shifts in agricultural practices can lead to large proportional increases in farm receipts. While livestock receipts have risen somewhat in British Columbia since 1971, the share of vegetable crops (mostly greenhouse), small fruits (berries), floriculture, nursery plants, and grass sod for lawns has increased from 38% to 81% of total crop receipts. Sales of tree fruits declined from 23% to 8% of total crop receipts, while the share of wheat fell from 7% to 0.3%. Wheat is grown primarily in BC's Peace River region in the northeast, which is part of the prairie grain belt east of the Rocky Mountains. In this region, more valuable crops such as canola have increasingly replaced wheat. Tree fruit sales, on the other hand, fell because landowners lacked incentives to plant new tree varieties, thereby continuing to produce fruits that are now considered inferior to those from other places (see Lusztig 1990). At the same time, direct payments from the federal and provincial governments accounted for only 4% of farm receipts in British Columbia compared to 13% for all of Canada (average of 2002–2006), mainly because fewer farmers in British Columbia produced crops eligible for federal payments, while, with the exception of land use, the provincial government pays less attention to the farm sector than in other provinces.

British Columbia has not lost farms and farmers in the same way as the rest of Canada primarily because farms outside the Peace River region have become smaller and more intensively farmed, or used principally for hobby purposes or as a rural residence while maintaining official farm status (Stobbe, Cotteleer, and van Kooten 2009). Population growth in British Columbia over

Table 1. Selected Human Population and Farm Statistics over 35 Years, Canada, British Columbia, and the Saanich Peninsula

	1971	2006	% Change
Canada			
Population	21,570,000	31,610,000	+46.6%
Total no. of farms	366,100	229,400	−37.3%
Total farm area ('000 ha)	68,700	67,600	−1.6%
Area per farm (ha)	188	295	+56.9%
Land in crops ('000 ha)	27,800	35,900	+29.0%
Farm receipts (2006 $million)	24,290	36,950	+52.1%
British Columbia			
Population	2,185,000	4,113,000	+88.3%
Total no. of farms	18,400	19,800	+7.8%
Total farm area ('000 ha)	2,360	2,840	+20.3%
Area per farm (ha)	128	143	+11.7%
Land in crops ('000 ha)	442	586	+32.6%
Farm receipts (2006 $million)	1,160	2,290	+97.4%
Saanich peninsula (North Saanich, Central Saanich, and Saanich)			
Population	73,800	134,800	+82.8%
Total no. of farms	425	510	+20.0%
Total farm area (ha)	4,820	5,170	+7.2%
Area per farm (ha)	11	10	−10.6%
Land in crops (ha)	2110	2,510	+18.7%
Farm receipts (2006 $million)[a]	36.7	54.3	+47.9%

Source: Statistics Canada, Census of Population, Agricultural Census, and CANSIM Table 002-0001.

[a]Farm receipts are shown for the entire Capital Regional District (683 farms in 1971, 991 farms in 2006), since 1971 data are only available at the census division level, not census subdivision. In 2006, farm receipts for Saanich peninsula were $41.65 million (77% of the total for the Capital Regional District).

the past 35 years has outstripped national rates. In this context of high development pressure and negative externalities at the urban-rural fringe, farmland conservation is only effective if agricultural activity is economically viable.

For most farms in British Columbia, the largest capital investment is in land, with land prices a key determinant of long-term farm survival and profitability, although rental markets may fill the gap in the short-term. Smaller land parcels in this region are often rented at low rates to farmers by landowners who can then qualify for significant tax reductions (Stobbe, Cotteleer, and van Kooten 2009). High land prices in British Columbia pose a significant obstacle for new or expanding farmers wanting to purchase land, because its value is not solely based on its agricultural potential, but also on its suitability for residential purposes.

As a province-wide program, the ALR presents a unique opportunity to: (1) assess the impact of nonvoluntary regulation on farmland prices and (2) evaluate how proximity to urban development affects agricultural land. If the regulatory framework is credible (i.e., it reduces the likelihood of nonagricultural development and utilization), ALR land near areas with high development pressure should be priced lower than similarly located non-ALR farmland, at least partially serving to mitigate the challenges facing agricultural producers in the urban-rural fringe. Removing land from the ALR is a lengthy legal process with high transaction costs and an uncertain outcome, which ought to depress the price of otherwise desirable developable land. On the other hand, if agricultural land has become fragmented, the likelihood of its removal from the ALR could increase, while, if rural estates or hobby farms are sufficiently small, they might simply be treated as large residential lots with rural benefits and lower taxes.

The Saanich Peninsula on Vancouver Island, just north of the provincial capital of Victoria, has experienced very few changes in ALR boundaries. From 1974 to 2006, only 1.7% (76 ha) of the ALR area in this region was approved for removal from protective status, with 42 ha constituting one parcel removed in 1977 (Stobbe et al. 2011). The impact of the ALR in the Capital Regional

District (CRD), comprising Victoria and the surrounding municipalities, is likely similar to other major agricultural regions in the province that are under high urban pressure. The CRD is the second largest population center in the province, the public sector is the principal employer, land prices and urban development pressure are high, and the region is home to an expanding number of rural estates.

Theory and Methodology

This article examines the effect of 35 years of strict agricultural zoning on the price of agricultural land at the urban-rural fringe. We identify the zoning effect by comparing the prices of restricted land versus similar properties not under such restrictions. In agricultural land markets, land prices reflect the anticipated net returns from the land over time. Thus, productivity potential (i.e., soil and climatic characteristics) and market accessibility (i.e., locational aspects) play an important role.

At the urban-rural fringe, the value of a parcel of land can be decomposed into a residential and an agricultural component. The current market price P_i (\$/ha) of land parcel i should reflect the discounted value of the streams of expected agricultural plus residential rents over some relevant period of length T:

$$(1) \qquad P_i = E\left[\int_0^T A_i(x_i,t)e^{-rt}\,dt + \int_0^T R_i(x_i,t)e^{-rt}\,dt\right]$$

where A_i and R_i refer to the respective agricultural and residential rents accruing to parcel i as a function of zoning, location, and other characteristics of the land, denoted x_i, and the time period t when they are expected to accrue, where r is the discount rate. At the time that land is removed from the ALR and converted to urban uses, land rents have no further agricultural component (Lynch, Gray, and Geoghegan 2007). Where rural estates and hobby farms are prevalent, residential and agricultural rents are concurrent and, along with development restrictions, determine the market price.

