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The Influence of Canopy Cover on Property Values in a Small Southern US City

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Abstract. Urban forests have been shown to impact residential property values in the United States and other countries. This study demonstrates a hedonic pricing analysis estimating the impact of urban forest canopy cover on single-family residential property values using Lakeland, Tennessee, during the period of 2001 to 2005 as a typical study area for the southern United States. Canopy cover on the lot was not a significant contributor to property values. However, a 1.0% increase in canopy within buffers of 100 m, 500 m, and 1 km surrounding the lot was associated with a 0.12%, 0.17%, and 0.21% increase in home sales prices, respectively. Although the percentage increases were small, given the price of a home in areas like these, the dollar values were high. These results can be used to assist urban planners and policy makers in prioritizing forested lands for conservation and to evaluate economic effects of urban forestry policies and programs.

Keywords. Canopy Cover; Hedonic Pricing; Residential Property; Urban Forests.

INTRODUCTION

Urban forests provide a wide variety of societal goods and services such as energy conservation, improved air quality, hydrological benefits, noise reduction, human health benefits, outdoor recreation, aesthetics, and increased real estate values (Dwyer et al. 1992; Maco and McPherson 2003; Nowak et al. 2007). The impact of urban forests on real estate values can be estimated with the use of the nonmarket technique, the Hedonic Pricing Method (HPM)(Flores 2003), by assuming that the selling price of a home is a function of the structural (e.g., house size, number of bathrooms), neighborhood (e.g., housing density, school district), and environmental characteristics associated with that home (Freeman 2003). The environmental features can include proximity to open space, presence of trees, and amount of tree canopy cover (McConnell and Walls 2005; Saphores and Li 2012; Siriwardena et al. 2016). Tree canopy cover can come from a variety of urban forest types and locations, which may have varying effects on property values (Pandit et al. 2014). For instance, property values may be affected by the canopy cover from trees growing on an individual lot or from trees growing in the surrounding landscape (Sander et al. 2010). These trees may be growing in large patches (Netusil et al. 2010) or as individual street trees in the public right-of-way (Donovan and Butry 2010). Further, urban forest canopy cover may be evaluated in the context of dense urban areas with little tree cover (Saphores and Li 2012) or suburban communities with relatively high canopy levels. Studies that clarify the externality value of urban tree cover in its various forms and locations can inform decision making about urban forest programs and policies such as large-scale planting initiatives (Saphores and Li 2012).

Objectives

Hedonic pricing studies of urban forest values are regionally specific and rare for small communities (Brander and Koetse 2011) such as Lakeland, Tennessee, USA. For instance, Brander and Koetse (2011) found "important regional differences in preferences for open space." Thus, applying values from hedonic pricing studies to other regions may be problematic. In the US mid-south (defined here as Tennessee, Arkansas, and Mississippi), there are approximately 1,142 incorporated communities (US Census Bureau 2017; University of Tennessee 2019). Of those, 1,119 (98%) had fewer than 50,000 residents in the 2010 census. A literature review revealed only one urban forestry hedonic pricing study in one of those 1,119 communities, and this was an evaluation of the value of forested views (Poudyal et al. 2010). Therefore, the goal of this study on the value of canopy cover in Lakeland was to provide a unique contribution to the literature with potential applicability to a large swath of the communities in the region. Specific objectives were to determine: (1) if, and how much, urban forest canopy cover is influencing property values in locales such as Lakeland, Tennessee, and (2) what are the potential management and policy implications based on the study results.

Literature Review

HPM has been widely used in urban forestry research to evaluate positive and negative externalities of urban forests and the impact of those externalities on property values (Holmes et al. 2010; Price et al. 2010; Brander and Koetse 2011; Siriwardena et al. 2016; Song et al. 2018). Studies have varied widely in their location and research focus.

In Perth, Australia, broad-leaved street trees were shown to increase property prices by AUD $16,889 (Pandit et al. 2013). Tyrvainen (1997) found that apartments located closer to forested areas had higher property values than those located farther away in North Carelia, Finland, while in Krakow, Poland, Zygmunt and Gluszak (2015) demonstrated a 3.0% increase in property values that were 100 m closer to forested areas. Also, Anthon et al. (2005) found that residential properties in the cities of Arhus and Zealand, Denmark, that were closest to a newly planted forest had sales prices approximately 9.0% higher than those further away.

Several hedonic pricing studies have been completed in the western United States. For instance, Donovan and Butry (2010) found that street trees located in the public rights-of-way of Portland, Oregon, were associated with a 3.0% increase in home sales price. Also, in Portland, Oregon, Netusil et al. (2010) found that increasing tree cover in heavily forested neighborhoods would cause a decline in property values, potentially due to the blocking of desirable mountain or city views. However, they found that increasing tree cover in neighborhoods where trees were sparse would have the opposite effect. Mei et al. (2017) found that residents in five California communities preferred canopy cover near their homes, but demonstrated a "diminishing marginal willingness to pay for additional tree cover." In Grand County, Colorado, mountain pine beetle (*Dendroctonus ponderosae*) was shown to reduce property values by USD $648 (for every beetle-killed tree within 0.1 km from a house) (Price et al. 2010). Further, Kim and Wells (2005) found that increased tree density within 0.5 km of homes was associated with decreased property values in Flagstaff, Arizona, most likely due to the negative externality of perceived fire danger associated with dense forests in the region.

