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## **The Effects of Open Space on Residential Property Values**

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### **Abstract:**

Using residential sales data from central Maryland, this paper employs a hedonic pricing model to test whether different types of open space land uses have different marginal effects on the value of neighboring residential properties. The identification problems that arise when the surrounding open space is privately owned and developable and therefore part of the residential land market are addressed using an instrumental variables estimation technique. The results show that most types of open space are valued attributes of residential location, and that different types of open space have significantly different effects on residential property values.

**Keywords:** open space, land use, hedonic pricing model, valuation



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## Introduction

The decision to preserve open space is often made based on the value of the natural amenities associated with the land, e.g. the biodiversity, wildlife habitat, or scenic views provided by the land. However, rather than being valued for what it is, anecdotal evidence suggests that open space is often valued most for what it is not, i.e. for not being development (Krieger, 1999). Particularly in exurban areas experiencing growth pressures from nearby metropolitan areas, preserving open space is viewed by many as a way to prevent the negative effects that are perceived to be associated with development, e.g., congestion, loss of privacy, increased crime, and a lost sense of community. Several contingent valuation studies provide empirical evidence of this willingness-to-pay for preserved open space as a means of deflecting development. For example, Halstead (1984) and Beasley, Workman and Williams (1986) estimate that households' willingness to pay to preserve an acre of average quality farmland increases from \$50 to \$150 per household when the replacement for agriculture is hypothesized to be high density rather than low density development. Kline and Wichelns (1994, 1996) find that support for farmland preservation programs in the Northeast U.S. is greatest in those counties experiencing the largest increases in population and in housing and property values.

Evidence of the value of open space has also been provided by hedonic pricing models (Bell and Bockstael, 1999; Cheshire and Sheppard, 1995; Garrod and Willis, 1992; Geoghegan, Wainger, and Bockstael, 1997; Leggett and Bockstael, 1999; Tyrväinen and Miettinen, 2000). This method allows estimation of the marginal value of open space by isolating its spillover effect on neighboring residential property values.

Estimates can then be used to calculate an individual property owner's willingness-to-pay for a marginal change in the open space surrounding the property. Results from this literature are mixed. For example, Garrod and Willis (1992a, 1992b) test whether different types of forests affect neighboring housing prices. They distinguish among types of tree stocks and find that deciduous trees located within the same one-kilometer grid as residential homes significantly increase house prices, but that spruce conifers significantly decrease house prices. Geoghegan, Wainger, and Bockstael (1997) examine the effect of surrounding agricultural and forested lands on the value of residential exurban land in a central Maryland region. They find different open space effects, depending on the size of the neighborhood considered: within a tenth of a kilometer radius, the proportion of open space positively impacts land values, but within a one kilometer buffer negatively influences land prices. Cheshire and Sheppard (1995) estimate the effects of publicly and privately held open space on residential property values using separate datasets from two medium-sized towns in England. They find different results that depend on the amount of open space amenities in the two towns. Only if the amount of either public or private open space is sufficiently scarce in the towns is a positive and significant effect found on residential property values. Tyrväinen and Miettinen (2000) find that distance to the nearest small area of forest has a negative and significant effect on housing prices in a semi-rural area in Finland and that the presence of a forest view from the housing unit has a positive influence. However, other open space variables are not found to be significant, including the relative amount of forested area within the housing neighborhood and distance to the nearest large forested area.

The inconclusive results from the hedonic pricing literature regarding the positive amenity value of open space can be explained to some extent by differences in the kinds of open space considered, the specification of the open space variables, the relative scarcity of the open space, and other differences across study regions. Results depend on the types of land uses used to represent open space and on whether the open space is publicly or privately held. In addition, the size of the neighborhood considered and whether surrounding open space is represented in proximity terms, i.e. as a distance measure, or as a proportion of the total neighborhood area affect the results. Lastly, the characteristics of the study area, in particular, the population mix and the degree to which it is a built-up, urban area vs. a relatively rural one, matter as well. However, these results may also vary due to an identification problem that is associated with estimating certain types of open space effects using a hedonic pricing model. Irwin and Bockstael (2000) argue that, because privately owned open space that surrounds a residential property is part of the same market as the residential property, an endogeneity problem arises in estimating these kinds of land use spillover effects using a hedonic pricing model. None of the papers referenced above address this potential identification problem, which leads to biased estimates if the open space variables are indeed endogenous to the residential land market.

