Planning for open space conservation: Using GIS to match cultural values and ecological quality of open spaces

by

Zhifang Wang

A dissertation submitted in partial fulfillment
of the requirements for the degree of
Doctor of Philosophy
(Landscape Architecture)
in The University of Michigan
2008

Doctoral Committee:
- Professor Joan I. Nassauer, Chair
- Professor Daniel G. Brown
- Professor Robert W. Marans
- Research Social Scientist Paul H. Gobster, USDA Forest Service

To my husband and son

Acknowledgements

First and foremost, I would like to express my deep gratitude to my advisor, Prof. Joan I. Nassauer, for her years of patient mentoring, financial/mental support, and invaluable advice for my personal and professional development. She is not only an advisor but also a role model for me all along my education here. I learn a lot by observing her passion in scientific reasoning, critical thinking, scrutiny in reading and writing scientific papers, hard working, enthusiasm and commitment to the field of landscape architecture. What I learn from her will continue guiding me through my future career. I also like to thank Prof. Daniel G. Brown, who is so sharp and smart to quickly get the critical but weak parts of my research both conceptually and methodologically. His questions and comments are always clear and inspiring for me to continue my research. Also, I greatly appreciated the rigor and kind heart with which Professor Robert W. Marans and Paul H. Gobster responded to both my oral and written ideas along the way. I appreciate the help and commitment of Professor Marans as my cognate committee member after his retirement from the department of urban planning. And I appreciate Paul H. Gobster for all his invaluable advice on the dissertation as a member of my committee remotely from Chicago. I would also like to thank all faculty members and students in the School of Natural Resources and Environment, for all your enthusiasm in environmental issues and dedications in exploring solutions for the sustainable future of the earth. I much more understand my role and my responsibility as a landscape architect after years of being with you all in this unique green building.

The research has been made possible in part by funding from the National Science Foundation (NSF) *Biocomplexity in the Environment Program (BCS-0119804)*, the University of Michigan Rackham Graduate School, and the University of Michigan School of Natural Resources & Environment. I much appreciate all those funding resources for me to work out my research.

Last but not least, I own a great deal to my family and particularly to my husband Peng Sun. Thanks for all the unconditional love and complete confidence in me. Your moral and emotional support had kept me going through the ups and downs during this elongated journey in finishing my TERMINAL degree.

Table of Contents

List of Figures

Figure

List of Tables

Table

Abstract

The dilemma for open space conservation in exurbia is that, while people move to exurbia for open space experiences and to be closer to environments that they perceive as natural, exurban development occupies open space and impacts the structure, function and dynamics of ecological systems. The aim of this dissertation is to explore the values associated with living near open space, which is essential to successful conservation efforts because of the critical role that human preference can play in strategic exurban planning and the future shape of broader landscape patterns.

Three issues are discussed in three Chapters. Chapter II examines how nearby open space and differences among types of open spaces, may be related to exurban residents' home-buying choices. It suggests that open space plays an important role in exurban homeowners' home-buying choices. And exurban homeowners have varied preferences for different types of open spaces, which should be designed / planed with different strategies.

Chapter III is a theoretical exploration of potential causal explanations for relationships between *preference* for having open space near one's home and *actually having* open space landuse / landcover (LULC) near one's home. It suggests that people's choice of living environment, may cause them to value nearby open space, rather than nearby open space inculcating human preference. And, maintaining forests and wetlands as a part of exurban landscapes can be part of strategic planning efforts that satisfy respondents' preference and simultaneously preserve open space as natural habitat.

Chapter IV investigates potentials and challenges of using landscape metrics to infer cultural values of landscapes. The study suggests that landscape metrics may not validly measure landcover characteristics that are related to some landscape cultural

values for many possible reasons including: inherent limitations of metrics tested, construct differences between planimetric data and landscape experience, data resolution etc.

People are generally unwilling to give up their desires and needs, but we can use what we know about human preference and need to formulate new landscape patterns. A better understanding of the values associated with living near open space will contribute to the development of new sustainable landscape patterns in exurbia.

Chapter I

Introduction

Open space conservation is challenging in exurbia, where societal desires for open space experiences may impact these very open space characteristics and their ecological services.

Exurban development has been variously defined as large lot development on previously undeveloped land (NAHB,1992), or as "discrete, areally organized subdivision[s] with an internal street pattern, located in a rural setting…far enough beyond the frontier of suburban development that it will not be engulfed by the expanding city within the foreseeable future "(Patel, 1980, p9) or as an area "within the range that commuters are willing to travel to the central city, suburban centers, or perimeter/beltway areas for work" (Nelson and Dueker, 1990, p93). In this study, we defined exurban residential development by infrastructure characteristics: homes that have their own well and septic systems, with lot sizes at least 0.5 acres, the minimum lot size required where government sewer and water infrastructure is not provided in our study area, southeast Michigan.

Exurban residential development, is expanding on the edges of urban and suburban regions throughout the US (Carruthers and Ulfarsson, 2002; Daniels and Lapping, 2005; Heimlich and Anderson, 2001; Lovaas, 2002; Zhang et al., 2008). By the end of the twentieth century, exurbia covered a larger area than urban land in America (Heimlich and Anderson, 2001; Theobald, 2001). At the same time, preference for living near open space has been identified as a driver for people moving to exurban areas (Fernandez et al., 2005; Kaplan and Austin, 2004; Vogt and Marans, 2004).

The increase in exurban residential development poses major challenges for open space conservation because this development encroaches on land previously occupied by agriculture, forests, wetlands, or other ecosystems (Burchell et al., 2002; Burchell and Mukherji, 2003; Lovaas, 2002). The rate of exurban development accelerated in 1992 to 1997 compared to the previous five years: the average annual rate of open space lost to development increased 50 percent to 2.1 million acres (Lovaas, 2002). Meanwhile, the ecological disturbance exurban development provokes is arguably much more significant than that might be caused in urban areas since exurban development occurs in a relatively less-altered landscape (Radeloff et al., 2005).

The dilemma is that, while people move to exurbia for open space experiences and to be closer to environments that they perceive as natural, exurban development occupies open space and impacts the structure, function and dynamics of ecological systems (Heimlich and Anderson, 2001). The impacts of exurban development include the loss of native biodiversity, the introduction of exotic species, increased soil erosion, and degraded water quality (Burchell et al., 2002; Collinge, 1996). This dilemma suggests that the long term availability of open space, as well as the quality of ecosystem services provided by that open space, depends on responsible planning for future exurban development that maintains the most valuable open space patterns even as development occurs.

Open space is a widely used term without a consistent definition (Appler, 2004). Open space can be defined as an area preserved or managed by local people or government (Francis et al., 1984), or a publicly-owned / publicly-accessible place for recreation or habitats (Girling and Helphand, 1994), or an unbuilt environment absent of infrastructure (Benedict and McMahon, 2002; Hollis and Fulton, 2002). In this study on exurban development, we define *open space* as unbuilt environment protected from development, such as forests, wetlands, public parkland, public playing fields, golf courses or other landuse/landcover (LULC) not served by public sewer and water infrastructure. Agricultural landscape is not considered as open space in this research because it is mostly not protected from development in southeast Michigan. Rather, agriculture is most widely converted to built uses when development occurs. Studies showed that cropland and rangeland provided more than half of the area for urban expansion (Vesterby et al., 1994).

Exurban planning for open space can aim to satisfy exurban homeowner preferences for open space experience. In addition, open space also provides other ecosystem services like habitat and water quality protection. For instance, wetlands can recharge aquifers, filter nutrients and toxics, cycle carbon and nitrogen, stabilize climates as well as serving as habitat for a large majority of the species considered endangered or threatened (Mitsch and Gosselink, 1993). Forests can regulate hydrological flow, prevent soil erosion, produce oxygen and serve as habitats (Guo et al., 2001). Nassauer (1995, 1997) has pointed out that cultural preferences and environmental values are not always aligned (especially when ecological systems are not visible or not visually pleasant), but that cultural acceptance is essential to encourage the public to sustain ecosystem services rather than changing or destroying beneficial ecosystems.

My dissertation on understanding local respondents' preferences for open space is organized as three papers, presented respectively in Chapter II, Chapter III, and Chapter IV.

Chapter II examines local exurban homeowners' stated preferences for different types of open spaces. It addresses three questions: 1) To what extent is open space important when exurban homeowners choose their homes? This part of the research replicated selected items from the questionnaire for the Detroit Area Survey (DAS) (Marans, 2003) and an analysis of its exurban respondents (Fernandez et al., 2005). 2) Which types of open spaces are more preferred by exurban homeowners? 3) Do exurban homeowners who place higher importance on living near open space prefer different types of open spaces? Answers to these research questions will help managers and policy makers plan for different open space types in exurban settings.

The primary goal of Chapter III is to explore potential causal explanations for relationships between *preferences* for having open space near one's home and *actually having* open space LULC near one's home. This study examines both *sorting* by home-buying choice as a potential cause and an exposure to nearby open space *environments* as a potential cause for homeowner preference for having nearby open space. S*orting* could occur if homeowners buy their homes in order to be nearby open spaces. It would suggest that exurban homeowners who value living near open space would be more likely to buy homes that are near more open space. In addition, an exposure to nearby open space *environments* can be a potential cause for homeowner preference for having nearby open space. If experience of open space landscape characteristics affects preference for those characteristics, exurban homeowners who actually live near open space would have stronger preferences for having open space nearby because they have had longer experience of it.

Chapter IV builds on Chapter III. Chapter III examines the association of open space preference with the composition of open space LULC near respondent homes, and Chapter IV investigates whether the configuration of open space LULC types near respondent homes is also associated with respondent open space preference. Landscape metrics were chosen to measure both landscape composition and configuration. This chapter discusses the potentials as well as the challenges of using landscape metrics to infer exurban homeowner's open space preferences. This study shares the same beliefs as Tyrväinen et al. (2007) that, if social aspects can be mapped using GIS, these values of landscape can be visible to be compared with ecological and technical aspects of planning, and it may be easier to achieve more balanced and sustainable landscape planning.

This dissertation contributes to the growing literature in understanding individual preferences for living environments and nearby open spaces in the sprawl process, particularly by investigating different preferences for varied open space types and emphasizing open space LULC near exurban homes. In addition, this research contributes to the conceptual understanding of human-landscape interactions by examining potential causal explanations for relationships between preferences for having open space near one's home and actually having open space LULC near one's home. Also, this research contributes to the understanding of the linkage between landscape metrics and landscape cultural values by examining the association of landscape metrics with one cultural value: exurban homeowner's preference for their living environment since landscape planning and management could be greatly enhanced by a better understanding of the relationship between landscape-scale factors and exurban homeowner's preference for their living environment. People are generally unwilling to give up their desires and needs, but we can use what we know about human preference and need to formulate new landscape patterns (Nassauer, 1993; Nassauer, 2005). A better understanding of the values associated with living near open space will contribute to the development of new sustainable landscape patterns in exurbia.

References:

Achs, N. (1992). Exurbia. *The American City and County* **107**, 64.

Appler, D. R. (2004). America's converging open space protection policies: evidence from New Hampshire, Virginia, and Oregon. *Urban Lawyer* **36**, 341-374.

Benedict, M. A., and McMahon, E. T. (2002). Green infrastructure: smart conservation for the 21st century. *Renewable Resource Journal* **20**, 12-17.

Burchell, R., Lowenstein, G., Dolphin, W., Galley, C., Downs, A., Seskin, S., Still, K., and Moore, T. (2002). "Cost of Sprawl-2000," Rep. No. TCRP Report 74. National Academy Press, Washington, DC.

Burchell, R. W., and Mukherji, S. (2003). Conventional development versus managed growth: the costs of sprawl. *American Journal of Public Health* **93**, 1534-1540.

Carruthers, J. I., and Ulfarsson, G. F. (2002). Fragmentation and sprawl: evidence from interregional analysis. *Growth Change* **33**, 312-340.

Collinge, S. K. (1996). Ecological consequences of habitat fragmentation: implications for landscape architecture and planning. *Landscape and Urban Planning* **36**, 59-77.

Daniels, T., and Lapping, M. (2005). Land preservation: an essential ingredient in smart growth. *Journal of Planning Literature* **19**, 316-329

Fernandez, L. E., Brown, D. G., Marans, R. W., and Nassauer, J. I. (2005). Characterizing location preferences in an exurban population: implications for Agent Based Modeling. *Environmental Planning B-Planning and Design* **32**, 799-820.

Francis, M., Cashdan, L., and Paxson, L. (1984). "Community Open Space," Island Press, Covelo, CA.

Girling, C. L., and Helphand, K. I. (1994). "Yard, Street, Park: The Design of Suburban Open Space," Joan Wiley & Sons, Inc., New York.

Guo, Z. W., Xiao, X. M., Gan, Y. L., and Zheng, Y. J. (2001). Ecosystem functions, services and their values: A case study in Xingshan County of China. *Ecological Economics*, 141-154.

Heimlich, R. E., and Anderson, W. D. (2001). "Developing the urban fringe and beyond: impacts on agriculture and rural land," Rep. No. Report Number 803. USDA Economic Research Service, Washington, DC.

Hollis, L. E., and Fulton, W. (2002). "Open space protection, conservation meets growth management." http://www.solimar.org/pdfs/hollisfultonopenspace.pdf Last retrieved on Nov 12, 2004.

Kaplan, R., and Austin, M. E. (2004). Out in the country: sprawl and the quest for nature nearby. *Landscape and Urban Planning* **69**, 235-243.

Lovaas, D. (2002). Growing up, growing out: some rust belt cities sprawl without population growth. *E: The Environmental Magazine* **13**, 14-15.

Marans, R. W. (2003). Understanding environmental quality through quality of life studies: the 2001 DAS and its use of subjective and objective indicators. *Landscape and Urban Planning* **65**, 75-85.

Mitsch, W. J., and Gosselink, J. G. (1993). "Wetlands," John Wiley and Sons, Inc., New York, NY.

Nassauer, J. I. (1993). "Ecological function and the perception of suburban residential landscapes," Rep. No. NC-163. USDA Forest Service North Central Forest Experiment Station General Technical Report, St. Paul, MN.

Nassauer, J. I. (2005). Using cultural knowledge to make new landscape patterns. *In* "Issues in Landscape Ecology" (J. A. Wiens and M. R. Moss, eds.), pp. 274-280. Cambridge University Press, Cambridge UK.

Nelson, A. C., and Dueker, K. J. (1990). The exurbanization of America and its planning policy implications. *Journal of Planning Education and Research* **9**, 91-100.

Patel, D. I. (1980). "Exurbs: Residential Development in the Countryside," University Press of America, Washington D.C.

Radeloff, V. C., Hammer, R. B., and Stewart, S. I. (2005). Rural and suburban sprawl in the U.S. Midwest from 1940 to 2000 and its relation to forest fragmentation. *Conservation Biology* **19**, 793-805.

Theobald, D. M. (2001). Land-use dynamics beyond the American urban fringe. *The Geographical Review* **91**, 544-64.

Tyrväinen, L., Mäkinen, K., and Schipperijn, J. (2007). Tools for mapping social values of urban woodlands and other green areas. *Landscape and Urban Planning* **79**, 5-19.

Vesterby, M., Heimlich, R. E., and Krupa, K. S. (1994). "Urbanization of Rural Land in the United States." AER-673. U.S. Department of Agriculture, Economic Research Service.

Vogt, C. A., and Marans, R. W. (2004). Natural resources and open space in the residential decision process: a study of recent movers to fringe counties in southeast Michigan. *Landscape and Urban Planning* **69**, 255-269.

Zhang, Y., He, H. S., and Yang, J. (2008). The wildland-urban interface dynamics in the southeastern U.S. from 1990 to 2000. *Landscape and Urban Planning* **85**, 155-162.

Chapter II

Different types of open space and their importance to exurban homeowners

Abstract

In exurbia, societal desires for open space experiences may impact these very open space characteristics and their ecological services. This paper examines how nearby open space, and differences among types of open spaces, may be related to exurban homeowners' home-buying choice. In an image-based web survey of 494 exurban homeowners in southeast Michigan, we investigated the importance of different factors in their home-buying choice and their preferences for seven different types of open spaces. Our study confirms that open space is very important to exurban homeowners in their home-buying choice, ranking second only to home price. Among seven open space types, the most preferred types are forests, lakes and streams, followed by wetlands and prairie. Playing fields and golf courses are least preferred. When we compared the perceptions of exurban homeowners who considered open space less important in choosing their current neighborhood with those who considered it more important, those who considered open space more important had significantly stronger preferences for forests, streams, lakes, wetlands and prairie open space types.

Keywords: Preference, residential development, forest, wetland, stream, planning

1. Introduction

Exurban residential development, or unsewered large lot development on previously undeveloped land, is a continuing trend in the USA. Unprecedented exurban residential development has spread out beyond urban and suburban development in many regions (Carruthers and Ulfarsson, 2002; Daniels and Lapping, 2005; Heimlich and Anderson, 2001; Lovaas, 2002; Zhang et al., 2008). One reason that people may prefer to live in exurban locations is greater exposure to open space. Increases in exurban residential development, however, have become a concern because of loss of open space (Burchell et al., 2002; Burchell and Mukherji, 2003; Lovaas, 2002). To assist managers and policy makers in considering the value of different types of open space in sustainable regional development patterns, we asked:

1) To what extent is open space important to exurban homeowners when they choose their neighborhood and homes?

2) Which types of open space are more preferred by exurban homeowners?

3) Do exurban homeowners who place higher importance on living near open space prefer different types of open spaces?

Exurban development has been variously defined as large lot development on previously undeveloped land (NAHB,1992), or as "discrete, areally organized subdivision[s] with an internal street pattern, located in a rural setting…far enough beyond the frontier of suburban development that it will not be engulfed by the expanding city within the forseeable future "(Patel, 1980) or as an area "within the range that commuters are willing to travel to the central city, suburban centers, or perimeter/beltway areas for work" (Nelson and Dueker, 1990, p93). In this study, we defined exurban residential development by infrastructure characteristics: homes that have their own well and septic systems, with lot sizes at least .5 acres, the minimum lot size required where government sewer and water infrastructure is not provided in our study area, southeast Michigan.

