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Valuing Environmental Assets on Rural Lifestyle Properties

**Maksym Polyakov, David J. Pannell, Ram Pandit,
Sorada Tapsuwan, and Geoff Park**

Lifestyle landowners value land for its amenities and ecological characteristics and could play an important role in managing and conserving native vegetation in multifunctional rural landscapes. We quantify values of ecosystem services captured by owners of rural lifestyle properties in Victoria, Australia, using a spatial hedonic property price model. The value of ecosystem services provided by native vegetation is maximized when that vegetation occupies about 40 percent of the area of a lifestyle property. Since the current median proportion of native vegetation is 15 percent, most lifestyle landowners could benefit from increasing the area of native vegetation on their properties.

Key Words: ecosystem services, lifestyle landowners, native vegetation, spatial hedonic model

In developed countries, many rural areas that once functioned primarily as agricultural land have become multifunctional landscapes. One of the primary determinants of this shift is consumption of natural amenities (Irwin et al. 2010). Many lifestyle seekers, downshifter, economic migrants, and retirees move to rural areas because they place importance on natural amenities, they search for a better quality of life, and they want to get away from the economic constraints of urban living (Chipeniuk 2004, Gurran 2008, McGranahan 2008). This mode of migration has caused a shift in rural land ownership from agriculture-focused, traditional farmers to amenity-focused, “lifestyle” owners (Sorice et al. 2012).

Maksym Polyakov is a research assistant professor and David J. Pannell is Winthrop Professor and director of the Centre for Environmental Economics and Policy, School of Agricultural and Resource Economics, University of Western Australia. Ram Pandit is an assistant professor in the School of Agricultural and Resource Economics at the University of Western Australia. Sorada Tapsuwan is a resource economist at CSIRO Ecosystem Science and an adjunct lecturer in the School of Agricultural and Resource Economics at the University of Western Australia. Geoff Park is a knowledge broker at North Central Catchment Management Authority in Victoria, Australia. Corresponding Author: *Maksym Polyakov • Centre for Environmental Economics and Policy • School of Agricultural and Resource Economics • University of Western Australia • Crawley, WA, 6009 • Australia • Phone +618.6488.5509 • Email maksym.polyakov@uwa.edu.au.*

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Lifestyle landowners are rural residents who value land for its natural amenities, do not consider land use as a primary source of income, and have diverse cultural contexts and ideas about land and nature (Majumdar, Teeter, and Butler 2008, Mendham and Curtis 2010). The increasing number of lifestyle landowners in some rural areas is likely to have a significant impact on future land uses and land covers since owners' approaches to the land will drive their land-management preferences (Sorice et al. 2012). Because lifestyle landowners do not derive income primarily from agriculture and often have limited local knowledge and experience, there is a risk that their land use decisions could result in damage to natural resources (e.g., soil erosion or overgrazing) (Sengupta and Osgood 2003). On the other hand, since these residents value the land for its amenities and ecological characteristics more than for its agricultural capabilities (Gill, Klepeis, and Chisholm 2010), they may bring changes to rural landscapes that increase the provision of public goods and services for society (e.g., ecological restoration).

In rural landscapes, government agencies and natural resource management bodies have traditionally targeted commercial farmers when promoting conservation-enhancing management practices. Little attention has been paid to engaging lifestyle landowners in such practices (Pannell and Wilkinson 2009). Research has provided a good understanding of the spatial extent and trajectory of demographic changes in rural landscapes (Barr, Karunaratne, and Wilkinson 2005, Luck, Black, and Race 2011) and the diversity of motivations and preferences of lifestyle landowners (Sorice et al. 2012). However, studies have not endeavored to quantify the benefits that lifestyle landowners derive from on-property and off-property environmental assets (Sengupta and Osgood 2003).

The Millennium Ecosystem Assessment (2005) defines ecosystem services as benefits people obtain from ecosystems. Ecosystem services are broadly classified into provisioning, supporting, regulating, and cultural services (Millennium Ecosystem Assessment 2005). Environmental assets in rural landscapes provide a variety of ecosystem services that can be captured privately by landowners and collectively by society. For example, native vegetation provides private recreational and amenity benefits to the landowner and public benefits to society by supporting biodiversity and regulating water flows. Information about the private benefits that stem from such services in rural landscapes is important for individuals responsible for designing effective policy instruments aimed at managing natural resources (Pannell 2008) and management practices that can be adopted by landowners (Pannell et al. 2006). The optimal reallocation of rural land between different land uses or change of management practices depends on the balance between societal and private benefits from different land uses or management practices.

The economic value of privately captured ecosystem services generated by environmental assets in rural landscapes is capitalized in property prices and can be estimated using the hedonic pricing method (Rosen 1974). Economists frequently use the hedonic pricing method to analyze amenity values of open space (Geoghegan, Wainger, and Bockstael 1997, Irwin 2002, Mahmoudi et al. 2013); protection of open space (Borchers and Duke 2012), trees (Donovan and Butry 2010, Pandit et al. 2013), wetlands (Tapsuwan et al. 2009), and views (Fraser and Spencer 1998); and disamenity associated with agricultural land use (Kuminoff 2009) in urban and suburban residential housing markets. A much smaller segment of the literature explores the value of on-farm

recreational and aesthetic ecosystem services (Bastian et al. 2002, Torell et al. 2005) or the value of both on-farm and off-farm land-based ecosystem services (Ma and Swinton 2011).