The northern and eastern United States have also had a number of hedonic pricing studies. For instance, Morales (1980) demonstrated that homes in Manchester, Connecticut, with "good" forest cover, defined as 50% to 60% mature tree cover, commanded a 6.0% to 9.0% increase in sales price over homes with no forest cover. Also, Sander et al. (2010) found that canopy cover within 100-m and 250-m buffers of homes in Ramsey and Dakota Counties, Minnesota, had a significant impact on property values, while canopy cover on the lot did not. They further noted that increasing tree cover within the adjacent neighborhoods beyond 40% to 60% led to property value decreases. In Cincinnati, Ohio, Dimke et al. (2013) found that percent canopy cover on residential lots accounted for approximately 8.5% and 9.5% of the sale value during the winter and summer, respectively. Payton et al. (2008) found the most significant positive effects from urban forests in Indianapolis, Indiana, were due to tree cover at the neighborhood level. And in West Milford, New Jersey, Holmes et al. (2010) documented the loss in residential property values due to the damage caused by the hemlock woolly adelgid (*Adelges tsuga*) infestation.

Fewer hedonic pricing studies have appeared in the southern United States. However, in Pensacola, Gainesville, Orlando, and Miami, Florida, Escobedo et al. (2015) showed how neighborhood-level tree cover had a significant influence on property values, but lot-level tree cover did not. In Athens, Georgia, Anderson and Cordell (1988) evaluated the value of front yard trees and found the presence of "landscape" trees was associated with a 3.5% to 4.5% increase in home sales prices. Also, Mansfield et al. (2005) found that increasing lot-level tree cover by 10% increased home sales price by USD $800 in North Carolina's Research Triangle. In Tennessee, Poudyal et al. (2010) found that an increase of one acre in a forested view near Nashville can increase house prices by USD $30.

METHODS

Study Area

This study took place within the municipal boundaries of Lakeland, Tennessee. Lakeland is a suburban community with approximately 10,848 residents (US Census Bureau 2011), located within Shelby County in West Tennessee (Figure 1). The median household income was $84,851 per year and median home value $232,000 (2011 USD; US Census Bureau 2011). Land use consisted of approximately 27% residential, 28% nonforestry related agricultural, 2% commercial and industrial, and 43% open space (City of Lakeland 2007a). Open spaces within the city consisted of five public parks, one private golf course, numerous common open spaces within neighborhoods, private nonindustrial woodlands, and undeveloped passive use areas such as wooded areas with walking trails and lakes (City of Lakeland 2006). To date, the private golf course remains open, and the parks system has expanded to seven public parks with the addition of one active use park and one passive use park.

At the time of study, Lakeland was typical of many small communities in the US mid-south (US Census Bureau 2017), especially the suburbs of metropolitan areas. Lakeland was similar in size to approximately 98% of the cities in Tennessee, Arkansas, and Mississippi, as previously mentioned. Further, the average house value, as reported by the US Census Bureau for 2013 to 2017, for 144 small cities surrounding metropolitan areas in the noncoastal southern US was USD $266,395 (US Census Bureau 2017), similar to Lakeland's average house value for this time frame of USD $275,465. While it would be useful to compare canopy coverage in these communities, these data were not readily available at the time of this writing. It seems apparent though that Lakeland is fairly typical of the small, southern, suburban city which is likely experiencing suburban growth at the expense of forest land.

Sample Selection

Sample sites were collected from the Certified Roll of the Shelby County Tennessee Assessor of Property.

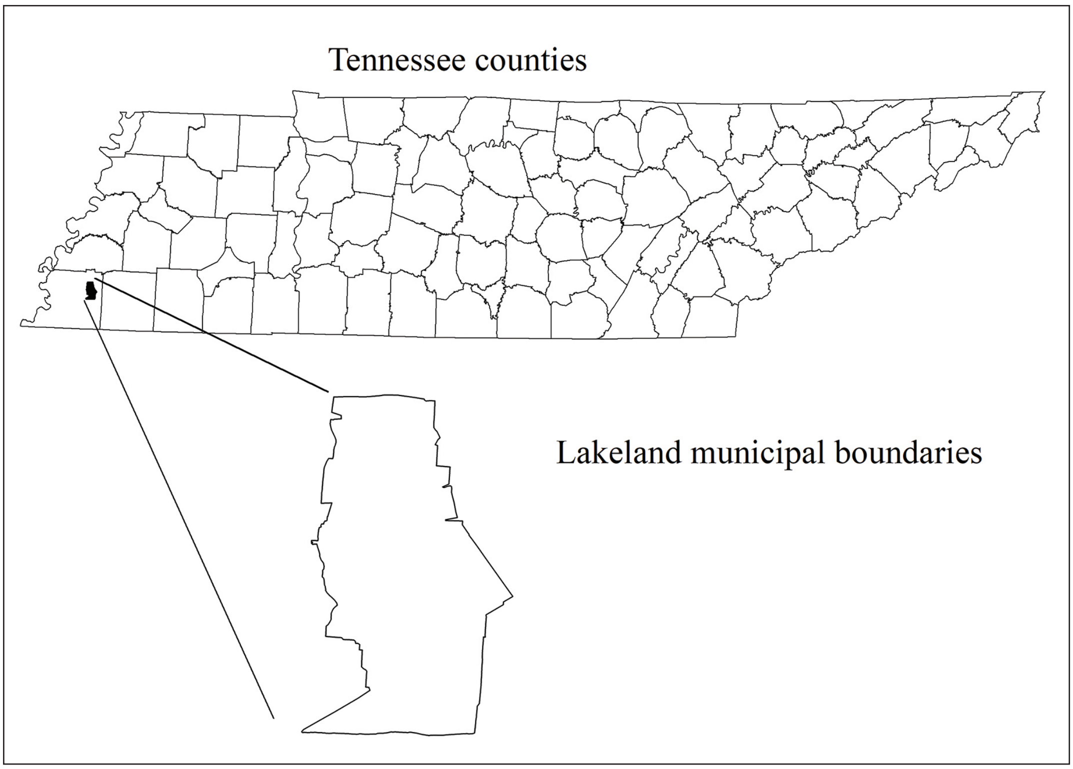

Figure 1. Location of City of Lakeland within Shelby County, Tennessee, USA.