Open space is another widely used term without a consistent definition (Appler, 2004). Open space can be defined as an area preserved or managed by local people or government (Francis et al., 1984), or a publicly-owned / publicly-accessible place for recreation or habitats (Girling and Helphand, 1994), or an unbuilt environment absent of infrastructure (Benedict and McMahon, 2002; Hollis and Fulton, 2002). In this study on exurban development, we define *open space* as unbuilt environment protected from development, such as forests, wetlands, public parkland, public playing fields, golf courses or other landuse/landcover (LULC) not served by public sewer and water infrastructure. Agricultural landscape is not considered as open space in this research because it is mostly not protected from development in southeast Michigan. Rather, agriculture is most widely converted to built uses when development occurs. Studies showed that cropland and rangeland provided more than half of the area for urban expansion (Vesterby et al., 1994).

Exurban planning for open space can aim to satisfy exurban homeowner preferences for open space experience. In addition, open space also provides other ecosystem services like habitat and water quality protection. For instance, wetlands can recharge aquifers, filter nutrients and toxics, cycle carbon and nitrogen, stabilize climates as well as serving as habitat for a large majority of the species considered endangered or threatened (Mitsch and Gosselink, 1993). Forests can regulate hydrological flow, prevent soil erosion, produce oxygen and serve as habitats (Guo et al., 2001). Nassauer (1995, 1997) has pointed out that cultural preferences and environmental values are not always aligned (especially when ecological systems are not visible or not visually pleasant), but that cultural acceptance is essential to encourage the public to sustain ecosystem services rather than changing or destroying beneficial ecosystems.

2. Literature review

Studies of home-buying choice or home location preferences have tended to focus on location in the metropolitan pattern or effects of personal factors rather than the importance of nearby open space. A series of national surveys in the USA have consistently shown that half the American population prefers to live in an area close to a city but not in a city. Another 30% of respondents prefer to live in city and the other 20%

prefer to live in a small place far from a city (Brown et al., 1997). Other studies find that most American homebuyers prefer single-family detached dwellings in locations with low densities and ease of automobile use (e.g. Blackwood and Carpenter, 1978; Myers and Gearin, 2001; Talen, 2001).

However, nearby open space and the experience of nature is also important in home-buying choice. Exurban respondents of the Kentucky Bluegrass rated the most important aspects of their community to be peaceful, quiet surroundings; safety and low crime; open space; and closeness to nature (Patel, 1980). Similarly, a study of exurban neighborhoods in Michigan shows a strong preponderance of nature-related descriptions when respondents were asked to describe their neighborhoods to friends (Kaplan and Austin, 2004). Another report from the same study (Kaplan 2004) concludes that the availability of forests play an important role in predicting participants' ratings of community satisfaction. Analysis based on the 2001 Detroit Area Study (DAS) reports that open space is one important factor influential to home-buying choice (Fernandez et al., 2005; Vogt and Marans, 2004). The National Association of Realtors (NAR) found that 57% of their respondents, if they were in the market to buy a new home, were more likely to select a neighborhood that is close to open spaces over another one without open spaces nearby. Furthermore, 50% of respondents were willing to pay 10% more for a house located near a park or other protected open space, but only 42% were willing to pay as much as $10,000 more. Also, 80% of their respondents supported the idea of preserving farmland, natural areas, streams corridors, true wilderness areas and historic sites (NAR 2001).

Open space may influence home-buying choice, according to the results of these studies. However, when compared with other factors in home-buying choice, open space has been found to be relatively less important. Recent research from the National Association of Realtors and National Association of Home Builders (NAHB, 2002) found that price, location, and amenities were the top three factors taken into account before purchasing a house. For important features in purchasing a next home, at least 40% of people preferred houses to be spread out, less traffic in the neighborhood, lower property taxes, bigger homes, bigger lots and less developed areas (NAHB, 2002). Peiser and Schwann (1993) analyzed house prices in a Dallas neighborhood and Kopits et al. (2007)

studied 89 subdivisions in Maryland. They both concluded that people put a high value on open space, but that open space was seen as much less valuable as the large size of private lots themselves. Similarly, Vogt and Marans (2004) concluded that open space preference was not always important for homeowners. Sometimes, it can be overshadowed by considerations for neighborhood design, school, and convenience to school/work.

Other types of studies also shed light on the relative importance of different open space types for homeowners. Although they are not explicitly linked to people's home-buying choice, perception research analyzes varied preferences for different types of open spaces, and property valuation studies measure how residential property prices are affected by surrounding open spaces. In general, perception studies agree that vegetation (forests, parks, woody areas, etc.) and water features (lakes, streams, etc.) are preferred over built-up settings (e.g. Bishop and Hulse, 1994; Chiesura, 2004; Gobster, 1992, 1994; Gobster, 1999; Kaplan, 2001; Kaplan and Austin, 2004; Kaplan and Herbert, 1987; Kaplan and Talbot, 1988; Kent and Elliot, 1995; Nassauer, 1995; Shafer, 1969; Sullivan et al., 2004; Ulrich, 1986; Zube, 1974; Zube et al., 1974) and related positively to property values (Bolitzer and Netusil, 2000; Crompton, 2001; Do and Grudnitski, 1995; Garrod and Willis, 1992a; Geoghegan, 2002; Geoghegan et al., 1997; Lee and Linneman., 1998; Luttik, 2000; Lutzenhiser and Netusil, 2001; Nassauer et al., 2001; Tyrväinen and Vaananen, 1998). The effects of wetlands on perception has been mixed (Nassauer, 2004; Zube, 1975; Zube et al., 1974) and the effect on property values vary from either positive to negative depending partially on wetland types (Bin and Polasky, 2002; Bin and Polasky, 2005; Doss and Taff, 1996; Mahan et al., 2000). Playing fields seem to reduce both property values (Crompton, 2001) and preference (Kaplan and Kaplan, 1989; Ryan, 1997). Forests are reported to have more positive influence on people's preferences (Austin, 2004; Herzog, 2000) and property values (Garrod and Willis, 1992a, b; Luttik, 2000).

3. Methods

3.1 Data

The data used in this study were drawn from an image-based web survey for a larger research project about spatial land use and ecological effects at the rural-urban interface (Brown et al., 2008). In April 2005, 494 southeast Michigan homeowners were surveyed from those who lived in homes that have their own well and septic systems, with lot sizes at least 0.5 acres, the minimum lot size required where government sewer and water infrastructure is not provided in our study area, southeast Michigan. These exurban locations were operationalized by zip code and municipal boundaries: 207 zip codes in ten counties of southeast Michigan but exclude metropolitan areas like Detroit, Ann Arbor, and Flint. Our study area includes the most rapidly growing areas of Michigan. Research conducted by Southeast Michigan Council of Governments (SEMCOG) indicated that the area of developed land in seven counties increased by 17.7% during the period of 1990-2000, while the total population grew by 5%. Washtenaw and Livingston Counties grew by 26% and 50% respectively during the period of 1990-2000 (SEMCOG, 2003). Within our exurban study area, we recruited respondents who had previously agreed to receive invitations to participate in web-based surveys. This was a cluster sample of respondents who had previously agreed to receive invitations to participate in web surveys[1]. Details about the web-based survey for the larger project were summarized in another paper (Nassauer et. al in prep).

468 homeowners completed all questions in our survey. Respondents nearly all resided in exurban zip codes of ten counties in the southeast Michigan area (Figure 2.1). Their age ranged from 20 to 75, with most between 30 to 60 years old. Of all participants, 6.4% were younger than 30, and 8.8% were older than 60. No children lived in the homes of 38% of respondents. Less than half, 41.9% completed some college; and 40.5% had finished college. Half of respondents had full time jobs, 14% had part time jobs, and the other 36% of respondents were not employed. By 1980, only 9.5% had moved to their current homes, but more than half (58.6%) had moved in after 1995.

---

[1] Respondents all were volunteer members of SurveySpot, http://www.surveyspot.com/

 # Figure 2.1 approximately here

For this investigation, we used questionnaire items about:

- The importance of different factors to respondents' choices in moving to their current neighborhood and homes;
- Respondents' preferences for different types of open spaces near their homes; and
- Background and demographic characteristics including years living in that area, age, household income, number of children at home, education and employment status.

3.2 Home-buying choice

To address our first research question: To what extent is open space important to exurban homeowners when they choose their neighborhood and homes, we used items addressing the importance of different factors in homeowners' decisions to move to their current neighborhood and homes. These items replicated items in 2001 Detroit Area Survey (DAS) (Fernandez et al., 2005; Marans, 2003; Vogt and Marans, 2004), in which a four-point importance scale ranging from "very important (4)" to "not at all important (1)" was used to rate the following thirteen items: close to work, good schools, housing costs and good value, convenient to places such as shopping and schools, loss of recreational opportunities, attractive appearance of neighborhood, community size, people similar to me, appearance and layout of the dwelling, familiar with area, close to nature areas, openness and spaciousness of area, close to family and friends.

3.3 Preference for different open space types

To address our second question: Which types of open space are more preferred by exurban homeowners?, we used responses to image-based items that presented respondents with images that showed seven types of exurban open spaces of southeast Michigan: both natural-appearing open space types (forests, streams, lakes, wetlands and prairie) and more obviously-manipulated landscapes, such as golf courses and playing fields (Figure 2.2). Respondents were randomly assigned to view one of two different replicates of each type of open space. Respondents were told to rate their preference for the open space shown in each image assuming it was within 3 miles of their new home but not next to their property. They rated by a seven-point Likert scale with 1 as “strongly do not prefer” and 7 as “strongly prefer”.

Of the two sets of seven open space images (Figure 2.2), 233 respondents were randomly assigned to the first set and 235 were assigned to the second set. T-tests comparing the rating of each open space type between these two respondent groups produced no significant differences between replicates. This indicates that the specific image for each open space type, and its sequence in the questionnaire did not bias ratings. We then considered the survey as a pool of 468 respondents rating seven types of open spaces.

 # Figure 2.2 approximately here

3.4 Respondent groups

For our third research question, whether exurban homeowners who put higher importance on living near open space prefer different types of open spaces, we used the data from our first research question to divide respondents into groups who perceived open space nearby as very important, somewhat important, or relatively unimportant to their home-buying choice. The process to divide the respondents into groups is summarized in the analysis and results.

3.5 Analysis techniques

Statistical analyses for our research were executed in SPSS13.0 for Windows. To address our first research question, i.e., to what extent open space is important when exurban homeowners choose their neighborhood and homes, we replicated the technique of Fernandez et al. (2005) in their analysis of the 2001 DAS data. We employed a principal component factor analysis (PCA) with varimax rotation to generate meaningful themes among the thirteen variables measured for home-buying choice. We used factors with eigenvalues greater than 1.00 and alpha coefficients greater than 0.70. We also measured mean ratings for those thirteen variables and compared their relative importance for respondents’ decisions to move to their current neighborhood and homes. We used descriptive statistics to address our second research question, i.e., which types of open spaces are more preferred by exurban homeowners. For our third research question, whether exurban homeowners who put higher importance on living near open space in home-buying choice prefer different types of open spaces, we used the results of our PCA analysis for our first research question to divide survey respondents into groups who perceived nearby open space as very important, somewhat important, or relatively unimportant to their home-buying choice. We used K-means cluster analysis of the factor score of the open space factor to cluster respondents into these groups, and we compared their preferences for different open space types by ANOVA (Analysis of Variance between groups). Significance level of $p < 0.05$ was used and reported for all statistical tests.

4. Results

4.1 Importance of open space in home-buying choice

We found that open space is important to home-buying choice in exurban southeast Michigan. As shown in Table 2.1, from thirteen variables that respondents rated for their importance in choosing their current home, we derived four factors, which we described as open space, neighborhood design and cost, social concern, and school and recreational opportunities. The factor of *neighborhood design and cost* includes items about housing costs and good value, attractive appearance of neighborhood, and appearance and layout of the dwelling. It is most important in respondent decisions, and the mean values of individual items range from 3.37 to 3.54. Second most important is *open space*, which includes close to natural area and openness and spaciousness of area, each of which have mean ratings above 3.24. Quality of schools is also relatively important to exurban homeowners (mean=3.17). The other individual items (mean ratings below 3.0) were rated far lower than neighborhood design/cost, open space and good schools. The factor analysis result is similar to that of Fernandez et al. (2005), except that their open space factor for DAS data also includes an item about recreational opportunities.

 # Table 2.1 approximately here

Comparing the four factors, open space (eigenvalue = 3.14) was most powerful in explaining the variance of exurbanite's home-buying choice, explaining 50.5% of the total variance of the thirteen items related to individual home-buying choice.

4.2 Preferences for different open space types

The second research question is about which types of open space are more preferred by exurban homeowners. As shown in Table 2.2, forests are most preferred, followed by lakes and streams. Golf courses and playing fields, the more obviously manipulated landscapes, are least preferred. The low preference standard deviation for forests indicates that our respondents have relatively high agreement about their preference for forests. As the preference means of different types of open spaces decrease, the variances increase. This means that our respondents have more varied preferences for the generally less preferred open space types, like golf courses and playing fields. Some homeowners strongly prefer them while the others strongly dislike them. Paired samples T tests of ratings of different types of open spaces demonstrate that exurban homeowners' open space preferences can be divided into three groups by respondent ratings: most preferred open space types (forests, lakes and streams), preferred open space types (prairie and wetland), and least preferred open space types (golf courses and playing fields) (Table 2.3).

 # Table 2.2 approximately here

 # Table 2.3 approximately here

4.3 Differences among respondent groups

To investigate whether exurban homeowners who put higher importance on living near open space prefer different types of open spaces, we did K-means cluster analysis to divide respondents into respondent groups according to the factor score of open space from PCA analysis, which indicates the importance our respondents put on open space in their home-buying choice. Respondents were divided into three respondent groups: 161 exurban homeowners, i.e., "very important" respondents, were classified as putting very high importance on open space in their home-buying choice with mean factor score of 1.03. 215 respondents, having a mean factor score of 0.02 were classified as putting somewhat important on open space in their home-buying choice, i.e., “somewhat important” respondents. The remaining 92 exurban homeowners, with low mean of factor scores (m= -1.82), were classified as finding open space relatively unimportant to their home-buying choice, i.e., “unimportant” respondents.

 # Figure 2.3 approximately here

Figure 2.3 shows the mean preference rating of different open space types by the three respondent groups divided according to their different importance on open space in home-buying choice. We have three primary findings here. First, our respondents produced relatively similar preference patterns across different open space types regardless of the different importance they put on living nearby open space in their home-buying choice. Respondents who put very high important on open space in their home-buying choice most preferred forests with a mean rating of 6.68 (min=1; max=7). Streams and lakes followed with mean ratings of 6.5. For these “very important” respondents, preference for forests was not significantly different from preference for lakes and streams ($p > 0.05$). “Very important” respondents gave relatively high ratings to prairie and wetland also (mean ratings higher than 5.7). Playing fields and golf courses, the more obviously manipulated landscapes, got the lowest preference values less than 4.15 (Table 2.4). Exurban homeowners in the other two respondent groups produced similar rankings across open space types, but relatively lower mean ratings of each open space type. Forests, lakes and streams were preferred over wetlands and prairie; and wetlands and prairie were preferred over playing fields and golf courses (Table2.5 and Table 2.6). Second, as shown in Table 2.7, we found that preferences for certain open space types are significantly different among respondent groups. Compared with other respondents, “very important” respondents had significantly greater preferences for forests, streams, lakes, prairie and wetlands. The same result was found when comparing “somewhat important” respondents with “unimportant” respondents. However, playing fields and golf courses (with mean ratings around 4.1) were consistently least preferred by all exurban homeowners regardless of the importance they placed on open space in their home-buying choice. Third, we found that the most preferred type of open spaces differed across groups. Forests were most preferred by “very important” respondents; forests, streams and lakes were about equally preferred by “somewhat important” respondents; and lakes were most preferred by those who placed the lowest importance on open space in their home-buying choice.

 # Table 2.4 approximately here

 # Table 2.5 approximately here

 # Table 2.6 approximately here

 # Table 2.7 approximately here

5. Discussion

Our finding of the importance of open space in home-buying choice is consistent with many previous studies (Fernandez et al., 2005; Kaplan and Austin, 2004; Vogt and Marans, 2004). In this study, open space was second only to cost and property value as the second most important factor in choosing an exurban home, even more important than access to work or school. This finding differs from conclusions by the National Association of Home Builders (NAHB, 2002) and Vogt and Marans (2004), who found that location relative to urban features was more important than open space. Our survey targeted exurban homeowners while the others did not, and differences in our results may indicate distinct characteristics of people who live in exurban settings. For example, Crump (2003) argued that exurban respondents place more value on nearby open spaces and natural environments, while suburban respondents are more concerned with cost and access to highways.

Our finding that some open space types are preferred over others has important implications for exurban land use planning. The overarching preference for forests nearby is not a surprise considering results from many previous studies either about preferences for forests (Austin, 2004; Kaplan and Austin, 2004; Kaplan et al., 2004; Ryan, 1997; Sullivan, 1994) or increased property values due to adjacency to forests (Bolitzer and Netusil, 2000; Crompton, 2001; Garrod and Willis, 1992b; Geoghegan, 2002; Lee and Linneman., 1998). Beside forests and water (lakes and streams) was the most preferred open space types, and that result is also consistent with many past studies. Also, forests and water in southeast Michigan have high potential to be native ecosystems with high ecological values. Hence, we suggest that maintaining forests, lakes, and streams as a part of exurban landscapes should be planned to satisfy exurban homeowner preferences and to enhance ecological quality. One study about lot prices could offer an important planning strategy for allocating individual lots near forests. The study found that being nearby to forests significantly increases lot prices, particularly for lots that back onto a forest preserves (Bolitzer and Netusil, 2000).