Hedonic pricing models are used in land pricing applications to determine the relative price impacts of spatial and other characteristics. In this article, the key independent variable, inclusion in the ALR, is exogenous to the model; that is, zoning decisions are assumed to be independent of property prices. As noted above, the process for obtaining a variance to or exclusion from the ALR is onerous, and successful applications are rare.

These data are from sales of individual properties. Properties may be sold more than once, meaning that the same property can show up in the sales data multiple times. We utilize a hierarchical linear model to accommodate the temporal structure of these data. In the hierarchy, sales comprise the individual level of the model, which are then clustered by year and by property. The hedonic model is written as:

$$(2) \qquad \ln(P_i) \sim N(\mu_i, \sigma_p^2), \text{ where}$$

$$(3) \qquad \mu_i = \alpha_t + x_{i,j}\beta_j + V_i z_t + ALR_i\delta_t + ALR_i V_i \gamma_t + a_k, \text{ and}$$

$$(4) \qquad \alpha_t \sim N(A_0 + A_1 T_i, \sigma_A^2)$$

$$(5) \qquad z_t \sim N(Z_0 + Z_1 T_i, \sigma_A^2)$$

$$(6) \qquad \delta_t \sim N(D_0 + D_1 T_i, \sigma_A^2)$$

$$(7) \qquad \gamma_t \sim N(D_0 + G_1 T_i, \sigma_A^2)$$

$$(8) \qquad a_k \sim N(0, \sigma_u^2)$$

P_i = sales price;
i = parcel observation (1 to n);
j = index of the group-level independent variables (1 to J);
t = index on year (1 to 35, where $1 = 1974, 2 = 1975, \ldots 35 = 2008$);
k = index on individual parcels;
$ALR_i = 1/0$ indicator if the property is in the ALR;
$V_i = 1/0$ indicator if the property is unimproved (i.e., without buildings or structures of assessed value);
T = continuous measure of time (0 to 34, where $0 = 1974, \ldots 34 = 2008$).

Equation (3), at the individual level, models the natural logarithm of price as a hierarchical linear model with an $n \times j$ matrix of fixed effects, β_j, which quantify the impact of each of the independent variables, x_j; along with a series of terms clustered within years (equations 4–7), and a set of random intercepts, which are clustered within properties (equation 8). The within-year effects include an intercept term; α_t, an estimate of the random parameter z_t, the time-variant impact of a property being unimproved; an estimate of the random parameter δ_t, the time-variant impact of a property being included in the ALR; and an estimate of the random parameter γ_t, the additional time-variant impact of the properties being both unimproved and in the ALR.

Because this study aims to assess the impact of the ALR over time, equations 4–7 contain a linear latent growth model (LGM) to capture the impact of the ALR over time (Duncan et al. 1997; Muthén 1997; Bliese and Ployhart 2002). In the LGM, the time-variant effects estimate the mean price of sales in a given year and accommodate year-over-year fluctuation in prices. A linear fit to the random effects estimates the trend over time. Modeling time in this fashion allows macroeconomic factors (e.g., interest rates, population growth) to exert an independent effect in each time period, while still being pulled toward the overall effect of time across all years.[1] Equation 4 captures the mean linear latent growth in property values over time. Here, the mean value of sales at time t, A_t, consists of an estimate of A_0, the mean logarithm of price in 1974, and an estimate of A_1, the slope on T – a continuous variable from 0 (=1974) to 34 (=2008).[2] The same basic structure is followed in the estimate of δ_t, the estimate of the effect of the ALR on improved properties in year t. D_0 estimates the mean shift in the log of price of ALR land in 1974, and D_1, the slope of the coefficient on time. Likewise $\delta_t + \gamma_t$ is the estimated effect of ALR inclusion for unimproved properties. At the beginning of the time series, the effect of the ALR is assumed constant across improved and unimproved properties—indicated by the common intercept, D_0, between equations 6 and 7. Because the ALR system was newly implemented, it is unlikely that market determination of the impact of the system would have differentiated between these two property types. The within property term a_k, captures unobserved, time-constant characteristics that might make a property prone to being sold multiple times.

Beyond unimproved and ALR status, the remaining independent variables are only added at the individual level. While it is possible that the impact of property characteristics changes over time, modeling these as time-variant creates a significant loss in degrees of freedom. Fixed, time-invariant variables require one degree of freedom. Random, time-variant variables cost an estimated 42 degrees of freedom (1 for each time period, plus the hyper-parameters). Using deviance information criterion (DIC) as a guide, we calculated the DIC with each of the independent variables added as random effects. The preferred model had all the variables as fixed and time-invariant, except for the indicator variable for ALR and the indicator variable for unimproved properties.

The simple hedonic model assumes that factors such as size and location exert a uniform effect on price over a variety of land types. However, Shonkwiler and Reynolds (1986) argue that parcels with different uses should be segmented since the shadow prices of characteristics will differ. For instance, commuting distance may have less impact on the price of unimproved farmland than on agricultural properties with residences. However, by virtue of the methods for establishing reserve boundaries in 1973, ALR properties are likely better suited to agricultural use than farmed properties not in the ALR. As a result, ALR status may capture the most significant difference between properties. To investigate whether grouping the properties is necessary for modeling, land was initially classified into four property types based on primary use – residential (nonwaterfront with residential buildings), unimproved (nonwaterfront, no buildings), nonresidential (nonwaterfront with commercial or industrial buildings), and waterfront (properties with some portion waterfront). The 26 waterfront properties were excluded from analysis because their high price places them within a different market than other properties. Dropping these observations does not lead to a major reduction in the available data. With the remaining three categories, we constructed several models to determine how

[1] A number of macroeconomic variables were considered for inclusion, including interest rates and population growth, but these were not significant when time was included in this manner. This indicates that the chosen model sufficiently accounts for the trends in inflation-adjusted land prices.

[2] We also tested other, nonlinear formulations for the influence of time. We compared a simple random-intercepts model against a linear, log-linear, quadratic, and exponential growth function. In the linear model, the coefficient on time is significant; however, in alternate models the coefficients do not reach significance.

best to model property type. Based on the DIC, a better fit was obtained by combining residential and nonresidential properties into a single category—improved properties. Retaining an indicator for unimproved land generated the best model fit, with the added benefit of making the results comparable with Anderson and Weinhold (2008), and Jaeger, Plantinga, and Grout (2012), who considered only unimproved farmland in Wisconsin and the Pacific Northwest, respectively.