Transactions were limited to those occurring during 2001 to 2005 to minimize influences from volatility associated with the market disruptions of 2007 and beyond (Federal Housing Finance Agency 2013), while not utilizing dates too early to accurately identify tree cover (Smith et al. 2002). While the sale period and canopy cover data reflect an earlier time period, this study can serve as a classic example of what is still occurring or about to occur in many US South communities of similar size (US Census Bureau 2017). It also was assumed that public perceptions may not be that different now versus earlier in the century, as evidenced by Lakeland's more recent passage of new land development regulations emphasizing retention of forested lands (City of Lakeland 2013a; City of Lakeland 2013b). Furthermore, our methodology remains valid for other communities to follow. The instrument type was limited to warranty deeds, and transactions were limited to those representing the sale of single family, detached residential homes. Non-arm's length transactions, as indicated in the sale value code from the tax assessor's records, were identified and removed from the sample. Parcels zoned agricultural and commercial were also removed. Finally, parcels greater than 0.5 ha were excluded to minimize the substitution effect noted by Mansfield et al. (2005), wherein large forested areas on the lot were associated with a decrease in importance of adjacent forest cover. The final sample size was $N = 1,257$, approximately 25% of all lots available in Lakeland during that time.

Data Collection

The dependent variable was chosen as the home sales price, compounded from the sale year to 2005 values and transformed by the natural logarithm as is common in the hedonic pricing literature (Taylor 2003; Donovan and Butry 2011; Sander and Haight 2012). Sales prices were gathered from the Assessor's parcel card and appended into the attribute table of each sample parcel. This amount was then compounded to 2005 levels using the interest rate from the Consumer Price Index (CPI) for the southern region during the study time period (US Bureau of Labor and Statistics 2005).

Variables on structural characteristics of the house included lot size, finished floor area, number of bathrooms, age of house at the time of sale, and presence or absence of a fireplace or pool. Data on structural variables were obtained from the Assessor's parcel data cards, which were appended into each parcel's feature class attribute table in a geographical information system (GIS) database. A brief description of each variable and its expected relationship to the dependent variable is provided (Table 1) as well as descriptive statistics for each variable (Table 2).

For this analysis, we assumed that larger lots and larger homes would command higher sales prices and that this relationship would not be linear (Taylor 2003; Boslett 2011). That is, as lot and house size increased, house prices were expected to increase at a decreasing rate. To account for this nonlinear relationship, lot and house size variables were logarithmically transformed using the natural log (Sander et al. 2010). All other structural variables were left untransformed.

In HPM studies, neighborhood variables help control for the effects of the surrounding built environment (Schlapfer et al. 2015). Neighborhood variables included distance to arterial roadways, distance to shopping center, and school districts (Tables 1 and 2). These data were collected or created using GIS software and from various City of Lakeland documents and plans.

Streets were categorized as arterial roadways based on the city's Major Road Plan (City of Lakeland 2009). Streets with a listed capacity of greater than a collector street were considered arterial as well as all streets that were four lanes or more, with posted speed limits of 72 km/hr or greater. The Euclidean distance from each sample parcel to the nearest arterial roadway was then determined using GIS proximity tools. It was assumed that, with all other variables held constant, the closer a home to an arterial roadway, the lower its value due to noise and potential traffic congestion (Lutzenhiser and Netusil 2001). However, this relationship was assumed to be nonlinear in that the negative effect of proximity to arterial roadways was expected to increase at a decreasing rate (Boslett 2011). Therefore, this variable was logarithmically transformed using the natural log.

Distance to shopping centers was calculated in a similar manner as distance to arterial roadways. Shopping centers were first identified using the Assessor's land use codes and confirmed by the City of Lakeland Zoning Map (2007b). Each property identified was visited to confirm its commercial land use. Examples of uses included in this designation were restaurants, retail centers, supermarkets, convenience centers, and shopping plazas. The GIS proximity tool was used to determine Euclidean distance in meters to the nearest shopping center from each sample parcel, and results

Table 1. Description and expected coefficient signs of variables used in the Hedonic Pricing Model for Lakeland, Tennessee, USA.

Variables	Description	Expected sign
Dependent		
Price05	Home sales price (2005 USD)	N/A
Structural		
LotSize	Lot size in square meters	Positive
HouseSize	Floor area of home in square meters	Positive
SaleAge	Age in years of home at the time of sale	Negative
Bath (#)	Number of bathrooms at the time of sale	Positive
Fireplace	Number of fireplaces	Positive
Pool	Dummy variable for presence or absence of swimming pool	Positive
Neighborhood		
NearArt	Distance in meters to nearest arterial roadway	Positive
NearC2	Distance in meters to nearest commercial business	Positive
Elem_Dist	Dummy variable for elementary school district	N/A
Middle_Dist	Dummy variable for middle school district	N/A
Environmental		
CanPER_LOT	Percent tree cover on the sample parcel	Positive
Canopy_100 m[a]	Percent tree cover within the 100-m buffer	Positive
Canopy_500 m[a]	Percent tree cover within the 500-m buffer	Positive
Canopy_1 km[a]	Percent tree cover within the 1-km buffer	Positive
DistPubPar	Distance in meters to nearest public park	Negative
DistLake	Distance in meters to nearest lake	Negative
DistGolf	Distance in meters to nearest golf course	Negative

[a] Buffers were non-overlapping.

were added to the attribute table. It was assumed that as distance to shopping centers decreased, the sales price of a home would increase, all other variables being held constant, due to the convenience of close shopping (Sander and Haight 2012). However, an increase in traffic congestion and traffic lights may counter this positive impact. As with distance to arterial roadways, distance to shopping centers was logarithmically transformed using the natural log.