Playing fields and golf courses, the more obviously manipulated landscapes, were least preferred as open space types. This is consistent with research finding that playing fields reduce both the property values (Crompton, 2001) and elicit lower preferences (Kaplan and Kaplan, 1989; Ryan, 1997). Nevertheless, playing fields have an important role to play in communities. Recent calls for the development of new urbanism or traditional neighborhood involve the allocation of convenient infrastructure/facilities, including playing fields, within walking distance to homes. The result of our study suggests that the location of playing fields within a community should be strategically selected to satisfy respondent preferences. Homeowners' low preference for golf courses contradicts the popularity of golf community developments and Do and Grudnitski (1995), who examined the effect of golf courses on residential house prices in San Diego, California and concluded that golf courses have a significant positive effect on the prices of adjacent homes. Our results suggest that open space types other than golf could further enhance property values and community satisfaction.

Planning for wetlands and prairie in exurbia can be challenging. The significantly different preferences for wetlands between "somewhat important" respondents and "unimportant" respondents suggest that wetlands near residential areas may not be preferred by all homeowners. This result is consistent with findings from previous studies, which suggest that the effects of wetlands on perception (Zube, 1975; Zube et al., 1974) and property values (Bin and Polasky, 2002; Bin and Polasky, 2005; Boyer and Polasky, 2004; Doss and Taff, 1996; Mahan et al., 2000; Nassauer, 2004) vary from either positive to negative depending partially on wetland types. Similarly, preferences for prairie also change significantly across respondent groups who put different importance on living near open space in home-buying choice. Prairie and wetlands are valuable ecosystems in southeast Michigan. Since not all exurban homeowners have high preference to live near wetlands and prairie as reported in our research, future exurban development should rely on careful design to protect wetlands and prairie ecosystems while providing preferable living environments for exurban homeowners. Especially with prairie and wetland open space types, design may dramatically affect preference (Nassauer, 1993; Nassauer, 2004).

Exurban homeowners who place different importance on living near open space in their home-buying choice ranked their preferences for different open space types similarly. Forests, lakes and streams were preferred over wetlands and prairie; and wetlands and prairie were preferred over playing fields and golf courses. The similarity across respondent groups might be explained two ways. First, some exurban homeowners may inherently prefer certain types of open spaces as suggested by preference research. Second, exurban homeowners may prefer to have certain types of open space nearby their homes because certain types have potential to increase their property values. For instance, lakefront properties command a premium price for the private access and views they offer (Lansford and Jones, 1995). In our study, lakes are consistently preferred across respondent groups, and lakes are the most preferred open space type for those who put lowest importance on living near open space in their home-buying choice.

6. Conclusion

Exurban development is the result of a complex array of human desires, market forces, and policy choices. The aim of this study is to provide information for policymakers and designers about exurban homeowner preferences for open spaces in home decision making. We concluded that open space plays an important role in affecting people's preferences for living in exurban locations because open space was ranked second only to house price in homeowners' home-buying choice. Another finding is that exurban homeowners have varied preferences for different types of open spaces. In general, natural-appearing open space types (forests, streams, lakes, wetlands and prairie) are preferred by most exurban homeowners over more obviously-manipulated landscapes, such as golf courses and playing fields.

Unprecedented exurban development in the USA has led to tension between the desire to have open space nearby and the loss of open space. Therefore, both the ecological health of exurban areas and the long term availability of open space experiences depend on planning exurban development to maintain desirable open space patterns and experiences, even as more development occurs. Our research suggests that maintaining forests and water features (lakes and streams) as a part of exurban landscapes can be planned to satisfy respondents' preferences and to enhance ecological quality. Careful design of wetland and prairie is essential to protect these less consistently preferred ecosystems. As for golf courses and playing fields, their development should be restricted considering their limited ecological values and their locations within a community should be strategically allocated to better satisfy exurban homeowners' preference for open spaces nearby.

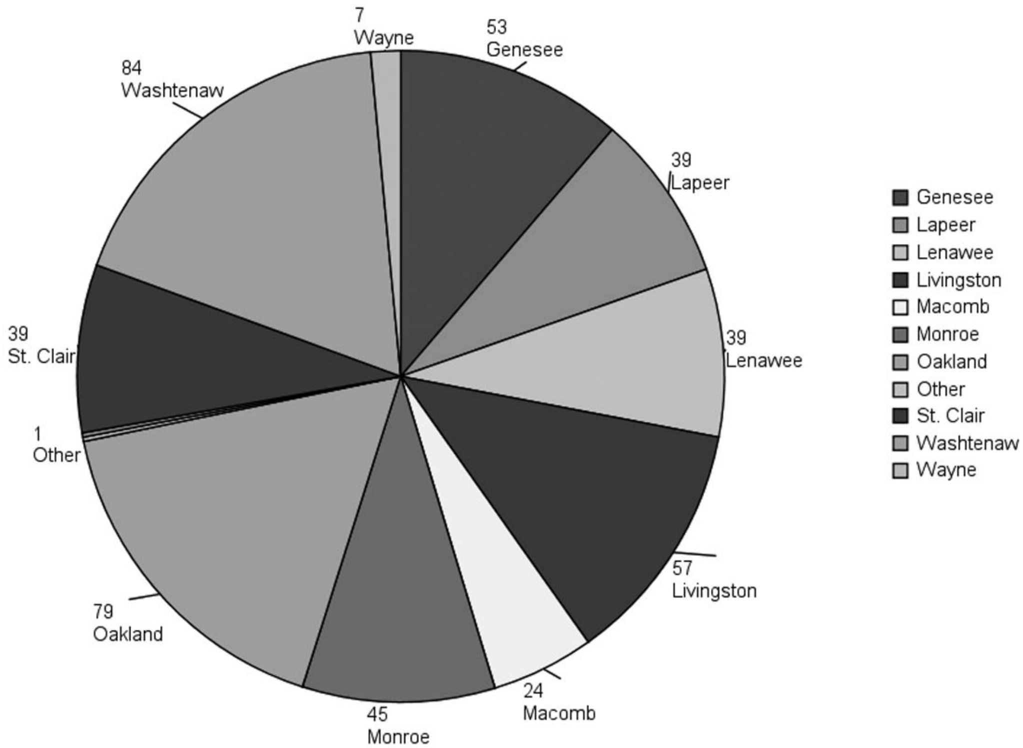


Figure 2.1 Sample distribution in ten counties, southeast Michigan

Forests1: Mean=6.24, SD=1.06

Forests2: Mean=6.40, SD=0.92

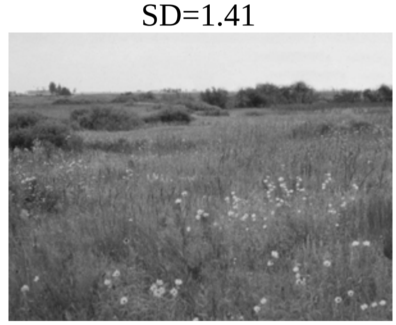
Lakes1: Mean=6.18, SD=1.11

Lakes2: Mean=6.36, SD=1.05

Wetland1: Mean=5.29, SD=1.45

Wetland2: Mean=5.27, SD=1.41

Prairie1: Mean=5.64, SD=1.24



Prairie2: Mean=5.57, SD=1.38

Golf courses1, Mean=3.98, SD=1.77

Golf courses2, Mean=4.27, SD=1.76

Streams1: Mean=6.20, SD=1.08

Streams2: Mean=6.25, SD=1.11

Playing field1: Mean=4.01, SD=1.45

Playing field2: Mean=4.27, SD=1.55

Figure 2.2: Preferences for different types of open spaces (two images for each type)

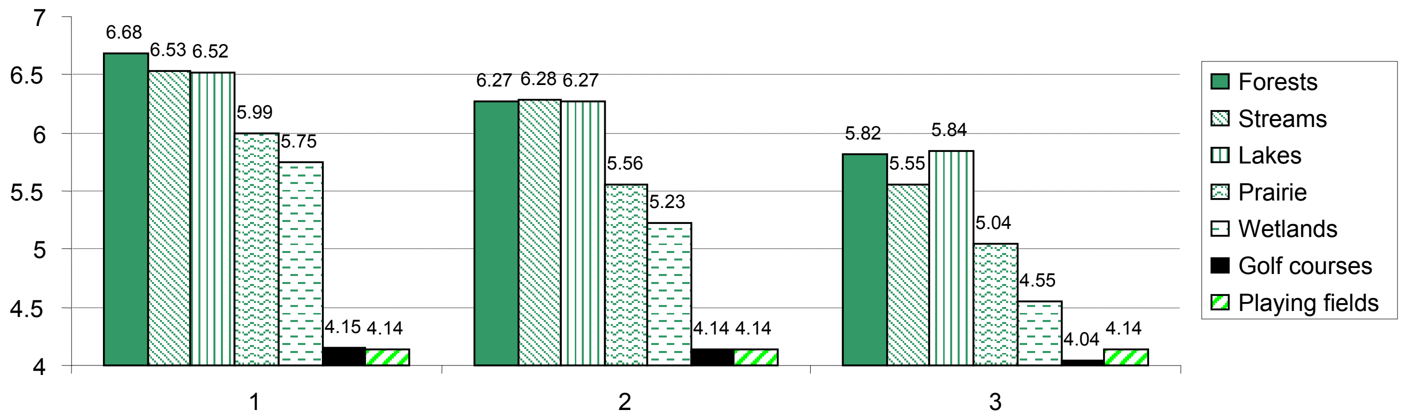


Figure 2.3: Preference for different types of open spaces by respondent groups that place different importance on living near open space in their home-buying choice

Notes: 1: "Very important" respondents (n=161)
2: "Somewhat important" respondents (n=215)
3: "Not important" respondents (n=92)

Table 2.1: Principle Components Analysis (PCA) and descriptive statistics of homeowners' stated importance on different items in their home-buying choice (n=468) [a,b]

Home-buying factors (Eigenvalue) and items (indented)	Mean	S.D.
***Open space (**3.137)*		
Close to natural areas (woods, ponds, streams, etc.)	3.24	.80
Openness and spaciousness of area	3.39	.72
Neighborhood design and cost (1.925)		
Housing costs and good value	3.54	.65
Attractive appearance of neighborhood	3.37	.67
Appearance and layout of the dwelling	3.44	.69
Social factors (1.287)		
People similar to me	2.66	.87
Familiar with area	2.72	.92
Close to family and friends	2.68	1.0
Recreation and activities (1.1)		
Good schools	3.17	1.08
Lots of recreational opportunities	2.72	.870
Others		
Close to work[c]	2.61	.96
Convenient to places such as shopping and schools[c]	2.85	.81
Community size[c]	2.99	.83

[a], The sample(N=468) includes single-family homeowners in their current home who live in our designated exurban areas.
[b], Scale where "1" equals "not at all important" to "4" equals "very important."
[c], Separated as individual items after reviewing factor analysis. Items had low loading coefficients and/or loaded almost equally on two factors.

Table 2.2: Preferences for different types of open spaces

Open space type	n	Mean	S.D.
Golf courses	468	4.12	1.77
Playing fields	468	4.14	1.50
Wetlands	468	5.28	1.43
Prairie	468	5.61	1.31
Streams	468	6.22	1.10
Lakes	468	6.27	1.09
Forests	468	6.32	0.99

Table 2.3: Paired sample test of open space preferences for all respondents

Pairs	Paired Differences				t	df	Sig. (2-tailed)
	Mean	Std. Deviation	95% Confidence Interval of the Difference				
			Lower	Upper			
forest – wetland	1.04	1.47	0.91	1.18	15.33	467	0.00
forest - lake	**0.05**	**1.26**	**-0.07**	**0.16**	**0.84**	**467**	**0.40**
forest - stream	**0.10**	**1.19**	**-0.01**	**0.20**	**1.75**	**467**	**0.08**
forest - prairie	0.71	1.15	0.61	0.82	13.38	467	0.00
forest - playing fields	2.18	1.79	2.01	2.34	26.30	467	0.00
forest - golf course	2.20	2.02	2.01	2.38	23.52	467	0.00
wetland - lake	-0.99	1.39	-1.12	-0.87	-15.44	467	0.00
wetland - stream	-0.95	1.29	-1.06	-0.83	-15.85	467	0.00
wetland - prairie	-0.33	1.53	-0.47	-0.19	-4.65	467	0.00
wetland - playing field	1.13	2.02	0.95	1.32	12.14	467	0.00
wetland - golf course	1.15	2.29	0.95	1.36	10.92	467	0.00
lake - stream	**0.05**	**0.99**	**-0.04**	**0.14**	**1.02**	**467**	**0.31**
lake - prairie	0.66	1.55	0.52	0.80	9.30	467	0.00
lake - playing field	2.13	1.75	1.97	2.29	26.33	467	0.00
lake - golf course	2.15	1.94	1.97	2.32	23.97	467	0.00
stream - prairie	0.62	1.44	0.49	0.75	9.30	467	0.00
stream - playing field	2.08	1.81	1.92	2.25	24.93	467	0.00
stream - golf course	2.10	2.04	1.91	2.29	22.26	467	0.00
prairie - playing field	1.46	1.94	1.29	1.64	16.35	467	0.00
prairie - golf courses	1.48	2.20	1.28	1.68	14.59	467	0.00
playing field - golf course	**0.02**	**1.80**	**-0.14**	**0.18**	**0.23**	**467**	**0.82**

Table 2.4: Paired sample test of open space preferences for "very important" respondents, those who put very high importance on living near open space in their home-buying choice (n=161)

Pairs	Paired Differences				t	df	Sig. (2-tailed)
	Mean	Std. Deviation	95% Confidence Interval of the Difference				
			Lower	Upper			
forest – wetland	0.93	1.37	0.72	1.14	8.66	160	0.00
forest - lake	**0.16**	**1.05**	**0.00**	**0.33**	**1.94**	**160**	**0.07**
forest - stream	**0.16**	**0.90**	**0.02**	**0.30**	**2.19**	**160**	**0.06**
forest - prairie	0.69	1.03	0.53	0.85	8.53	160	0.00
forest - playing field	2.54	1.72	2.27	2.81	18.69	160	0.00
forest - golf course	2.53	1.92	2.24	2.83	16.77	160	0.00
wetland - lake	-0.77	1.26	-0.97	-0.57	-7.75	160	0.00
wetland - stream	-0.78	1.27	-0.97	-0.58	-7.76	160	0.00
wetland - prairie	**-0.24**	**1.54**	**-0.48**	**0.00**	**-2.00**	**160**	**0.08**
wetland - playing field	1.61	1.94	1.31	1.91	10.52	160	0.00
wetland - golf course	1.60	2.13	1.27	1.93	9.54	160	0.00
lake - stream	**-0.01**	**0.86**	**-0.14**	**0.13**	**-0.09**	**160**	**0.93**
lake - prairie	0.53	1.43	0.31	0.75	4.69	160	0.00
lake - playing field	2.38	1.75	2.11	2.65	17.29	160	0.00
lake - golf course	2.37	1.87	2.08	2.66	16.10	160	0.00
stream - prairie	0.53	1.31	0.33	0.74	5.16	160	0.00
stream - playing field	2.39	1.73	2.12	2.65	17.51	160	0.00
stream - golf course	2.38	1.95	2.08	2.68	15.46	160	0.00
prairie - playing field	1.85	1.91	1.55	2.15	12.31	160	0.00
prairie - golf course	1.84	2.07	1.52	2.17	11.33	160	0.00
playing field - golf course	**-0.01**	**1.83**	**-0.29**	**0.28**	**-0.04**	**160**	**0.97**

Table 2.5: Paired sample test of open space preferences for "somewhat important" respondents, those who put somewhat importance on living near open space in their home-buying choice (n=215)

Pairs	Paired Differences				t	df	Sig. (2-tailed)
	Mean	Std. Deviation	95% Confidence Interval of the Difference				
			Lower	Upper			
forest – wetland	1.03	1.41	0.84	1.22	10.72	214	0.00
forest - lake	**0.00**	**1.19**	**-0.16**	**0.16**	**-0.06**	**214**	**0.95**
forest - stream	**-0.02**	**1.16**	**-0.18**	**0.14**	**-0.23**	**214**	**0.81**
forest - prairie	0.71	1.14	0.55	0.86	9.09	214	0.00
forest - playing field	2.12	1.72	1.89	2.35	18.11	214	0.00
forest - golf course	2.13	2.03	1.85	2.40	15.36	214	0.00
wetland - lake	-1.04	1.38	-1.22	-0.85	-10.99	214	0.00
wetland - stream	-1.05	1.29	-1.22	-0.88	-11.98	214	0.00
wetland - prairie	**-0.33**	**1.52**	**-0.53**	**-0.12**	**-3.14**	**214**	**0.09**
wetland - playing fields	1.09	1.82	0.84	1.33	8.78	214	0.00
wetland - golf course	1.09	2.31	0.78	1.40	6.94	214	0.00
lake - stream	**-0.01**	**0.88**	**-0.13**	**0.10**	**-0.23**	**214**	**0.82**
lake - prairie	0.71	1.55	0.50	0.92	6.73	214	0.00
lake - playing field	2.13	1.63	1.91	2.34	19.17	214	0.00
lake - golf course	2.13	1.92	1.87	2.39	16.27	214	0.00
stream - prairie	0.73	1.46	0.53	0.92	7.27	214	0.00
stream - playing field	2.14	1.70	1.91	2.37	18.46	214	0.00
stream - golf course	2.14	2.01	1.87	2.41	15.68	214	0.00
prairie - playing field	1.41	1.89	1.16	1.67	10.94	214	0.00
prairie - golf course	1.42	2.28	1.11	1.73	9.12	214	0.00
playing field - golf course	**0.00**	**1.78**	**-0.23**	**0.24**	**0.04**	**214**	**0.97**

Table 2.6: Paired sample test of open space preferences for "unimportant" respondents, those who put relatively unimportance on living near open space in their home-buying choice (n=92)