The models are estimated using a Bayesian framework. We selected a Bayesian over a maximum-likelihood-based framework for two reasons. First, our model contains a number of additive and nonlinear effects, which, because a Bayesian approach produces a full posterior distribution, allows for the straightforward calculation of standard errors, something much more difficult in an maximum-likelihood-approach (Kruschke 2011; Ntzoufras 2009). In addition, Bayesian models are more likely to produce unbiased estimates and correct standard errors when there are small numbers of observations within years and small differences between years (Park, Gelman, and Bafumi 2004; Browne and Draper 2006). Because our model relies on the interpretation of the hierarchical parameters, using the best available estimation procedure is critical.

In all cases, the unknown parameters are assigned so-called noninformative priors. All the regression coefficients are given a normal distribution with a mean of zero and a variance of 100. The overall variance, σ_p^2, is given a diffuse inverse gamma prior with $a = b = 0.01$. The hierarchical standard deviation parameters are assigned uniform (0,1) priors in accordance with Gelman (2006). The upper limit of one was chosen as a theoretical limit in the amount of variability we would expect. Because of the choice of these priors and the relatively large sample size, none of these priors exert a significant impact on the final results.

Testing for Spatial Dependencies

As developed so far, our model does not include spatial dependencies. Spatial autocorrelation, where the previous selling price of neighboring properties impacts the price of the subject property, and temporal autocorrelation, where the previous sales price of the subject property impacts its future selling price, are potential issues in these data. In order to test if spatial and temporal factors exert a significant impact—and need to be included in the final model—we constructed a testing model that incorporates the spatial and temporal structure in the data and compared it to a model that *excludes* spatial and temporal effects.

Our motivation behind the spatial/temporal modeling is to account for unobserved variables that may be influencing sales price—a common approach when modeling real estate transactions (Basu and Thibodeau 1998; Pace, Barry, and Sirmans 1998; LeSage and Pace 2009). This is a panel dataset, and temporal ordering requires that future sales not be allowed to exert a spatial impact on past sales. Single properties may also be sold multiple times. As others have done, we assume that previous selling price only exerts a significant impact on either itself or its neighbors if the previous sale occurred in the past 5 years (Pace et al. 1998, 2000). The weight matrix was modified to enforce this temporal ordering.

A *k*-nearest neighbor approach was used to calculate spatial weights under the assumption that, in years with more past sales data, owners would look to nearer properties, and, in years with fewer sales, they would look further afield (Pace et al. 1998). We assume that all parcels in this relatively small study area are potential comparables. To identify neighboring properties, the centroid for each property and the Euclidean distance between all centroids were calculated. A priori, we assumed that the fifteen nearest neighbors for each property capture the majority of the spatial effects (as per Pace et al. 1998). In the spatial weights matrix, the fifteen nearest neighboring properties are candidates for comparison. We added zeroes to the weight matrix when such observations were either sold in the future or more than 5 years in the past. Where the subject property was sold in the past 5 years, the diagonal of the matrix was assigned a one. We standardized the rows in the matrix so that each sums to one (i.e., restricting the rows matrix to sum to one, see Anselin and Hudak 1992).

We then used the spatial weight matrix to run a series of robust Lagrange multiplier tests (Anselin et al. 1996; Kim, Phipps, and Anselin 2003) on the model, to determine if the spatial effects exert a significant impact, net of the other covariates in the model. We also ran a spatial Durbin model (SDM) and compared model fit to the unweighted model using Akaike information criterion as the model selection criterion. The SDM can be motivated by a concern about both omitted variables and model uncertainty and includes both a lagged dependent variable and a disturbance in the error term (LeSage and Pace 2009).

Data

Farmland sales and classification records from a variety of sources were combined to form a unique data set. Property sales data for the period 1974–2008 in the three municipalities of the Saanich Peninsula were acquired from LandCor Data Corporation, a company that compiles data from various government sources. Included in the dataset are sales prices and property improvement status at time of sale. All prices are corrected for inflation to 2006 real Canadian dollars using the Canadian CPI. The reference year 2006 was chosen to allow for comparison with 2006 census data.

Other property variables are based on observations in a single year. Cadastral and assessment data (2006) were obtained from local municipalities and the BC Assessment Authority. At the parcel level, the assessment data classified land by broad use categories (including farmland), and ALR boundaries were confirmed by spatial data from the Province's Agricultural Land Commission. The BC Ministry of Agriculture, Food, and Fisheries conducted a Land Use Inventory (LUI) in 2004; this provided parcel-level details on land use for ALR properties and for properties outside the ALR that were classified as farmland.[3] The LUI consisted of visual examinations of properties from roadside and other access points. Farms were thus inventoried for agricultural activities, water management, scale of operation, and whether or not farm products were sold directly to the public ("direct marketing"). Properties were designated as "hobby farms" if agricultural activity appeared to be for amenity use only, such as would be the case for a residential property with a small number of horses (BC Ministry of Agriculture, Food and Fisheries 2004).

By matching property ID numbers between data sources, we ensured that all observations maintained consistent ALR status and were not affected by subdivision throughout the 35-year timeframe.[4] Due to the nature of the data sources, some land-use characteristics may have changed over time, so that a property used for vegetable production in 2004 may have had a different use at time of sale in the 1970s, for example. Using current land-use characteristics, the expectation of few changes is conservative because any such changes would reduce significance in the model. Indeed, the presence of a statistically significant impact suggests stability over time. Also, we make a Ricardian assumption regarding land use: throughout the timeframe, a landowner is assumed to choose the use that maximizes the value of the land subject to institutional (e.g., zoning), cost, technology, and other constraints. In that sense, agricultural land use is strongly related to soil type and significant capital investments (buildings, fences), all of which tend not to change quickly.

We define "active farmland" as that designated agriculture, hobby farm, or abandoned pasture in the 2004 LUI, while "potential farmland" is taken to consist of all other properties in the ALR or properties with farm-class tax status but where no current or recent agricultural use is noted (i.e., the land use activity could be residential, commercial, or recreational).[5] Figure 1 illustrates the location of active and potential farmland on the Saanich peninsula. Properties classified as potential farmland within the sales dataset tended to be smaller in size, with steeper slopes and located farther away from Victoria and are nearly all within the ALR. With few non-ALR properties, it is difficult to assess the influence of the ALR on sales

[3] Farm-class status in BC is designated by the provincial assessment authority, BC Assessment. This is separate from municipal land-use zoning.