School districts were digitized directly from Shelby County Schools district maps (Shelby County Schools 2013). At the time of the study, there were two elementary school districts, two middle school districts, and one high school district within Lakeland. These districts have since changed to one elementary, one middle, and one high school district. Boundaries of the elementary and middle schools for the study period were digitized in GIS. Dummy variables were used to represent different districts. This was important since schools have been shown to impact a family's decision on where to purchase a home (Chin and Foong 2006).

Tree cover was determined using heads up digitizing on a 2006 Shelby County color orthographic image obtained from the United States Department of Agriculture (USDA) Natural Resources Conservation Service's (NRCS) Geospatial Data Gateway (USDA 2006). This image was chosen due to having a date close to the study period and having resolution necessary to accurately determine tree cover, thus allowing for the analysis of conditions in the city at the transaction time. All areas of the city were digitized for canopy cover, and concentric buffers of 100 m, 100 to 500 m, and 500 m to 1 km were established around each sample parcel. To be consistent with the literature and to adjust for unequal buffer sizes, area of canopy cover (m^2) was converted to percent canopy cover on each parcel and within each of the nonoverlapping buffers (Boslett 2011; Sander and Haight 2012; Siriwardena et al. 2016). It was assumed that as canopy cover near the home increased, home sale value would also increase (Sander et al. 2010).

Euclidean distance to environmental features such as lakes, public parks, and golf courses were included,

Table 2. Descriptive statistics for variables used in the Hedonic Pricing Model for Lakeland, Tennessee, USA.

Variables	Minimums	Maximums	Means
Dependent			
Price05 (2005 USD)	$115,539	$756,884	$246,592
Structural			
LotSize (m^2)	423	3,883	1,336
HouseSize (m^2)	106	541	251
SaleAge (yrs)	0	34	5
Bath (#)	2	5	2.5
	% with	*% without*	
Fireplace	86	14	
Pool	13	87	
Neighborhood			
NearArt (m)	19	1,588	686
NearC2 (m)	1	5,402	1,465
	% Donelson	*% Lakeland*	
Elem_Dist	16	84	
	% Arlington	*% BonLin*	
Middle_Dist	53	47	
Environmental			
CanPER_LOT (%)	0	80	8
Canopy_100 m (%)[a]	0	65	12
Canopy_500 m (%)[a]	7	65	27
Canopy_1 km (%)[a]	15	67	35
DistPubPar (m)	0	744	158
DistLake (m)	0	2,840	575
DistGolf (m)	0	6,654	2,054

[a] Buffers were non-overlapping.

as these features have been shown to contribute to property values (McConnell and Walls 2005). Lakes over 1 ha were digitized using aerial imagery. City-owned parks were identified using the city's Comprehensive Land Use Plan (2007a). Parcel boundaries from the Lakeland parcel map were used to delineate the one golf course in operation at the time of the study. It was assumed that reduced distances to these environmental features would increase housing prices at a decreasing rate (Boslett 2011). Thus, these distance variables were transformed using the natural logarithm. A summary of environmental variables is provided in Tables 1 and 2.

Hedonic Price Model

An ordinary least squares (OLS) regression was used to estimate the Hedonic Pricing Model similar to Sander et al. (2010).

The equation follows as:

$$\ln P_i = \beta_0 + \beta_1 S_i + \beta_2 N_i + \beta_3 Q_i + \varepsilon_i \quad (1)$$

where the dependent variable ($\ln P_i$) is the natural log of the property sales price compounded to 2005 using the CPI (Mansfield et al. 2005), while S_i represents a vector of structural characteristics associated with the i^{th} property, N_i represents a vector of neighborhood characteristics associated with the i^{th} property, Q_i represents environmental characteristics associated with the i^{th} property, and ε_i represents the error term.

The model was then evaluated for heteroscedasticity using the Breusch-Pagan test and for spatial autocorrelation using Moran's I with a contiguity-based spatial weights matrix. Lagrange Multiplier (LM) tests were used to determine the source of spatial dependence following methods of Anselin and Rey (2014). A spatial autoregressive error model (SEM) was developed based on the LM tests and the specific nature of the spatial dependence. The SEM model generated heteroscedastic consistent standard errors as well as a new regression term to represent the spatially dependent error expression (Anselin and Rey 2014). The hedonic equation thus became:

$$\ln P_i = \beta_0 + \beta_1 S_i + \beta_2 N_i + \beta_3 Q_i + \beta_4 T_i + \lambda W\mathrm{u} + \varepsilon_i \quad (2)$$

where λ represents the coefficient of spatial autoregression, W an $n \times n$ weights matrix, u an $n \times 1$ vector of spatial error terms (Anselin and Rey 2014), T is a vector of time dummy variables for each year of the study (2001 to 2005), and all other symbols are as described in Equation 1. Time dummy variables were included to account for changes in buyer's expectations and preferences from year to year (Maddison 2008). The criterion for significance in all tests was 0.05.