Pairs	Paired Differences				t	df	Sig. (2-tailed)
	Mean	Std. Deviation	95% Confidence Interval of the Difference				
			Lower	Upper			
forest – wetland	1.26	1.75	0.90	1.62	6.90	91	0.00
forest - lake	**-0.02**	**1.70**	**-0.37**	**0.33**	**-0.12**	**91**	**0.90**
forest - stream	**0.26**	**1.60**	**-0.07**	**0.59**	**1.57**	**91**	**0.12**
forest - prairie	0.77	1.38	0.49	1.06	5.35	91	0.00
forest - playing field	1.67	1.95	1.27	2.08	8.23	91	0.00
forest - golf course	1.77	2.10	1.34	2.21	8.10	91	0.00
wetland - lake	-1.28	1.57	-1.61	-0.96	-7.83	91	0.00
wetland - stream	-1.00	1.33	-1.27	-0.73	-7.23	91	0.00
wetland - prairie	**-0.49**	**1.55**	**-0.81**	**-0.17**	**-3.02**	**91**	**0.06**
wetland - playing field	**0.41**	**2.38**	**-0.08**	**0.91**	**1.66**	**91**	**0.10**
wetland - golf course	0.51	2.35	0.02	1.00	2.08	91	0.04
lake - stream	**0.28**	**1.36**	**0.00**	**0.56**	**1.99**	**91**	**0.08**
lake - prairie	0.79	1.73	0.44	1.15	4.41	91	0.00
lake - playing field	1.70	1.95	1.29	2.10	8.32	91	0.00
lake - golf course	1.79	2.06	1.37	2.22	8.34	91	0.00
stream - prairie	0.51	1.57	0.19	0.84	3.12	91	0.00
stream - playing field	1.41	2.02	1.00	1.83	6.72	91	0.00
stream - golf course	1.51	2.18	1.06	1.96	6.66	91	0.00
prairie - playing field	0.90	1.96	0.50	1.31	4.42	91	0.00
prairie - golf course	1.00	2.15	0.56	1.44	4.46	91	0.00
playing field - golf course	**0.10**	**1.79**	**-0.27**	**0.47**	**0.52**	**91**	**0.60**

Table 2.7: Different preferences for each type of open space among respondent groups

Dependent Variable	(I)Respondent group	(J) Respondent group	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Upper Bound	Lower Bound
Forest	very important	Somewhat important	.42(*)	0.10	0.00	.19	.65
		Unimportant	.87(*)	0.12	0.00	.58	1.16
	Somewhat important	Very important	-.42(*)	0.10	0.00	-.65	-.19
		Unimportant	.45(*)	0.12	0.00	.17	.73
	Unimportant	Very important	-.87(*)	0.12	0.00	-1.16	-.58
		Somewhat important	-.45 (*)	0.12	0.00	-.73	-.17
Wetland	Very important	Somewhat important	.52(*)	0.14	0.00	.18	.85
		Unimportant	1.2(*)	0.18	0.00	.78	1.62
	Somewhat important	Very important	-.52(*)	0.14	0.00	-.85	-.18
		Unimportant	.68(*)	0.17	0.00	.28	1.08
	Unimportant	Very important	-1.2(*)	0.18	0.00	-1.62	-.78
		Somewhat important	-.68(*)	0.17	0.00	-1.08	-.28
Lake	Very important	Somewhat important	0.25	0.11	0.06	-.01	.51
		Unimportant	.69(*)	0.14	0.00	.36	1.01
	Somewhat important	Very important	-0.25	0.11	0.06	-.51	.01
		Unimportant	.43(*)	0.13	0.00	.12	.74
	Unimportant	Very important	-.69(*)	0.14	0.00	-1.01	-.36
		Somewhat important	-.43(*)	0.13	0.00	-.74	-.12
Stream	Very important	Somewhat important	0.24	0.11	0.06	-.01	.50
		Unimportant	.97(*)	0.14	0.00	.65	1.29
	Somewhat important	Very important	-0.24	0.11	0.06	-.50	.01
		Unimportant	.73(*)	0.13	0.00	.42	1.03
	Unimportant	Very important	-.97(*)	0.14	0.00	-1.29	-.65
		Somewhat important	-.73(*)	0.13	0.00	-1.03	-.42
Prairie	Very important	Somewhat important	.44(*)	0.13	0.00	.12	.75
		Unimportant	.95(*)	0.17	0.00	.56	1.34
	Somewhat important	Very important	-.44(*)	0.13	0.00	-.75	-.12
		Unimportant	.52(*)	0.16	0.00	.14	.89
	Unimportant	Very important	-.95(*)	0.17	0.00	-1.34	-.56
		Somewhat important	-.52(*)	0.16	0.00	-.89	-.14
Playing field	Very important	Somewhat important	0.00	0.16	1.00	-.37	.37
		Unimportant	0.00	0.20	1.00	-.46	.46
	Somewhat important	Very important	0.00	0.16	1.00	-.37	.37
		Unimportant	0.00	0.19	1.00	-.44	.44
	Unimportant	Very important	0.00	0.20	1.00	-.46	.46
		Somewhat important	0.00	0.19	1.00	-.44	.44
Golf course	Very important	Somewhat important	0.01	0.19	1.00	-.43	.44
		Unimportant	0.11	0.23	0.89	-.44	.65
	Somewhat important	Very important	-0.01	0.19	1.00	-.44	.43
		Unimportant	0.10	0.22	0.90	-.42	.62
	Unimportant	Very important	-0.11	0.23	0.89	-.65	.44
		Somewhat important	-0.10	0.22	0.90	-.62	.42

References:

Achs, N. (1992). Exurbia. *The American City and County* **107**, 64.
Appler, D. R. (2004). America's converging open space protection policies: evidence from New Hampshire, Virginia, and Oregon. *Urban Lawyer* **36**, 341-374.
Austin, M. E. (2004). Resident perspectives of the open space conservation subdivision in Hamburg Township, Michigan. *Landscape and Urban Planning* **69**, 245-253.
Benedict, M. A., and McMahon, E. T. (2002). Green infrastructure: smart conservation for the 21st century. *Renewable Resource Journal* **20**, 12-17.
Bin, O., and Polasky, S. (2002). Valuing coastal wetlands: a hedonic property price approach. *Working Paper*. http://personal.ecu.edu/bino/vita.pdf. Last retrieved on Feb 10th, 2006.
Bin, O., and Polasky, S. (2005). Evidence on the amenity value of wetlands in a rural setting. *Journal of Agricultural and Applied Economics* **37**, 589-602.
Bishop, I. D., and Hulse, D. W. (1994). Prediction of scenic beauty using mapped data and Geographic Information Systems. *Landscape and Urban Planning* **30**, 59-70.
Blackwood, L. G., and Carpenter, E. H. (1978). The importance of anti-urbanism in determining residential preferences and migration patterns. *Rural Sociology* **43**, 31-47.
Bolitzer, B., and Netusil, N. R. (2000). The impact of open spaces on property values in Portland, Oregon. *Journal of Environmental Management* **59**, 185-193.
Boyer, T., and Polasky, S. (2004). Valuing urban wetlands: a review of non-market valuation studies. *Wetlands* **24**, 744–755.
Brown, D. L., Fuguitt, G. V., Heaton, T. B., and Waseem, S. (1997). Continuities in size of place preferences in the United States, 1972-1992. *Rural Sociology* **62(4)**, 408-428.
Burchell, R., Lowenstein, G., Dolphin, W., Galley, C., Downs, A., Seskin, S., Still, K., and Moore, T. (2002). "Cost of Sprawl-2000," Rep. No. TCRP Report 74. National Academy Press, Washington, DC.
Burchell, R. W., and Mukherji, S. (2003). Conventional development versus managed growth: The costs of sprawl. *American Journal of Public Health* **93**, 1534-1540.
Carruthers, J. I., and Ulfarsson, G. F. (2002). Fragmentation and sprawl: evidence from interregional analysis. *Growth Change* **33**, 312-340.
Chiesura, A. (2004). The role of urban parks for the sustainable city. *Landscape and Urban Planning* **68**, 129-138.
Crompton, J. L. (2001). The impact of parks on property values: a review of the empirical evidence. *Journal of Leisure Research* **33**, 1-31.
Crump, J. R. (2003). Finding a place in the country: exurban and suburban development in Sonoma County, Calif. *Environment and Behavior* **35**, 187–202.
Daniels, T., and Lapping, M. (2005). Land preservation: an essential ingredient in smart growth. *Journal of Planning Literature* **19**, 316-329
Do, A. Q., and Grudnitski, G. (1995). Golf courses and residential house prices: an empirical examination. *Journal of Real Estate Finance and Economics* **10**, 261-270.
Doss, C. R., and Taff, S. J. (1996). The influence of wetland type and wetland proximity on residential property values. *Journal of Agricultural and Resource Economics* **21**, 120–129.

Fernandez, L. E., Brown, D. G., Marans, R. W., and Nassauer, J. I. (2005). Characterizing location preferences in an exurban population: implications for Agent Based Modeling. *Environmental Planning B-Planning and Design* **32**, 799-820.

Francis, M., Cashdan, L., and Paxson, L. (1984). "Community Open Space," Island Press, Covelo, CA.

Garrod, G., and Willis, K. (1992a). The amenity value of woodland in Great Britain: a comparison of economic estimates. *Environmental and Resource Economics* **24**, 415–434.

Garrod, G., and Willis, K. (1992b). Valuing goods' characteristics: an application of the hedonic price method to environmental attributes. *Journal of Environmental Management* **34**, 59–76.

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

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

Girling, C. L., and Helphand, K. I. (1994). "Yard, Street, Park: The Design of Suburban Open Space," Joan Wiley & Sons, Inc., New York.

Gobster, P. H. (1992). "Managing visual quality in big, diverse urban parks: a case study of Chicago's Lincoln Park." USDA Forest Service North Central Forest Experiment Station, St.Paul.

Gobster, P. H. (1994). The urban savanna: reuniting ecological preference and function. *Restoration and Management Notes* **12**, 64-71.

Gobster, P. H. (1999). An ecological aesthetic for forest landscape management. *Landscape Journal* **18**, 54-64.

Guo, Z. W., Xiao, X. M., Gan, Y. L., and Zheng, Y. J. (2001). Ecosystem functions, services and their values: A case study in Xingshan County of China. *Ecological Economics*, 141-154.

Heimlich, R. E., and Anderson, W. D. (2001). "Developing the urban fringe and beyond: impacts on agriculture and rural land," Rep. No. Report Number 803. USDA Economic Research Service, Washington, DC.

Herzog, T. R., E.J. Herbert, Rachel Kaplan, and C.L. Crooks (2000). Cultural and developmental comparisons of landscape perceptions and preferences. *Environment and Behavior* **32**, 323-346.

Hollis, L. E., and Fulton, W. (2002). "Open space protection, conservation meets growth management." http://www.solimar.org/pdfs/hollisfultonopenspace.pdf Last retrieved on Nov 12th, 2004.

Kaplan, R. (2001). The nature of the view from home: psychological benefits. *Environment and Behavior* **33**, 507-542.

Kaplan, R., and Austin, M. E. (2004). Out in the country: sprawl and the quest for nature nearby. *Landscape and Urban Planning* **69**, 235-243.

Kaplan, R., Austin, M. E., and Kaplan, S. (2004). Open space communities - resident perceptions, nature benefits, and problems with terminology. *Journal of the American Planning Association* **70**, 300-312.

Kaplan, R., and Herbert, E. J. (1987). Cultural and sub-cultural comparisons in preferences for natural settings. *Landscape and Urban Planning* **14**, 281-293.
Kaplan, R., and Talbot, J. F. (1988). Ethnicity and preference for natural settings: a review and recent findings. *Landscape and Urban Planning* **15**, 107–117.
Kaplan, S., and Kaplan, R. (1989). "The Experience of Nature: A Psychological Perspective," Cambridge University Press, New York.
Kent, R. L., and Elliot, C. L. (1995). Scenic routes linking and protecting natural and cultural landscape features: A greenway skeleton. *Landscape and Urban Planning* **33**, 341-356.
Kopits, E., McConnell, V., and Walls, M. (2007). "The tradeoff between private lots and public open space in subdivisions at the urban-rural fringe," Rep. No. RFF DP 07-33. Resources for the future, Washington, DC.
Lansford, J. N. H., and Jones, L. L. (1995). Marginal price of lake recreation and aesthetics: a hedonic approach. *Journal of Agricultural & Applied Economics* **27**, 212-223.
Lee, C. M., and Linneman, P. (1998). Dynamics of the greenbelt amenity effect on the land market: the case of Seoul's Greenbelt. *Real Estate Economics* **26**, 107-129.
Lovaas, D. (2002). Growing up, growing out: some rust belt cities sprawl without population growth. *E: The Environmental Magazine* **13**, 14-15.
Luttik, J. (2000). The value of trees, water and open space as reflected by house prices in the Netherlands. *Landscape and Urban Planning* **48**, 161-167.
Lutzenhiser, M., and Netusil, N. R. (2001). The effect of open spaces on a home's sale price. *Contemporary Economic Policy* **19**, 291-298.
Mahan, B., Polasky, S., and Adams, R. (2000). Valuing urban wetlands: a property price approach. *Land Economics* **76**, 100-113.
Marans, R. W. (2003). Understanding environmental quality through quality of life studies: the 2001 DAS and its use of subjective and objective indicators. *Landscape and Urban Planning* **65**, 75-85.
Mitsch, W. J., and Gosselink, J. G. (1993). "Wetlands," John Wiley and Sons, Inc., New York, NY.
Myers, D., and Gearin, E. (2001). Current preferences and future demand for denser residential environments. *Housing Policy Debate* **12**, 633-659.
Nassauer, I. J. (1995). Culture and changing landscape structure. *Landscape Ecology* **10**, 229-237.
Nassauer, J. I. (1993). "Ecological function and the perception of suburban residential landscapes," Rep. No. NC-163. USDA Forest Service North Central Forest Experiment Station General Technical Report, St. Paul, MN.
Nassauer, J. I. (2004). Monitoring the success of metropolitan wetland restorations: Cultural sustainability and ecological function. *Wetlands* **24**, 756-765.
Nassauer, J. I., Kosek, S. E., and Corry, R. C. (2001). Meeting public expectations with ecological innovation in riparian landscapes. *Journal of the American Water Resources Association* **37**, 1439-1443.
National Association of Realtors. (2001). NAR survey shows public support for open space depends on use and cost. http://www/realtor/org/SG3.nsf/Pages/mngrtpressurvey?OpenDocument Last Retrieved on Sep19th, 2005.

National Association of Home Builders. (2002). Smart Growth, Smart Choices. http://www.nahb.org/publication_details.aspx?sectionID=154&publicationID=15 Last retrieved on Sep 19th, 2005.
Nelson, A. C., and Dueker, K. J. (1990). The exurbanization of America and its planning policy implications. *Journal of Planning Education and Research* **9**, 91-100.
Patel, D. I. (1980). "Exurbs: Residential Development in the Countryside," University Press of America, Washington D.C.
Peiser, R. B., and Schwann, G. M. (1993). The private value of public open space within subdivisions. *Journal of Architectural and Planning Research* **10**, 91-104.
Ryan, R. (1997). Attachment to urban natural areas: effects of environmental experiences. Unpublished dissertation, University of Michigan, Ann Arbor, MI.
Shafer, E. L. (1969). Perception of natural environment. *Environment and Behavior* **1**, 71-82.
Southeast Michigan Council of Governments. (2003). "Land Use Change in Southeast Michigan: Causes and Consequences." SEMCOG, Detroit, MI.
Sullivan, W. C. (1994). Perceptions of rural-urban fringe: citizen preferences for natural and developed settings. *Landscape and Urban Planning* **29**, 85–101.
Sullivan, W. C., Anderson, O. M., and Lovell, S. T. (2004). Agricultural buffers at the rural-urban fringe: an examination of approval by farmers, residents, and academics in the Midwestern United States. *Landscape and Urban Planning* **69**, 299-313.
Talen, E. (2001). Traditional urbanism meets residential affluence: An analysis of the variability of suburban preference. *Journal of the American Planning Association* **67**, 199.
Tyrväinen, L., and Vaananen, H. (1998). The economic value of urban forest amenities: an application of the contingent valuation method. *Landscape and Urban Planning* **43**, 105–118.
Ulrich, R. S. (1986). Human responses to vegetation and landscapes. *Landscape and Urban Planning* **13**, 29-44.
Vesterby, M., Heimlich, R. E., and Krupa, K. S. (1994). "Urbanization of Rural Land in the United States." AER-673. U.S. Department of Agriculture, Economic Research Service.
Vogt, C. A., and Marans, R. W. (2004). Natural resources and open space in the residential decision process: a study of recent movers to fringe counties in southeast Michigan. *Landscape and Urban Planning* **69**, 255-269.
Zhang, Y., He, H. S., and Yang, J. (2008). The wildland-urban interface dynamics in the southeastern U.S. from 1990 to 2000. *Landscape and Urban Planning* **85**, 155-162.
Zube, E. H. (1974). Cross-disciplinary and intermode agreement on the description and evaluation of landscape resources. *Environment and Behavior* **6**, 69-89.
Zube, E. H., David G. Pitt, and Thomas W. Anderson (1975). Perception and prediction of scenic resource values of the northeast. *In* "Landscape Assessment: Values, Perceptions, and Resources" (E. H. Zube, Robert O. Brush, and Julius Gy Fabos, ed.), pp. 151-182. Dowden, Hutchinson & Ross, Inc., Stroudsburg.

Zube, E. H., Pitt, D. G., and Anderson, T. W. (1974). "Perception and Measurement of Scenic Resources in the Southern Connecticut River Valley," Rep. No. Publication No. R-74-1. University of Massachusetts, Amherst.