[4] Any property removed from the ALR and ceasing to have farm-class status during the 35-year timeframe would not have been included in the 2004 LUI. Also, any properties sold and then subdivided would not be included in our database, as the new property roll number assigned after subdivision (even if within the LUI) would not match the property roll number from time of sale.

[5] Of issue for the models would be situations where properties changed between agriculture and nonagricultural uses. With the trend toward increased development in the region, most such changes would be from agriculture. Therefore, all properties with no agricultural activity in 2004 are removed from the analysis, since there is no way to determine when the change occurred.

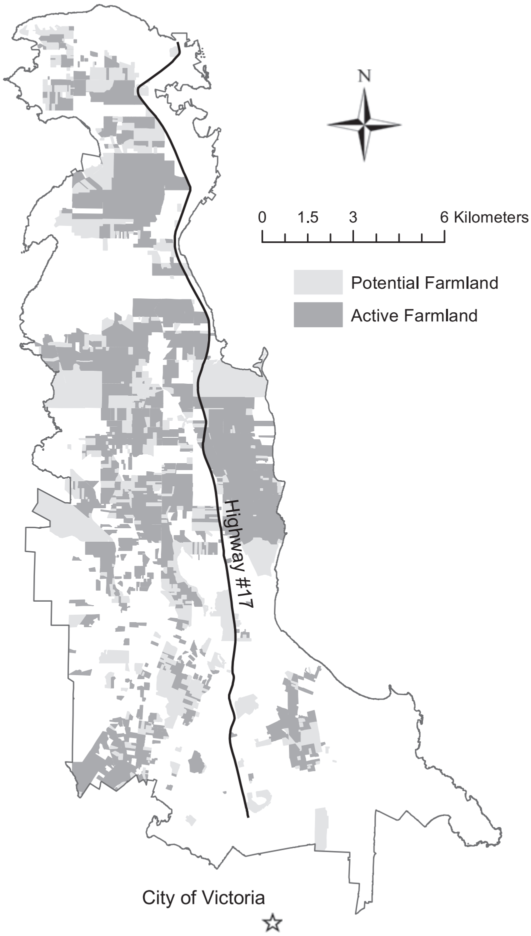

Figure 1. Location of actively farmed parcels (included in hedonic models), and potentially farmable parcels

of potential farmland. Therefore, the empirical analysis excludes these observations and focuses only on the active farmland. Sales that incorporated more than one parcel were also excluded. Not all properties classified as farms fall within the ALR; in the 2004 LUI, 78.6% of all active farmland properties were in the ALR.

The final panel dataset consists of 1,214 observations of farmland parcel sales. These data represent a total of 704 individual parcels of land—586 improved parcels and 118 unimproved. Of these, 406 (92 unimproved) properties were sold once, 161 (19 unimproved) twice, 92 (6 unimproved) three times, 25 (0 unimproved) four times, 13 (1 unimproved) five times, 6 (0 unimproved) six times, and 1 (0 unimproved) nine times. In total, 1,061 of the sales were of improved properties and 153 unimproved. These parcels account for 36% of all properties included in the 2004 LUI. Higher turnover is observed in the improved versus the unimproved properties, with 46% and 22% of the parcels, respectively, sold more than once in the 35-year time period.

Because our outcome of interest, price per hectare, is highly skewed, we use the natural logarithm of this value as the dependent variable in this analysis. To make individual sales comparable, we include as control variables a range of factors known to influence sales price. Parcel size is added because the demand for rural residences results in higher prices for smaller properties (Nickerson and Lynch 2001). Parcel size was found to exert a nonlinear effect and is added in its raw form and as a log-transformed variable.[6] Farm type is added to the model as a series of indicator variables. These reflect the varying infrastructure and environmental factors associated with different farm types. With multiple categories possible for any one property, the data enabled comparison of farm types that include cattle (beef or dairy), horses, poultry, other livestock, forage, tree fruit and/or berries, nursery and/or greenhouse, vegetable, vineyard, direct market (i.e., farm stands, agri-tourism, or bed-and-breakfast), and hobby farm. We retained the three farm types—horses, direct market, and vegetable—that improved model fit. Elevation is also included because properties with higher elevation may have high scenic value. Distance to Victoria and distance to Highway 17 in kilometers (km) are also included. Proximity to Victoria influences the residential desirability of a property for commuters. On the other hand, farms closer to Victoria may face negative interactions with residential neighbors, potentially depressing property values. Proximity to Highway 17, the main commuting corridor, could also affect price through road noise, commuting time, and

[6] As a robustness check, we partitioned our model by size, running separate analyses for properties larger than 2 ha and properties 2 ha and below. We chose 2 ha for this separation because our model suggests that there is a major change in the impact of size around this point (see figure 2). Our substantive findings do not change. We also ran a series of models with a variety of nonlinear terms (log, squared, cubic, exponential) and determined that including size and the log of size produced the best fit.

Table 2. Summary Statistics for Farmland Sales Model, $n = 1214$

Variable	Mean	Median	St. Dev.	Min	Max
Sale Characteristics					
Sale Price per ha, $'000s	220.8	173.6	192.6	9.72	2 890
Physical characteristics					
Parcel size, ha	3.58	2.02	5.26	0.17	83.2
Distance to ALR boundary for parcels within ALR, km	0.22	0.06	0.31	0.00	1.70
Cluster index[a]	0.55	0.55	0.32	0.0	1
Distance to Victoria, km	15.9	15.1	5.96	4.75	30.3
Distance to Highway #17, km	1.9	1.8	1.1	0.0	5.2
Maximum elevation, m	63.7	60.0	32.8	0.0	180
— (binomial variables, % of observations) —					
Improved parcel	87.4				
Unimproved parcel	12.6				
ALR variables					
Property in the ALR	77.3				
Improved parcels in ALR	*76.8*				
Unimproved parcels in ALR	*80.4*				
Farm types					
Horses (horse farm or stables)	33.2				
Vegetable	8.9				
Direct market	6.7				

Sources: 2004 MAL Land Use Inventory, ALC map of ALR, LandCor Property Sales.
[a]Cluster index = Proportion of parcel perimeter bordering nonfarmland × ln(farm block area, m^2).

accessibility. Finally, to address the issue of farmland fragmentation, we add a cluster index to the model. This calculated index is a function of (a) the proportion of parcel boundaries that border other farmland and (b) the total amount of farmland connected to the parcel. The cluster index for each parcel was calculated as:

(9) $$I = P_b/P_t \times lnS$$

where P_b is the parcel perimeter that borders other farmland, P_t is the total parcel perimeter, and S is the size of the farmland block (m^2). Beginning with values of zero for entirely fragmented land parcels, the cluster index increases as a parcel is surrounded by more farmland and when the farmland is within larger contiguous blocks. A parcel of farmland surrounded by other farms is expected to experience fewer conflicts with urban neighbors, and one within a larger farm block may be able to draw on more farm resources or assistance from neighboring farmers. Land with a higher cluster index (i.e., more connected with other farms) is indicative of greater agricultural value, but it may also have a lower likelihood for development approval and thus be less desirable to developers.