RESULTS

Overall Model Performance and Fit

Measures of model performance and fit as well as statistical analyses were conducted using the spatial statistics tools within GeoDa Space software. Table 3 reports the results of all model performance statistics. The goodness of fit for the HPM was high, as indicated by an adjusted R^2 of 0.92. Both the Joint F-Statistic and Joint Wald Statistic were significant at the $P < 0.01$ level, indicating that the overall model was significant. Multi-collinearity was estimated using the Variance Inflation Factor (VIF) with the commonly

Table 3. Results of ordinary least squares regression model diagnostics and spatial dependence tests used in the Hedonic Pricing Model for Lakeland, Tennessee, USA.

	Test	Values	*P*-values
Model fit	Adjusted R^2	0.923	
Model significance	Joint F-Statistic	718.593	0.0000*
Heteroscedasticity	Breusch-Pagan	464.675	0.0000*
Spatial dependence	Moran's *I*	0.452	0.0000*
	Lagrange Multiplier (lag)	2.564	0.1093
	Lagrange Multiplier (error)	143.218	0.0000*

* Statistical significance at $P < 0.01$.
$n = 1,257$

utilized limit of 10 (Boslett 2011). The largest VIF was 4.8, and the average VIF was 2.5; thus it was assumed that multi-collinearity was not an issue in the model.

Heteroscedasticity was evaluated using the Breusch-Pagan test, which was significant at $P < 0.001$. Consistent with Sander et al. (2010) and Anselin and Rey (2014), standard errors are adjusted for the presence of heteroscedasticity within the SEM regression model. Utilizing standard errors which were considered heteroscedasticity-consistent allowed for a more confident conclusion from the regression model (Kennedy 2008). The Moran's *I* test for spatial autocorrelation was significant ($P < 0.001$) using a contiguity-based weights matrix indicating spatial clustering. This suggested that a home's sale price is at least partially explained by the price of nearby homes (Mueller and Loomis 2008). To better determine the nature of this spatial dependence, LM tests were conducted, consistent with Sander and Haight (2012). The LM test for an error source of spatial autocorrelation was significant ($P < 0.001$), but the LM test for the lag term was not ($P = 0.11$). This indicated that the spatial autocorrelation was not due to a lag process, but rather to a spatial error process (Anselin et al. 1996) likely due to a spatially correlated omitted variable (Meuller and Loomis 2008; Sander and Polasky 2009). Omitted variables can be "quite common in hedonic property value studies since it is difficult to obtain all the house characteristics that matter to consumers" (McConnell and Walls 2005) and can lead to inefficient and unconvincing estimators if not addressed (Pandit et al. 2013). Thus, a spatial autoregressive error model (SEM) was utilized to account for this spatial dependence (Anselin and Rey 2014), and a log-linear model form was utilized, which is noted to perform best in the presence of omitted variables (Cropper et al. 1988).

Model Results

All structural variables except "fireplace" were significant at the $P < 0.05$ level (Table 4) and had the expected relationship to the dependent variable. That is, as lot size (LN_Lot), house size (LN_House), and number of bathrooms (Bath) increased, sales price also increased. Presence of a pool was also associated with a higher sales price. However, as age of the home (SaleAge) increased, sales price decreased. Among the structural variables, house size had the greatest influence on sales price with a 1.0% increase in house size being associated with a 0.5% increase in sales price.

All neighborhood variables were significant at the $P < 0.05$ level, and coefficient signs all indicated expected relationships. Specifically, as distance to shopping centers (LN_Shop) and arterial roadways (LN_Art) became greater, home sales prices also increased. School districts revealed that homes in the Lakeland Elementary district had higher sales prices than those in the Donelson Elementary district, while those in the Arlington Middle district had higher prices than in the Bon Lin Middle district. The neighborhood variable with the highest influence on sales price was elementary school district, where being in the Donelson Elementary district was associated with a 9.2% decrease in sales price, holding all other variables constant.

The environmental variable, percent canopy cover on the lot (CanPerLOT), was not significant ($P = 0.5293$). The remainder of the canopy cover variables, such as cover percent in a 100-m buffer, 100-m to 500-m buffer, and 500-m to 1-km buffer surrounding the lot were all significant at the $P < 0.05$ level and had an expected relationship to the dependent variable as revealed by the coefficient sign. Specifically, as canopy percent rose, sales price also rose. Distance to lake (LN_Lake) was both significant at the $P < 0.05$ level and had the expected negative coefficient sign, indicating that homes closer to lakes sold for higher prices holding all other variables in the model constant. Distance to public parks (LN_Park) was significant at $P < 0.05$ but had an unexpected relationship with the dependent variable. Specifically, as distance to parks decreased, home sales prices also decreased. Distance to golf course was not significant at the P < 0.05 level.

The time dummy variables for 2002 (Time_01) and 2003 (Time_02) were nonsignificant ($P = 0.393$ and $P = 0.705$ respectively), but 2004 (Time_03) and 2005 (Time_04) were significant ($P = 0.006$ and $P = 0.000$ respectively)(Table 4). The coefficients for 2004 and 2005 were positive, which suggests that, all other variables being the same, homes in 2004 and 2005 sold for higher prices.