Chapter III

The importance of nearby open space in exurban homeowner's choices

Abstract

A better understanding of the values associated with living near open space is essential to successful conservation efforts, because of the critical role that human preference can play in exurban planning and the future shape of broader landscape patterns. To investigate how exurban homeowners' preference for open space might be related to the land use and landcover (LULC) near their homes, we used a web survey of exurban homeowners in southeast Michigan (n=468) to measure exurban residents' stated preference for having open space near their home, and we used geographic information systems (GIS) to measure open space LULC types near their home addresses. Our analysis of the relationship between stated preference and nearby open space suggests that exurban homeowners are living in areas that match their preferences for having open space nearby. Homeowners who put higher importance on living near open space in their home-buying choice tend to live in areas with higher concentrations of deciduous forests, wetlands or shrubs. For future landscape planning, this research suggests that open space LULC that can sometimes enhance ecological quality (i.e., woodlands, wetlands), could also satisfy exurban homeowners' open space preferences.

Keywords: Preference, land use, landcover, exurban, GIS, planning

1. Introduction

Landscape ecologists can play an important role in identifying better ways to understand the complex interactions between humans and the biosphere and then applying this understanding to balance human needs and a sustainable future (Forman, 1995; Forman and Godron, 1986; Golley, 1987; Nassauer, 1995; Naveh, 1991). One important means of application is landscape planning, which can allocate land uses based on human needs and preferences while minimizing their environmental impact. Landscape planning is particularly critical where challenging tensions between humans and the biosphere exist.

Such conflicts exist in exurbia, where societal desires for open space experiences may impact these very open space characteristics and their ecosystem services. Exurban development has been variously defined as large lot development on previously undeveloped land (NAHB,1992), or as "discrete, areally organized subdivision[s] with an internal street pattern, located in a rural setting…far enough beyond the frontier of suburban development that it will not be engulfed by the expanding city within the foreseeable future "(Patel, 1980, p9) or as an area "within the range that commuters are willing to travel to the central city, suburban centers, or perimeter/beltway areas for work” (Nelson and Dueker, 1990, p93). In this study, we defined exurban residential development by infrastructure characteristics: homes that have their own well and septic systems, with lot sizes at least 0.5 acres, the minimum lot size required where government sewer and water infrastructure is not provided in our study area, southeast Michigan.

Exurban residential development, large lot development on previously undeveloped land, is expanding on the edges of urban and suburban regions throughout the US (Carruthers and Ulfarsson, 2002; Daniels and Lapping, 2005; Heimlich and Anderson, 2001; Lovaas, 2002; Zhang et al., 2008). By the end of the twentieth century, exurbia covered a larger area than urban land in America (Heimlich and Anderson, 2001; Theobald, 2001). At the same time preference for living near open space has been identified as a driver for people moving to exurban areas (Fernandez et al., 2005; Kaplan and Austin, 2004; Vogt and Marans, 2004). The increase in exurban residential development poses major challenges for open space conservation because this development encroaches on land previously occupied by agriculture, forestry, wetlands, or other ecosystems (Burchell et al., 2002; Burchell and Mukherji, 2003; Lovaas, 2002). Moreover, the rate of exurban development is accelerating. Comparing 1992 to 1997 to the previous five years, the average annual rate of open space lost to development increased 50 percent to 2.1 million acres (Lovaas, 2002). Meanwhile, the ecological disturbance exurban development provokes is arguably much more significant than that which might be caused in urban areas since exurban development occurs in a relatively less-altered landscape (Radeloff et al., 2005).

The dilemma is that, while people move to exurbia for open space experiences and to be closer to environments that they perceive as natural, exurban development occupies open space and impacts the structure, function and dynamics of ecological systems. This dilemma suggests that the long term availability of open space, as well as the quality of ecosystem services provided by that open space, depends on responsible planning for future exurban development that maintains open space patterns even as development occurs.

Open space is a widely used term without a consistent definition (Appler, 2004). Open space can be defined as an area preserved or managed by local people or government (Francis et al., 1984), or a publicly-owned / publicly-accessible place for recreation or habitats (Girling and Helphand, 1994), or an unbuilt environment absent of infrastructure (Benedict and McMahon, 2002; Hollis and Fulton, 2002). In this study on exurban development, we define *open space* as unbuilt environment protected from development, such as forests, wetlands, public parkland, public playing fields, golf courses or other landuse/landcover (LULC) not served by public sewer and water infrastructure. Agricultural landscape is not considered as open space in this research because it is mostly not protected from development in Southeast Michigan. Rather, agriculture is most widely converted to built uses when development occurs. Studies showed that cropland and rangeland provided more than half of the area for urban expansion (Vesterby et al., 1994).These LULC vary greatly in the ecosystem services they provide: some have high potential as habitat or to maintain water quality, others offer primarily human recreation.

In this paper we investigate how exurban respondents' preferences for having nearby open space are related to the open space LULC near their homes. Our primary goal is to explore potential causal explanations for relationships between *preference* for having open space near one's home and *actually having* open space LULC near one's home. A significant body of work has investigated the association of LULC types with landscape preference, but those studies do not examine how preferences might be related to the immediate surroundings of one's home (Bishop and Hulse, 1994; Dearden, 1980; Franco et al., 2003; Palmer, 2004; Zube et al., 1989; Zube et al., 1974). We explore both *sorting* by home-buying choice as a potential cause and an exposure to nearby open space *environments* as a potential cause for homeowner preference for having nearby open space. These two potential causes for preference have different implications for planning and policy making.

 # Figure 3.1 approximately here

S*orting* could occur if homeowners buy their homes in order to be nearby open spaces. Hannon's (1994) theory of geographical discounting states that people, animals and plants consistently seem to prefer to distance themselves from objects they fear and to draw close to things they desire. And this theory has been supported by several studies (Brody et al., 2004; Brown et al., 2002; Norton and Hannon, 1997). It would suggest that exurban homeowners who value living near open space would be more likely to buy homes that are near more open space, perhaps especially open space of types they prefer, while home buyers with different open space preferences would choose to live in locations with those different characteristics.

On the other land, if experience of open space landscape characteristics affects preference for those characteristics, people who actually live near open space would have stronger preferences for having open space nearby. This influence of experience would be supported by transactional theory, which identifies landscape experiences as important sources of information that affect landscape perception and values (Gobster et al., 2007; Ittelson and Cantril, 1954; Nassauer, 1995; Sell et al., 1984; Zube, 1987).

In addition, we investigated whether people who consider having open space nearby as to be more important when they buy a home actually live in areas with different open space LULC types. This is especially important because different open space types provide different ecosystem services. For instance, wetlands can recharge aquifers, filter nutrients and toxics, cycle carbon and nitrogen, help to stabilize climates, and serve as habitat for a large majority of the species considered endangered or threatened (Mitsch and Gosselink, 1993). Forests can regulate hydrological flow, prevent soil erosion, produce oxygen and serve as habitat (Guo et al., 2001).

Several studies suggest that preference for open space near residential areas is related to living near open space. For instance, Vogt and Marans (2004) studied homeowners in southeast Michigan and found that respondents in open space neighborhoods (subdivisions designed to conserve open space and natural features) (n=119) rate open space and natural features as far more important than do those living in conventional single-family houses (n=421). In a different study examining perceptions of respondents of the River Raisin corridor in rural Michigan, Ryan (1998) found that respondents (120 property owners) preferred LULC types that occur near their residences. For example, respondents living in forested areas most prefer natural areas while respondents of farm land areas most prefer farm landscapes, and respondents who live near farm land prefer a domesticated backyard landscape more than do respondents of forested areas. Development density is another way to approximate open space characteristics, assuming that lower density development has more open space characteristics. Dearden (1984) differentiated landscapes using the concept of housing density, and he found that the lower the density of housing residents (n=90) occupied, the higher their preference for wilderness environments. Based on this past research as well as our own research goals, we investigated whether:

Hypothesis I: People for whom having open space near their homes was important in their home-buying choice actually live near more open space.

Hypothesis II Regardless of how important having open space nearby was to their home-buying choice, people who would more greatly value having open space adjacent to their home actually live near more open space.

Hypothesis III: Homeowners who place different levels of importance on having open space in the neighborhood when choosing to buy their home live in areas with different open space LULC types.

2. Methods

Our survey was part of a larger research project examining spatial patterns of land use and their ecological effects at the rural-urban interface: Agent-based modeling and evaluation of alternative policies and interventions (Brown et al., 2008). Details about our study area, which encompasses the exurban area of ten counties in southeast Michigan, are described in Chapter II. We defined *exurban* locations as areas without public sanitary sewer systems, and we operationalized our definition by zip code: 207 zip codes in ten counties of the Detroit, Ann Arbor, and Flint metropolitan areas. This region comprises the most rapidly growing areas of Michigan.

To examine our hypotheses, we addressed three key concepts: stated *importance* of open space in home-buying choice, homeowners' stated *preference* for having open space adjacent to their home, and the amount and *different types of open spaces* near the home. *The importance of open space* refers to stated preference for nearby open space when homeowners bought their home, as measured by four-point Likert scales for two variables: importance of being close to natural areas, and importance of openness/spaciousness of the area nearby. *Preference for open space* refers to respondents' stated value of having open space adjacent to the their current home as measured by a seven-point Likkert scale, ranging from "greatly reduces how much I value my home" to "greatly increases how much I value my home". *Open space types* nearby were measured by using GIS data capturing different LULC types within a comfortable walking distance (400 meters) from a respondent's home. Alexander et al (1977) suggested that people will go to open spaces within three-minutes walking distance. In another study, local access was defined as no more than ¼ mile (approximately 400 meters) from all housing units in the neighborhood (Calthorpe, 1989). Atash (1994) considered 400 meters to be approximately five minutes walking time, the distance "the average American will walk rather than drive." This distance is also cited by the Ontario Ministry of Transportation and Ontario Ministry of Municipal Affairs (1992) as the maximum distance transit users are likely to walk to a transit stop.

2.1 Image-based web survey

In April 2005, we conducted an image-based web survey of exurban homeowners in the designated zip codes above, and we received 494 complete responses. The web questionnaire included a wide variety of questions about people's residential choices in exurbia. Respondents nearly all resided in exurban zip codes of ten counties in the Southeast Michigan area. Their age ranged from 20 to 75, with most between 30 to 60 years old. Of all participants, 6.4% were younger than 30, and 8.8% were older than 60. No children lived in the homes of 38% of respondents. Less than half, 41.9% completed some college; and 40.5% had finished college. Half of respondents had full time jobs, 14% had part time jobs, and the other 36% of respondents were not employed. By 1980, only 9.5% had moved to their current homes, but more than half (58.6%) had moved in after 1995. Details are summarized in Nassauer et al (I*n prep)*. In this paper, we report on analysis of only some questionnaire items, including preference for open space, as described above.

Another variable was stated importance of having open space nearby in home-buying choice. Questionnaire items asked homeowners to indicate how much certain home characteristics had influenced their decision to move to their current neighborhood. These items replicated items in a previous survey of the Detroit area (Fernandez et al., 2005; Vogt and Marans, 2004), and details about these items can be found in Chapter II. They included: close to work, good schools, housing costs and good value, convenient to places such as shopping and schools, loss of recreational opportunities, attractive appearance of neighborhood, community size, people similar to me, appearance and layout of the dwelling, familiar with area, close to nature areas, openness and spaciousness of area, close to family and friends. Analyzing these items, we replicated the principal components analysis (PCA) done for the Detroit area survey (Fernandez et al. 2005), and we derived four factors of two or more variables influential to home-buying choices (see Chapter II). One of the factors is *open space*, composed of the natural areas and openness variables, which strongly influences exurbanite homeowners' home-buying choice. The factor analysis result is similar to Fernandez et al.(2005)'s analysis Of DAS data, except that their open space factor also includes an item about recreational opportunities. Items for the open space factor ranked second only to the other significant factor, *home price*. The factor of *open space* is used to define the importance of open space in this paper because it represents people's personal choice to live near open space when they purchased their current home.

2.2 Open space amount and types nearby

To measure open space types nearby their exurban homes, we used home addresses of respondents who volunteered this information. 468 of 494 respondents provided valid addresses, which we encoded as a GIS data layer.

Open space types were generated from 2001 LULC data at a 30-meter resolution (State of Michigan). As suggested by Palmer (2004), 30 meters is a workable resolution for some studies related to respondent perception since 30 meters is slightly smaller than a residential lot at a density of 4 dwelling units per acre, and the 30 meter by 30 meter grain is smaller than the division of land with which local residents are most familiar. The 2001 LULC data has 35 classes, from which we generated seven types of open space LULC (Table 3.1). Their spatial distribution can be seen in Figure 3.2.

 # Table 3.1 approximately here

 # Figure 3.2 approximately here

The percentage of each of the seven open space LULC types "nearby" each respondent's home was calculated in ArcMap 9.1. "Nearby" was defined as within a radius of 400 meters of each respondent's home address. 400 meters (0.2 miles) was used because this distance is known as a comfortable walking distance. We also calculated the total amount of open space "nearby" each respondent's home. We summed the percentage of the seven open space types to get the total percentage of open space in the 400 meter vicinity of each respondent's home. As homeowners who put higher importance on open space in their home buying might have much more open space nearby than do other homeowners. We compare percentage of different open space LULC types as a proportion of the total open space near each respondent home. The control of the total open space nearby is necessary to examine the real differences among open space types as stated in Hypothesis III.

2.4 Analysis techniques

We provided for both statistical and spatial queries by using ArcMAP 9.1 to 'join' the data collected from our web survey to the spatial data. We examined statistical relationships between open space preference and open space LULC types using the Statistical Package for Social Sciences (SPSS 13.0).

To test our hypotheses of homeowner preference for having open space nearby, we used correlation analyses. For Hypothesis I, testing for *sorting* by home-buying choice as a potential cause, the factor score of the *open space* factor in home-buying choice (importance of open space) was correlated with the total amount of open space near a respondent's home. We hypothesized that the stated importance of open space in home-buying choice would be significantly and positively correlated with the total amount of open space near a respondent's home. For Hypothesis II testing for an exposure to nearby open space *environments* as a potential cause regardless of the stated importance of open space in home-buying choice, we used partial correlation to examine the relationships between respondent's preference for open space and the total amount of open space nearby, after controlling on home-buying choice. The control variable in the partial correlation was the factor, stated importance of open space in home-buying choice. We hypothesized that respondents' preference for open space would be significantly and positively correlated with the total amount of open space nearby even after controlling on the importance of open space in home-buying choice. For Hypothesis III, about differences among open space LULC types, we examined the correlation of the stated importance of open space factor with the nearby area in each open space LULC type, as well as the partial correlation of the nearby area in each open space LULC type with the open space preference variable. We hypothesized that percentage of some open space LULC types as a proportion of the total open space nearby would significantly and positively correlate with the importance of open space and/or preference for open space while other open space LULC types may have negative or non-significant correlations with the importance of open space and/or preference for open space. In all our tests, we tested for statistical significance at $p<0.05$.

3. Results

3.1 Open space preference

We found that exurban homeowners perceived open space adjacent to their homes as affecting the value of their home. The respondents highly valued open space adjacent to their homes with very low variance: mean rating=6.1 and standard deviation=1.23 (figure 3.3). Exurban homeowners seem to have relatively low heterogeneity in their preference for having open space nearby.

#Figure 3.3 approximately here

3.2 Importance of open space

As discussed above, we measured the stated importance of open space in respondents' home-buying choice employing the standardized factor score from principal component analysis (PCA). The open space factor was composed of two questionnaire items: respondents' ratings of the importance of the proximity to natural areas and the importance of the openness and spaciousness of the area. Each of these two items has a mean rating higher than 3.24, ranking second only to the home price items (mean rating higher than 3.40). This suggests that open space is very important in exurban homeowner's home-buying choice. Factor scores for the open space factor indicate the relative importance of open space in exurban homeowner's home-buying choice (Chapter II). The higher the factor score, the greater effect of the open space factor is in exurban homeowner's home-buying choices.

3.3 Nearby LULC types

Our exurban study area has 21.8% deciduous forests and 8.4% herbaceous openland. Each of the other open space LULC types covers less than 5% of our study area.

 # Table 3.2 approximately here

The land areas nearby (within 400 meters radius) our respondent homes, on average, are similar to the LULC types in our exurban study area. The most dominant LULC nearby respondent homes is deciduous forests; the mean percentage of deciduous forests was 22.2% with a minimum coverage of 0.2% and maximum coverage of 68.3%.And other open space LULC types occupied even less than 1% of the area near respondents' homes (Table 3.2).

3.4 Casual explanations

In this research we hypothesized that *sorting* by home-buying choice is a potential cause and exposure to nearby open space *environments* is another potential cause for homeowner preference for having open space nearby.

Our analysis supports the sorting by home-buying choice as a cause for homeowner preference for having open space nearby. Respondents' stated importance of having open space nearby when they bought their homes was significantly correlated with the total amount of open space near their home ($r=0.18$, $p<0.01$). Exurban homeowners who placed a higher importance on open space in their home-buying decisions live in areas with more open space.

Our analysis did not support the exposure to nearby open space *environments* as a potential cause for homeowner preference for having open space nearby their home. We tested whether homeowners' preferences for having open space nearby was correlated with the total amount of open space adjacent to their home, and we found virtually no correlation ($r=0.04$, $p=0.67$) after controlling for stated importance of open space in respondent home-buying choice. If we assume that the control variable: stated importance of open space in home-buying choice, validly measures respondent preferences before they were exposed to their current home neighborhood, then our results indicate that actually living nearby open space does not significantly further affect their open space preferences.

3.5 Differences in preferences for different open space LULC types nearby

Our results support Hypothesis III, that respondents who place different levels of importance on having open space in the neighborhood when they bought their home live in areas with different open space LULC types. As shown in Table 3.3, homebuyers for whom having open space nearby was more important in their purchasing decision tend to live nearby open spaces with significantly more deciduous forests, wetlands and shrubs. We found that the amount of nearby area in water LULC types was not significantly related to the importance of nearby open space in home-buying choices. Amount of herbaceous openland, park and golf courses were related negatively but not significantly with the importance of nearby open space in buying a home. This suggests that those who place higher importance on open space in home-buying choice choose to live in areas with open space LULC that has potential for greater ecosystem services; deciduous forests, and wetlands and shrubs.