Results

Summary data for farmland sales are provided in table 2. Our outcome variable, sale price per hectare, is highly skewed with a mean of $220,800/ha and a median of $173,600/ha. Property size is also skewed, with significantly more small properties. The mean property size is 3.6 ha, the median 2.0 ha. Over 87% of the sales are of improved properties. Of these, 77% are in the ALR. A slightly higher proportion of unimproved properties are in the ALR (80%).

Testing for Spatial and Temporal Autocorrelation

The robust spatial lag LM statistic was 2.28 ($p = 0.131$), and the robust spatial error LM statistic was 0.0836 ($p = 0.773$), indicating that spatial dependency is not a major problem. Running the SDM model, the AIC was 1187.4, while it was 1164.4 for the unweighted model, indicating a small improvement in fit. A spatial Hausman test between the SDM and the unweighted model was not significant, indicating that the coefficients (but not necessarily the estimated standard errors) in the SDM and the unweighted models are not significantly different (Pace and LeSage

Table 3. Significant Factors Affecting Active Farmland Prices on the Saanich Peninsula, 1974–2008 ($n = 1214$)

Factor	Estimated Coefficient	Credible Interval 2.5%	Credible Interval 97.5%
Time invariant coefficients			
ln(Lot size, ha)	−0.706	−0.761	−0.653
Lot size (ha)	0.014	0.006	0.022
Distance to the ALR (km)	0.079	−0.018	0.177
Distance to Victoria (km)	−0.073	−0.147	0.007
Distance to the highway (km)	−0.033	−0.058	−0.006
Maximum elevation (100 m)	0.104	0.009	0.193
Cluster index	−0.098	−0.196	0.004
Horses	0.055	−0.007	0.117
Vegetables	−0.170	−0.270	−0.078
Direct marketing	0.083	−0.023	0.205
Time-variant (hierarchical) growth model coefficients			
A_0 (Mean Price at year = 1974)	11.431	11.307	11.566
A_1 (Slope on Mean Price)	0.041	0.035	0.047
Z (Mean shift unimproved)	−0.492	−0.734	−0.261
Z_1 (Slope on unimproved)	−0.015	−0.032	0.003
D_0 (Mean Shift ALR)	0.099	−0.043	0.239
D_1 (Slope on ALR)	−0.009	−0.015	−0.002
G_1 (Slope on ALR × Unimproved)	0.019	0.007	0.032
Standard Deviations			
σ_u	0.270	0.239	0.302
σ_a	0.125	0.099	0.155
σ_p	0.278	0.259	0.296

Note: Dependent variable is natural logarithm of inflation-adjusted price per hectare (2006 CAD).

2008). The combined impact of these tests indicates that, with the included controls, omitted variables are not a major concern. The chosen set of independent variables thus absorbs potential bias from a spatial-temporal autoregressive/error process. We therefore run the final models without a spatial component.

The Effects of Size, Land Use, and Geography

Table 3 presents the results from the hedonic land price model. Exponentiating the value of A_0 gives the estimate of the average price per hectare in 1974 with all indicator variables set to zero and all continuous coefficients at their mean. Parcel size is a highly significant factor affecting farmland prices. Figure 2 plots size against price per hectare and shows that smaller parcels are worth far more per unit area than larger ones, even when controlling for the presence of buildings. This is as expected in a market with high demand for residential properties and has been observed in other studies (Nickerson and Lynch 2001).

The cluster index (which denotes connectivity between farmland properties) has a negative impact on prices. Thus, more connected farmland has lower value. For every unit increase in the cluster index, the price per hectare is reduced by 9% (the percent differences are calculated by taking the exponential of the coefficient and subtracting one). This suggests that, even without the ALR, greater connectivity within a farm block provides some protection from development pressure and real estate speculation. It should be noted that the ALR layout alone connects farm properties with one another, so ALR properties have a higher cluster index compared to those outside the ALR (respective means of 9.8 and 4.0, *t*-test $p < 0.001$). Therefore, if ALR status was not included within the model, the price impact of fragmentation would be even greater.

Distances from both the city of Victoria and from Highway 17, the main commuting corridor, exert a negative impact on price. This provides further proof that property value is significantly affected by commuting costs. A 1-km increase in the distance

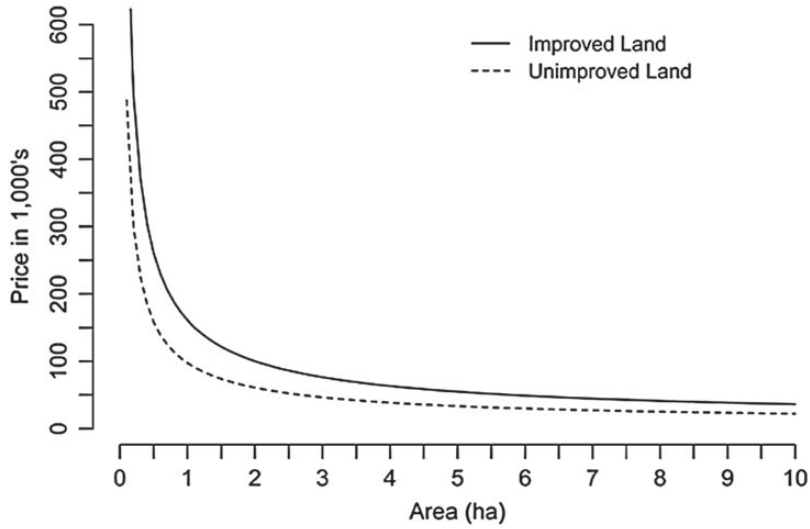

Figure 2. Modeled farmland value in relation to parcel size, Saanich Peninsula, 2008, net of other factors

to Victoria results in a 7% price reduction, while a similar increase in the distance from Highway 17 reduces price by 3%. A similar farmland price response for distance to the city was also observed in the state of Maryland (Nickerson and Lynch 2001). In contrast, farmland prices in rural areas of the Netherlands increased by €910/ha (0.6%) for each additional kilometer of distance from nearby residential areas, suggesting little effect of commuting value and greater demand for farmland farther from negative urban externalities (Cotteleer, Gardebroek, and Luijt 2008). The distance to the ALR boundary has a positive impact on prices for properties within the ALR. A 1-km increase in distance results in an 8% increase in price. The trend toward increased ALR farmland value when located farther within the protected zone may suggest a monetary benefit of fewer negative interactions with nonfarm neighbors, but a lack of statistical significance prevents a strong conclusion. A 100-m change in the maximum elevation increased prices by 11%. Higher elevation (which tends to be associated with greater slope) is related to demand for residential properties with hill-top views.

