Land Use Policy 26 (2009) 837–845

Contents lists available at ScienceDirect

Land Use Policy

journal homepage: www.elsevier.com/locate/landusepol

The value of views and open space: Estimates from a hedonic pricing model for Ramsey County, Minnesota, USA

Heather A. Sander[a,*], Stephen Polasky[b,1]

[a] University of Minnesota, Conservation Biology Program, Dept. of Geography, 414 Social Science Building, 267 19th Avenue S., Minneapolis, MN 55455, USA
[b] University of Minnesota, Dept. of Applied Economics, 337E Classroom Office Building, University of Minnesota, 1994 Buford Avenue, St. Paul, MN 55108, USA

ARTICLE INFO

Article history:
Received 14 December 2007
Received in revised form 9 May 2008
Accepted 22 October 2008

Keywords:
Open space
Views
Hedonic pricing
Geographic information systems (GISs)

ABSTRACT

We examined how environmental amenities, particularly views and open space access, impact residential home sales prices in Ramsey County, MN using a hedonic pricing model. Home sale prices increase with closer proximity to parks, trails, lakes, and streams. Proximity to lakes produced the greatest impact on home sale value of these distance variables, followed by parks, trails, and streams. Increasing view areal extents as well as increasing the amount of water and grassy land covers in views also resulted in increased sale prices. Increased view richness in terms of the number of different land cover types in a view reduced home sale prices. These results illustrate the importance of these environmental amenities to single-family homeowners and can be used to inform land use planning and policy decisions aimed at their preservation.

Introduction

Development decisions in the United States frequently fail to consider the values of environmental amenities. As a result, development may occur in ways that greatly reduce these amenities with negative environmental, economic, and social consequences. Communities rarely intentionally omit such amenities from their planning, rather, they fail to consider them because they lack means for incorporating them into market driven land use decision-making or because they are unaware of their values. If the values of these amenities were better-recognized and incorporated into land use planning, negative impacts associated with urbanization could be minimized. In this way, greater recognition of the economic impacts of environmental amenities could provide justification for actions that seek to preserve them.

Open space areas provide communities with numerous amenities, among them opportunities for recreation, scenic views, and even a simple absence of development (Irwin, 2002). Open space also benefits human health by providing a location for outdoor exercise or to escape the stresses of urban environments (Giles-Corti et al., 2005; Krenichyn, 2006; Maller et al., 2006; Roemmich et al., 2006; Song et al., 2007) and may provide ecological benefits, for example, by acting as habitat for wildlife or improving water or air quality. Open space is frequently reduced as communities urbanize and along with it go the public goods it provides. Recognition of the economic benefits of open space access could enable planners to accurately assess the trade off between protecting open space and allowing land to develop (Hobden et al., 2004).

While the open space benefits described above are clearly of importance to people, their value may be difficult to quantify. As a result, communities may overlook such benefits in their planning. The benefits of open space and other environmental amenities, however, may be capitalized in the sales prices of homes in a community. If so, estimates of the dollar value of these benefits can be derived by careful analysis of home prices. Indeed, the effect of open space on residential property values has been the subject of much study in the last decade and numerous studies have found that increased proximity to open space increases home sale prices. Crompton (2001) reviewed 30 studies that investigated the impact of parks on property values, finding that all but five reported positive impacts on property values. These impacts varied considerably with park attributes (e.g., area, and type), but generally could be considered to be 10–20% of property values. Crompton also found general agreement among studies that the impact of parks on home values extends at least 500 feet and, in some cases, up to 2000 feet into surrounding neighborhoods.

Studies completed since the writing of Crompton's review support the ideas that parks positively contribute to home sales prices and that this effect varies with open space type, protection status, and size (Bolitzer and Netusil, 2000; Hobden et al., 2004;

* Corresponding author. Tel.: +1 651 249 1514; fax: +1 612 624 1044.
E-mail addresses: evans324@umn.edu (H.A. Sander), polasky@umn.edu (S. Polasky).
[1] Tel.: +1 612 625 9213; fax: +1 612 625 2729.

0264-8377/$ – see front matter © 2008 Elsevier Ltd. All rights reserved.
doi:10.1016/j.landusepol.2008.10.009

Lutzenhiser and Netusil, 2001; Wu et al., 2004). For example, recent studies found that larger parks increase property values more than smaller parks (Lutzenhiser and Netusil, 2001; Tajima, 2003), natural area parks have a greater impact on home sale prices than most other park types (Lutzenhiser and Netusil, 2001), and permanently protected open space increases property values more than developable open space (Geoghegan, 2002; Irwin, 2002). Increased proximity to open space with specific natural habitat types, for instance, forest and wetland, also significantly increases home sale prices (Mahan et al., 2000; Thorsnes, 2002). In these recent studies, the impacts of open space on home sale prices vary and are difficult to compare largely because studies used different methodologies, focused on different regions and time periods, measured open space access differently, and calculated marginal implicit prices for open space access in different manners. For example, Lutzenhiser and Netusil (2001) calculated marginal implicit prices of between \$342 and \$13,916 depending on park type and distance in Portland, OR; Wu et al. (2004) calculated an increase in home value per foot of \$0.24 for a 1000 foot decrease in distance to parks in Portland, OR; and Anderson and West determined that the value of the average home increased by between \$246 and \$1790 depending on park type when the distance between a home and park were halved in the Minneapolis-St. Paul, MN area. Recent studies also indicate that other landscape conditions may influence the degree to which open space impacts property values. For example, open space was found to be of greater value in neighborhoods that were dense, high-income, high-crime, highly urban, or that had many children in the Minneapolis-St. Paul metropolitan area (Anderson and West, 2006). Because open space access is often reduced as communities develop, recognition of the positive value of such open space could be an important component of landscape planning in urbanizing communities.