To our knowledge, only two studies have used the hedonic pricing method to value benefits of environmental amenities captured by landowners of rural residential and lifestyle properties. Specifically, Sengupta and Osgood (2003) studied the effect of remoteness and greenness on the value of ranchettes (small ranches) in Yavapai County in Arizona. They found that isolation is a disamenity that decreases the value of ranchettes whereas greenness increases their value. White and Leefers (2007) analyzed the effect of natural resource amenities on the value of rural residential properties in two counties in Michigan and found that proximity to lakes and open spaces increases the residential sales price while proximity to forest does not. Both studies examined the amenity values of the surrounding landscape, but the value of environmental assets located on the rural residential lifestyle properties was not studied.

In this study, we quantify the value of private benefits generated by environmental assets located on rural lifestyle properties in Victoria, Australia. We use a spatial hedonic model to estimate the value of native vegetation on the properties that is captured by landowners and determine whether the value is affected by the size of an asset—the extent of native vegetation cover. Such information is useful to managers of natural resources when they are developing programs that target ecological restoration on private land.

Methods

Lifestyle landowners derive benefits from the consumption features of their properties. Consumption features consist of human-built structures (**B**), which provide a place to live, and amenities that are associated with the property. Argent, Smailes, and Griffin (2007) defined site and location attributes as amenities that are important for lifestyle landowners. Site attributes are environmental assets (**E**) that provide cultural, recreational, and aesthetic amenity values to the landowners. Location attributes (**L**) relate to accessibility of offsite employment, services, entertainment, and recreation. Furthermore, many lifestyle landholders have an interest in small-scale agricultural production on their properties (Pannell and Wilkinson 2009) so environmental assets related to agricultural production (**A**) can also be important features of such properties.

The values of the features and characteristics of lifestyle properties cannot be estimated directly by observing price because they are not traded on the market. However, if one assumes that lifestyle properties are differentiated goods traded on the market, one can estimate implicit prices of the utility-bearing characteristics using hedonic analysis (Rosen 1974). Let \mathbf{X}_i be the vector of attributes of lifestyle property i that consists of vectors \mathbf{A}_i , \mathbf{B}_i , \mathbf{E}_i , and \mathbf{L}_i and $P_i = p(\mathbf{X}_i)$ is the price of property i where $p(\cdot)$ is a function that describes the relationship between the price of the lifestyle property and its attributes. Then $p_j = \partial p(\mathbf{X}) / \partial x_j$ is the implicit price of attribute j (Ma and Swinton 2011).

Spatial data such as property sales prices often exhibit spatial dependency relationships among observations (Anselin 1988). The presence of spatial dependencies in property sales data causes bias and inconsistent or inefficient coefficient estimates when modeling the data using the ordinary least squares (OLS) method. Testing for the presence of spatial dependencies and estimating

spatial models require an assumption about the way in which observational units are believed to influence each other (see Anselin (1988) and Taylor (2003)). This is generally done using a spatial weight matrix, \mathbf{W} , that contains one row and one column for every feature. The cell value for any given row/column combination is the weight that quantifies the spatial relationship between the row and column features. Spatial weight matrices are usually row-standardized, which means that the sum of the weights in each row adds to unity, facilitating interpretation of the regression coefficients. Currently, there is no consensus among practitioners on the most appropriate type of weight matrix for spatial hedonic models, and the challenge of selecting the best matrices has led to ad hoc approaches in practice (Tapsuwan et al. 2012). One approach used to define the spatial weight matrix when observations are not immediate neighbors is inclusion of N nearest neighbors or observations within a certain cutoff distance. Among the assumptions made about weakening of spatial relationships with distance, the most common is that the spatial relationship decays proportionally to the inverse distance between the observations (Maddison 2009). To avoid arbitrary specification of the weight matrix, Donovan, Champ, and Butry (2007) determined a cutoff distance by visually inspecting the empirical semivariogram constructed from the residuals of an OLS model. In this study, we used an empirical covariogram of OLS-model residuals to determine both the cutoff distance and the decay function of the spatial relationship for the spatial weight matrix. An empirical covariogram is a covariance between pairs of residuals depending on the distance (lag) between observations and is given as

$$(1) \quad C(h) = \frac{1}{N(h)} \sum_{N(h)} (z(s_i) - \bar{z})(z(s_j) - \bar{z})$$

where $C(h)$ is a covariance at lag h , $N(h)$ is a number of observations with lag h , and $z(s_i)$ is the value of a variable (a residual in our case) at point s_i . Covariogram data can be fitted with a number of models (Tu, Sun, and Yu 2007). We selected an exponential model for this study:

$$(2) \quad C(h) = \sigma \times \exp\left(-\frac{h}{r}\right)$$

where σ is "scale" and r is "range," both being parameters to estimate. We chose the cutoff distance based on when the covariance decay reached 5 percent of its maximum value. For the exponential covariogram model, the value of covariance reaches 5 percent of its maximum value at the distance $h = 3 \times r$.

