Pricing Environmental Amenities: Economic Benefits of Vegetation, Water, and Parks

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I. Why put a price on nature?

Valuing nature in monetary terms allows us to…

- Incorporate the value of natural amenities in economic decision-making processes
- Prevent a failure to consider natural amenities in land use and development policy
- Prevent people from taking natural amenities for granted

Economic valuation studies document the value of environmental amenities, for example:

- green space in Jinan City, China and Castellon, Spain (1 - 2)
- open water in Knox County, Tennessee (3)
- tree cover, views of natural land cover, nature trails, green space, and lakes and streams in the Twin Cities Metropolitan Area of Minnesota, U.S.A. (4 - 7)

II. Inferring the price of a non-market commodity

Hedonic pricing:
The price of a market commodity as a function of a set of characteristics

- Analysts often consider home sale values in their hedonic pricing of environmental amenities
- A look at a set of some of the characteristics that determine home sale prices reveals why

Structural Characteristics

- Finished square feet
- Age
- Lot acreage

Neighborhood Characteristics

- School quality
- Traffic volume
- Scenery

Environmental Characteristics

- Green space accessibility
- Degree of tree cover
- Access to open water

→ Home Sale Price

III. Research purpose

This study aims to…

- Reveal whether or not people value different types of green space as opposed to green space in general
- Demonstrate the importance of natural land cover in urban areas
- Create a foundation for conducting future studies investigating the social, spatial, and temporal contexts in which people value nature

Using a case study approach building on previous work in the Twin Cities Metropolitan Area (TCMA) by Sander, Haight, and Polasky through…

- Considering additional classes of urban green space
- Providing a more contemporary analysis of the Twin Cities Metropolitan Area using data from 2012

IV. Hedonic price modeling

Ordinary Least Squares (OLS) linear regression

The following Ordinary Least Squares regression equation represents the hedonic price concept:

$$y = X\beta + \varepsilon$$

y: observed price of market commodity
X: variables representing a set of characteristics influencing y
β: coefficients describing the relationships between X and y
ε: difference between observed values of y and values of y predicted by $X\beta$

Simultaneous Autoregressive (SAR) modeling

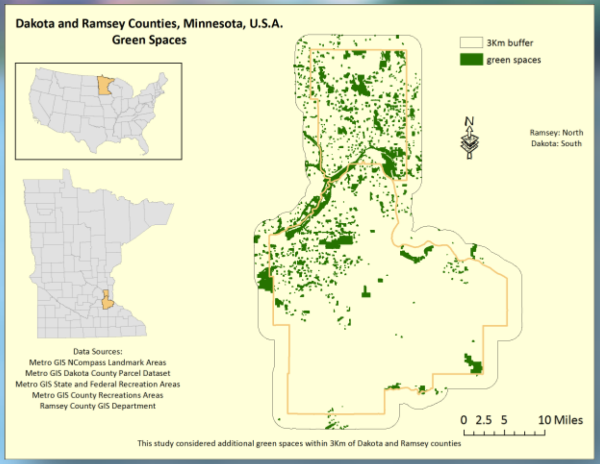
Modifying OLS regression to account for spatial autocorrelation

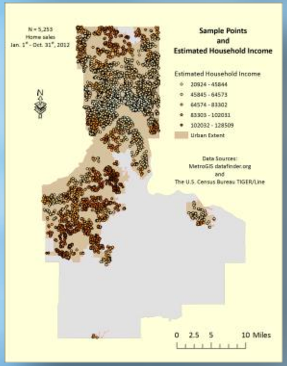
Spatial autocorrelation (SAC): When observed values are more similar or different than can be expected from random observations depending on distance from one another, inherent in most spatially-structured variables