The forest type we discussed here does not include coniferous areas because this study found that coniferous lands have non-significant and negative relationships with people's importance on open space in home selection choices. One explanation for this finding is that conifers, for the most part, are not native to southeast Michigan. Coniferous lands identified on the LULC map are mainly plantation or Christmas tree farms, neither native nor particularly attractive.

 # Table 3.3 approximately here

4. Discussion

The sorting by home-buying choice as a cause for homeowner preference for open space nearby stresses the importance that individual preferences and choices have in shaping landscape change. As Irwin and Bockstael (2004) point out, sprawl is often driven by individual choices over location and land use. Although the sprawl process is not necessarily a simple aggregation of individual choices, individual preferences can play an important role. The importance of individual choices is also reflected in the recent trend of agent-based modeling of land use changes, which seeks to model and predict the individual decision making that drives land use allocation and consequently large scale landscape changes (Brown et al., 2004; Brown and Robinson, 2006; Evans and Manson, 2007). Our larger interdisciplinary project uses agent-based modeling to understand how individual land use decision-making formulate landscape changes and test alternative policies and interventions that could reduce environmental costs and enhance environmental benefits (Brown et al., 2008).

The significance of sorting by home-buying choice in our study suggests that some previous research may benefit from further interpretation. Many studies have suggested that people living in a certain landscape type prefer that type, and one study even found that perceptions of water quality were spatially autocorrelated across a region (Brody et al., 2004; Brody et al., 2005). In our study, the significance of sorting by home-buying choice suggests that people may choose to live near their preferred landscape characteristics more than exposure to nearby landscape characteristics inculcating preference. Our conclusion contributes to a long history of challenges to the rather resilient theory of environmental determinism. It also helps to explain the predictable vigor of local respondents' Not In My Back Yard (NIMBY) response to nearly any change in the existing character of most neighborhoods – even when the proposed change seems to be an "improvement" in the eyes of its advocates.

Americans move from one place to another quite frequently. The spatial correlation of perception with the physical characteristics nearby may be caused by people with different perceptions choosing to live in different landscape types. The high mobility rate in America further supports the importance of sorting by home-buying choice in terms of understanding the values homeowners have for the landscape near their homes. This may be particularly true in exurban landscapes, where incomes tend to be higher than the median for most metropolitan areas, allowing people to have more choices in where they live (Nelson and Sanchez, 1997). According to the US Census Bureau, the average American moves 11.7 times in a lifetime. Regardless of why Americans move, the high mobility rate gives them a chance to "sort" for their preferred living environment. Possibly, this high mobility also prevents them from developing a deep landscape familiarity than might produce a measurable environmental cause.

Our research did not support the exposure to nearby open space environments as a potential cause of homeowner preference for having open space near their home. On the average, more than half of our respondents, 58.6% moved into their current homes after 1995; they had lived in their current homes less than 10 years. Only 9.5% of respondents moved to their current homes before 1980. Another possible explanation for the lack of a significant environmental cause in our study is that people living in exurbia have limited interactions with their surrounding environment. People living in sprawling development rely heavily on a car for daily transportation, which limits their interaction with the surrounding environment. This could change if recreational and public transit oriented infrastructure in the exurban landscape increases people's interaction with their local landscapes, especially since some of the literature shows that certain types of infrastructural improvement have the potential to support increased participation in outdoor activities (Transportation Research Board 2005; Giles-Corti and Donovan, 2002; Jackson, 2003; Lee and Moudon, 2004; Lee and Moudon, 2006; Macintyre et al., 2002; Powell et al., 2003).

While this study supports only the sorting by home-buying choice as a cause of homeowner preference for open space nearby, it does not discount the potential importance that the environmental experience may have on the spatial interaction between humans and the biosphere at different spatial or time scales. For example, what people learn to prefer as they live in one landscape may lead them to seek similar landscape characteristics when they move to another place. The importance of sorting by home-buying choice may be attributed in part to our study area being exurban America, with its own spatial scale, social mobility, and long daily car commuting time. Our study may be useful as a means of anticipating some of the consequences for human-biosphere interactions if settlement patterns in other parts of the world take on some of these same characteristics.

Our findings that those who place higher importance on open space in their home-buying choice live in areas with more deciduous forests, wetlands or shrubs is consistent with their reported preferences for different types of open spaces near their homes (Chapter II). The same respondents reported that they most prefer to have forests near their homes, when given different open space choices, and they also highly prefer wetlands and prairie.

Our results concerning the value of water come as a surprise. In a previous study, we found that people highly prefer to have streams and lakes near their own homes (Chapter II). However, in this paper, we found no relationship between peoples' importance on open space in home-buying choice and the percentage of bodies of water near their homes. One possible explanation is that lakefront properties command a premium price for the private access and views they offer (Lansford and Jones, 1995). Some people who want to live near open space cannot afford to live nearby lakes or streams even though they might prefer to do so.

Our study provides important take-home messages for landscape planning with regard to what should be maintained, what can be developed and what should be limited in development, when considering exurban homeowners' home-buying choices. We found that deciduous forests, wetlands and shrub lands are LULC types that people want to live near, particularly for those who put high importance on open space in their home-buying choice. Because these LULC types are considered native ecosystems in southeast Michigan, we suggest that as development of open spaces continues to occur, maintaining forests as a part of exurban landscapes will satisfy respondents' preference while preserving native ecosystem types. Some LULC types have no significant relationship with exurban homeowners' open space preference, including herbaceous openland, coniferous lands. And coniferous lands may not play any significant role in the preservation of native ecosystems, according to our knowledge of southeast Michigan. We suggest that these lands could be the LULC types to be potentially developed without significantly impacting people's desire for open space experiences or the ecosystem health of the region.

5. Conclusion

A better understanding of the values associated with living near open space is essential to successful conservation efforts, because of the critical role that human preference can play in strategic exurban planning and the future shape of broader landscape patterns. In this paper, we aim to illuminate through two main findings how exurban homeowner preference for open space might be related to open space LULC near their homes. First, in the newly developed exurban landscape of America, people's choice of living environment, may cause them to value nearby open space, rather than nearby open space inculcating human preference. Second, our study suggests that deciduous forests, wetlands and shrubs are open space LULC types that people want to live near, particularly for those individuals who place a high value on open space in their home-buying choice. As these LULC types are significant elements of the native ecosystems in southeast Michigan, we suggest that maintaining forests and wetlands as a part of exurban landscapes can be part of strategic planning efforts that satisfy respondents' preference and simultaneously preserve open space as natural habitat. People are generally unwilling to give up their desires and needs, but we can use what we know about human preference and need to formulate new landscape patterns (Nassauer, 1993; Nassauer, 2005). A better understanding of the values associated with living near open space will contribute to the development of new sustainable landscape patterns in exurbia.

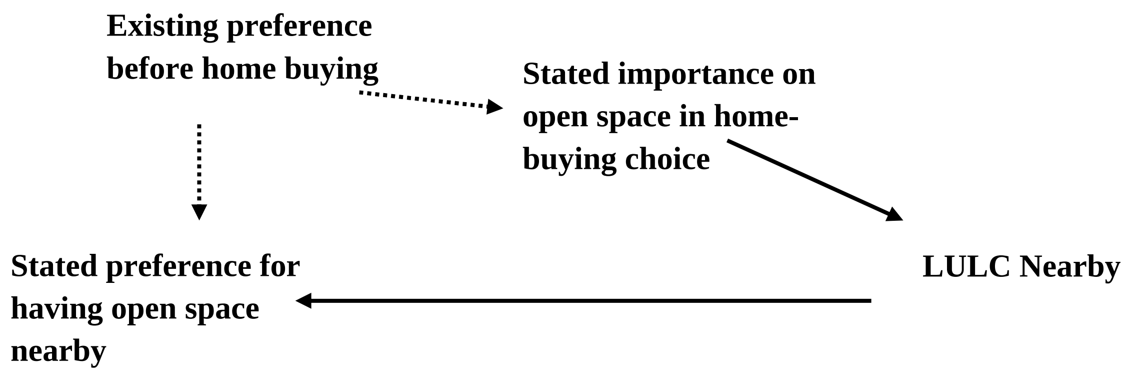


Figure 3.1: The conceptual relationships among stated importance on open space in home-buying choice, LULC nearby and stated preference for having open space nearby

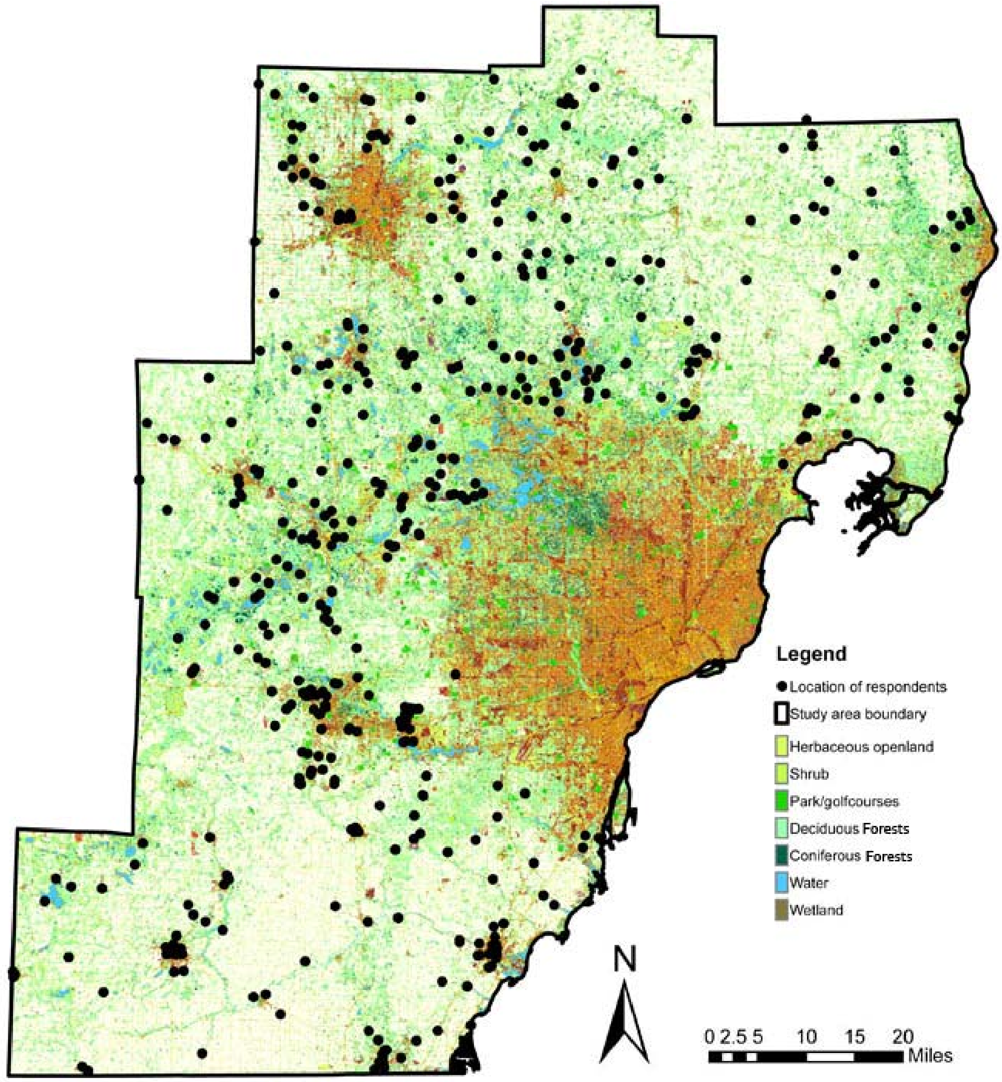


Figure 3.2: Respondent locations with open space LULC types nearby

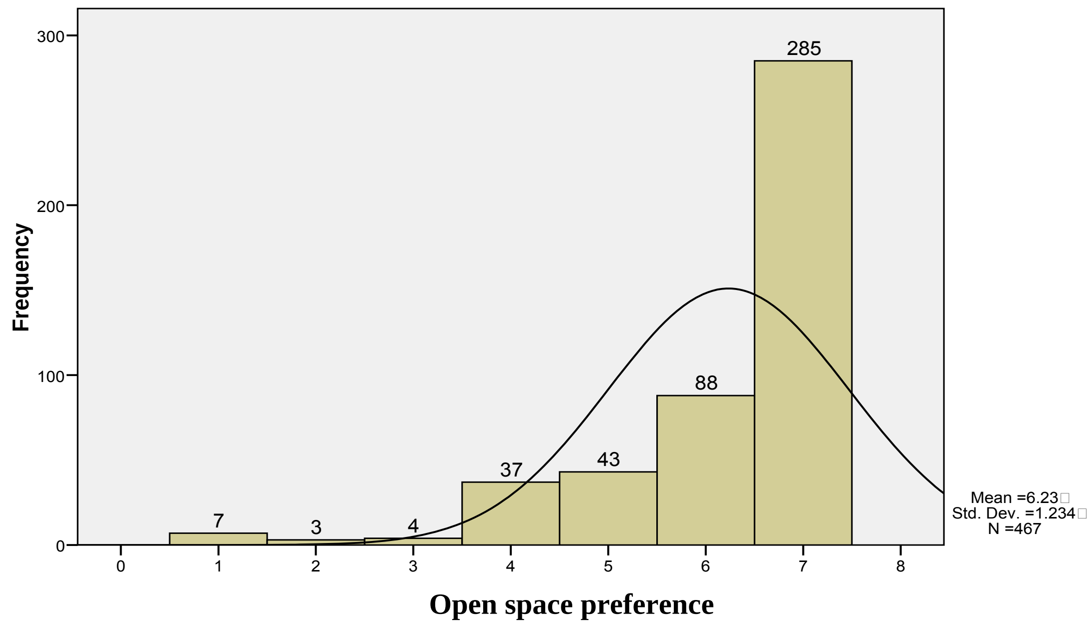


Figure 3.3: Histogram of preference for having open space adjacent to homes

Table 3.1: D**escription of the seven open space LULC types**

Open space LULC types	**Description**
Parks / Golf Courses	Land area with less than 25% of the ground covered by tree canopy and maintained for recreational purposes
Deciduous Forests	Land area with over 60% coverage of northern hardwood association, oak association, aspen association, other upland deciduous, mixed upland deciduous, lowland deciduous forest, lowland mixed forest
Coniferous Forests	Land area with over 60% coverage of pines, other upland conifers, mixed upland conifers, upland mixed forest, lowland coniferous forest
Wetlands	Land area with over 60% coverage of emergent wetland, mixed non-forest wetland, floating aquatic
Water	Land area with more than 70% water
Shrub	Land area with over 60% coverage of upland shrub / low-density trees, lowland shrub,
Herbaceous Openland	Land area with less than 25% of the ground is covered by tree canopy, and less than 25 % of the canopy is woody shrubs/trees

Table3.2: Descriptive statistics of LULC near respondent homes compared with the overall LULC of our exurban area

Survey sample (n=468)			**Zip code selection area**
Percentage of LULC within walking distance	Mean	Std. Deviation	Percentage of LULC type
Parks/ golf courses	0.008	0.047	0.004
Deciduous forests	0.222	0.135	0.218
Coniferous forests	0.061	0.060	0.032
Water	0.029	0.081	0.015
Wetlands	0.029	0.035	0.033
Shrub	0.032	0.031	0.044
Herbaceous openland	0.124	0.084	0.084

Table 3.3: Correlations of open space LULC types with stated importance in home-buying choices

	Herbaceous openland	**Shrub**	**Parks and golf courses**	**Deciduous forests**	**Coniferous forests**	**Water**	**Wetlands**
Corr. Coe.	-.05	.09*	-.01	.19*	-.06	.00	.12*
Sig. (2-tailed)	.32	.02	.89	.00	.15	.99	.00
N	468	468	468	468	468	468	468

**Correlation is significant at the 0.05 level (2-tailed).*

References:

Alexander, C., Ishikawa, S., and Silverstein, M. (1977). "A pattern language," Oxford University Press, New York.

Appler, D. R. (2004). America's converging open space protection policies: evidence from New Hampshire, Virginia, and Oregon. *Urban Lawyer* **36**, 341-374.

Atash, F. (1994). Redesigning suburbia for walking and transit: emerging concepts. *Journal of Urban Planning and Development* **120**, 48-57.

Benedict, M. A., and McMahon, E. T. (2002). Green infrastructure: smart conservation for the 21st century. *Renewable Resource Journal* **20**, 12-17.

Bishop, I. D., and Hulse, D. W. (1994). Prediction of scenic beauty using mapped data and Geographic Information Systems. *Landscape and Urban Planning* **30**, 59-70.

Transportation Research Board (2005). "Does the built environment influence physical activity? Examining the evidence," Rep. No. Special Report No.282, Washington, D.C.

Brody, S. D., Highfield, W., and Alston, L. (2004). Does location matter?: measuring environmental perceptions of creeks in two San Antonio watersheds. *Environment & Behavior* **36**, 229-250.

Brody, S. D., Highfield, W., and Peck, B. M. (2005). Exploring the mosaic of perceptions for water quality across watersheds in San Antonio, Texas. *Landscape and Urban Planning* **73**, 200-214.

Brown, D. G., Page, S. E., Riolo, R., and Rand., W. (2004). Agent-based and analytical modeling to evaluate the effectiveness of greenbelts. *Environmental Modeling and Software*, 1097-1109.

Brown, D. G., and Robinson, D. T. (2006). Effects of heterogeneity in residential preferences on an Agent-Based Model of urban sprawl. *Ecology and Society* **11**, 46.

Brown, D. G., Robinson, D. T., An, L., Nassauer, J. I., Zellner, M., Rand , W., Riolo, R., Page, S. E., Low, B., and Wang, Z. (2008). Exurbia from the bottom-up: confronting empirical challenges to characterizing complex systems. *GeoForum* **39**, 805-818.