Two types of spatial dependencies can exist in a model: a spatial lag relationship and a spatial error relationship. A spatial error relationship occurs when the errors of the model are spatially correlated due to unobserved variables or measurement errors in variables related to the location of a property. The spatial error hedonic model is thus defined as:

$$(3) \quad \begin{aligned} \mathbf{P} &= \alpha + \mathbf{X}'\boldsymbol{\beta} + \boldsymbol{\varepsilon} \\ \boldsymbol{\varepsilon} &= \lambda \mathbf{W}\boldsymbol{\varepsilon} + \mathbf{u} \end{aligned}$$

where α is the intercept, \mathbf{X} is the vector of the attributes of a property, $\boldsymbol{\beta}$ is the vector of parameters to be estimated, $\boldsymbol{\varepsilon}$ is the spatially correlated error term, \mathbf{W} is the $n \times n$ spatial weight matrix, λ is the spatial error coefficient, and \mathbf{u} is an uncorrelated error term, i.e., $\mathbf{u} \sim N(0, \sigma^2)$.

A spatial lag relationship occurs when the sales price of a property is affected by the sales price of neighboring properties. This contradicts the assumption of the standard hedonic method that the value of a composite good is determined by its characteristics. However, in reality, spatial lags can occur when collecting new information is costly and potential buyers use comparable sales from previous time periods to determine the value of a property (Maddison 2009). The spatial lag hedonic model is defined as

$$(4) \quad P = \alpha + X'\beta + \rho W'P + \varepsilon$$

where ρ is the spatial lag coefficient.

Due to simultaneity, we cannot estimate spatial error and spatial lag models using the OLS method; a maximum-likelihood or instrumental variable method is needed. To control for spatial autocorrelation and overcome heteroskedasticity, we applied a general spatial two-stage least-squares (GS2SLS) procedure to the data. It produces spatial heteroskedastic- and autocorrelation-consistent (HAC) estimators of the variance-covariance matrix of the model coefficients (Kelejian and Prucha 2010, Piras 2010).

Study Area and Data

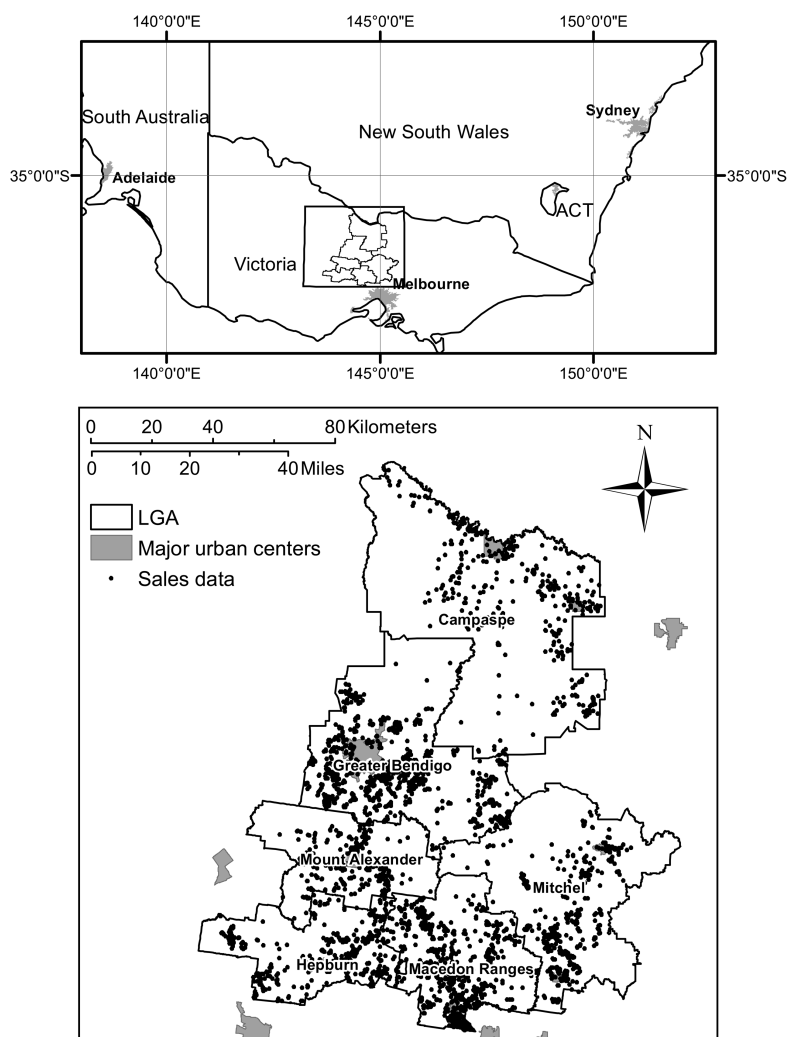
This study focuses on five Local Government Areas (LGAs) in Central Victoria, Australia, that stretch from the northern outskirts of Melbourne's metropolitan area to the Murray River. The elevation of the study area ranges from 1,013 meters (3,323 feet) in the south to 73 meters (240 feet) in the north (Figure 1). Annual rainfall varies from 1,200 millimeters (47 inches) in the southeast to 300 millimeters (12 inches) in the northwest. Prior to European settlement, the dominant types of vegetation in the region were woodlands (52 percent), forests (37 percent), and grasslands (8 percent). Currently, only about 25 percent of the 1.5 million hectares in the study region remain covered by native vegetation; the rest was cleared, mainly for extensive agriculture, in the late nineteenth and early twentieth century. The proportion of native woodland and forest in each LGA varies (see Table 1). Public lands, which include national, state, and regional parks, comprise about 18 percent of the study area. Irrigated (mostly in the northeast) and dryland agriculture dominate the region with some horticulture and lifestyle farming in close proximity to major population centers. The population of the area is about 230,000 with the majority of residents concentrated in larger towns, including Bendigo, Castlemaine, and Echuca.