The scenic quality of a landscape is also altered as urbanization occurs with consequent affects on values. Changes in scenic amenities may also be reflected in property values. Bourassa et al. (2004) reviewed 35 studies that examined the impact of views on home values. Although these authors found some variation in study conclusions, particularly in earlier studies, they noted that the bulk of studies reported that views positively impacted the values of residential homes. This impact varied widely from 1% (Beron et al., 2001) to as much as 147% (Benson et al., 1997). The authors suggest several reasons for this variation, among them that studies used different variables, types of views, and methods and were conducted in different cities at different points in time. A closer look at the studies reviewed and the few studies published since reveals that views including certain land use and land cover types impact property values considerably. These include water (Benson et al., 1998; Bishop et al., 2004; Bourassa et al., 2004; Jim and Chen, 2006; Loomis and Feldman, 2003; Luttik, 2000), urban green space areas (Bishop et al., 2004; Jim and Chen, 2006), and forests (Tyrvainen and Miettinen, 2000), all of which have been found to positively impact property values. Indeed, ocean views have been found to increase property values by as much as 60% (Benson et al., 1998). Conversely, views of industrial lands and roads have been found to negatively impact home values (Lake et al., 2000b). View structure or composition may also influence land sale prices. For example, views with more diversity (i.e., more land cover types) were found to increase property values in the state of Wyoming, USA (Bastian et al., 2002).

Some studies, however, have reported the impacts of views on property values to be insignificant. A study conducted in Glasgow, Scotland, concluded that views containing parks, water, and vegetation did not significantly influence property values (Lake et al., 2000a,b). Similarly, Paterson and Boyle (2002) found the impacts of views of agricultural land and water on property prices to be inconsequential. Thus, although views with certain characteristics do appear to positively impact property values, no general consensus exists as to the extent of these impacts (Yu et al., 2007) and the values calculated by studies are difficult to compare given that they used different methods, study areas, time frames, and means for quantifying views. Given the potentially large changes in views that occur with development, an important research question is the value of such changes as perceived by community residents. Assessing the impacts of land use and land cover changes on views is likely to become increasingly important to land use and natural resource planners. Here again, recognition of the value of this amenity could be an important component of landscape planning in urbanizing communities.

As environmental amenities are frequently negatively affected by urbanization and because this is often reflected in home sale prices, estimates of the monetary value of these impacts would serve to improve land use planning. This study identifies the degree of influence of the two environmental amenities discussed in the preceding paragraphs, view quality and open space access, on residential property values in Ramsey County, MN using a hedonic pricing model. In estimating the values of these amenities, we hope not only to illustrate their importance to residential property owners, but also to provide planners and policy makers with estimates of values that would permit them to better evaluate the impacts of land use change before decisions are made and landscape changes become irreversible. Our results may thus be used to inform land use planning so as to minimize the negative economic, social, and environmental outcomes associated with urbanization.

The hedonic price model

The hedonic price model applied in this paper uses data on housing prices along with observable characteristics of the house and the environment to estimate the marginal implicit price of each characteristic. The marginal implicit price of individual characteristics can be estimated using a multiple regression model with housing price as the dependent variable and various characteristics as explanatory variables (see Freeman, 2003 for a complete description of the hedonic pricing model). Under the assumptions that the housing market is in equilibrium and that the area studied lies within a single housing market, the estimated marginal implicit prices derived from regression coefficients represent the price an individual would be willing to pay for an additional unit of a particular characteristic holding all other characteristics constant. So, for example, the estimated value of proximity to open space could be derived from the coefficient on proximity to open space in the regression model.

We use ordinary least squares regression analysis to estimate the hedonic pricing model to relate home sale price to the parcel, structural, neighborhood, and environmental characteristics of each property. This model may be written as

$$\ln P_i = \beta_0 + \beta_1 S_i + \beta_2 N_i + \beta_3 Q_i + \varepsilon_i$$

where P_i is the price of property i, S_i is a vector of parcel and structural characteristics of property i (e.g., lot size, number of rooms, age, house style), N_i is a vector of neighborhood characteristics (e.g., neighborhood crime rate, population density, household income), Q_i is a vector of environmental characteristics (e.g., proximity to lakes, proximity to open space, views), and ε_i is an error term. The natural log of home sale value is the dependent variable. Natural logs were also used for distance variables and for lot acreage, finished square feet, and view area variables since the effect of these variables on home sale price was expected to decline with increased levels of these characteristics. Details on the estimation procedure and variables are described below.

It is important to note that although the hedonic pricing method may be used to estimate some of the value associated with environmental amenities, it typically does not provide a full estimate of value. The value estimated using the hedonic model reflects only the value of environmental amenities that accrue to the owners of single-family homes. Such benefits are typically highly localized. For example, in the case of open space, benefits valued by homeowners include access to recreational space and increased scenery and wildlife viewing opportunities (Thorsnes, 2002). Other less localized benefits, for instance pollution filtration, carbon sequestration or more general provision of public goods, are not likely to be captured by the hedonic pricing method because they are less likely to be capitalized in the values of nearby homes. As such, the hedonic pricing method can be used to provide a partial, not total, estimate of the value of many environmental amenities.

Study area and data

The study area, Ramsey County, MN, USA, is located in the east-central portion of the state (Fig. 1) in the Minneapolis-St. Paul metropolitan area. It is a largely urban county with a population of nearly 500,000. The county encompasses an area of 441 km^2 and contains 19 cities, including St. Paul, the state capital of MN. The Mississippi River runs along the south and southwestern borders of the county.

Real estate, structural and sales data used in this study came from the Metro GIS Regional Parcel Dataset. This dataset contains spatially-referenced ownership, tax, structural, and sale data for all parcels in the seven county Minneapolis-St. Paul metropolitan area. Using this dataset, we identified 5364 single-family residential properties that sold in Ramsey County in 2005. Data were screened to remove properties with incomplete or questionable attribute data. After screening, the final dataset consisted of 4918 single-family residential properties.

Both estimated market values for taxation purposes and actual sales values were available for all properties in the data set. We used actual sales values as the dependent variable in this study. Actual sales values are preferable in hedonic pricing studies as assessment values may not accurately match market prices (Freeman, 2003). The mean and median sale prices for single-family residential properties sold in 2005 were $255,955 and $222,000, respectively. Home sale prices ranged from $65,000 to $1,740,000.