Using residential sales data from a suburban/exurban region in central Maryland, this paper employs a hedonic pricing model to test whether neighboring open space is a valued attribute of residential location and, if so, whether different types of open space are valued differently. Open space is distinguished first by whether the land is preserved

or is developable and second by the land use type. In doing so, the goal is to explore whether preserved open space carries a premium with it and whether the landscape amenities that are associated with different open space land uses, e.g. crops vs. pasture, have different marginal effects on nearby residential properties. The identification problems that arise in estimating open space effects with a hedonic pricing model are addressed by using an instrumental variables estimation approach. The results show that open space is a valued attribute of residential location and that different types of open space have significantly different effects on the value of residential properties.

### **Estimating Open Space Effects**

Hedonic pricing models offer a means to estimate the marginal implicit prices of characteristics associated with a differentiated market good, such as housing. The hedonic price function, which posits price as a function of the quantities of a good's attributes, arises through the interactions of many buyers and sellers in the market. As a result, it describes the locus of equilibrium points between buyers and sellers in the market. The marginal implicit price of any of the good's attributes is found by differentiating the hedonic price function with respect to the attribute. Evaluated at an individual's optimal choice, this implicit price represents the individual's marginal willingness-to-pay for the attribute.

For the purposes of this paper, we specify the hedonic residential house pricing model as:

$$P_i = f(H_i, N_i, L_i; \beta, \lambda, \delta),$$

where  $P_i$  is the residential sales price of the  $i^{th}$  property,  $H_i$  is a vector of structural characteristics associated with the house,  $N_i$  is a vector of neighborhood/location variables,  $L_i$  is a vector of neighborhood land use variables, each of which measures the proportion of the surrounding land that is in a particular land use, and  $\beta$ ,  $\lambda$ , and  $\delta$  are the respective parameter vectors to be estimated.

A variety of econometric issues arise in estimating hedonic models. An issue that is specific to the estimation of land use spillovers with hedonic models is the potential endogeneity of these variables. As discussed by Irwin and Bockstael (2000), privately held open space that is developable is a part of the market for residential land and, therefore, subject to the same economic forces that determine a location's residential value. This implies that variables measuring the influence of surrounding open space on residential property values will be endogenous. As a result, identification problems arise that will bias the open space coefficients. Specifically, Irwin and Bockstael argue that two identification problems arise in this context. The first is the standard type of econometric identification problem due to endogenous explanatory variables. Consider two neighboring parcels,  $i$  and  $j$ . Whether parcel  $j$  is in a residential or open space land use is influenced by its value as a residential location, which, because of the spillover effect, is a function of parcel  $i$ 's land use. In turn, parcel  $i$ 's land use is determined by its residential property value, which is a function of parcel  $j$ 's land use. Therefore, the residential value of parcel  $i$  is a function of the residential value of parcel  $j$ , and vice versa, and the measure of surrounding open space around parcel  $i$ , which is a function of parcel  $j$ 's residential value, is endogenous. The second problem arises because the factors that cause parcels to be more or less valuable in residential use are spatially

correlated. If any of these spatially correlated explanatory variables are omitted from the estimation, then any variable measuring surrounding open space will be correlated with the error term.

Other econometric issues include specification, multicollinearity, extent of the market, and spatial autocorrelation. Drawing upon evidence that choosing a simpler functional form is generally more robust to situations in which omitted variables may be a problem (Cropper, Deck, and McConnell, 1988), we use a simple log-log model, in which the dependent variable is the log of sales price and the right hand side variables are expressed in terms of logs (with the exception of dummy variables and percentage variables that vary between zero and one). Multicollinearity is likely to exist. However, the size of the dataset (55,799 observations) will help to offset the loss of information caused by this problem. The market for housing in the study area is a regional one that is likely comprised of more local, but overlapping markets for housing. Observations are drawn from the northwest (Howard County), central (Anne Arundel County) and southern (Calvert and Charles counties) parts of the regional market, but do not comprise the entire market. Lastly, spatial autocorrelation is likely to be present in the data, given the spatial nature of the problem. As outlined by Anselin (1988), spatial autocorrelation of the errors will produce inefficient, but unbiased, estimates. However, this inefficiency is more than likely offset by the large number of observations used to estimate the model.