Brown, G. G., Harris, C. C., and Reed, P. (2002). Testing a place-based theory for environmental evaluation: an Alaska case study. *Applied Geography* **22**, 49-76.

Burchell, R., Lowenstein, G., Dolphin, W., Galley, C., Downs, A., Seskin, S., Still, K., and Moore, T. (2002). "Cost of Sprawl-2000," Rep. No. TCRP Report 74. National Academy Press, Washington, DC.

Burchell, R. W., and Mukherji, S. (2003). Conventional development versus managed growth: the costs of sprawl. *American Journal of Public Health* **93**, 1534-1540.

Calthorpe, P. (1989). Pedestrian pockets: new strategies for suburban growth. *In* "The Pedestrian Pocket Book: A New Suburban Design Strategy" (D.Kelbaugh, ed.), pp. 7-20. Princeton Architectural Press, New York.

Carruthers, J. I., and Ulfarsson, G. F. (2002). Fragmentation and sprawl: evidence from interregional analysis. *Growth Change* **33**, 312-340.

Daniels, T., and Lapping, M. (2005). Land preservation: an essential ingredient in smart growth. *Journal of Planning Literature* **19**, 316-329

Dearden, P. (1980). A statistical technique for the evaluation of the visual quality of the landscape for land-use planning purposes. *Journal of Environmental Management* **10**, 51-68.
Dearden, P. (1984). Factors influencing landscape preferences: an empirical Investigation. *Landscape Planning* **11**, 293-306.
Evans, T. P., and Manson, S. (2007). Space, complexity, and agent-based modeling. *Environment and Planning B-Planning & Design* **34**, 196-199.
Fernandez, L. E., Brown, D. G., Marans, R. W., and Nassauer, J. I. (2005). Characterizing location preferences in an exurban population: implications for Agent Based Modeling. *Environmental Planning B-Planning and Design* **32**, 799-820.
Forman, R. T. (1995). "Land Mosaics," Cambridge University Press, New York, NY.
Forman, R. T. T., and Godron, M. (1986). "Landscape Ecology," John Wiley & Sons, New York.
Francis, M., Cashdan, L., and Paxson, L. (1984). "Community Open Space," Island Press, Covelo, CA.
Franco, D., Franco, D., Mannino, I., and Zanetto, G. (2003). The impact of agroforestry networks on scenic beauty estimation- the role of a landscape ecological network on a socio-cultural process. *Landscape and Urban Planning* **62**, 119-138.
Giles-Corti, B., and Donovan, R. J. (2002). The relative influence of individual, social and physical environment determinants of physical activity. *Social Science & Medicine* **54**, 1793-1812.
Girling, C. L., and Helphand, K. I. (1994). "Yard, Street, Park: The Design of Suburban Open Space," Joan Wiley & Sons, Inc., New York.
Gobster, P. H., Nassauer, J. I., Daniel, T. C., and Fry, G. (2007). The shared landscape: what does aesthetics have to do with ecology? *Landscape Ecology* **22**, 959-972.
Golley, F. B. (1987). Introducing landscape ecology. *Landscape Ecology* **1**, 1-4.
Guo, Z. W., Xiao, X. M., Gan, Y. L., and Zheng, Y. J. (2001). Ecosystem functions, services and their values: a case study in Xingshan County of China. *Ecological Economics*, 141-154.
Hannon, B. (1994). Sense of place: geographic discounting by people, animals, and plants. *Ecological Economics* **10**, 157-174.
Heimlich, R. E., and Anderson, W. D. (2001). "Developing the urban fringe and beyond: impacts on agriculture and rural land," Rep. No. Report Number 803. USDA Economic Research Service, Washington, DC.
Hollis, L. E., and Fulton, W. (2002). "Open space protection, conservation meets growth management." http://www.solimar.org/pdfs/hollisfultonopenspace.pdf Last retrieved on Nov 12, 2004.
Ittelson, W. H., and Cantril, H. (1954). "Perception: a transactional approach," Doubleday, New York.
Jackson, L. E. (2003). The relationship of urban design to human health and condition. *Landscape and Urban Planning* **64**, 191-200.
Kaplan, R., and Austin, M. E. (2004). Out in the country: sprawl and the quest for nature nearby. *Landscape and Urban Planning* **69**, 235-243.

Lansford, J. N. H., and Jones, L. L. (1995). Marginal price of lake recreation and aesthetics: a hedonic approach. *Journal of Agricultural & Applied Economics* **27**, 212-223.
Lee, C., and Moudon, A. V. (2004). Physical activity and environment research in the health field: implications for urban and transportation planning practices and research. *Journal of Planning Literature* **19**, 147-181.
Lee, C. M., and Moudon, A. (2006). The 3Ds + R: quantifying land use and urban form correlates of walking. *Transportation Research Part D: Transport and Environment* **6**, 204-215.
Lovaas, D. (2002). Growing up, growing out: some rust belt cities sprawl without population growth. *E: The Environmental Magazine* **13**, 14-15.
Macintyre, S., Ellaway, A., and Cummins, S. (2002). Place effects on health: how can we conceptualise, operationalise and measure them? *Social Science and Medicine* **55**, 125-139.
Mitsch, W. J., and Gosselink, J. G. (1993). "Wetlands," John Wiley and Sons, Inc., New York, NY.
Nassauer, I. J. (1995). Culture and changing landscape structure. *Landscape Ecology* **10**, 229-237.
Nassauer, J. I. (1993). "Ecological function and the perception of suburban residential landscapes," Rep. No. NC-163. USDA Forest Service North Central Forest Experiment Station General Technical Report, St. Paul, MN.
Nassauer, J. I. (2005). Using cultural knowledge to make new landscape patterns. *In* "Issues in Landscape Ecology" (J. A. Wiens and M. R. Moss, eds.), pp. 274-280. Cambridge University Press, Cambridge UK.
Naveh, Z. (1991). Some remarks on recent developments in landscape ecology as a transdisciplinary ecological and geographical science. *Landscape Ecology* **5**, 65-73.
Nelson, A. C., and Sanchez, T. W. (1997). Exurban and suburban residents: a departure from traditional location theory? *Journal of Housing Research* **8**, 249-276.
Norton, B., and Hannon, B. (1997). Environmental values: a place-based approach. *Environmental Ethics* **19**, 227-245.
Palmer, J. F. (2004). Using spatial metrics to predict scenic perception in a changing landscape: Dennis, Massachusetts. *Landscape and Urban Planning* **69**, 201-218.
Powell, K. E., Martin, L. M., and Chowdhury, P. P. (2003). Places to walk: convenience and regular physical activity. *American Journal of Public Health* **93**, 1519.
Radeloff, V. C., Hammer, R. B., and Stewart, S. I. (2005). Rural and suburban sprawl in the U.S. Midwest from 1940 to 2000 and its relation to forest fragmentation. *Conservation Biology 19, no. 3*.
Ryan, R. L. (1998). Local perceptions and values for a midwestern river corridor. *Landscape and Urban Planning* **42**, 225-237.
Sell, J. L., Taylor, J. G., and Zube, E. H. (1984). Toward a theoretical framework for landscape perception. *In* "Environmental Perception and Behavior. Research paper in geography #209" (T. F. Saarinen, D. Seamon and J. L. Sell, eds.), pp. 61-83. University of Chicago Press, Chicago.
Theobald, D. M. (2001). Land-use dynamics beyond the American urban fringe. *The Geographical Review* **91**, 544-64.

Vesterby, M., Heimlich, R. E., and Krupa, K. S. (1994). "Urbanization of Rural Land in the United States." U.S. Department of Agriculture, Economic Research Service.

Vogt, C. A., and Marans, R. W. (2004). Natural resources and open space in the residential decision process: a study of recent movers to fringe counties in southeast Michigan. *Landscape and Urban Planning* **69**, 255-269.

Zhang, Y., He, H. S., and Yang, J. (2008). The wildland-urban interface dynamics in the southeastern U.S. from 1990 to 2000. *Landscape and Urban Planning* **85**, 155-162.

Zube, E. H. (1987). Perceived land use patterns and landscape values. *Landscape Ecology* **1**, 37-45.

Zube, E. H., Friedman, S., and Simcox, D. E. (1989). Landscape change - perceptions and physical measures. *Environmental Management* **13**, 639-644.

Zube, E. H., Pitt, D. G., and Anderson, T. W. (1974). "Perception and Measurement of Scenic Resources in the Southern Connecticut River Valley," Rep. No. Publication No. R-74-1. University of Massachusetts, Amherst.

Chapter IV

Potentials and challenges of using landscape metrics to infer cultural values of landscapes

Abstract

In response to the worldwide demand for landscape-level indicators of cultural values, this paper explores the potential to infer one type of cultural value, open space preferences, from landscape metrics. Using several analysis approaches, we examined the relationship between landscape characteristics measured by landscape metrics and open space preferences (POSH) of 468 exurban homeowners in southeast Michigan. We found that homeowners' preference for having open space near their home is not significantly correlated with landscape metrics of open space landuse/landcover (LULC) that exists near their homes, but it is weakly correlated with landscape metrics of development nearby. These results suggest that: 1) Landscape metrics may not validly measure LULC characteristics that are related to some landscape cultural values. This lack of validity could occur for many possible reasons including: inherent limitations of metrics tested, construct differences between planimetric data and landscape experience, data resolution, data LULC types. 2) Open space may be most valued simply for not being developed rather than for its particular open space LULC characteristics.

Keywords: GIS, landuse and landcover, exurbia, landscape planning, open space, preference

1. Introduction

Landscape metrics often have been used to monitor changes in landscape patterns (Baudry and Tatoni, 1993; DiBari, 2007; Hara et al., 2005; Martinuzzi et al., 2007; Pedlowski et al., 1997) and examine potential associations between landscape pattern with certain ecological processes (Andrén, 1994; Flaspohler et al., 2001; Forman and Godron, 1986; Haire et al., 2000; McIntyre, 1995; Sperber et al., 2004). However, the use of landscape metrics to infer landscape cultural values has been less fully explored. If landscape metrics are found to be useful for inferring landscape cultural values (i.e., a community's social and symbolic interpretations of a landscape (Hall, 1966; Rapoport, 1982)), this could be a powerful tool to align ecological and cultural values of multifunctional landscapes across regions.

To understand possible relationships between landscape metrics and cultural values, we reviewed relevant studies of both landscape perception (quantitative measures of preference related to landscape pattern) and revealed preference for homes (hedonic models of home prices that were related to landscape pattern metrics). For studies of home prices, we chose studies specifically using landscape metrics in modeling home prices. For landscape perception research, we used three selection criteria to select only studies that tested the relationship between GIS-based measurements of landscape patterns and empirical measurements of perception. First, we used studies that employed quantitative analysis of public survey data rather than studies based on expert judgment (e.g. BLM, 1986). Second, we reviewed only studies that used GIS-based measurements of landscape patterns, excluding research that used other means to categorize characteristics of a landscape (e.g. Heath et al., 2000; Herzog and Gale, 1996; Herzog and Shier, 2000; House, 1997; Kent, 1993; Stamps, 2002, 2003). Third, we reviewed studies that empirically measured landscape perception, not focusing on studies that did not test the validity of landscape indicators against empirical measures of cultural values (e.g. Girardin and J. Weinstoerffer, 2002; Lim, 2002; Slak and Lee, 2002; T. Pinto-Correia, 2002; W. Fjellstad, 2002). The several studies that met all three criteria are summarized in table 4.1.

 # Table4.1 approximately here

Reviewing this literature, we identified three challenges for investigating relationships between landscape patterns and landscape cultural values. The first is selecting what landscape patterns to be measured. Each study uses different pattern measures, and each finds only some of them to be powerful in predicting perceived or revealed landscape values. For instance, some studies investigate only landscape composition (Bishop and Hulse, 1994; Dearden, 1980) and other studies explore both landscape composition and landscape configuration (Acharya and Bennett, 2001; Dramstad et al., 2006; Franco et al., 2003a; Geoghegan et al., 1997; Kong et al., 2007; Palmer, 2004; Zube et al., 1974). The studies do not use the same metrics, and even similar metrics have no consistent effects across studies (as shown in table 4.1). Among hundreds of landscape metrics now available, the challenge is how to strategically select and examine the uses of landscape metrics with the purpose of using those selected metrics consistently across contexts.

Second, different studies used different approaches to delineate study or sample areas for measuring landscape metrics. Six different methods were used in the studies we reviewed. Zube (1974) calculated physical variables within view dimensions, and this seems to be the same as the viewshed concept used in Palmer's (2004) research. Similarly, Bishop (1994) used the viewshed method but also considered three distance zones within each viewshed. Dearden (1980) measured metrics within a 1km square and Franco et al.(2003b) operationalized the visible area as "1km*130^{o} radius area centered in the visual point". Dramstad et al. (2006) used the area covered by each photograph as a viewshed. Different revealed preference studies use circle with different radius lengths from the homes that are priced in their hedonic models (Acharya and Bennett, 2001; Geoghegan et al., 1997; Kong et al., 2007).

Finally, the appropriate data resolution to measure landscape pattern in order to make inferences about landscape cultural values is unclear. Data resolution is inconsistent among studies, with some very large differences. For example, Bishop (1994) generated metrics from a1ha grid, while Palmer (2004) used a 30*30 square meters cell size, and Dramstad et al. (2006) and Kong (2007) used a 10m*10m grid.

Because some landscape metrics are highly sensitive to changes in extent and scale (Saura and Martinez-Millan, 2001; Wu et al., 2003), inconsistency across studies in protocols for delineating sample area and in data resolution makes it difficult to draw generalizable conclusions from the studies, or even about study methods, including the usefulness of landscape metrics. In our study, we paid special attention to these challenges.

Our work contributes to understanding of the linkage between landscape metrics and landscape cultural values by examining the association of landscape metrics with one cultural value: exurban homeowner's preference for their living environment. Particularly in exurbia, where societal desires for open space experiences may impact these very open space characteristics and their ecological service, landscape planning and management could be greatly enhanced by a better understanding of the relationship between landscape-scale factors and exurban homeowner's preference for their living environment.

Exurban residential development, or large lot development with wells and septic systems, is accelerating in the USA (Carruthers and Ulfarsson, 2002; Heimlich and Anderson, 2001; Lovaas, 2002; Theobald, 2001). Preference for living nearby open spaces has been identified as a driving factor for people moving to exurban areas (Fernandez et al., 2005; Kaplan and Austin, 2004; Vogt and Marans, 2004). However, the increase in exurban residential development poses major challenges for open space conservation because this development encroaches on land previously occupied by agriculture, forestry, wetlands, or other ecosystems (2004; Burchell et al., 2002; Burchell and Mukherji, 2003; Lovaas, 2002).

Open space is a widely used term without a consistent definition (Appler, 2004). Open space can be defined as an area preserved or managed by local people or government (Francis et al., 1984), or a publicly-owned / publicly-accessible place for recreation or habitats (Girling and Helphand, 1994), or an unbuilt environment absent of infrastructure (Benedict and McMahon, 2002; Hollis and Fulton, 2002). In this study on exurban development, we define *open space* as unbuilt environment protected from development, such as forests, wetlands, public parkland, public playing fields, golf courses or other landuse/landcover (**LULC**) not served by public sewer and water infrastructure. Agricultural landscape is not considered as open space in this research because it is mostly not protected from development in southeast Michigan. Rather, agriculture is most widely converted to built uses when development occurs. Studies showed that cropland and rangeland provided more than half of the area for urban expansion (Vesterby et al., 1994).

In this paper, we examine specifically whether exurban homeowners' preference for having open space adjacent to their homes (**POSH**) can be inferred from landscape metrics. We chose this topic for several reasons. First, landscape metrics exist for both the composition and configuration of LULC. If POSH can be inferred from landscape metrics, metrics could be a useful tool for landscape planning to strategically manipulate not only the composition (which kinds of LULC should be planned) but also landscape configuration (what shape a LULC patch should be and how different patches should be arranged spatially). Second, landscape metrics have been used to indicate ecological values of landscapes (Andrén, 1994; Flaspohler et al., 2001; Forman and Godron, 1986; Haire et al., 2000; McIntyre, 1995; Sperber et al., 2004). If POSH can be inferred from landscape metrics, this may help future research or landscape planning to align ecological and cultural values of open space in exurbia. Third, considering the rapidly changing landscape patterns worldwide, there is a growing demand for landscape-level indicators for landscape monitoring and assessment. Decision-makers need to quantify landscape status and changes in order to better respond to the changing trends for sound resource management. Landscape indicators have been suggested as critical for the management of multifunctional landscapes by the Organization for Economic Cooperation and Development (2001). Landscape metrics offered by Fragstats (McGarigal et al., 2002), in particular, quantify LULC patterns relatively quickly and easily and have been widely suggested as landscape level indicators (Leitäo and Ahern, 2002; Leitao et al., 2006).

2. Methodology

The study area is southeast Michigan, which includes the most rapidly growing areas of Michigan (SEMCOG, 2003). We examined exurban areas outside of main city boundaries in ten counties of the Detroit, Ann Arbor, Flint metropolitan areas: Genesee, Lapeer, Lenawee, Livingston, Macomb, Monroe, Oakland, St. Clair, Washtenaw and Wayne, operationalized by the 207 zip codes in this area (Chapter II).

To investigate whether POSH can be inferred from landscape metrics, we used two different types of data: exurban homeowner preference for open space (POSH), as measured in an image-based web survey and LULC within walking distance of survey respondents' home, as measured in a GIS analysis.

2.1 Data from web survey

Web survey data measured respondent POSH. The web survey included a wide variety of questions, and was part of a large research project about spatial land use and ecological effects at the rural-urban interface: Agent-based modeling and evaluation of alternative policies and interventions (Brown et al., 2008). In May 2005, 494 exurban homeowners in southeast Michigan completed the survey. Details about the survey can be seen in Chapter II. We measured POSH by a seven-point Likkert scale, asking respondents to indicate how much they would value open space directly adjacent to their property. A rating of 1 meant "greatly reduce how much I value my home" and 7 meant "greatly increase how much I value my home".