Marginal Implicit Prices

Marginal implicit price for percent tree cover was calculated as the dollar value change in home sales price for a 1.0% change in canopy cover. For example, the coefficient for canopy cover within the 100-m buffer was 0.0012194. Therefore, when assessed at the mean home value of USD $246,592 (2005), the marginal implicit price of a 1.0% increase in tree cover within the 100-m buffer translated to a $301 increase in sales price.

$$(\$246{,}592 \times 1.0012194) - \$246{,}592 = \$301 \quad (3)$$

Similarly, the coefficient of 0.0016599 suggests that a 1.0% increase in canopy cover within the 100-m to 500-m buffer was associated with an increase in sales price of $409 when evaluated at the mean sales price. The impact of canopy cover continues to grow in the 500-m to 1-km buffer, where the coefficient of 0.0020803 suggests that a 1.0% increase in canopy cover was associated with a $513 increase in sales price when evaluated at the mean sales price.

DISCUSSION

This study demonstrated that, in some instances, trees located on properties surrounding a residential lot can provide more value to residents than trees located directly on the lot. Specifically, while tree cover on the lot was not a significant contributor to home sales price, the amount of tree cover within the surrounding buffers (100 m, 100 to 500 m, and 500 m to 1 km) was associated with an increase in property values. These results were generally consistent with the literature, in that increases in tree cover near the home has typically been shown to have a positive influence on property values (Holmes et al. 2006; Boslett 2011; Sander and Haight 2012; Siriwardena et al. 2016). This study was the first to demonstrate such an effect in a small suburban community in Tennessee, Arkansas, or Mississippi, and therefore may provide policy implications for small, rapidly growing southern cities.

Canopy Cover on the Lot

Research results have been mixed on whether trees on individual properties contribute to their value compared to trees in the neighborhood. Some studies have concluded that these "yard" trees are significant to a property's value (Morales 1980; Anderson and Cordell 1988; Mansfield et al. 2005; Mei et al. 2017), while others have concluded that they are not (Holmes et al. 2006; Sander et al. 2010; Pandit et al. 2013; Escobedo et al. 2015). This study demonstrated that the value of "yard" trees should be evaluated within the context of the surrounding landscape and not in isolation. Many homes in Lakeland were 10 years old or less and had relatively low levels of canopy cover. For instance, the average lot-level canopy cover for homes 10 years old or newer at the time of sale was 5.9%, while the average for homes greater than 10 years old was 20.4%. This was likely due to newer neighborhoods being cleared in preparation for concrete slab foundations. In fact, approximately 88% of neighborhood lots 10 years old or less were cleared during construction based on aerial photo analysis. Also, any planted trees in these newer neighborhoods may not have matured to the point of providing canopy. Thus, the lack of value for tree cover on the lot shown by this study may be due to the lack of *availability* of wooded lots. Home buyers may have wanted trees when they purchased their lot but were unable to find a home with substantial tree canopy cover. This could be evaluated in future studies by examining tree planting behavior on these newer lots and by interviewing or surveying homeowners.

An alternative explanation for the lack of significance for canopy cover on the lot is that the high

Table 4. Spatial autoregressive error model results with heteroscedasticity consistent standard errors and *P*-values for each variable in the Hedonic Pricing Model for Lakeland, Tennessee, USA.

Variables	Coefficients	Standard errors	*z*-values	*P*-values
Structural				
LN_Lot	0.1044677	0.1050464	7.2766568	0.0000000***
LN_House	0.5251278	0.0191295	27.4512616	0.0000000***
SaleAge	-0.0082595	0.0009896	-8.3465279	0.0000000***
Bath	0.0369635	0.0066114	5.5908658	0.0000000***
Fireplace	0.0057857	0.0089748	-0.6446613	0.5191467
Pool	0.0317781	0.0080229	3.9609478	0.0000747***
Neighborhood				
LN_Shop	0.0276300	0.0070488	3.9198346	0.0000886***
LN_Art	0.0216532	0.0070628	3.0658142	0.0021708***
Elem_Dist	-0.0918034	0.0149187	-6.1536026	0.0000000***
Middle_Dist	0.0459017	0.0138266	3.3198083	0.0009008***
Environmental				
CanPerLOT	-0.0001774	0.0002819	-0.6291426	0.5292557
Can_100 m	0.0012194	0.0003609	3.3784164	0.0007290***
Can_100-500 m	0.0016599	0.0006279	2.6436359	0.0082021***
Can_1 km	0.0020803	0.0006118	3.4003428	0.0006730***
LN_Park	0.0093613	0.0042528	2.2012049	0.0277215**
LN_Lake	-0.0377514	0.0048158	-7.8389969	0.0000000***
LN_Golf	-0.0045363	0.0027391	-1.6561087	0.0976998*
Time Dummies				
Time_01	0.0081095	0.0094953	0.8540559	0.3930740
Time_02	0.0031504	0.0083083	0.3791934	0.7045442
Time_03	0.0238470	0.0086345	2.7618211	0.0057480***
Time_04	0.0693893	0.0096271	7.2076790	0.0000000***

* Statistical significance at $P < 0.10$.
** Statistical significance at $P < 0.05$.
*** Statistical significance at $P < 0.01$.
$n = 1{,}257$

percentage surrounding the lot acted as a substitute for yard trees. That is, having easy access to forests may have obviated the need or desire for trees on the lot. Also, homeowners may have felt that the perceived risk of yard trees failing and causing property or personal damage made them less appealing than neighborhood trees. Furthermore, the Lakeland Natural Resources Department conveyed that the surrounding forest lands were frequently used by nearby residents as informal recreational sites (N. Bridgeman, personal communication). Thus, having an abundance of neighborhood-level tree cover may have limited the importance of yard trees. This reflects Brander and Koetse (2011) who noted that the value of urban open space goes up as the resource becomes scarcer. As the city develops, and amount of tree cover changes, a follow-up study would shed light on this possibility.

