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# **Identifying Priority Target Areas for Knoxville-Knox County Hillside and Ridgetop Protection Plan: Using Value of Visual Amenity during the Real Estate Boom of 2002-2006 and the Recession of 2008**

**Matthew H. Chadourne, Seong-Hoon Cho, Roland K. Roberts**  
**Department of Agricultural and Resource Economics,**  
**The University of Tennessee**  
**2621 Morgan Circle**  
**Room 231E**  
**Knoxville, TN 37996-4518**  
**Phone: 206-465-2260**

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# Identifying Priority Target Areas for Knoxville-Knox County Hillside and Ridgetop Protection Plan: Using Value of Visual Amenity during the Real Estate Boom of 2002-2006 and the Recession of 2008

Matthew H. Chadourne, Seong-Hoon Cho, Roland K. Roberts  
Department of Agricultural and Resource Economics, The University of Tennessee, Knoxville, TN 37996-4518

## Introduction

Hillside development and its regulation in Knox County, Tennessee:

- Scenic hillside properties of the region are attractive places to live.
- Hillside and ridgetop areas are highly visible throughout the county and 60% of the county's forested lands are in these areas.
- A lack of zoning and building regulation in the region has fostered increased hillside development.

The Joint City-County Taskforce on Ridge, Slope, and Hillside Development and Protection was empowered in 2009. The taskforce focuses on protecting the ridge lines and hillsides by:

- Altering or creating new development policies including revising zoning laws and imposing limits on development in new areas.
- Increasing requirements on density of new housing developments and placing restrictions on building heights.
- Changing rules on hill side grading and planning possible reforestation and restoration efforts.

## Objectives

The goal is to contribute to the process of screening high priority target areas for protection and reforestation (3 specific objectives):

- 1) Find the value added to house price by views of the ridges and hillsides during two separate periods (i.e., an economic boom and a recession).
- 2) Determine the distribution of marginal implicit prices of views in the county to highlight spatial variation between the two periods.
- 3) Identify areas with consistently high visual amenity values across both periods that could serve as high priority target areas for the Taskforce.

## Methods

**1) Spatial Model:** Since the price of a house is strongly influenced by the prices and quality of houses in its neighborhood, there may be a need to allow the hedonic parameters to vary over space including parameters that represent the effects of view of hillsides and ridgetops. Consequently, two separate locally weighted regressions that correct for spatial autocorrelation in housing-price models are estimated for the repeat sales of houses for 2000–2006 and 2008 data.

**2) Check for spatial error and lag:** Residuals of the locally weighted regression are tested for spatial error autocorrelation using a Lagrange Multiplier (LM) test for several spatial weight matrixes.

**3) Locally weighted regression with spatially autocorrelated disturbances:** Two separate locally weighted regressions that correct for spatial autocorrelation were then created for the 2000-2006 and 2008 periods.

**4) Marginal price estimation:** The marginal implicit prices of forest land cover and other significant land cover types were estimated from the regressions by taking the the partial derivative of the hedonic price function with respect to the area of a particular land cover type.

## Equations

Locally Weighted Hedonic Regression:

$$\ln \hat{p}_i = \sum_k \beta_k (u_i, v_i) x_{ik} + \varepsilon_i, \sim \varepsilon_i \sim \Theta, \sum_{j=1, j \neq i}^n w_{ij} \varepsilon_j + \xi_i \quad \xi_i \sim iid(\sigma^2)$$

where  $p_i$  is sales transaction price of a house  $i$ ;  $x_{ik}$  is a vector of  $m$  variables including viewshed of hillside forest land;  $(u_i, v_i)$  denotes the coordinates of the  $i$ th house among  $n$  houses;  $\beta_k$  represents the local parameters associated with house  $i$ ;  $w_{ij}$  is an element of an  $m$  by  $n$  spatial weighting matrix between points  $i$  and  $j$ ; and  $\lambda$  is a spatial error autoregressive parameter. For simplicity, notation for the two different time periods is suppressed as the same model is applied to each time period.

Parameter Estimates from the Spatial Model:

$$\hat{\beta}(u_i, v_i) = \left( X' (I - \lambda W)' A(u_i, v_i) (I - \lambda W) X \right)^{-1} X' (I - \lambda W)' A(u_i, v_i) (I - \lambda W) P$$

where  $A$  is  $n$  by  $n$  matrix that attends to spatial heterogeneity, with diagonal elements identifying the location of other houses relative to house  $i$  and zeros in off-diagonal positions, and  $P$  is a vector of  $\ln p_i$ . The filtering mechanism  $(I - \lambda W)$ , where  $I$  is an identity matrix,  $\lambda$  is a spatial error autoregressive parameter and  $W$  is a spatial weight matrix, partials out spatial error autocorrelation associated with the explanatory and dependent variables while estimating local coefficients.

Pseudo-standard errors:

$$\text{cov}(\hat{\beta}(u_i, v_i)) = \sigma_i^2 \left( X' (I - \lambda W)' A(u_i, v_i) (I - \lambda W) X \right)^{-1}$$

Pseudo-standard errors for the  $i$  sets of regression parameters are based on the covariance matrix (cov) where  $\sigma_i^2 = e' (I - \lambda W)' A(u_i, v_i) (I - \lambda W) e / (q - k)$  is the variance associated with the  $i$ th regression point. Statistical significance of the estimates from the locally weighted regression with spatially autocorrelated disturbances at the  $i$ th regression point is evaluated with Pseudo-t tests derived from the Pseudo-standard errors of the location-specific covariance matrices.

## Results

- The only view variable that was significant in both periods was forest land. The per acre value of the view of forest land changed little (see the table to the right) implying that view has similar values in periods of prosperity and recession.
- The view of Barren/scrublands was not a significant variable in the value of a house during the housing boom but it was significant during the recession, reducing a house's value by an average of \$1,559.75 per visible acre. This may mean that consumers are less willing to endure a view of unpleasant land covers during a recession, further reinforcing the notion that quality views are important to consumers.
- The distribution of the value added by forest land changed very little between time periods and the highest value added areas are in the south western region of the county (see map). This area contains Farragut, a suburb of Knoxville, and a region of Knoxville called Sequoia Hills.
- These areas in the south west could be high priority target areas for future preservation or restoration efforts.

## Marginal Implicit Price Estimations

	Forest Land (per acre values)				Barren/ Scrubland
	2002-2006	2008	Change	%	2008
Quartile 1	\$1,984.39	\$1,901.84	\$(82.55)	-4.16%	\$(1,727.32)
Median	\$2,698.73	\$2,668.26	\$(30.48)	-1.13%	\$(1,079.98)
Quartile 3	\$3,872.71	\$3,944.62	\$71.92	1.86%	\$(752.31)
Mean	\$3,415.32	\$3,423.78	\$8.46	0.25%	\$(1,559.75)

Value added by views of forest land in the period 2002-2006  
(Highlighted areas are the regions of the Hillside and Ridgetop protection area under consideration)