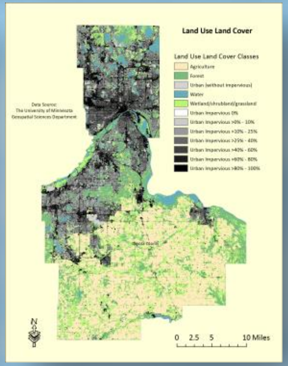
- SAC can occur among the observed values of the dependent variable, the OLS error residuals (ε), or both
- SAR lag models address the former, error models the latter, and mixed models both
- SAR models add a term to the OLS equation that represents the spatial relationship between observations as defined by the analyst
- Statistical diagnostics indicated a mixed model as most appropriate, but the software used in this analysis (GeoDa) does not support this, used error
- Added sub-market dummy variables to further mitigate effects of SAC

Source: Anselin & Bera, 1998

V. The study area

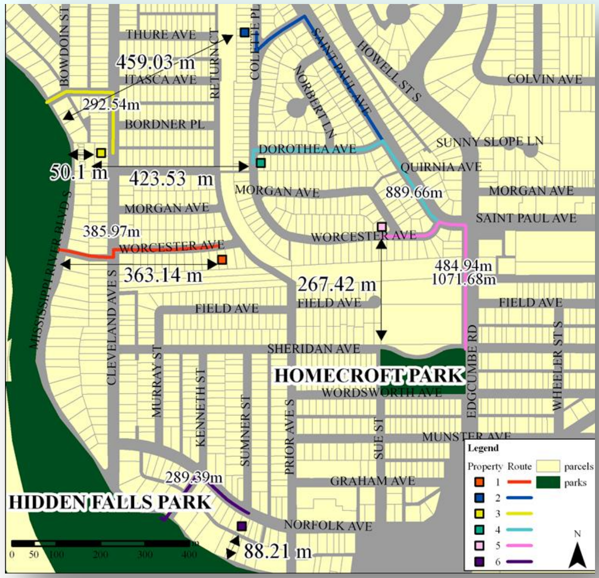






VI. Euclidean vs. network distance

Image source: Produced by Heather A. Sander based on data from the Twin Cities Metropolitan Council



VII. Model variables

Name/Type	Definition	Expected Relationship
Dependent		
SALE_VALUE ($)	dependent variable, home sale price	N/A
Structural		
GRG_SQ_FT	square footage of garage, value of 0 indicates no garage	positive
FIN_SQ_FT	home finished square footage	positive
ACRES	lot acreage	positive
AGE	home age in years	negative
Neighborhood		
MCA_AVG	average MCA* score of school attendence areas in which house is located	positive
P_ARTRL (m)	euclidean distance to nearest principal arterial road	positive
M_ARTRL (m)	euclidean distance to nearest minor arterial road	positive
MJR_C (m)	euclidean distance to nearest major connector	positive
MNR_C (m)	euclidean distance to nearest minor connector	positive
CBD (m)	euclidean distance to St. Paul or Minneapolis CBD	positive
UNI_4YR (m)	euclidean distance to nearest university or four-year college campus	positive
HHI ($)	estimated household income	positive
Environmental		
PAVG_IMP (%)	percent impervious land cover 1Km around home	negative
TRAILS (m)	euclidean distance to nearest major trail	negative
WATER (m)	euclidean distance to nearest body of water or stream	negative
LARGE (m)	road network distance to nearest mixed-use park ≥ 3 acres	negative
NATURAL (m)	road network distance to nearest natural area park	negative
SMALL (m)	road network distance to nearest mixed-use park < 3 acres	negative
ATHLETIC (m)	road network distance to nearest outdoor athletic/sports complex	negative
OLA (m)	road network distance to nearest outdoor off-leash area	negative
GOLF (m)	road network distance to nearest golf course	negative
	*MCA: Minnesota Comprehensive Assessment	