In terms of the three measures of farm type, vegetable farms were priced, on average, 16% lower, which is likely related to low investments in nonmobile capital. Horse-related uses increased property values by 6%. Direct farm marketing trended toward an increase in land prices (by 9%) and is most likely a result of capital investments in farm-market stands, on-farm marketing, or related facilities.

The Impact of Time and ALR Zoning

Time exerts a significant upward pressure on per-unit land prices. Figure 3 shows the change in the prices of property over time for unimproved land and land with residences and/or other buildings. For a median-sized parcel (2 ha), the price of unimproved farmland increased 2 1/2 times from \$56,330/ha in 1974 to \$136,353/ha in 2008. In the same period, improved land increased in value from \$92,134/ha to \$371,387/ha. The average price in the given year, plotted in grey in the figure, shows significant jumps in the early 1980s, 1990s, and mid-2000s. These increases coincided with higher population growth rates in the province that likely affected demand for land.

Figure 4 plots the difference in price between ALR and non-ALR land for improved and unimproved land. At its inception, ALR land was more valuable than that outside the reserve, with an average ALR parcel worth 10% more in 1974 (coefficient D_0 from table 3). Agricultural potential may have driven initial prices, as the best quality agricultural land was included within the ALR boundary. For improved land (almost 90% of sales observations), the positive relationship between ALR status

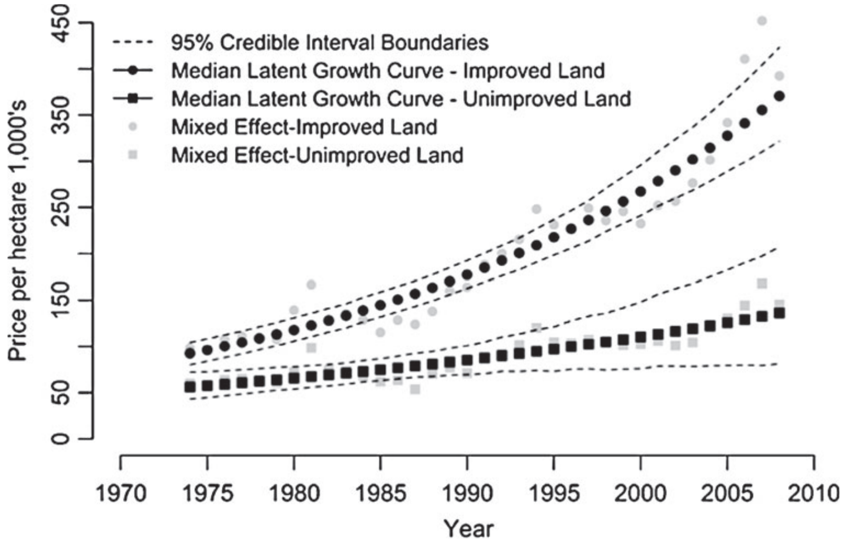

Figure 3. Modeled price per hectare for average size parcel (2 ha), Saanich Peninsula farmland, net of other factors, 1974–2008

and price reversed in the late 1980s, and by 2008, improved farmland in the ALR was worth 19% *less* than otherwise similar non-ALR farmland. The significant negative price impact of the ALR after 35 years indicates an expectation of zoning permanency, or at least reflects the high transaction costs entailed in removing properties from the ALR. By reducing the price of ALR-zoned farmland, the farmland preservation policy transfers some of the costs of farmland protection onto long-time landowners (who "lost" an opportunity to sell at a higher price) and away from current and prospective farmers who now need to invest less in the necessary land capital. However, with the development option value increasing over a relatively long time period, landowners in the region had a significant amount of time in which to understand the potential costs before actually encountering them. Model testing indicated no interaction effects between ALR and distance to Victoria; hence, ALR zoning exerts a similar negative impact on price at all distances on the peninsula. Because commuting costs increase with distance from the city, such interactions might be expected in other farming regions that are not as constrained in size (i.e., being on a peninsula surrounded by ocean, properties in this study were no more than 30 km from the city).

For unimproved land, ALR properties outpaced non-ALR farmland in value. By 2008, unimproved ALR farmland was worth 55% *more* than non-ALR land. Because the ALR attempted to include all of the high-quality farmland when created, non-ALR land tends to be of poorer quality for agriculture. Therefore, the initial price difference represents the quality premium on agricultural land. The fact that the difference has increased over time suggests that unimproved farmland within the ALR has become scarcer, especially as existing properties with homes and other buildings have been converted to less intensive agriculture (e.g., hobby farms, rural estates).