We collected information on a set of structural, neighborhood, and environmental variables for each property in the dataset using a geographic information system (GIS). These variables are summarized in Table 1 along with the expected impact of each variable on home sales prices. Descriptive statistics for each variable may be found in Table 2. Data for all structural variables came from the Metro GIS Regional Parcel Dataset described above with two exceptions. Because the elevation of the land on which a property sits has previously been found to influence its sales price (Mahan et al., 2000; Wu et al., 2004), we determined the lot elevation for each property using a 10 m digital elevation map (DEM) available from the Twin Cities Metropolitan Council and GIS techniques. We also estimated a dummy (categorical) variable for each property to identify whether it was situated within the boundaries of a flood zone as determined by the Federal Emergency Management Agency (FEMA) and as indicated by a polygon dataset available from the Minnesota Department of Natural Resources. We included this variable because we felt that properties that were more prone to flooding would experience reduced sales prices due to the risk

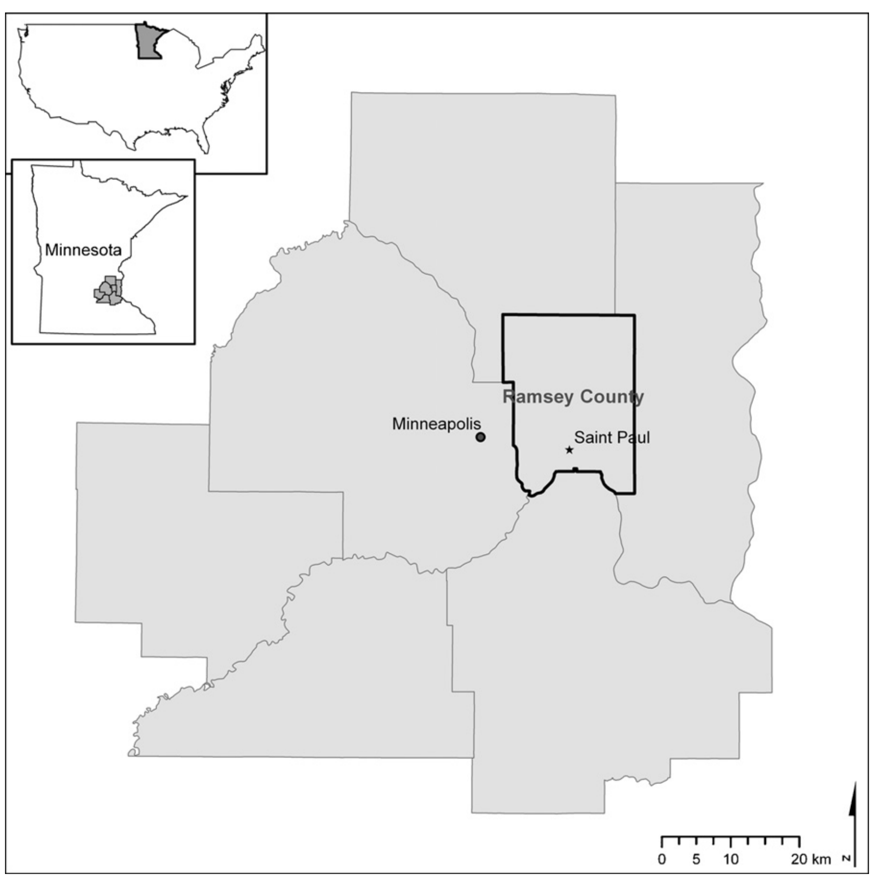

Fig. 1. Location of the study area, Ramsey County, MN.

Table 1
Definitions for study variables and expected relationship to home sale values.

Variable name	Definition	Expected relationship to sale price
Structural variables		
age	Year home was built subtracted from 2005	Positive
sqft	Finished square feet in home	Positive
acres	Lot area in acres	Positive
basement	Dummy variable indicating presence (1)/absence (0) of basement	Positive
elevation	Elevation of lot on which the home sits in feet	Positive
flood	Dummy variable indicating whether lot is in a FEMA floodway (1) or not (0)	Negative
Neighborhood variables		
busyrd	Distance to closest road with high traffic volume in m	Positive
cbd	Distance to closest central business district (Minneapolis or St. Paul) in m	Negative[a]
shop	Distance to closest shopping center in m	Positive
college	Distance to closest college or university in m	Negative[a]
mca_3rd	Average 3rd grade Minnesota Comprehensive Assessment score for local elementary school	Positive
mca_5th	Average 5th grade Minnesota Comprehensive Assessment score for local elementary school	Positive
mca_ms	Average 7th grade Minnesota Comprehensive Assessment score for local middle school	Positive
tax_rate	Tax amount divided by estimated market value of home (times 100)	Negative[a]
View variables		
viewarea	Viewshed area in square m	Positive
elev_std	Standard deviation of elevations in a viewshed (measure of relief)	Positive
view_rich	View richness calculated as percentage of possible land use and land cover types present in a viewshed	Negative[a]
per_forest	Percentage of a viewshed composed of forest	Positive
per_grassy	Percentage of a viewshed composed of grassy land covers	Positive
per_water	Percentage of a viewshed composed of water	Positive
dtstp_view	Dummy variable indicating if a property has a view of downtown St. Paul (0 if no, 1 if yes)	Positive
Open space variables		
lgpkrd	Road distance to closest park in m	Negative[a]
traileuc	Euclidean distance to closest trail in m	Negative[a]
lake	Euclidean distance to closest lake in m	Negative[a]
stream	Euclidean distance to closest stream in m	Negative[a]
Market segment variables (reference location is east St. Paul)		
nw_st_paul	Home location dummy variable (1 if northwest St. Paul, otherwise 1)	Positive
sw_st_paul	Home location dummy variable (1 if southwest St. Paul, otherwise 1)	Positive
c_st_paul	Home location dummy variable (1 if central St. Paul, otherwise 1)	Positive
sd282_623	Home location dummy variable (1 if St. Anthony-New Brighton/Roseville school districts, otherwise 1)	Positive
sd621	Home location dummy variable (1 if Mounds View school district, otherwise 1)	Positive
sd622	Home location dummy variable (1 if N. St. Paul-Maplewood school district, otherwise 1)	Positive
sd624	Home location dummy variable (1 if White Bear Lake school district, otherwise 1)	Positive

[a] For distance variables, a negative expected relationship indicates that individuals pay more to live closer to a feature.

of property damage and higher insurance rates (Bin and Polasky, 2004).