The data consist of arms length, single transactions of owner-occupied residential properties within Anne Arundel, Calvert, Charles, and Howard counties in Maryland. This region contains part of the urbanized Washington D.C. – Baltimore, MD corridor, but is largely comprised of suburban and exurban communities. The 55,799 sales

occurred between January 1995 and December 1999. The data are from the *Maryland Office of Assessment and Taxation* and are made available in geocoded format by the *Maryland Office of Planning* through *Maryland Property View*, a GIS data product. Additional spatial variables were generated using ArcInfo GIS software.

In distinguishing types of open space, different classifications are possible, e.g., by land use, land cover, ownership type, development potential, or geographic location. Ideally, the classification would reflect individuals' own perceptions of different types of open space. We surmise that people distinguish land first by whether it is in a preserved state (vs. being developable) and second by its land use. Using this approach, the first distinction is between privately owned open space with development rights intact, i.e. land that could be developed at anytime, vs. privately owned land whose development rights have been sold or land that is publicly held, neither of which will be developed in the future. Privately owned lands that are developable are further distinguished based on land use. This yields five different measures of surrounding open space: (1) cropland that is privately owned (CROP), (2) pasture lands that are privately owned (PAST), (3) forested lands that are privately owned (FOREST), (4) privately owned land that is protected from development, including agricultural easements and privately owned conservation areas (CONSV); and (5) open space land owned by the federal, state, or county governments (PUBLIC). These values are measured in proportionate terms and indicate the percent of the total land area within a 400-meter<sup>1</sup> radius that is classified as a particular type of open space. Federally owned open space lands are sometimes military installations, which may have a potentially different spillover effect than federal parks

and other federally owned open space that is publicly accessible. In fact, all of the federally owned land in Anne Arundel County is in a military use, including the largest contiguous area of open space in the study area (Ft. Meade). To control for these differences in Anne Arundel County, a dummy variable is included to indicate whether the public land is located in this county or not (PUBAA).

While we expect the signs of the open space coefficients to be positive, it is not obvious *a priori* which types of open space would be expected to confer greater value. To the extent that preserved open space is perceived as being guaranteed open space into the future, this reduction in uncertainty may carry a premium with it. However, public open spaces are often destination sites for people from outside the local area and may also generate a nuisance spillover if they lead to less privacy and greater congestion than privately held open space. Among privately held open space, pasture lands might be expected to confer greater value than either crops or forests because these lands generally offer more scenic views.

Several other neighborhood variables are included in the model in order to control for variation in other aspects of location. Two additional measures of land use spillovers are included to capture the externality effects of development: the percent of surrounding land within a 400-meter radius that is in low density residential land use (LOWDRES) and in commercial or industrial land use (COMIND). Depending on the mix of spillovers, these surrounding land uses may either increase or decrease the value of a residential property. The location of parcels relative to major urban centers is likely to matter. Measures of the distance via the major roads network to the two major centers in

the study area, Washington D.C. (DISTDC) and Baltimore, MD (DISTBA), are included. Several socioeconomic variables, taken from the 1990 *U.S. Census of Population* and measured at the block group level, are included as measures of neighborhood quality: median household income (MHHINC), population density (POPDEN), the percent of the neighborhood population that is African American (BLPOP), and the percent of the neighborhood population that has some education beyond high school (EDUGHS). *A priori*, we expect that residential sales price will decrease with population density and the percentage of the population that is African American and increase with median household income and the education level of the population. Most public services are provided on a county level in Maryland. To control for differences in these services, we include county dummies for three of the four counties in the study area: Calvert (CA), Charles (CH), and Howard (HO) counties.