We acquired property sales data for the State of Victoria from the Valuer General's Office in Victoria. The records contain information on the sales price, sales date, land area, land use, and standard parcel identifier (SPI) for each property. We adjusted the sales prices (in Australian dollars) to 2011 price levels using a consumer price index (CPI) obtained from the Australian Bureau of Statistics. As of January 1, 2011, AU\$1 was equal to US\$1.023.

We used the SPIs to combine records of sales data with the state's cadastral parcel layer. This analysis employed records of properties sold between 2001 and 2011 that were classified as "vacant rural lifestyle" or "rural lifestyle" and were composed of between 1 and 20 hectares (2.5 to 49.4 acres). Rural lifestyle properties are defined as vacant land or single residential dwellings on larger allotments of land (usually between 1 and 20 hectares) in rural, semirural, and

Table 1. Population and Land Cover Statistics of the Study Area

| Local Government Area | Area in Thousand Hectares | Population in 2006 | Percent Native Vegetation |
|-----------------------|---------------------------|--------------------|---------------------------|
| Campaspe | 451.8 | 36,209 | 8.3 |
| Greater Bendigo | 299.9 | 93,252 | 33.1 |
| Hepburn | 147.2 | 13,732 | 40.7 |
| Macedon Ranges | 174.8 | 38,360 | 27.7 |
| Mitchell | 286.2 | 30,928 | 25.1 |
| Mount Alexander | 152.9 | 17,066 | 36.0 |
| Total | 1,512.8 | 229,547 | 24.6 |

**Figure 1. Location of the Study Area and Sales Data**

bushland settings where primary production use is secondary to the value of the residential home site and associated residential improvements. We excluded any property for which the land area recorded in the sales database deviated by more than 10 percent from the area calculated by a geographic information system (GIS). If the same property had been sold multiple times, we retained only the latest sale record for the analysis. The final sample consisted of 2,802 observations.

We calculated the proportion of native vegetation on each property and within 2 kilometers (km) of the property using the TREEDEN25 GIS dataset developed by the Department of Sustainability and Environment in Victoria with 1999 SPOT panchromatic imagery composed of 10-meter pixels. The dataset identifies areas covered by woody vegetation that exceeds 2 meters in height and for which crown cover exceeds 10 percent. The date of the TREEDEN25 observations precedes our study period. According to findings in a recent study by Kyle and Duncan (2012), there has been very little change in the native vegetation cover in northcentral Victoria between 1991 and 2008. Native vegetation clearance controls introduced in 1986 permit clearing only for residential development. Since the majority of the preclearance vegetation types in the area were woodland and forest, we assumed that TREEDEN25 provides an accurate representation of the extent of native vegetation during the study period. We calculated the proportion of native vegetation on each property as the ratio of the area of woody vegetation to the total property area and the proportion of native vegetation within 2 km of the property as the ratio of the area of woody vegetation within 2 km of the property to the area of the 2-km buffer.

We used a Victoria Land Systems data set (Rees, Rowan, Ransome, and Russell 2000) to identify dominant soil textures in the study area. In addition, three GIS data sets (WETLANDS, ISC_REACH2004, and PLM100) developed by the Department of Sustainability and Environment in Victoria identified lakes, rivers and creeks, and parks. We obtained average annual rainfall data from the website of the Australian Bureau of Meteorology¹ and calculated property slopes using the 90-meter-resolution digital elevation model (Jarvis et al. 2008). Spatial and tabular data on the populations of urban centers and localities came from the 2006 Census of Population and Housing from the website of the Australian Bureau of Statistics.² These data were used to calculate a measure of population accessibility for each observation.

Empirical Model

The dependent variable in the hedonic model was the CPI-adjusted sales price per hectare for lifestyle properties. Using the Box-Cox test, we determined that the most appropriate functional form was the hedonic price function with a natural-log-transformed dependent variable. To control for the diminishing marginal value of land, we included the natural log of property area. Most of the lifestyle properties were improved with houses and other structures but the database included only the number of bedrooms. Because our dependent variable was the CPI-adjusted sales price per hectare, we used the number of

¹ Australian Bureau of Meteorology: www.bom.gov.au.

² Australian Bureau of Statistics: www.abs.gov.au.

bedrooms divided by the property's area in hectares to represent the level of structural attribute per unit of land (Maddison 2009).