Neighborhood variables were estimated for each property using several data sources. First, as access to certain amenities and disamenities may impact home sale prices, Euclidean distances from each parcel centroid to the closest shopping center, central business district, road with a high traffic volume, and college or university were calculated using a GIS. We located shopping centers using GIS polygon files available from the Twin Cities Metropolitan Council depicting major shopping centers and central business districts using Twin Cities Metro Transit downtown fare zones for Minneapolis and St. Paul. College and university locations were identified using the Metro GIS Regional Parcel Dataset described previously and high traffic volume roads were identified from the Met Council and The Lawrence Group Functional Class Roads dataset. As home sale prices may be also influenced by the quality of neighborhood schools, we calculated the average Minnesota Comprehensive Assessment test scores for each neighborhood school at the third, fifth, and seventh grade levels to indicate school quality. We obtained test scores for the year 2005 from the Minnesota Department of Education (http://education.state.mn.us/MDE/Data/index.html) and averaged scores for each school and grade level and linked them to each residential property by their 2005 elementary and middle school district in a GIS. Because the level of taxation in a property's community has been found to impact sales prices in past studies (Mahan et al., 2000), we calculated an additional variable, tax rate, using estimated market values and tax rates from the parcel dataset.

To include the impacts of a property being located in different Ramsey County submarkets, we divided the Ramsey County housing market into a series of market segments. Initially, we delineated market segments using major school districts. This division proved reasonable for the suburbs, where there were relatively few sales and there was relatively little diversity within each district, but not for St. Paul, which has only one major school district, contained more than half of all properties sold in 2005, and has large diversity across neighborhoods. As such, we further divided St. Paul based on middle school districts, then merged adjacent school districts with similar attributes. This resulted in the creation of eight housing submarkets, listed here in order of mean residence sale price from lowest to highest: east St. Paul (reference location), central St. Paul, North St. Paul-Maplewood School District, northwest St. Paul, White Bear Lake School District, St. Anthony-New Brighton and Roseville School Districts, Mounds View School District, and southwest St. Paul. Dummy variables were used to identify each parcel's market segment.

Open space access may be assessed in several ways in hedonic pricing studies. Some studies use dummy variables to indicate the presence or absence of open space areas within a specified distance of a property (Lutzenhiser and Netusil, 2001; Netusil, 2005). More commonly, however, studies utilize continuous measurements that identify the land area or percent of open space within a specified

Table 2
Descriptive statistics for quantitative variables.

Variable name	Mean	Standard deviation	Median	Minimum	Maximum
Structural variables					
sale_value	255954.79	127018.48	222000.00	65000.00	1740500.00
age	60.02	28.59	55.00	1.00	141.00
sqft	1399.74	635.84	1226.00	440.00	7040.00
acres	0.24	0.24	0.17	0.04	4.42
elevation	919.74	44.82	921.00	720.00	1068.00
Neighborhood variables					
busyrd	137.07	138.43	110.00	0.00	1880.00
cbd	5457.53	4063.68	4418.59	0.00	18577.96
shop	1372.99	730.59	1297.88	30.00	5750.24
college	2583.69	1940.50	2115.78	8.42	9594.02
mca_3rd	1523.09	94.54	1518.15	1335.58	1732.40
mca_5th	1558.49	105.60	1563.06	1391.93	1735.23
mca_ms	1461.55	110.14	1464.28	1383.76	1525.22
tax_rate	1.00	0.16	1.00	0.52	4.32
View variables					
viewarea	160039.60	191502.81	97402.76	7087.36	2153152.83
elev_std	12.28	10.37	9.69	0.00	114.73
view_rich	30.73	13.71	31.58	5.26	73.68
per_forest	4.21	10.25	0.00	0.00	93.00
per_grassy	0.79	4.41	0.00	0.00	63.00
per_water	2.34	9.88	0.00	0.00	93.18
Open space variables					
lgpk_rd	609.46	432.37	524.30	0.00	2853.41
traileuc	612.18	256.69	452.93	0.00	4315.34
lake	958.24	758.54	721.11	0.00	3500.00
stream	1041.62	781.87	825.65	0.00	3907.86

$n = 4918$.

buffer distance from sampled properties (Geoghegan et al., 1997; Acharya and Bennett, 2001; Geoghegan, 2002; Irwin, 2002; Ready and Abdalla, 2005; Kong et al., 2007), the distance or travel time from a property to the nearest open space area (Bolitzer and Netusil, 2000; Lake et al., 2000a; Shultz and King, 2001; Tajima, 2003; Wu et al., 2004; Anderson and West, 2006; Kong et al., 2007) or the size of a property's nearest open space area (Lutzenhiser and Netusil, 2001). We chose to use the distance to each property's nearest open space area to indicate access to these areas in this study for two reasons. First, previous studies in the study area found that such distance variables contributed significantly to home sales prices (Doss and Taff, 1996; Anderson and West, 2006). Second, we felt that open space areas were likely to be accessed using road networks or, where possible, by crossing other parcels in a roughly as-the-crow-flies manner and that distance measurements would thus best approximate homeowners' perceptions of their access to open space. We believed that open space proximity would thus provide the best measure of open space access for residential parcels in the study area.

We calculated each residential parcel's proximity to open space features of interest in a GIS. These included terrestrial parks 1 ha or larger in area, recreational greenway trails, lakes, and streams as these features are often the sites of outdoor recreational activities in the Minneapolis-St. Paul Metropolitan area. To locate parks, we used a parks polygon layer created by combining data from two datasets including parks, The Lawrence Group Landmarks and Twin Cities Metropolitan Council Regional Recreation Open Space Features, and selected those parks with areas of 1 ha or greater. In this case, parks included recreational parks, wildlife refuges, nature reserves, and wildlife management areas. We identified trails using two GIS datasets, Metropolitan Council Regional and State Trails and a bikeways dataset from the Minnesota Department of Transportation. Following screening of both datasets to remove trails that used city streets and planned or proposed trails, we merged them to produce a single recreational trail dataset that included paved and unpaved recreational greenway trails. Lakes and streams were identified using GIS datasets available from the Minnesota Department of Natural Resources.