In addition to variation across neighborhood and locational attributes, variation across the housing stock is also likely to be significant. A number of different structural attributes are included in order to control for this. These include an index variable that rates the grade of the dwelling unit on a scale of 0-9, with 9 being the highest grade (DWGRADE); a dummy variable indicating whether the dwelling is a detached unit (DWTYPE); number of full baths (BATHS\_FU); number of half baths (BATHS\_HA); the square feet of the structure (AREA); the footprint of the house (FTPRNT); the age of the house (AGE); and the year of the sale (YRSALE). Lastly, lot size is hypothesized to influence the residential value of a property (LSIZE).

Estimates from the OLS regression are presented in Table 1. All of the housing attributes are significant at the .0001 level and are of the expected sign. Residential

housing price is increasing in the grade and type of housing unit and increasing at a decreasing rate in the size of the house, as measured by the footprint and number of square feet, as well as the size of the lot. In addition, sales price is decreasing at a decreasing rate with the age of the house. All of the locational variables are significant at the .0001 level and most are of the expected sign as well. The value of a residential property is found to be increasing at a decreasing rate in the median income level of households living within the block group in which the property is located and decreasing at a decreasing rate in the population density of the same area. Price is increasing in the percent of the local population that has attained an educational level greater than high school and decreasing in the proportion of the local population that is African American. Consistent with the basic premise of the urban bid rent model, residential prices are decreasing, at a decreasing rate, with distance from the major urban center of Washington D.C. Counter to expectations, a positive bid-rent gradient is found for Baltimore, the other major urban center in the study region. This is likely the result of the particular land uses that are located just south of Baltimore, which include large industrial sites and a large international airport. Given that the majority of the study area lies south of Baltimore, these undesirable land uses may be driving the positive price gradient. All three of the county dummies included in the model are negative and significant, reflecting the fact that these counties are less desirable as a residential location than Anne Arundel County, *ceteris paribus*.

Of primary interest are the measures of land use spillovers and in particular, the open space measures. Both the privately owned conservation lands and publicly owned open space (CONSV and PUBLIC) are found to have a positive and significant effect on

the value of neighboring residential properties. However, the coefficients associated with privately owned open space that is developable and in crops (CROP) and pasture (PAST) land uses are positive, but not at all significant. In addition, the coefficient on privately owned forests (FOREST) is negative and insignificant. Other land use spillovers are found to have a significant effect: low density residential land use (LOWDRES) is estimated to have a positive influence on neighboring residential housing values and commercial/industrial land uses (COMIND) a negative effect.

As discussed earlier, the estimated OLS coefficients associated with neighboring land uses that are a part of the residential land market may be biased due to an endogeneity problem. A joint Hausman specification test of the coefficients associated with CROP, PAST, FOREST, LOWDRES, and COMIND shows that the OLS estimates are significantly different from instrumental variables (IV) estimates, confirming the suspicion that these variables are endogenous to the residential housing market.<sup>2</sup> The IV estimation is performed using exogenous features of the landscape as instruments. These variables are correlated with the spatial pattern of these land uses, but are believed to be exogenous to the residential housing market. They include the parcel's slope and the soil's drainage ability; whether the parcel has high quality soils - a proxy for the opportunity cost of development; and distance from the two urban centers (in log form).

Results from the instrumental variables estimation are reported in Table 2. The estimated coefficients associated with housing, locational and neighborhood socioeconomic characteristics remain unchanged in sign and significance. In addition, the estimated influence of privately owned conserved open space and publicly owned lands (CONSV and PUBLIC) remains positive and significant, although both coefficients

have decreased somewhat in significance level. In contrast to the OLS estimates, the coefficients associated with the instrumented land use measures are now significant. The coefficients associated with the two measures of agricultural open space, CROP and PAST, are positive and significant at the .0001 and .01 levels respectively. Counter to expectations, the coefficient associated with surrounding forested lands (FOREST), is negative and significantly different from zero. Lastly, while the influence of surrounding commercial/industrial land uses continues to have a negative and significant effect on residential value, surrounding low density residential land is now estimated to have a negative and significant effect on residential values (at the .03 level).