To account for on-property ecosystem services, we included a soil characteristic, the property slope, annual precipitation, and the proportion of the property covered by native vegetation. The soil characteristics were represented by two binary variables indicating soil texture—"sand" and "clay"—with loam as the default texture. Steeper slopes can enhance the amenity value of land when the slopes create attractive views. In the predominantly dry Australian environment, rainfall can positively influence amenity value through creation of green landscapes and the availability of water for domestic uses (Argent, Smailes, and Griffin 2007). We hypothesized that native vegetation is an environmental asset that would contribute to the amenity value of a lifestyle property. We also assumed that this asset has a diminishing marginal return that is captured by including a quadratic term for the variable representing the proportion of native vegetation. Furthermore, to test whether the amenity value of native vegetation diminishes with property size, we included an interaction effect of the proportion of native vegetation with the natural log of property area. To control for the amenity value of native vegetation in surrounding landscapes, we included the proportion of native vegetation within a 2-km (1.24 mile) buffer of the property and its squared term.

We represented the location attributes, which describe accessibility of the property to recreational facilities, by Euclidean distances to the nearest state, national, or regional park, to the nearest lake that exceeded 100 hectares, and to the nearest river or creek. Accessibility to employment, services, and entertainment can be measured by distances to populated places such as cities, towns, or other urban centers that offer a variety of such amenities. However, the quantity and variety of such amenities is usually greater in places with larger populations. To account for accessibility to these amenities, we used the population interaction index (PII) (Breneman 1997), which has been used in other studies to model rural property values and returns to rural land (Livanis et al. 2006, Polyakov and Zhang 2008b). We defined this inverse distance-weighted index of the population within a certain distance as

$$(5) \quad PII_i = \sum_{j=1}^{J_i} \frac{Q_j}{D_{i,j}} \quad \forall i$$

where PII_i is the PII for property i , Q_j is the population of urban center or locality j , and $D_{i,j}$ is the Euclidean distance between property i and urban center or locality j in meters. We included urban centers and localities within a 350-km (217-mile) radius of the property.

Because our data set spans eleven years, we included a trend variable in a continuous form to represent each year beginning on January 1, 2001, plus squared and cubic terms. These variables capture the growth dynamics of property prices. Descriptive statistics of the model variables are presented in Table 2.

Results

Table 3 shows OLS results for the hedonic model of rural land prices. The model explains 77 percent of the variance of the dependent variable. Figure 2 shows the empirical covariogram of the OLS residuals and clearly suggests the presence of nonlinear spatial dependency among the observations that curtails

after approximately 20 km. The results of nonlinear least-square estimations of the exponential covariogram model are presented in Table 4. A plot of the fitted

Table 2. Descriptive Statistics of the Variables

| Variable | Mean | Standard Deviation | Median | Minimum | Maximum |
|--|---------|--------------------|--------|---------|-----------|
| Price (AU\$ per hectare) | 115,038 | 131,233 | 70,482 | 1,008 | 1,816,874 |
| Area (hectares) | 6.4 | 4.9 | 4.5 | 1.0 | 20.0 |
| Bedrooms per hectare | 0.7 | 0.8 | 0.4 | 0.0 | 4.1 |
| Sands | 0.02 | 0.12 | 0 | 0 | 1 |
| Clays | 0.89 | 0.31 | 1 | 0 | 1 |
| Slope (degrees) | 2.7 | 2.1 | 2.2 | 0.0 | 20.2 |
| Annual precipitation (millimeters) | 693.5 | 177.9 | 660.5 | 399.0 | 1,361.0 |
| Proportion of native vegetation | 0.27 | 0.30 | 0.15 | 0.00 | 1.00 |
| Proportion of native vegetation within 2-km buffer | 0.31 | 0.23 | 0.25 | 0.00 | 0.96 |
| Distance to river (kilometers) | 2 | 3 | 1 | 0 | 18 |
| Distance to lake (kilometers) | 18 | 12 | 14 | 0 | 57 |
| Distance to park (kilometers) | 9 | 8 | 7 | 0 | 35 |
| PII | 95.3 | 27.8 | 87.2 | 44.0 | 175.5 |
| Trend (years) | 5.3 | 2.7 | 5.0 | 0.0 | 10.5 |

Note: N = 2,802.

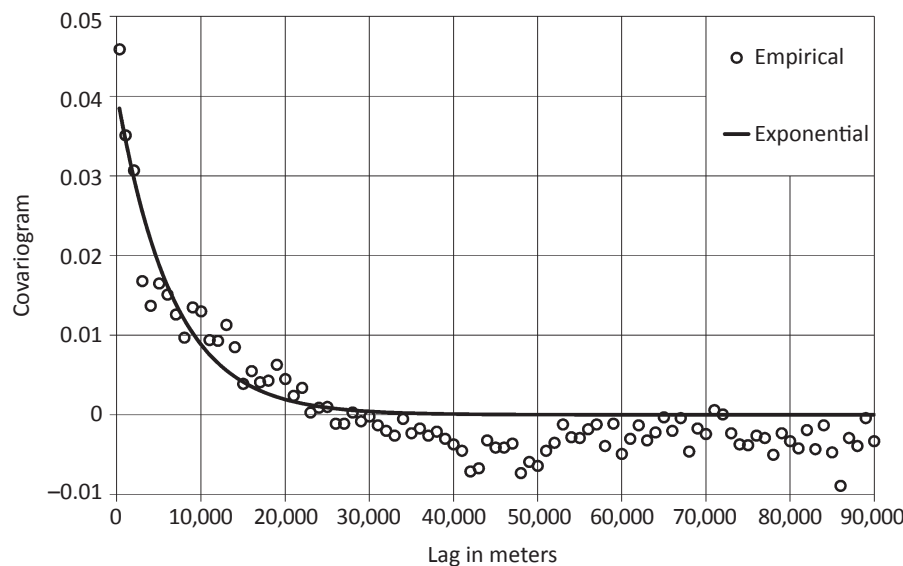


Figure 2. Covariogram of the Residuals from the OLS Estimation of the Value of Lifestyle Properties