Distances were calculated within a GIS in two ways. First, we calculated Euclidean distances between the centroid of each subject residential property and the closest trail, lake, and stream. We then calculated road distances between each property and the closest large park. We calculated road distances to parks because we felt that they would better approximate homeowners perceptions of their access to open space as they would likely access these areas on roads rather than by cutting across other parcels in an as-the-crow-flies fashion. Initial model runs indicated that this was indeed the case as none showed significant results for the impact of Euclidean distance to parks on home sales prices. Thus, four open space access variables were used in the final analysis: Euclidean distances to the closest (1) trail, (2) lake, and (3) stream, and road distances to the closest (4) park.

To provide a measure of the scenic quality of the landscape surrounding each residential property, we calculated viewsheds using the VIEWSHED function in ArcGIS. This function computes the locations in a DEM that are connected to an observation location, in this case, each home sold in 2005, by a line-of-sight within a specified distance accounting for the location, height, and angle of view of the viewer in three dimensions. Because existing DEMs for the area did not include aspects of the built environment likely to obstruct views, we constructed a DEM for use in viewshed calculation using the following steps. First, we obtained a GIS dataset containing the footprints and locations of all Ramsey County buildings over 7.5 m^2 in area from the Ramsey County Surveyor's Office. We assigned a height to each building based on its land use type, if a parcel's land use classification was not residential, or based on its dwelling type, if a parcel was classified as residential, as indicated by the parcel dataset. The mean number of stories in buildings of each type was identified via visual surveys of 20 buildings of each type and multiplied by three, assuming stories to be 3 m on average, and

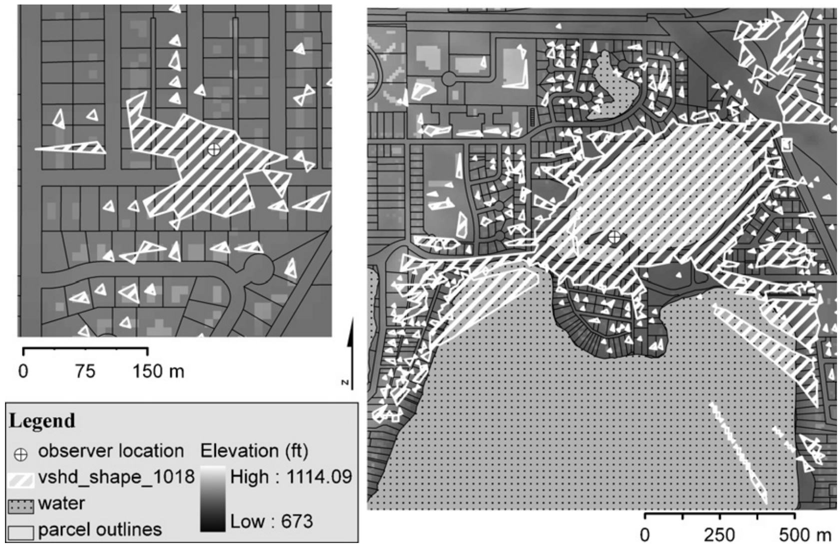

Fig. 2. Sample viewsheds.

adding 2 m to account for roof and basement offsets. Based on previous studies, we considered building heights assigned using this methodology to be representative of actual building heights (Lake et al., 2000a; Sander and Manson, 2007) so that calculated viewsheds would accurately approximate actual views. We generated a final DEM for use in viewshed calculation by converting the resulting vector layer to raster format and summing this with an existing 10 m DEM for the area available from the Twin Cities Metropolitan Council.

We calculated a viewshed for each property using the DEM created above and locating observer points at the top story of each home in each sampled parcel such that one observer point was located on each exterior surface. We specified a maximum view radius of 1000 m. Viewsheds calculated in this manner identified areas that would be visible from top story windows in each home and would likely represent each property's best view. Example viewsheds are provided in Fig. 2.

In order to incorporate the estimated viewsheds in the hedonic analysis, we calculated a series of view quality metrics for each property. The first, areal extent quantified the overall area encompassed by each view and was calculated using simple GIS techniques. We also computed metrics to quantify the composition of each property's viewshed. To identify the composition of each viewshed in term of land covers of interest, we calculated the areas of three, more natural land cover classes, forest (including areas of contiguous tree cover with minimal amounts of impervious surface), water (e.g., lakes, and streams), and grassy areas (e.g., lawns, golf courses, playing fields, prairie patches), in each viewshed using a 2005 land cover map available from the University of Minnesota's Remote Sensing and Geospatial Analysis Laboratory and computed the percentage of each viewshed composed of each of these land covers. We also computed the richness of each viewshed as the percentage of possible land cover classes it contained. For instance, a home with a viewshed containing 10 of 15 possible land cover types would have a calculated richness of 67%. This provided a measure of complexity for each view. Because views of urban cityscapes may impact property values, we also located properties with views of downtown St. Paul, that is, views that intersected Metro Transit's downtown St. Paul fare zone, and identified these using a dummy variable. Lastly, we used GIS techniques to identify the standard deviation of landscape elevations present in each view. This provided a measure of the relief, or elevation range, present in a view.

Results and discussion

Table 3 presents the results of this analysis. Residuals were examined for spatial autocorrelation by calculating Moran's *I* statistic. The resulting Moran's *I* estimate, 0.0015, was not significant ($p > 0.05$), so we did not correct for spatial autocorrelation in this estimation. We tested for heteroskedasticity using a Breusch-Pagan test. The resulting test statistic was significant at the 1% level. We corrected for this by generating heteroskedasticity-consistent standard errors using White's method (White, 1980).

All structural and neighborhood variables were statistically significant at the 5% level. All signs for structural variables and most signs for neighborhood variables were as predicted. The signs for two neighborhood variables were not as expected, those for distance to the closest central business district and distance to the closest shopping center. We had expected these variables to indicate the ease with which homeowners could access shopping and places of business. However, our results indicate that proximity to these features has other negative consequences that reduce property values. It thus seems likely that these features may have nuisance values, perhaps as a result of increased noise levels, congestion, and crime rates in their vicinities that outweigh the amenity value.