To evaluate the marginal values of these open space effects, the estimates from Table 2 and the mean values of all explanatory variables are used to calculate the change in the mean property's predicted price given a one acre change in the amount of surrounding open space. Using this method, we find that an increase of one acre in the amount of privately owned conservation land increases the residential value of the mean property by approximately \$268, 0.17 percent of the predicted residential value. A similar increase in the amount of publicly owned land increases the residential value by about \$82, 0.05 percent of the predicted value. The estimated impact of a one acre increase in surrounding cropland on the value of the mean residential property is \$913 or 0.59 percent of the property's value. Alternatively, a one acre increase in the amount of surrounding pasture land is estimated to increase the residential value of a property by \$1,618 or 1.0 percent of the property's value. Lastly, a one acre increase in surrounding

forested land is found to decrease the sales price by \$388 or 0.25 percent of the property's value.

Applying large sample theory to the IV estimators, we use the chi-squared test statistic to test whether the various open space coefficients are significantly different from each other.<sup>3</sup> The results of these tests are reported in Table 3. Although the pasture land coefficient is the largest in absolute magnitude, it is not estimated with as much precision as some of the other coefficients. As a result, it is found to be not significantly different from the estimates associated with cropland, privately owned conservation lands, or public lands. On the other hand, the effect of cropland on residential value is found to be significantly larger than the effect of publicly owned lands and marginally different from the effect of privately owned conservation lands. Although the estimated effect of privately owned conservation land on residential property values is larger than the estimated effect of publicly owned land, it is not found to be significantly different. Lastly, the negative coefficient associated with surrounding forested lands is found to be significantly different from all four of the other open space coefficients.

### **The Value of Open Space Preservation vs. Development**

Estimates from the hedonic pricing model can be used to explore the implications of the results for open space preservation policies. A scenario that is particularly relevant for this study area, as well as many exurban areas of the U.S., is the value of converting farmland to low density residential development vs. preserving it as open space. The estimated coefficients and the mean values of all explanatory variables are used to calculate the value to an individual homeowner of preserving a 10-acre plot of

surrounding farmland vs. converting it to a low density residential land use. If a 10-acre plot of farmland within a 400-meter radius of a residential property is preserved as an agricultural easement (privately owned conservation land) rather than converted to low-density residential development, we find that the value of the residential property increases by \$10,428 or 6.6 percent of the mean residential value. Alternatively, if this land is purchased outright by the government and becomes public land rather than low-density housing, the benefit to the individual property owner is calculated to be \$8,577 or 5.7 percent of the mean residential value. The difference between the two types of preserved open space, \$1,851, is the windfall that the homeowner receives from the surrounding preserved area being privately vs. publicly owned. As discussed earlier, this difference may be attributable to a nuisance spillover associated with public lands. In either case, the homeowner benefits from the preservation of the farmland relative to its conversion to low-density residential development. If we consider a case in which more than one residential property is within 400 meters of the farmland, then the benefits to preserving the land would clearly increase, depending on the density of the neighboring residential development. In this study area, residential zoning in areas that still have farmland (i.e. exurban or rural areas) typically ranges from 1 to 3-acre minimum lot size. If the 10-acre parcel of farmland were located in the center of this type of residential development, then the projected increase in property values of these homes if the land was preserved as an agricultural easement vs. developed would range from \$29,198 to \$88,638 or \$2,920 to \$8,864 per acre.<sup>4</sup>