Canopy Cover in the Buffers

The area within which tree cover influences property values varies in the literature (Tyrvainen and Miettinen 2000; Mansfield et al. 2005; Sander et al. 2010) with a general theme of diminishing effects as distance to tree cover from the lot becomes greater. Similar to Boslett (2011) and Sander and Haight (2012), this study found that increases in percentage of tree canopy cover within 100 m of the lot had a significant, positive influence on sales price. However, unlike these studies, this research did not find that the effect diminished with distance from the home. In fact, this study found, similar to Holmes et al. (2006) and Cho et al. (2011), that significant influences actually increased as buffer size increased. This could be due to the increased percentage of tree canopy cover within each nonoverlapping buffer. For instance, average canopy cover in the 100-m to 500-m buffer surrounding the sample parcel was 27%, more than three times greater than the average lot-level canopy cover of 8%. These neighborhood trees, located nearby but off property, may have provided a greater marginal utility than those on the lot because they provided visual, aesthetic, and perhaps recreational benefits without requiring “substantial involvement in their management” by the homeowner (Pandit et al. 2013). That is, residents may value urban forests but not want to pay for their maintenance (Saphores and Li 2012; Mei et al. 2017).

Parks and Golf Courses

Distance to public parks was a significant variable in the model but had a positive coefficient indicating that homes closer to parks sold for less holding all other variables constant. Previous studies have noted that parks can be considered amenities or liabilities depending on a number of factors, such as amounts of activity, noise, traffic, and lighting (Lutzenhiser and Netusil 2001). Also, in this study, each sample parcel was located less than 200 m from a 13-ha forested property. While this forested open space was generally private, it appears to have been serving as a de facto recreational space, as evidenced by the informal trails that were common in these areas (N. Bridgeman, personal communication), thereby providing the desired recreational opportunities to nearby residents and precluding the need or desire for public parks. Future studies could explore whether the type of open space, its attributes (e.g., structured or informal trails), and its ownership status had an impact on property values. This information would be useful for policy makers when determining which types of open spaces to prioritize for conservation and which tools to utilize, such as conservation easements, land acquisitions, or common open space requirements. These results can serve notice to other, similar communities as well in this regard.

Distance to golf courses was not a significant variable. It was anticipated that a golf course would be a positive amenity as has been noted in previous studies (Do and Grudnitski 1995; Lutzenhiser and Netusil 2001; Nicholls and Crompton 2007). However, there was only one golf course operating in Lakeland at the time of this study. Furthermore, this course was located in the southwest corner of the city across an interstate highway from most of the lots in the city, with only 8% of the sample lots abutting the course. It may simply not play a role in purchasing decisions for homeowners other than those located immediately surrounding or abutting the course.

Management Implications and Future Studies

The City of Lakeland has pursued conservation strategies in the past, focusing on maximizing tree cover either by retention of individual trees or protection of existing forest lands (City of Lakeland 2004; Lakeland Tree Management Ordinance 2004; City of Lakeland 2007a). In the future, urban and community forest managers and policy makers could use these study results to locate priority areas for tree planting or protection such that benefits would accrue to multiple properties, thereby maximizing benefits. Specifically, this study suggested that the city could have maximized benefits to the community by focusing their tree protection efforts on forest lands surrounding residential neighborhoods. It should be acknowledged, though, that these results are limited in their applicability, as the residents’ preferences for tree cover may have changed since the time of the study. In fact, future studies could evaluate the effects of the city’s conservation strategies by comparing property value effects before and after the implementation of specific policies. However, the results do suggest that there are alternative approaches to maximizing the impact of urban forest canopy cover on property values besides retention of trees on individual home lots. In fact, these results suggest that communities should consider alternatives, such as retention of forested conservation lands near residential development, as a potential method for maximizing community tree cover. These results may be applicable to other similarly sized communities.

Continuing research efforts could also use the HPM to evaluate impacts of conservation and urban forestry policies on property tax revenues (Anderson and Cordell 1988; Cho et al. 2011; Siriwardena et al. 2016; Nesbitt et al. 2017). For example, officials could model changes in canopy cover within particular parks or evaluate effects of open space conservation strategies by using estimated coefficients for canopy cover within the three nonoverlapping buffers (100 m, 100 to 500 m, and 500 m to 1 km). These coefficients could be applied to average sales prices within the buffers to model potential property value impacts and subsequent property tax revenues. As an example, estimated coefficients from this study were applied to all parcels that fell within buffers surrounding a city park to simulate a 1.0% increase in canopy cover. It was found that a total of 969 parcels would be affected by this canopy change for a total property value increase of approximately USD $300,000 (2005), *ceteris paribus*. This, in turn, translated to an annual property tax revenue increase of approximately $1,050 based on a tax assessment ratio of 0.25 and a residential property tax rate of 1.4% in place at the time. Based on the size of this park, a 1% increase in canopy equated to 121 m^2 of canopy cover, or one tree with approximately 6 m of crown spread radius, which could be achieved with one small to medium sized tree (Lakeland Tree Management Ordinance 2004).

Also, it is known that home sales have time and space components that must be addressed when developing models. Attempts in this study to control for spatial and temporal variations included the use of a spatial autoregressive error model and the use of time dummy variables. However, future studies should evaluate the effects of using spatio-temporal models with a particular emphasis on the development of weighting matrices that incorporate a temporal component similar to Maddison (2008). That is, the weights matrix should incorporate nearby home sales, but only those that sold in the recent past and are thus most likely to influence home buyers' decisions.