Table 3. Regression Results

| Variable | OLS Model | | Spatial Error Model | |
|--|------------|----------|---------------------|----------|
| Intercept | 11.1100*** | (0.0974) | 11.0259*** | (0.2261) |
| log(Area) | -0.7371*** | (0.0179) | -0.7273*** | (0.0205) |
| Bedrooms per hectare | 0.4790*** | (0.0316) | 0.4772*** | (0.0348) |
| Bedrooms per hectare squared | -0.0856*** | (0.0094) | -0.0877*** | (0.0093) |
| Sands | 0.2456*** | (0.0826) | -0.0255 | (0.1056) |
| Clays | -0.2848*** | (0.0420) | 0.0385 | (0.0725) |
| Annual precipitation | 1.3E-4* | (7.5E-5) | -2.1E-4 | (1.6E-4) |
| Slope | -0.0409*** | (0.0116) | -0.0121 | (0.0111) |
| Slope squared | 0.0033*** | (0.0009) | 0.0012 | (0.0009) |
| Proportion of native vegetation | 0.6811*** | (0.1251) | 0.6462*** | (0.1179) |
| Proportion of native vegetation squared | -0.7191*** | (0.1228) | -0.6971*** | (0.1187) |
| Proportion of native vegetation \times log(Area) | -0.0444 | (0.0367) | -0.0705** | (0.0354) |
| Proportion of native vegetation within 2-km buffer | 0.0768 | (0.1708) | 0.4106** | (0.1931) |
| Proportion of native vegetation within 2-km buffer squared | 0.0179 | (0.1882) | -0.4459** | (0.2035) |
| log(Distance to river) | -0.0851*** | (0.0156) | -0.0657*** | (0.0232) |
| log(Distance to lake) | -0.0567*** | (0.0127) | -0.0733** | (0.0316) |
| log(Distance to park) | -0.0625*** | (0.0126) | -0.1019*** | (0.0247) |
| PII | 0.0092*** | (0.0005) | 0.0093*** | (0.0013) |
| Trend | 0.2803*** | (0.0355) | 0.2983*** | (0.0351) |
| Trend squared | -0.0409*** | (0.0077) | -0.0446*** | (0.0075) |
| Trend cubed | 0.0021*** | (0.0005) | 0.0024*** | (0.0005) |
| Spatial error | | | 0.8555*** | (0.0306) |
| Number of observations | 2,802 | | 2,802 | |
| R-squared | 0.7667 | | | |
| Adjusted R-squared | 0.7651 | | | |

Note: Standard errors are in parentheses. * Significant at 10 percent level; ** significant at 5 percent level; *** significant at 1 percent level.

exponential covariogram against the empirical covariogram with regression residuals (Figure 2) suggests a reasonably good fit.

We constructed the row-normalized spatial weight matrix, **W**, using a threshold distance of 18.5 km, which is three times the “range” parameter of the exponential covariogram. The weights of the individual elements of the matrix are proportional to the covariance predicted using equation (1). We constructed two alternative spatial weight matrices: one based on the eight nearest neighbors and the other based on an 18.5-km cutoff distance with inverse distance weight. We then tested those OLS model residuals for autocorrelation. Moran I statistics and the results of Lagrange multiplier (LM) and robust Lagrange multiplier (RLM) tests using the three spatial weight matrices are presented in Table 5. The Moran I statistic indicates a clustering pattern in the residuals. The LM and RLM tests indicate the presence of spatial error and spatial lag dependencies, though spatial error dependency is much more prominent. Furthermore, caution should be exercised when interpreting these results for spatial lag because the LM and RLM tests do not take the temporal component into account. In our model, the LM and RLM diagnostic statistics had greater and more statistically significant values in the test of the model involving the exponential weight specification of the spatial weight matrix. Therefore, we estimated a spatial error model that used the spatial weight matrix involving exponential spatial weight specification.