## Conclusions

Results from this analysis show that surrounding open space significantly influences the residential sales price of houses and that different types of open space have differing effects. Using an instrumental variables approach to control for the endogeneity of some of the open space variables, we find that the estimated marginal values for five different types of surrounding open space range from  $-0.25$  to  $1.0$  percent of the value of the mean property given a one acre change in the amount of the surrounding open space. Surrounding pasture land that is privately owned and potentially developable is found to convey the largest premium on residential properties. However, the estimate associated with this variable is not found to be significantly larger than the estimate of the privately held conservation lands coefficient, suggesting that, while there is not a premium associated with privately owned preserved open space relative to pasture land, there is also not a penalty. The effect of cropland on residential property values is found to be significantly larger than the effect of public lands. This suggests that on net, the potential nuisance spillovers associated with public lands outweigh the potential added benefit of living next to a preserved open space area. The negative coefficient associated with surrounding forested land could be driven by the particular mix of tree stocks in the study area. As Garrod and Willis (1992) found for their study area in Britain, certain types of trees increase the value of residential properties whereas other types may depress the value. However, the rationale for a net negative effect of forests on residential values is not obvious. This result could be an indication that the instrumental variables strategy, designed to address the endogeneity problem by breaking the correlation with the error term, did not fully resolve this problem.

The estimated marginal values associated with the different types of open space investigated in this paper certainly do not capture all of the potential values associated with open space. For example, they do not include the value that non-property owners may ascribe to open space, including the values held by visitors to public parks. In addition, they do not include any nonuse values associated with open space, e.g., the role that open space plays in protecting groundwater, wildlife habitat, and natural places. Nonetheless, they do provide insight into the value that open space confers to neighboring residential properties. Using the estimates from the model and the mean values of all explanatory variables, we find that preserving open space instead of converting it to a low-density residential land use benefits nearby homeowners by increasing the value of their residential properties. This result explains the motivation behind the attitude of many new homeowners living in exurban areas who welcome the opportunity to move to a semi-rural area, but, once they've settled in, want to prevent others from doing the same.<sup>5</sup> It provides evidence that these homeowners have a positive willingness to pay for policies that would prevent neighboring open space from being developed either by preserving the land through purchase-of-development rights programs or through government's outright purchase of the land.

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**Table 1: OLS Estimation Results**

Dependent Variable: log(price)  
 Number of Observations: 55,799

R-squared: 0.7062  
 R-squared adjusted: 0.7061

Variable	Parameter Estimate (b)	Standard Error	t-statistic H <sub>0</sub> : b = 0	Prob H <sub>0</sub> true
Intercept	4.271347	0.112992	37.802	0.0001
DWGRADE	0.160696	0.002444	65.764	0.0001
DWTYPE	0.169759	0.003964	42.827	0.0001
BATHS_FU	0.066926	0.002219	30.162	0.0001
BATHS_HA	0.045189	0.002399	18.839	0.0001
FTPRNT	0.100729	0.005605	17.972	0.0001
AREA	0.346289	0.005038	68.737	0.0001
LSIZE	0.026993	0.001543	17.493	0.0001
AGE	-0.01991	0.001024	-19.439	0.0001
YRSALE	0.02276	0.000766	29.72	0.0001
DISTBA	0.058259	0.003335	17.469	0.0001
DISTDC	-0.06171	0.004745	-13.004	0.0001
MHHINC	0.11469	0.006245	18.364	0.0001
POPDEN	-0.02833	0.001066	-26.566	0.0001
BLPOP	-0.05706	0.00912	-6.257	0.0001
EDUGHS	0.175079	0.009765	17.929	0.0001
LDRES	0.053754	0.006196	8.676	0.0001
COMIND	-0.04525	0.013176	-3.435	0.0006
CROP	0.001082	0.009825	0.11	0.9123
PAST	0.000299	0.012222	0.024	0.9805
FOREST	-0.00349	0.006422	-0.543	0.587
CONSV	0.233445	0.073753	3.165	0.0016
PUBLIC	0.078374	0.020649	3.796	0.0001
PUBAA	-0.06937	0.027216	-2.549	0.0108
CA	-0.28211	0.005729	-49.246	0.0001
CH	-0.23843	0.005388	-44.25	0.0001
HO	-0.14119	0.003614	-39.072	0.0001