Implications and Conclusions

Using hedonic land pricing models, we examined whether the Agricultural Land Reserve in British Columbia reduces development pressure and preserves farmland at the urban-rural fringe. Results show that, over the history of the ALR, the price of a typical ALR-zoned property with residential and other buildings has changed in relation to land outside the reserve. Previously valued above non-ALR land, improved ALR-zoned land now has a significantly lower market value. We estimate the development option value on non-ALR land comprises 19% of the land price on average, similar to the

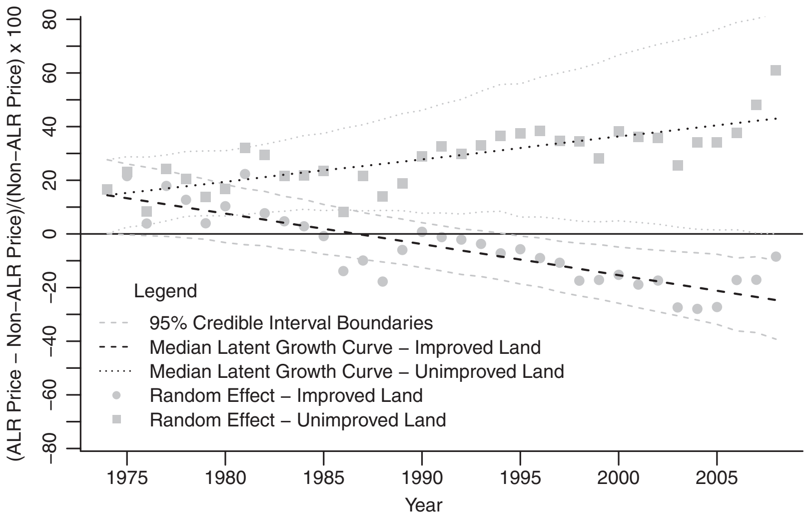

Figure 4. Modeled difference in farmland value over time between ALR and non-ALR land for improved and unimproved land, net of other factors, Saanich Peninsula

impact observed in other broad rezoning farmland protection programs near other growing urban areas (Vaillancourt and Monty 1985; Deaton and Vyn 2010). Would-be buyers of ALR land appear to recognize the potential costs associated with removal of the restriction.

However, the amount of land protected from development provides only a partial measure of a program's success. While looking at farmland conservation programs in Maryland and New York, Brabec and Smith (2002) concluded that the amount of land in active farming clarified the real effectiveness of a program; maintaining larger-sized parcels and avoiding fragmentation were key factors. Because BC's ALR protects land from development but does not dictate land use, it may not adequately preserve land for active agriculture. Reduced farmland values, especially for the typical 2- to 4-ha sized parcels in our study area, may encourage rural residential use in this growing metropolitan region. In addition, the agricultural property tax laws in British Columbia encourage only minimal production, requiring farm gate sales of only $2,500 per year to achieve tax breaks of more than $1,600 per year on the typical-size farm. As time and population growth progressed in the region, residential and other development pressure have increased. The strong, nonlinear relationship between land price and parcel size signifies that residential demand has a large impact on the rural land market. Higher land value is also associated with land closer to the city (reduced commuting costs) and at higher elevations (better views)—both factors that are valued by residential markets. In addition, lower market turnover is associated with agricultural characteristics (e.g., unimproved land, larger properties, and vegetables; but not horses), as is noted in other rural land markets (Kim and Goldsmith 2009).

Further, the results reveal an important interaction between property type and the impact of the ALR. The small proportion of unimproved land (12.6% of total sales) exhibits a different price response to zoning than the typical property with a home or other buildings. For these unimproved properties, ALR land currently has a 55% premium over non-ALR land. This increase in demand for unimproved ALR properties could signal that protection from development preserves the agricultural role of this land. If increasing development pressure is central to the price response on land with buildings, then unimproved land prices may be reflecting the residual demand for dedicated agricultural land.

Finally, the evidence suggests that, while the ALR does preserve farmland for future use, policy makers must combine regulatory protection with positive reinforcement of farming activity to support the agricultural use of land. Our model demonstrates that residential value is especially evident in the many smaller-sized parcels. Increased residential development pressure in the region could promote the shift from active agriculture to rural estates or hobby farms that have little agricultural productivity, with the benefit of lower land values due to the ALR. Therefore, the public may need to re-assess whether the ALR and the property tax laws are intended to protect active agriculture; or whether open space, urban containment, and environmental protection are a greater priority.

References

Agricultural Land Commission. 2005. *2004/05 Annual Service Plan Report*. Victoria, BC: Government of British Columbia.

———. 2006. *Preserving Our Foodlands*. Agricultural Land Commission. http://www.alc.gov.bc.ca/publications/preserve/preserve-print.htm (accessed 14 August 2014).

Anderson, K., and D. Weinhold. 2008. Valuing Future Development Rights: The Costs of Conservation Easements. *Ecological Economics* 68 (1–2): 437–46.

Androkovich, R., I. Desjardins, G. Tarzwell, and P. Tsigaris. 2008. Land Preservation in British Columbia: An Empirical Analysis of the Factors Underlying Public Support and Willingness to Pay. *Journal of Agricultural and Applied Economics* 40 (3): 999–1013.

Anselin, L., A.K. Bera, R. Florax, and M.J. Yoon. 1996. Simple Diagnostic Tests for Spatial Dependence. *Regional Science and Urban Economics* 26 (1): 77–104.

Anselin, L., and S. Hudak. 1992. Spatial Econometrics in Practice: A Review of Software Options. *Regional Science and Urban Economics* 22 (3): 509–36.

Basu, S., and T.G. Thibodeau. 1998. Analysis of Spatial Autocorrelation in House Prices. *Journal of Real Estate Finance and Economics* 17 (1): 61–85.

BC Ministry of Agriculture, Food and Fisheries. 2004. *Agfocus – A Guide to Agricultural Land Use Inventory*. Abbotsford, BC: Province of British Columbia, Ministry of Agriculture Food and Fisheries, Resource Management Branch.

BC Ministry of Forests, Lands and Natural Resource Operations. 2011. *Crown Land: Indicators and Statistics Report 2010*. Victoria, BC: Province of British Columbia.

Bliese, P.D., and R.E. Ployhart. 2002. Growth Modeling Using Random Coefficient Models: Model Building, Testing, and Illustrations. *Organizational Research Methods* 5 (4): 362–87.

Brabec, E., and C. Smith. 2002. Agricultural Land Fragmentation: The Spatial Effects of Three Land Protection Strategies in the Eastern United States. *Landscape and Urban Planning* 58 (2–4): 255–68.

Browne, W.J., and D. Draper. 2006. A Comparison of Bayesian and Likelihood-Based Methods for Fitting Multilevel Models. *Bayesian Analysis* (3): 473–514.

Campbell, C. 2006. *Forever Farmland: Reshaping the Agricultural Land Reserve for the 21st Century*. Vancouver, BC: David Suzuki Foundation.

Cotteleer, G., C. Gardebroek, and J. Luijt. 2008. Market Power in a GIS-Based Hedonic Price Model of Local Farmland Markets. *Land Economics* 84 (4): 573–92.

Cotteleer, G., and G.C. van Kooten. 2012. Expert Opinion Versus Actual Transaction Evidence in the Valuation of Non-Market Amenities. *Economic Modelling* 29 (1): 32–40.