Finally, tree canopy was examined without reference to the landownership or land conservation status on which the trees grew. However, it was known that the majority of forested lands surrounding sample parcels were privately owned and available for development. Residents who placed value on tree cover in these surrounding lands may or may not have been aware of their ownership status or development potential. Future studies could examine whether ownership status, such as private versus public, or conservation status, such as being developable, within a conservation easement, or a public property, has an impact on the value derived from these spaces. This would help policy makers better understand the implications of their open space protection strategies.

CONCLUSIONS

Canopy cover had a positive impact on home sales prices in Lakeland, Tennessee, during the period of 2001 to 2005, even though its presence on a lot was not significant. Impacts of canopy cover in lands surrounding a lot were significant, with a 1.0% increase in neighborhood canopy cover being associated with a 0.12% to 0.17% increase in home sales prices. This may have been due to the lack of canopy cover on the relatively newer homes in this study combined with the abundance of forested lands surrounding many homes. At the time of this study, residential land use accounted for approximately 27% of the land area. Thus, if the city grows with a business-as-usual model, it is likely that these surrounding forested lands, which comprise most of the canopy cover in the buffers used for this analysis, will be converted to residential use. Subsequent reduction in canopy cover may lead to the socially optimal level of canopy cover not being achieved without policy intervention. Therefore, the city, and other similar communities, should consider strategies that encourage or require retention of tree canopy cover to maintain existing property values. Results presented here suggest that the mechanism for achieving that tree canopy retention do not necessarily require large lot development or other mechanisms to promote tree retention on residential lots. Rather, tree retention in surrounding lands can achieve a similar or greater property value effect, giving land use planners policy options when considering different land use scenarios.

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Résumé. Il a été établi que les forêts urbaines ont un impact sur la valeur foncière des propriétés résidentielles aux États-Unis ainsi que dans d'autres pays. Cette étude démontre qu'une analyse des prix hédoniques estimant l'influence de la canopée urbaine sur la valeur foncière de propriétés résidentielles unifamiliales de Lakeland, Tennessee, pour la période de 2001 à 2005, est considérée comme une zone d'étude typique pour le Sud des États-Unis. La présence de canopée sur le terrain loti n'était pas en soi un élément contribuant à la valeur de la propriété. Toutefois, une augmentation de la canopée de 1.0% dans une zone tampon de 100 m, 500 m et 1 kilomètre entourant le terrain, était associée à un accroissement du prix de vente des maisons, respectivement de 0.12%, 0.17% et de 0.21%. Bien que les augmentations en pourcentage aient été faibles, considérant le prix d'une maison dans des régions comme celles-ci, les valeurs en dollars étaient élevées. Ces conclusions peuvent être utilisées afin d'aider les urbanistes et les décideurs politiques à prioriser les sites boisés pour la conservation et à évaluer les impacts économiques des politiques et des programmes en foresterie urbaine.

Zusammenfassung. Es hat sich herausgestellt, dass städtische Wälder den Wert von Wohneigentum in den Vereinigten Staaten und anderen Ländern beeinflussen. Diese Studie zeigt eine hedonische Preisanalyse, in der der Einfluss der städtischen Waldbedeckung auf den Wert von Einfamilien-Wohneigentum geschätzt wird. Als typisches Untersuchungsgebiet für den Süden der Vereinigten Staaten wurde Lakeland, Tennessee, im Zeitraum von 2001 bis 2005 herangezogen. Die Bewaldung des Grundstücks trug nicht wesentlich zu den Grundstückswerten bei. Allerdings war eine Zunahme der Waldbedeckung um 1.0% innerhalb von Puffern von 100 m, 500 m und 1 km um das Grundstück herum mit einem Anstieg der Verkaufspreise für Eigenheime um 0.12%, 0.17% bzw. 0.21% verbunden. Obwohl die prozentualen Erhöhungen gering waren, waren die Dollarwerte angesichts des Preises für ein Haus in solchen Gebieten hoch. Diese Ergebnisse können verwendet werden, um Stadtplanern und politischen Entscheidungsträgern bei der Festlegung von Prioritäten für die Erhaltung von Waldflächen zu helfen und um die wirtschaftlichen Auswirkungen städtischer Forstpolitik und anderer Programme zu bewerten.

Resumen. Se ha demostrado que los bosques urbanos afectan los valores de las propiedades residenciales en los Estados Unidos y otros países. Este estudio demuestra un análisis hedónico de precios que estima el impacto de la cubierta del dosel de los bosques urbanos en los valores de propiedades residenciales de una sola familia, durante el período de 2001 a 2005, utilizando Lakeland, Tennessee, como un área de estudio típica para el sur de los Estados Unidos. La cobertura del dosel en el lote no fue un contribuyente significativo a los valores de propiedad. Sin embargo, un aumento del 1.0% en el dosel dentro de los buffers de 100 m, 500 m y 1 km, que rodea el lote, se asoció con un aumento del 0.12%, 0.17% y 0.21% en los precios de venta de viviendas, respectivamente. Aunque los aumentos porcentuales fueron pequeños, dado el precio de una vivienda en áreas semejantes, los valores en dólares eran altos. Estos resultados se pueden utilizar para ayudar a los planificadores urbanos y a los encargados de formular políticas a priorizar las tierras boscosas para su conservación y para evaluar los efectos económicos de las políticas y programas forestales urbanos.