Our results clearly indicate that both open space proximity and view attributes influence home sale prices. The coefficients for most view variables were significant and positive, among them those for view area and view percent composition of water and grassy areas. The marginal implicit price of increasing the area of a home's viewshed by 100 m^2 evaluated at the mean home sale price ($255,955) and initial area of 1000 m^2 is $386. The marginal implicit prices of increasing the percentage of a home's view composed of grassy surfaces or water by 10%, evaluated at the mean home sale price, are $5517 and $7417, respectively. This illustrates a preference on the part of single-family homeowners for homes with large views including these land cover types.

Surprisingly, although the sign of the coefficient for the percentage of a view composed of forest was positive, this variable did not significantly impact home sales values, indicating that forested areas are not particularly desirable in residential views. This may be a result of the tendency for trees to restrict views. It is still possible that views that include a high proportion of tree cover, for instance, views of heavily treed residential streets, might positively influence home sale prices. However, this study examined only the influence

Table 3
Regression results.

Variable name	Est. coefficient	Standard error	*t*-Value
Structural variables			
constant	5.7963376[a]	0.28979233	20.001694
age	−0.0015039[a]	0.00015373	−9.782596
ln_sqft	0.5717987[a]	0.01005176	56.8854
ln_acres	0.1332237[a]	0.00834667	15.961286
basement	0.0791416[a]	0.03252299	2.4334057
elevation	0.0005768[a]	0.00007040	8.1926345
flood	−0.0812112[a]	0.04175447	−1.944971
Neighborhood variables			
ln_busyrd	0.0161386[a]	0.00219182	7.3631064
ln_cbd	0.0026645[b]	0.00124222	2.1449754
ln_shop	0.0229511[a]	0.00417394	5.4986527
ln_college	−0.0384366[a]	0.00426684	−9.0082033
mca_3rd	0.0004524[a]	0.00004938	9.1612123
mca_5th	0.0001652[a]	0.00004545	3.63545
mca_ms	0.0009389[a]	0.00018689	5.0239398
tax_rate	−0.0852605[a]	0.02683265	−3.1774923
View variables			
ln_viewarea	0.015095[a]	0.00443820	3.4011562
elev_std	0.0002878	0.00024630	1.1683778
view_rich	−0.0011095[a]	0.00025271	−4.3905254
per_forest	0.0001723	0.00028385	0.6071164
per_grassy	0.0021555[a]	0.00063264	3.4072016
per_water	0.0028978[a]	0.00042755	6.7777689
dtstp_view	−0.0466663[a]	0.01513651	−3.0830259
Open space variables			
ln_lgpkrd	−0.0053214[a]	0.00212533	−2.5037749
ln_traileuc	−0.0046619[a]	0.00151491	−3.0773717
ln_lake	−0.0084211[a]	0.00242615	−3.4709679
ln_stream	−0.0049768[b]	0.00235806	−2.1105395
Market segment variables (reference location is east St. Paul			
nw_st_paul	0.0530447[b]	0.02384070	2.2249629
sw_st_paul	0.3070399[a]	0.01607988	19.09466
c_st_paul	0.0322594[a]	0.00897607	3.5939302
sd282_623	−0.177884[a]	0.02671403	−6.6588224
sd621	−0.1930452[a]	0.02298509	−8.3987143
sd622	−0.1806954[a]	0.01886870	−9.5764628
sd624	−0.1818687[a]	0.02151404	−8.453491

Dependent variable = ln_price; $R^2 = 0.7915$; Adjusted $R^2 = 0.7901$; $F = 579.460$.
[a] $p < 0.01$.
[b] $p < 0.05$.

of views of forest land cover on home sale prices and did not examine the influence of views including varying amounts of tree cover in non-forested environments such as residential areas. This should be the subject of future study as the amount of tree cover visible from a property may influence its sale price.

The standard deviation of elevations found within a viewshed indicates the amount of relief in a view and was expected to positively influence home sale prices. Although this variable's coefficient had the expected sign, it was not significant ($p = 0.242711$). This indicates that the degree of relief in views does not influence home sale prices in the study area. However, the range of elevations in the study area is fairly low (less than 300 feet), so this may also be the result of low variation in this attribute in the region.

The sign of the dummy variable indicating that a property has a view of downtown St. Paul was negative, the opposite of what was expected. This relationship was significant at the 0.001 level. Calculating the marginal implicit price of downtown St. Paul views at the mean home sale price indicates that views of downtown St. Paul actually reduce home sale prices by $11,944. This, however, may result from the way in which this variable was measured and may not actually indicate negative values. Because this study used a maximum view distance of 1 km, properties located further than 1 km from downtown St. Paul were assumed not have views of the downtown area. It is possible that some of these properties actually do have views of downtown St. Paul, but this analysis identified only properties in close proximity to the downtown area as having these views. As properties near the downtown area tend to have low property values because of a number of factors, among them high crime rates, this would also explain this negative result.

The coefficient for view richness, which measures the number of land types visible, was also negative and significant. The marginal implicit price for increasing the richness of a view by 10% evaluated at the mean home sale price indicated a price decrease of $2834. This suggests a preference on the part of homeowners for views with low diversity, that is, a low number of lands cover types in view. We had expected this variable to positively impact home sale prices based on the results of a previous study that found increased diversity in views to be highly valued (Bastian et al., 2002). However, that study was conducted in Wyoming, a rural land market, where increased diversity likely corresponds to an increase in natural and agricultural land cover types visible in a view. In the Ramsey County area, where most land use and land cover classes are urban, higher view richness likely increases the number of different urban land use classes in view, making it more likely that undesirable urban land uses will be visible from a home.