Variable	Mean	SD	Min.	Max.
SALE_VALUE	221076	142459	30000	2850000
GRG_SQ_FT	464	221	0	2112
FIN_SQ_FT	1902	921	480	14493
ACRES	0.3	0.38	0.03	11.15
AGE	51	32	0	144
MCA_AVG	110.86	11.37	85.3	131.6
P_ARTRL	1650	1496	24	13229
M_ARTRL	368	343	15	2967
MJR_C	472	491	15	3674
MNR_C	6470	4221	22	14746
CBD	11615	9322	154	51898
UNI_4YR	8562	7982	14	33501
HHI	64573	18729	20924	128509
PAVG_IMP	35.25	9.79	0.31	78.63
TRAILS	3773	4343	18	29820
WATER	566	526	0	3112
LARGE	634	497	0	4192
NATURAL	1659	1139	0	11462
SMALL	1840	1374	0	7945
ATHLETIC	3143	2053	0	22538
OLA	5088	3129	0	32465
GOLF	2749	1600	0	8795

- Euclidean distance variables measured using ArcMap 10.1 “Near Tool”
- Road network distance variables measured using ArcMap 10.1 “Network Analyst” tool suite

Data sources: Twin Cities Metropolitan Council Parcel Dataset, Minnesota Department of Education, Minnesota Population Center: School Attendance Boundary Information System (SABINS), Metro GIS: datafinder.org, Minnesota Department of Transportation, The U.S. Census Bureau, The University of Minnesota Geospatial Sciences Department,

VIII. Results

Regression coefficients

Variable	Coefficient	SE	Z-value	Probability
CONSTANT	6.6390	0.3456	19.2114	0.0000
GRG_SQ_FT*	0.0001	0.0000	7.1567	0.0000
LN_FSQ_FT*	0.6801	0.0132	51.6911	0.0000
LN_ACRES*	0.0821	0.0101	8.1020	0.0000
LN_AGE*	-0.0643	0.0058	-11.0619	0.0000
MCA_AVG*	0.0036	0.0012	2.9140	0.0036
LN_PADIS*	0.0314	0.0079	3.9542	0.0001
LN_MADIS*	0.0363	0.0048	7.6404	0.0000
LN_MJR_C*	0.0151	0.0045	3.3177	0.0009
LN_MNR_C	0.0060	0.0104	0.5743	0.5658
LN_CBD*	0.0543	0.0252	2.1513	0.0314
LN_UNI_4YR*	-0.0718	0.0124	-5.8035	0.0000
MED_HHI*	<0.0000	<0.0000	5.7940	0.0000
PAVG_IMP*	-0.0026	0.0006	-3.9760	0.0001
LN_TRAILS	-0.0117	0.0081	-1.4484	0.1475
LN_WATER*	-0.0353	0.0060	-5.8596	0.0000
LN_LARGE	-0.0030	0.0030	-1.0136	0.3108
LN_NATURAL	-0.0004	0.0035	-0.1024	0.9184
LN_SMALL	-0.0020	0.0056	-0.3551	0.7225
LN_ATH	-0.0020	0.0090	-0.2234	0.8232
LN_OLA	0.0006	0.0137	0.0445	0.9645
LN_GOLF*	-0.0179	0.0063	-2.8646	0.0042
LAMBDA	0.7591	0.0231	32.8691	0.0000

Marginal implicit prices

	Change	Response
IMP	↓10%	↑$5748
WATER	↓100m	↑$780
GOLF	↓100m	↑$396

IX. Discussion

The meaning of insignificant results, next steps

- People may not care much about particular varieties of green space, but that does not mean they do not value green space in general (findings of previous studies support this)
- Areas of local significance may exist within the study extent; trail access provides an example of this
- Green space type may have significance in a local context
- A mixed SAR model will likely provide better results
- A local analysis in addition to the global one presented here will provide valuable insight through the potential to gain an understanding of the social and geographical contexts in which people value natural amenities

X. Conclusions

- Home owners will pay a considerable premium for vegetated land cover around their home, meaning this feature plays an important role in adding value to a home
- Home owners do not appear to care much about what type of green spaces they can easily access, but rather place value on accessible green spaces in general
- This research sets the stage for future research that can reveal the social and geographical contexts in which people value environmental amenities

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