Table 4. Results of Nonlinear Least Squares Fit for Empirical Covariogram

| Parameter | Estimate | Standard Error | Approximate 95-Percent Confidence Limits | |
|--------------|----------|----------------|--|---------|
| Scale | 0.0406 | 0.0027 | 0.0353 | 0.046 |
| Range | 6,145.2 | 613.9 | 4,925.4 | 7,365.1 |
| N | 91 | | | |
| F-statistics | 210.0*** | | | |

*** Significant at 1 percent level.

Table 5. Tests for Spatial Autocorrelation in the OLS Residuals

| Test | Spatial Weight Matrix | | |
|------------------------------------|-------------------------|--|-----------------------------------|
| | Eight Nearest Neighbors | 18.5-km Radius Inverse Distance Weight | 18.5-km Radius Exponential Weight |
| Spatial Error Dependence | | | |
| Moran I statistic standard deviate | 18.28*** | 28.42*** | 36.43*** |
| Lagrange multiplier test | 330.89*** | 788.42*** | 1,264.39*** |
| Robust Lagrange multiplier test | 326.83*** | 585.88*** | 1,048.11*** |
| Spatial Lag Dependence | | | |
| Lagrange multiplier test | 4.07** | 207.95*** | 227.97*** |
| Robust Lagrange multiplier test | 0.01 | 5.42** | 11.69*** |

* Significant at 10 percent level; ** significant at 5 percent level; *** significant at 1 percent level.

We present estimation results from the spatial error model in Table 3. As expected, the spatial error coefficients are positive and significant, confirming the presence of positive spatial relationships. Signs on the coefficients in the spatial model are mostly consistent with signs in the OLS model. The exceptions are most of the property characteristics derived from the GIS data. Soil, precipitation, and slope became insignificant in the spatial model, and the proportion of native vegetation within the 2-km buffer and its squared term became statistically significant. Furthermore, the magnitudes of the coefficients of distance-based variables changed in the spatial error model.

Per-hectare property value decreased with property size, which reflects declining marginal returns that are consistent with findings by Sengupta and Osgood (2003). Causes for this relationship include subdivision costs, reduced liquidity of larger properties, and lack of market information held by sellers (Chicoine 1981). The bedrooms-per-hectare coefficient and its squared term indicate that a house adds value to the property while house size, represented by the number of rooms, has a diminishing marginal return.

The coefficients of the soil-texture binary variables in the OLS model indicate that clay has a negative effect and sand has a positive effect on property value relative to loam. However, in the spatial error model, those coefficients became insignificant with reverted signs, which indicates that omitted variables that influence the value of lifestyle properties are correlated with the soil-texture variables. Similarly, annual precipitation is positive and significant in the OLS model, which is consistent with our *a priori* expectations; however, it becomes insignificant in the spatial error model. Note that annual precipitation is correlated with the PII ($r = 0.58$). It remains insignificant in the spatial error model even when the PII variable is removed. This suggests that precipitation may not be important in determining the value of lifestyle properties.

The presence of some native vegetation increases the value of lifestyle properties. However, its effect is diminishing as indicated by negative coefficients on the quadratic term for proportion of native vegetation. Figure 3 presents the marginal implicit price of the proportion of native vegetation over the range of those proportions for a property of median size (4.5 hectares) and median price (AU\$70,482) per hectare. The optimal proportion of native vegetation is about 40 percent, a ratio that increases property value by approximately AU\$7,400 per hectare or 10.5 percent of the median property price per hectare. However, a ratio of native vegetation that exceeds 80 percent reduces the value of the property to less than the value associated with no native vegetation. The optimal proportion of native vegetation changes with the size of the lifestyle property, ranging from 45 percent for a 1-hectare property to 30 percent for a 20-hectare property. The extent of native vegetation in the surrounding landscape also affects the property price and exhibits a diminishing marginal return (Figure 3). The optimal proportion of native vegetation within 2 km of a lifestyle property is approximately 45 percent, a ratio that increases the value of a median-sized property by AU\$6,600 per hectare.

Our results demonstrate that location characteristics are important determinants of lifestyle property values. Greater accessibility of recreational opportunities measured by nearer proximity to lakes, rivers, and parks increases property values. Being located 1 km closer to one of these recreational amenities increases the value of the median lifestyle property by AU\$5,452 per hectare for a river, AU\$1,886 per hectare for a lake, and AU\$3,535 per hectare for a park (Table 6). The PII, a measure of accessibility to employment, services, and

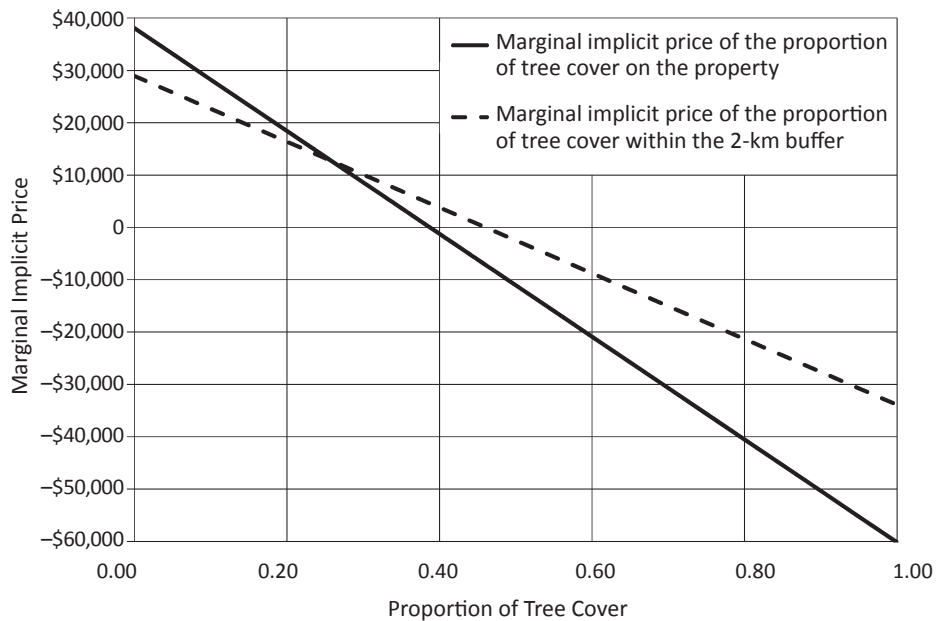


Figure 3. Marginal Implicit Prices of the Proportions of Native Vegetation on the Property and Proportions of Native Vegetation within the 2-km Buffer for a Median Property