The signs of all open space access variables were as expected, although not all variables were significant. This indicates that, in general, decreasing the distance to the nearest open space feature increases home sale prices. Homes located near both lakes and streams have significantly increased sale values. Evaluated at the mean home sale price and an initial distance of 1000 m, the marginal implicit price for reducing the distance to the nearest lake by 100 m produces a $216 increase in home sale value, the highest marginal implicit price of all open space feature types. Proximity to streams influenced home values to a lesser degree. The marginal implicit price for reducing the distance between a home and the closest stream by 100 m evaluated at the mean home sale price and a starting distance of 1000 m suggests a home sale price increase of $127. Thus, although it is desirable to live near a stream, it is more desirable to live near a lake.

Our results indicate that parks and trails are highly desirable features. The marginal implicit price for decreasing the road distance to the closest park by 100 m, when evaluated at an initial distance of 1000 m and the mean home sale value, indicates an increase in home sale value of $136 while the marginal implicit price for decreasing the Euclidean distance from a home to the closest trail evaluated in the same manner indicates an increase of $119. Thus, close proximity to parks on roads and to trails as-the-crow-flies increases home values. This suggests that individuals may be more inclined to access parks by roads, either by driving or walking, and perceive proximity to them on a road network. Conversely, individuals appear to consider proximity to trails in terms of straight-line distance and may not access them via roads, possibly because these features have more continuously located access points than parks. Thus, although both parks and trails do increase home sale prices, people appear to perceive and access them differently and this is reflected in the amount they pay to live near them.

Conclusions and policy implications

As urbanization intensifies in many parts of the United States, planners and policy makers will be forced to make important decisions about the arrangement and type of urban land uses in their communities. These decisions will determine the composition and arrangement of future landscapes. This, in turn, will influence the availability and condition of environmental amenities both locally and regionally. The values of these amenities should be given adequate consideration in making such decisions. Our results indicate that people value access to open space and scenic amenities. These values should be used to inform land use planning so that decisions minimize the negative economic, social, and environmental outcomes associated with urbanization.

This study provides quantitative estimates of the value of two environmental amenities that are often reduced in urbanizing communities, scenic quality and open space. Our results, like those of previous studies, clearly indicate that a preference exists for living near parks, trails, streams, and lakes. People are willing to pay more for increased proximity to these features as indicated by higher home values. In agreement with past studies, we also found that many aspects of views significantly influence home sales prices. Our findings indicate that residential homeowners pay more for views that encompass larger areas, include fewer land cover types, and include higher percentages of water and grassy land covers. Conversely, highly urban views of the downtown St. Paul cityscape significantly reduce home sale prices, although this may be an artifact of the process used in measuring this variable and may not indicate actual negative value. The values calculated for the amenities studied here alone may be enough to provide communities and developers with grounds for preserving them, but it is important to recognize that the values calculated here do not represent the total values of the amenities in question. Rather, they represent the values of these amenities as they are reflected in single-family home sales prices. As such, they do not include the values of these amenities that accrue to visitors or businesses nor are they likely to include ecological values that residents may fail to perceive directly. The total values of these amenities are thus likely to be higher than those estimated here.

These results have implications for land use planning in urban areas. Because open space access and view attributes, particularly those related to more natural land covers, positively influence home sale prices, they should be considered as communities plan their future land use. Failure to do so will not only impact the environmental amenities themselves, but will also result in negative economic, social, and ecological outcomes. Using the values calculated here could help planners to assess the tradeoffs inherent in developing to different densities and in different landscape configurations. Communities using such values in their planning could not only justify the preservation of open space features and scenic quality, but could also avoid negative economic consequences associated with lost tax revenues.

This study suggests a number of directions for future research. First, we examined the impact views with varying percent compositions of a variety of natural land cover types on home sale prices. We did not examine the impacts of views with different degrees and types of vegetated areas on home values. Although this might be difficult to accomplish on a large scale or with a large number of properties, the increasing availability of Light Detection and Ranging (LIDAR) data, from which vegetation may be extracted, may facilitate such studies. As the arrangement and type of vegetation in a home's view on a fine scale is likely to impact not only the home's sale price, but the environmental quality of its neighborhood, such studies could provide more detailed information for planners and policy makers. Also, this study did not examine the impacts of different urban land uses in views or of different combinations thereof on home sale prices and this should be explored in future studies. Additionally, it should be noted that the values of amenities will likely change over time. If development increases the scarcity of open space and other environmental amenities, these amenities may have increased value for nearby residents. On the other hand, increased provision of parks and open space may lower the marginal value of additional amenities. Studies across different regions with different scarcity of open space and other amenities would help to uncover the changing marginal value of amenities with scarcity. This subject warrants further examination in order to better inform land use planning. Lastly, this study did not look at how open space value as capitalized in home sale prices varies with neighborhood characteristics like density or distance from central business districts. Studies that examine these relationships will further serve to inform land use planning and policy so that urbanization may occur in a manner that minimizes its negative economic, social, and environmental impacts.

References

Acharya, G., Bennett, L.L., 2001. Valuing open space and land-use patterns in urban watersheds. Journal of Real Estate Finance and Economics 22 (2–3), 221–237.

Anderson, S.T., West, S.E., 2006. Open space, residential property values, and spatial context. Regional Science and Urban Economics 36 (6), 773–789.

Bastian, C.T., McLeod, D.M., Germino, M.J., Reiners, W.A., Blasko, B.J., 2002. Environmental amenities and agricultural land values: a hedonic model using geographic information systems data. Ecological Economics 40 (3), 337–349.

Benson, E.D., Hansen, J.L., Schwartz, A.L., Smersch, G.T., 1997. The influence of Canadian investment on US residential property values. Journal of Real Estate Research 13 (3), 231–249.

Benson, E.D., Hansen, J.L., Schwartz, A.L., Smersh, G.T., 1998. Pricing residential amenities: the value of a view. Journal of Real Estate Finance and Economics 16 (1), 55–73.

Beron, K., Murdoch, J., Thayer, M., 2001. The benefits of visibility improvement: new evidence from the Los Angeles metropolitan area. Journal of Real Estate Finance and Economics 22 (2–3), 319–337.

Bin, O., Polasky, S., 2004. Effects of flood hazards on property values: evidence before and after Hurricane Floyd. Land Economics 80 (4), 490–500.

Bishop, I.D., Lange, E., Mahbubul, A.M., 2004. Estimation of the influence of view components on high-rise apartment pricing using a public survey and GIS modeling. Environment and Planning B-Planning & Design 31 (3), 439–452.