**Table 2: IV Estimation Results**

Dependent Variable: log(price)  
 Number of Observations: 55,799

R-squared: 0.6212  
 R-squared adjusted: 0.6211

Variable	Parameter Estimate (b)	Standard Error	t-statistic H <sub>0</sub> : b = 0	Prob H <sub>0</sub> true
Intercept	4.492988	0.144816	31.025	0.0001
DWGRADE	0.159007	0.002966	53.618	0.0001
DWTYPE	0.164595	0.004797	34.311	0.0001
BATHS_FU	0.067896	0.002688	25.258	0.0001
BATHS_HA	0.045152	0.002906	15.535	0.0001
FTPRNT	0.09901	0.006799	14.562	0.0001
AREA	0.344704	0.006107	56.445	0.0001
LSIZE	0.028471	0.001893	15.042	0.0001
AGE	-0.0207	0.001206	-17.169	0.0001
YRSALE	0.022876	0.000926	24.694	0.0001
DISTBA	0.055066	0.004317	12.755	0.0001
DISTDC	-0.06783	0.005746	-11.804	0.0001
MHHINC	0.107268	0.007698	13.935	0.0001
POPDEN	-0.03055	0.001261	-24.219	0.0001
BLPOP	-0.07647	0.011233	-6.808	0.0001
EDUGHS	0.185924	0.01193	15.585	0.0001
LDRES	-0.146222	0.249626	-2.545	0.0109
COMIND	-0.63521	0.069523	-2.103	0.0355
CROP	0.708931	0.109769	6.458	0.0001
PAST	1.286399	0.513159	2.507	0.0122
FOREST	-0.31031	0.065183	-4.761	0.0001
CONSV	0.211792	0.08931	2.371	0.0177
PUBLIC	0.065567	0.024824	2.641	0.0083
PUBAA	-0.08353	0.033024	-2.529	0.0114
CA	-0.2756	0.007438	-37.053	0.0001
CH	-0.23884	0.006713	-35.58	0.0001
HO	-0.15044	0.004466	-33.689	0.0001

**Table 3**

$H_0$	Chi-Square Value ( $\chi^2$ )	Prob $H_0$ true
$\beta_{\text{past}} = \beta_{\text{crop}}$	1.048	> 0.100
$\beta_{\text{past}} = \beta_{\text{public}}$	2.375	> 0.100
$\beta_{\text{past}} = \beta_{\text{cons}}$	2.062	> 0.100
$\beta_{\text{past}} = \beta_{\text{forest}}$	3.034	0.100
$\beta_{\text{crop}} = \beta_{\text{public}}$	5.713	0.025
$\beta_{\text{crop}} = \beta_{\text{cons}}$	3.505	0.100
$\beta_{\text{crop}} = \beta_{\text{forest}}$	8.465	0.005
$\beta_{\text{public}} = \beta_{\text{cons}}$	1.578	> 0.100
$\beta_{\text{public}} = \beta_{\text{forest}}$	5.379	0.025
$\beta_{\text{cons}} = \beta_{\text{forest}}$	4.699	0.05

## Endnotes

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<sup>1</sup> Visual inspection of the distribution of residential properties relative to the pattern of surrounding land uses in the study area suggests that land uses within an immediate vicinity of residential parcels are contained within a 400-meter radius.

<sup>2</sup> The value of the joint Hausman test statistic is 118.81. This statistic is distributed chi-squared with five degrees of freedom and is significant at the 0.001 level.

<sup>3</sup> The chi-square test statistic is  $\chi^2 = (Rb - r)' [R(X'X)^{-1}R'] (Rb - r) / \hat{\sigma}^2$ , distributed with 1 degree of freedom, where R is a vector expressing the linear restriction to be tested, b is the estimated IV parameter vector, r = 0, and  $\hat{\sigma}^2$  is the estimated error variance.

<sup>4</sup> Assuming the 10-acre parcel is located within the center of residential development, an average of 8.5 residential properties would be within 400 meters of the parcel with 1-acre minimum lot size and an average of 2.8 properties if the minimum lot size were 3-acres.

<sup>5</sup> For anecdotal evidence of this phenomenon, see "On Edge," an article that appeared in the *Washington Post Magazine* on February 16, 1997 that documents attitudes of new homeowners in Charles County and their efforts to stop new development projects.