Deaton, B.J., and R.J. Vyn. 2010. The Effect of Strict Agricultural Zoning on Agricultural Land Values: The Case of Ontario's Greenbelt. *American Journal of Agricultural Economics* 92 (4): 941–55.

Duke, J.M., and L. Lynch. 2006. Farmland Retention Techniques: Property Rights Implications and Comparative Evaluation. *Land Economics* 82 (2): 189–213.

Duncan, T.E., S.C. Duncan, A. Alpert, H. Hops, M. Stoolmiller, and B. Muthén. 1997. Latent Variable Modeling of Longitudinal and Multilevel Substance Use Data. *Multivariate Behavioral Research* 32 (3): 275–318.

Gelfand, A.E., S.K. Ghosh, J.R. Knight, and C.F. Sirmans. 1998. Spatio-Temporal Modeling of Residential Sales Data. *Journal of Business and Economic Statistics* 16 (3): 312–21.

Gelman, A. 2006. Prior Distributions for Variance Parameters in Hierarchical Models. *Bayesian Analysis* 1 (3): 515–33.

Government of British Columbia. 1996. Farm Practices Protection (Right to Farm) Act. In *[RSBC 1996] Chapter 131*.

Henneberry, D.M., and R.L. Barrows. 1990. Capitalization of Exclusive Agricultural Zoning into Farmland Prices. *Land Economics* 66 (3): 249–58.

Jaeger, W.K., A.J. Plantinga, and C. Grout. 2012. How Has Oregon's Land Use Planning System Affected Property Values? *Land Use Policy* 29 (1): 62–72.

Kim, C.W., T.T. Phipps, and L. Anselin. 2003. Measuring the Benefits of Air Quality Improvement: A Spatial Hedonic Approach. *Journal of Environmental Economics and Management* 45 (1): 24–39.

Kim, J., and P. Goldsmith. 2009. A Spatial Hedonic Approach to Assess the Impact of Swine Production on Residential Property Values. *Environmental and Resource Economics* 42 (4): 509–34.

Kline, J.D., and D. Wichelns. 1996. Public Preferences Regarding the Goals of Farmland Preservation Programs. *Land Economics* 72 (4): 538–49.

Kruschke, J.K. 2011. *Doing Bayesian Data Analysis: A Tutorial with R and Bugs*. Burlington, MA: Elsevier.

LeSage, J.P., and R.K. Pace. 2009. *Introduction to Spatial Econometrics*. Boca Raton, FL: Taylor and Francis.

Liu, X.P., and L. Lynch. 2011. Do Zoning Regulations Rob Rural Landowners' Equity? *American Journal of Agricultural Economics* 93 (1): 1–25.

Lusztig, P.A. 1990. *Report of the Commission of Inquiry—British Columbia Tree Fruit Industry*. Victoria, BC.

Lynch, L., W. Gray, and J. Geoghegan. 2007. Are Farmland Preservation Program Easement Restrictions Capitalized into Farmland Prices? What Can a Propensity Score Matching Analysis Tell Us? *Review of Agricultural Economics* 29 (3): 502–09.

Muthén, B. 1997. Latent Variable Growth Modeling with Multilevel Data. In *Latent Variable Modeling and Applications to Causality*, ed. M. Berkane. New York: Springer.

Nickerson, C.J., and L. Lynch. 2001. The Effect of Farmland Preservation Programs on Farmland Prices. *American Journal of Agricultural Economics* 83 (2): 341–51.

Ntzoufras, I. 2009. *Bayesian Modeling Using Winbugs*. Hoboken, NJ: Wiley.

Pace, R.K., R. Barry, J.M. Clapp, and M. Rodriquez. 1998. Spatiotemporal Autoregressive Models of Neighborhood Effects. *Journal of Real Estate Finance and Economics* 17 (1): 15–33.

Pace, R.K., R. Barry, O.W. Gilley, and C.F. Sirmans. 2000. A Method for Spatial-Temporal Forecasting with an Application to Real Estate Prices. *International Journal of Forecasting* 16 (2): 229–46.

Pace, R.K., R. Barry, and C.F. Sirmans. 1998. Spatial Statistics and Real Estate. *Journal of Real Estate Finance and Economics* 17 (1): 5–13.

Pace, R.K., and J.P. LeSage. 2008. A Spatial Hausman Test. *Economics Letters* 101 (3): 282–84.

Park, D.K., A. Gelman, and J. Bafumi. 2004. Bayesian Multilevel Estimation with Poststratification: State-Level Estimates from National Polls. *Political Analysis* 12 (4): 375–85.

Quayle, M. 1998. *Stakes in the Ground. Provincial Interest in the Agricultural Land Commission Act. Report to the Minister of Agriculture and Food, Government of British Columbia*. http://www.agf.gov.bc.ca/polleg/quayle/stakes.htm (accessed 14 August 2014).

Rosen, S. 1974. Hedonic Prices and Implicit Markets: Product Differentiation in Pure Competition. *Journal of Political Economy* 82 (1): 34–55.

Runka, G.G. 2006. BC's Agricultural Land Reserve – Its Historical Roots. In *Post World Planners Congress Seminar—Planning for Food*. Vancouver, BC.

Schilling, B.J., K.P. Sullivan, and J.M. Duke. 2013. Do Residual Development Options Increase Preserved Farmland Values? *Journal of Agricultural and Resource Economics* 38 (3): 327–43.

Shonkwiler, J.S., and J.E. Reynolds. 1986. A Note on the Use of Hedonic Price Models in the Analysis of Land Prices at the Urban Fringe. *Land Economics* 62 (1): 58–63.

SmartGrowthBC. 2005. Smart Growth BC's Position on the Provincial Agricultural Land Reserve (ALR). Vancouver, BC.

Stobbe, T.E., G. Cotteleer, and G.C. van Kooten. 2009. Hobby Farms and

Protection of Farmland in British Columbia. *Canadian Journal of Regional Science* 32 (3): 393–410.

Stobbe, T.E., A.J. Eagle, G. Cotteleer, and G.C. van Kooten. 2011. Farmland Preservation Verdicts – Rezoning Agricultural Land in British Columbia. *Canadian Journal of Agricultural Economics–Revue canadienne d'agroeconomie* 59: 555–72.

Vaillancourt, F., and L. Monty. 1985. The Effect of Agricultural Zoning on Land Prices, Quebec, 1975–1981. *Land Economics* 61 (1): 36–42.