Bolitzer, B., Netusil, N.R., 2000. The impact of open spaces on property values in Portland, Oregon. Journal of Environmental Management 59 (3), 185–193.

Bourassa, S.C., Hoesli, M., Sun, J., 2004. What's in a view? Environment and Planning A 36 (8), 1427–1450.

Crompton, J.L., 2001. The impact of parks on property values: a review of the empirical evidence. Journal of Leisure Research 33 (1), 1–31.

Doss, C.R., Taff, S.J., 1996. The influence of wetland type and wetland proximity on residential property values. Journal of Agricultural and Resource Economics 21 (1), 120–129.

Freeman, A.M., 2003. The Measurement of Environmental and Resource Values, Theory and Methods, 2nd ed. Resources for the Future, Washington, DC, p. 4891.

Geoghegan, J., Wainger, L.A., Bockstael, N.E., 1997. Spatial landscape indices in a hedonic framework: an ecological economics analysis using GIS. Ecological Economics 23 (3), 251–264.

Geoghegan, J., 2002. The value of open spaces in residential land use. Land Use Policy 19 (1), 91–98.

Giles-Corti, B., Broomhall, M.H., Knuiman, M., Collins, C., Douglas, K., Ng, K., Lange, A., Donovan, R.J., 2005. Increasing walking—how important is distance to, attractiveness, and size of public open space? American Journal of Preventive Medicine 28 (2), 169–176.

Hobden, D.W., Laughton, G.E., Morgan, K.E., 2004. Green space borders—a tangible benefit? Evidence from four neighbourhoods in Surrey, British Columbia, 1980–2001. Land Use Policy 21 (2), 129–138.

Irwin, E.G., 2002. The effects of open space on residential property values. Land Economics 78 (4), 465–480.

Jim, C.Y., Chen, W.Y., 2006. Impacts of urban environmental elements on residential housing prices in Guangzhou (China). Landscape and Urban Planning 78 (4), 422–434.

Kong, F., Yin, H., Nakagoshi, N., 2007. Using GIS and landscape metrics in the hedonic price modeling of the amenity value of urban green space: a case study in Jinan City, China. Landscape and Urban Planning 79 (3–4), 252–420.

Krenichyn, K., 2006. 'The only place to go and be in the city': women talk about exercise, being outdoors, and the meanings of a large urban park. Health and Place 12 (4), 631–643.

Lake, I.R., Lovett, A.A., Bateman, I.J., Day, B., 2000a. Using GIS and large-scale digital data to implement hedonic pricing studies. International Journal of Geographical Information Science 14 (6), 521–541.

Lake, I.R., Lovett, A.A., Bateman, I.J., Day, B.H., 2000b. Improving land compensation procedures via GIS and hedonic pricing. Environment and Planning C-Government and Policy 18 (6), 681–696.

Loomis, J., Feldman, M., 2003. Estimating the benefits of maintaining adequate lake levels to homeowners using the hedonic property method. Water Resources Research 39 (9), 1259.

Luttik, J., 2000. The value of trees, water and open space as reflected by house prices in the Netherlands. Landscape and Urban Planning 48 (3–4), 161–167.

Lutzenhiser, M., Netusil, N.R., 2001. The effect of open spaces on a home's sale price. Contemporary Economic Policy 19 (3), 291–298.

Mahan, B.L., Polasky, S., Adams, R.M., 2000. Valuing urban wetlands: a property price approach. Land Economics 76 (1), 100–113.

Maller, C., Townsend, M., Pryor, A., Brown, P., St Leger, L., 2006. Healthy nature healthy people: 'contact with nature' as an upstream health promotion intervention for populations. Health Promotion International 21 (1), 45–54.
Netusil, N.R., 2005. The effect of environmental zoning and amenities on property values, Portland, Oregon. Land Economics 81 (2), 227–246.
Paterson, R.W., Boyle, K.J., 2002. Out of sight, out of mind? Using GIS to incorporate visibility in hedonic property value models. Land Economics 78 (3), 417–425.
Roemmich, J.N., Epstein, L.H., Raja, S., Yin, L., Robinson, J., Winiewicz, D., 2006. Association of access to parks and recreational facilities with the physical activity of young children. Preventive Medicine 43 (6), 437–441.
Ready, R.C., Abdalla, C.W., 2005. The amenity and disamenity impacts of agriculture: estimated from a hedonic pricing model. American Journal of Agricultural Economics 87 (2), 314–326.
Sander, H.A., Manson, S.M., 2007. Heights and location of artificial structures in viewshed calculation: how close is close enough? Landscape and Urban Planning 82 (4), 257–270.
Shultz, S.D., King, D.A., 2001. The use of census data for hedonic price estimates of open-space amenities and land use. Journal of Real Estate Finance and Economics 22 (2–3), 239–252.
Song, Y., Gee, G.C., Fan, Y.L., Takeuchi, D.T., 2007. Do physical neighborhood characteristics matter in predicting traffic stress and health outcomes? Transportation Research Part F-Traffic Psychology and Behaviour 10 (2), 164–176.
Tajima, K., 2003. New estimates of the demand for urban green space: implications for valuing the environmental benefits of Boston's big dig project. Journal of Urban Affairs 25 (5), 641–655.
Thorsnes, P., 2002. The value of a suburban forest preserve: estimates from sales of vacant residential building lots. Land Economics 78 (3), 426–441.
Tyrvainen, L., Miettinen, A., 2000. Property prices and urban forest amenities. Journal of Environmental Economics and Management 39 (2), 205–223.
White, H., 1980. A heteroskedasticity-consistent covariance-matrix estimator and a direct test for heteroskedasticity. Econometrica 48 (4), 817–838.
Wu, J.J., Adams, R.M., Plantinga, A.J., 2004. Amenities in an urban equilibrium model: residential development in Portland, Oregon. Land Economics 80 (1), 19–32.
Yu, S.M., Han, S.S., Chai, C.H., 2007. Modeling the value of view in high-rise apartments: a 3D GIS approach. Environment and Planning B-Planning & Design 34 (1), 139–153.