Note: Area 4.5 hectares. Price AU\$70,000 per hectare.

entertainment amenities, has a positive effect on lifestyle property values. The elasticity of this variable is 0.81, indicating that an increase in the population of the urban centers and locality by 1 percent, or a move 1 percent closer to such populated places, increases the value by 0.81 percent. For example, an increase in the population of a town situated 10 km from the property by 10,000 people or an increase in the population of a town situated 20 km from the property by 20,000 people would increase the value of the median property by AU\$653 per hectare. This result is consistent with results of the effect of the PII on land use

Table 6. Marginal Implicit Prices and Elasticities of Statistically Significant Variables at the Median of the Relevant Variables

| Variable | Marginal Implicit Price (AU\$) | Elasticity |
|--|--------------------------------|------------|
| Area | -11,418 | -0.73 |
| Bedrooms per hectare | 24,003 | 0.27 |
| Proportion of native vegetation | 23,695 | 0.05 |
| Proportion of native vegetation within the 2-km buffer | 13,104 | 0.05 |
| Distance to river | -5,452 | -0.07 |
| Distance to lake | -1,886 | -0.07 |
| Distance to park | -3,535 | -0.10 |
| PII | 653 | 0.81 |

changes along an urban-rural gradient in Georgia (Polyakov and Zhang 2008a) and of the effect of remoteness on ranchette prices in Arizona (Sengupta and Osgood 2003). Finally, the time-trend variable with its squared and cubic forms indicates growth of the value of lifestyle properties beyond inflation that slows after approximately 2006.

Discussion and Conclusion

Hobby farms, ranchettes, and lifestyle properties are an increasingly large part of multifunctional rural landscapes in developed countries, including Australia. Lifestyle landowners generally associate a variety of goals and aspirations with their properties and typically do not focus primarily on production. Consequently, they can play an important role in managing and conserving these landscapes. When setting conservation priorities, it is important to consider not only where the most valuable natural assets are located but also the willingness and capabilities of local residents and institutions that will be involved in protecting and enhancing those assets (Knight et al. 2010).

An emerging body of work is attempting to attribute conservation actions taken by lifestyle landowners to socioeconomic, demographic, and cultural factors (Curtis 2008, Seabrook, McAlpine, and Fensham 2008, Raymond and Brown 2011). Our research contributes to this effort by estimating the value that lifestyle landowners place on an environmental asset, native vegetation, on their properties.

We develop a spatial hedonic model of the value of lifestyle properties in rural Victoria, Australia. We find that native vegetation on a property and native vegetation, rivers, lakes, and parks within the surrounding landscape provide amenity benefits to the landowners. Native vegetation on a property has a positive, diminishing marginal implicit price. The value may arise from a preference for natural landscapes, the aesthetic appearance of natural vegetation, and/or the knowledge that the owner is providing habitat for native plants and animals. The marginal implicit price becomes negative when the ratio of native vegetation exceeds approximately 40 percent for the median lifestyle property. The median proportion of native vegetation in our sample is 15 percent so most lifestyle landowners in the region could benefit from revegetating portions of their properties. This finding is consistent with Race et al. (2010), which found that lifestyle landowners devoted considerable effort to (and thus presumably benefitted from) replanting and enhancing native vegetation in similar Australian environments.

The negative marginal implicit price of native vegetation occupying more than 40 percent of the property area reflects the diminishing marginal return inherent in many factors of production. Native vegetation is a type of land use that competes with other land uses valued by owners, and 40 percent of the median lifestyle property area may be the point at which the marginal benefit of native vegetation equates with the marginal benefit of pasture or other land uses. This conclusion is consistent with Pannell and Wilkinson (2009), which found that most lifestyle landholders positively view revegetating part of their properties but “have a strong reluctance to make environmentally beneficial changes that occupy the majority of their land.” Potential reasons include limits on owners’ ability to allocate resources to beneficial environmental changes, diminishing returns on environmental benefits from additional allocations, and owners’ preferences for semi-open landscapes (Williams and Cary 2002).

A preference for semi-open landscapes is also confirmed by our finding that the optimal proportion of native vegetation within 2 km of a lifestyle property is about 45 percent.

Our results demonstrate the importance of accounting for spatial interactions in hedonic models. Ignoring spatial interactions that are present in the data may lead to inaccurate interpretations of the results. Thus, one must test for spatial interactions in the data and apply appropriate controls to accommodate such interactions to derive valid inferences from hedonic modeling.

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