Web survey data also measured social/demographic background variables suggested to be associated with landscape preference in previous studies (e.g. Balling and Falk, 1982; Dearden, 1984; Franco et al., 2003a; García Pérez, 2002; Lyons, 1983; Medina, 1983; Strumse, 1994; Tahvanainen et al., 2001; Yamashita, 2002). The background variables investigated in our study include age, education, employment status, number of children at home, gender, income, and marriage status. Length of residence in current neighborhood was also examined since previous studies suggested that knowledge of the place and the natural surroundings may change with experience (Brown et al., 2002; Cantrill, 1998), and familiarity can affect landscape preference. In addition, exurban homeowners who are attracted to living in an exurban location recently may have different preferences from those who have made their living there for a long time. For instance, respondents living in traditional rural residential settings less than 12 years were found to appreciate the more natural qualities of the rural landscape than did long respondents (Ryan, 2002).

2.2 Landscape metrics

We paid special attention to data resolution, sample area and relevance in selection of landscape metrics since we found these are potential caveats in using landscape metrics to infer landscape cultural values from previous literature.

First, we GIS- encoded the home addresses of respondents who volunteered this information. 468 of 494 respondents were used in this study since some of them did not provide valid addresses to be locatable.

The respondent home addresses link respondent POSH with LULC nearby their home. The spatial LULC data we used in this study was generated from 2001 LULC data at a 30-meter resolution (State of Michigan). We chose the data with 30 meter resolution considering both data availability and arguments from previous literature in support of it as an appropriate scale in investigating landscape perception. While we would not assert that 30 meters is the appropriate resolution to study landscape cultural values, we investigated whether this common and widely available data resolution would allow inference of cultural values. As suggested by Palmer (2004), 30 meters may be an appropriate resolution for studies related to respondent perception since 30 meters is slightly smaller than a residential lot at a density of 4 dwelling units per acre. The 30 meter by 30 meter grain is smaller than the division of land with which local respondents are most familiar. In addition, USGS (U.S. Geological Survey) and local governments across the USA provide a wide variety of GIS data at 30 meter resolution, which makes it easier for the generalization and replication of our study to other areas.

From the 2001 LULC data, we generated eleven LULC classes in our study, which reveal different types of open spaces as well as some developable or developed areas with limited open space. Open space LULC types include parks and golf courses, water, wetlands, shrub, coniferous forests, deciduous forests and herbaceous openland. Another four LULC types represent developed or developable areas, including high density urban lands, low density urban lands, roads, and agriculture.

Our method considered both human experience of surrounding environment and the possible boundary effects in generating landscape metrics. First, we used a circle with a radius of 400 meters centered on each respondent's home location to operationalize. We chose 400 meters because it is commonly accepted in planning literature as a comfortable walking distance (Atash, 1994; Calthorpe, 1989).Our method also avoided boundary effects. Boundary effect relates to the arbitrary boundaries for analysis purposes, like the circle used in this study. Spatial processes are generally unbounded or at least fuzzy-bounded (Leung, 1987), and studies often impose artificial boundaries for analysis purposes. Such delineation does not accurately reflect natural boundaries and as a result some information can be lost. This often leads to the establishment of spurious relationships (Fotheringham and Rogerson, 1993; Griffith, 1983, 1985; Shaw and Wheeler, 1997). In our study, patches of different landscape classes can extend outside of our studied circle areas. If we calculated landscape metrics only within the 400 meter radius, some landscape patches would be truncated without representation of their actual patch sizes and shapes. To more validly measure the landscape patterns near respondent homes, we included full measurements of all patches within or touching the boundary of our 400 meter radius sample circles. This method is illustrated in figure 4.1.

 # Figure 4.1 approximately here

We compared the relationship of compositional versus spatial configuration metrics with POSH, choosing three aspects of landscape metrics: landscape composition (the amount of eleven LULC types), configuration of each landscape type (core area index, shape index, edge density, patch density), and overall landscape configuration (edge density, patch density, largest patch index, core area index, shape index, landscape diversity and evenness). These metrics (Table 4.2) were chosen first to represent different aspects of physical landscape characteristics near respondent homes, including different landscape types, the configuration of each landscape type, and the spatial organization of different landscape types. Also, these metrics are commonly implemented in various forms of landscape monitoring and are relatively simple to use and to interpret. Far more important, they have been suggested to have significant association with landscape cultural values by previous literature (e.g. Bishop & Hulse, 1994; Dearden, 1980; Franco, 2003; Palmer, 2004; Zube *et al.*, 1989; Zube *et al.*, 1974). All landscape metrics were generated using FRAGSTAT (McGarigal et al., 2002).

 # Table 4.2 approximately here

We also did a factor analysis of all selected metrics to reduce index redundancy as suggested by Ritter et al. (1995).

2.3 Analysis

Statistical analyses were executed using the Statistical Package for Social Sciences (SPSS 13.0). We analyzed our data primarily using descriptive statistics, correlations, univariate and multivariate analysis of variances. To examine the potential relationships of POSH with landscape metrics, we did correlation analysis of respondent POSH with selected landscape metrics measuring the configurations of different LULC types near respondent homes. For comparison, considering the availability of certain LULC types near respondent homes, we did another series of correlations analyzing the associations of POSH with selected landscape metrics measuring landscape patterns of certain LULC types only for those who do live near those LULC types. To explore possible effects of respondent social/demographic background, we executed a series of ANOVA (Analysis of Variance) analyses of POSH using social/demographic background as categorical variables. Finally, to understand which landscape metrics or social/demographic background can be more powerful in explaining POSH, we did a univariate linear regression, using stepwise selection, with both landscape metrics and social/demographic variables in the pool of explanatory variables.

3. Results

Our dependent variable, POSH, has a mean rating of 6.1 (min=1; max=7; Std. Deviation=1.23) (Chapter II and III). Around 60% of our respondents rated POSH as 7 while 2% rated it as 1 (Figure 4.2).

 # Figure 4.2 approximately here

3.1 Socioeconomic background

The respondent sample (n=468) reflects 2000 US Census of Population (U.S. Census Bureau) descriptions of our study area in most ways, including age, income, education and number of children.

Respondent age ranged from 20 to 75, with most between 30 to 60 years old. 6.4% of all participants were younger than 30, and 8.8% were older than 60.51. 38% of respondents had no children living at home. 41.9% completed some college; and 40.5% had finished college. Half had full time jobs, 14% had part time jobs, and the other 36% of respondents were not employed. 9.5%had moved to their current homes before 1980, but more than half (58.6%) had moved after 1995.

 # Table 4.3 approximately here

As shown in table 4.3, ANOVA analysis of POSH among exurban homeowners with different socioeconomic background demonstrates no significant results. This suggests that exurban homeowners with different socioeconomic background tend to value having open space adjacent their home to the same degree.

3.2 Landscape metrics

As discussed in Chapter III, sample areas within comfortable walking distance from respondent homes are dominated by open space, particularly deciduous forests, which cover 22.2% of the area.

As discussed above, we addressed the issue of index correlation and redundancy by doing a factor analysis of all metrics we had selected. In our study, metrics clustered according to different LULC types. For instance, the configuration metrics of forests and percentage of forests form one factor, and the configuration metrics of urban low density and percentage of low density urban land form another factor. The highest correlations exist within each landscape type rather than across landscape types and provide little new information for our data. Thus, in further analysis, we chose to use our selected metrics rather than the results of factor analysis.

3.3 Correlations

Table 4.4 shows Spearman correlations between different landscape metrics and POSH for all respondents. In general, our research found that exurban homeowners living in areas dominated by developed LULC types (low density urban, high density urban and roads) have significantly lower POSH than those living in areas with less developed LULC. The amount of herbaceous openland (primarily lawns associated with developed areas) near respondent homes, is negatively associated with POSH. In contrast, certain open space LULC near respondent homes, including deciduous forests and shrubs, are have positive associations with POSH. Those who live in areas with more area of deciduous forests or shrubs land nearby have significantly higher POSH. Agricultural lands, as a type of developable LULC, also have positive associations with POSH. The amounts of the other LULC types nearby respondent homes were not significantly associated with POSH.

Configurations of different LULC types were significantly associated with POSH (Table 4.4). Spatial configurations of urban developed LULC (low density urban, high density urban and roads) are negatively associated with POSH. Where urban developed LULC near respondent homes has larger core area, more complex shapes, denser patches and larger patch sizes, exurban homeowners tend to place less value on their adjacent open space. The more complex of agricultural patches nearby is, the more exurban homeowners value having open space adjacent to their homes. For undeveloped LULC like deciduous forests and shrubs, the larger their core area and patch size are, the more exurban homeowners living nearby value having open space adjacent to their homes. Also, for deciduous forests, the more complex their patch shapes, the more exurban homeowners value having open space adjacent to their homes. The significantly negative correlation of deciduous forest patch density with POSH further suggests that exurban homeowners living near patchy or fragmented deciduous forests tend to less value open space adjacent to their homes. In contrast, respondents living near patchy or fragmented wetlands tend to place higher values on having open space adjacent to their homes.

 # Table 4.4 approximately here

 # Table 4.5 approximately here

When we compared results in table 4.4, which describes correlations for all respondents, with table 4.5, which describes the correlation results for respondents who do have each LULC type near respondent homes, correlation were significantly different, especially for landscape shape, patch density, and mean patch size. Compared with all respondents (who may or may not live nearby any given LULC type), the POSH of those who live near developed LULC tend to be less strongly related to patch density and mean patch size of urban developed landscapes. For those living near agriculture, their POSH tends to less strongly related to the shape and mean patch size of agricultural landscapes. For those who live near wetlands, the shape of the wetlands is more strongly related to their POSH. The more complex wetland shapes are, the more respondents living nearby value having adjacent open space. Only 24 respondents actually lived nearby parks (n=24). For those who did live near parks, their POSH is associated with more park area, large core area of parks, more complex park shapes and higher density of park patches.

These comparisons suggest that special attention should be paid to the availability of certain LULC types within each study sample area, like in our research, the availability of certain LULC types near exurban homeowner's home. Information that could be provided by landscape metrics may be statistically masked by the spatial distribution of any given LULC type across the landscape sample. Patchy distribution of some LULC types across the landscape or across all samples can lead to some misleading results or at least may not reflect the real relationships of landscape patterns with landscape functions.

The overall landscape configuration metrics also have some significant correlations with POSH (table 4.6). The core area and naturalism index have significantly positive relationships with POSH. On the other hand, edge density links negatively with POSH. Landscape diversity and evenness are not significantly related to POSH. The results suggest that exurban homeowners would more prefer their adjacent open space if their surrounding landscape is more natural with fewer edges but larger core areas.

 # Table 4.6 approximately here

3.4 The predictors

The regression model developed from the socioeconomic variables and landscape metrics to explain POSH (for all 468 respondents) is shown in table 4.7. Like the correlation analysis, no single factor of socioeconomic variables makes a significant contribution in the model. Variation in exurban homeowners' socioeconomic background may have little relationship to POSH.

 # Table 4.7 approximately here

Only three metrics significantly contribute to the model: percentage of low density urban lands, landscape shape index of herbaceous openland and total core area index of high density urban lands. In total, they account for only approximately 16% of the variation in POSH.

The amount of low density urban LULC, the most common development type in exurbia, makes the strongest contribution to the model. It suggests that the more development (in this exurban situation, low-density development) near respondent homes, the less respondents would value open space nearby. The second most important contribution to the model comes from the landscape shape index of herbaceous openland, which is also linked negatively with POSH. Herbaceous openland in this study is primarily turf. The model indicates that exurban homeowners living in areas with complex shapes of turf tend to less value their adjacent open space. In addition, total core area index of high density urban lands (mainly industrial and commercial areas), is negatively associated with POSH.

4. Discussion

The result that variation in exurban homeowners' socioeconomic background may have little relationship to exurban homeowners' different POSH further confirms our arguments in another paper that our respondents, exurban homeowners, are a relatively homogeneous group of exurban homeowners in term of their POSH (Chapter II), who are different from urban and suburban people (Nelson and Sanchez, 1997). Similarly, as discussed in Fernandez *et al.* (2005), exurban homeowners are heterogeneous, but they have relatively low heterogeneity in their preference for having open space nearby.

Exurban respondents' preference for adjacent open space, in our study, cannot be inferred from landscape metrics measuring open space LULC types. All three landscape metrics entered as significant in the model are about the surrounding developed environment. There may be other explanations for the landscape metrics weak relationship with POSH. POSH may be the wrong dependent variable. It may be too general since it measures only how much exurban homeowners state that they would value having open space adjacent to their home. Its high mean value and rather low standard deviation suggest that open space measures that are more nuanced that POSH would be needed to reveal heterogeneity of POSH of exurban homeowners (see Chapter II).

The central hypothesis of this study is that landscape metrics would be able to explain a significant amount of variation in POSH. We found that, while some aspects of landscape structure have a significant correlation with POSH, they explain only a small proportion of its total variance (less than 16%). This lack of predictive power of our model leads us to reconsider the potential of landscape metrics in revealing landscape cultural value in two ways. First, perhaps existing landscape metrics are not sufficient to reveal landscape cultural value. By now, hundreds of landscape metrics have been proposed by various researchers to analyze different aspects of landscape patterns and most of them can be computed by the computer program FRAGSTATS (McGarigal and Marks, 1995). The large number of existing landscape metrics does not mean that they are sufficient for landscape management. Landscape management requires much more information about the relationship between patterns and processes (Opdam et al., 2001). As argued by Turner et al. (2001), "there is a need to build a collective library of empirical studies in which ecological responses are related to particular landscape configurations. Unfortunately, we have the power to measure and report more about landscape pattern that we can interpret in terms of effects on ecological processes. (p108)" It is far from being easy, nor is complete to integrate concepts and measurements from the theory of landscape ecology into landscape and resource management (Gustafson, 1998). More sophisticated metrics may be necessary to catch the variance in landscape patterns from which landscape cultural values could be inferred. Second, our results suggest only very cautious use of landscape metrics in planning applications.

Cultural value is about human experiences while landscape metrics is generated from planimetric data. We need to contemplate to what extent landscape metrics are useful in predicting landscape cultural values. As discussed by other researchers, existing landscape metrics seems to be more appropriate to compare patterns rather than making inferences (Corry and Nassauer 2005).

One further speculation of the use of landscape metrics is about the availability of certain LULC types near our respondent homes. As we compare table 4.4 and 4.5, we find some differences in the correlations and the differences may be explained for different reasons. For low/high intensity urban, the difference may be caused by the fact that exurban homeowners who do living in areas with low/high intensity urban landscapes, the patch density and mean patch size of developed landscapes are less relevant to them since they are already living adjacent to those developed LULC types. For the changes in agricultural shape index, it may be explained by the intrinsic shape of agricultural landscapes since agricultural landscapes are regularly managed in general and their shape can be less complicated. The standard deviation comparing agricultural landscapes for those who do live nearby agricultural LULC and all respondents confirms our speculation. As shown in table 4.8 and 4.9, if we look across all respondents including those who do not live nearby agricultural landscapes, the distribution of agricultural shape index spreads more. The more spreaded distribution of agricultural shape index statistically contributes to the significant correlation of agricultural shape index with POSH in table 4.5. The changes in park LULC is due to the small amount of exurban homeowners who do live near parks/golf courses. As too many exurban homeowners are recorded as zero for most park-related landscape metrics, the distribution variance of those metrics is reduced dramatically. This can explain why park-related landscape metrics are significantly correlated for those who do live near parks/golf courses, but not for all respondents. The problems of intrinsic landscape shapes and statistical analysis of landscape metrics tend to suggest that special attentions should be paid to the availability of certain landscape types within each study sample area. The common way of looking landscape metrics across landscape or across all samples can lead to some misleading results or at least may not reflect the real relationships of landscape patterns with landscape functions.

 # Table 4.8 approximately here

 # Table 4.9 approximately here

Another alternative explanation is that caveats in using landscape metrics to infer landscape values may lead to unexpected results. Many challenges exist for using landscape metrics to infer landscape cultural values, including data resolution, sample areas, edge effects and selection of appropriate landscape metrics. Those challenges are easily to be overlooked since the mechanics of applying landscape indices are easy. Similar concerns have been raised by others investigating the association of landscape metrics with ecological processes (Corry and Nassauer, 2005; Gustafson, 1998; Li and Wu, 2004). In cultural and planning research, human experiences need to be considered while addressing those challenges. When deciding data resolution and sample area, how people perceive or experience adjacent landscape should be considered as people's movement across landscape can be totally different from animals. Just like ecological research, cultural and planning studies about landscape metrics also should consider multiple scales because human's different landscape experiences can be across scales. People's landscape perception can be very specific about details, which raises the question of whether coarse-resolution spatial data is useful to infer landscape cultural values. However, people do drive around for everyday life, jog/bike for leisure and personal health. In selecting of landscape metrics for social research, understanding people's landscape experience is critical as well to ensure that only culturally relevant and meaningful metrics are examined.

5. Conclusion and further research

In response to many planning concerns and worldwide demand for landscape indicators, this paper explores the potential and challenges of using landscape metrics to infer POSH of exurban homeowners, one aspect of landscape cultural values. The study identifies that POSH is correlated with some landscape metrics measuring certain aspects of landscape composition and spatial configuration of the LULC types adjacent to respondent homes. However, all landscape metrics having significant contribution in predicting preference for having open space nearby are not about the components and spatial configuration of different open spaces, but developed environment. It seems to suggest that the extent to which open space may be most valued for simply not being development.

In this study, we paid special attention to several challenges in using landscape metrics to refer cultural values, and our study raises additional concerns. In conclusion, we summarize questions people should ask when considering use of landscape metrics to infer landscape values or landscape functions. Are available landscape metrics valid enough to measure the real landscape pattern or more landscape metrics are needed? Which landscape metrics should be selected among the pool to be used in research? How to solve the problem of metrics correlation and redundancy? What is the appropriate data resolution to evaluate the association of landscape metrics with landscape values? What is an appropriate sample area to generate landscape metrics? How to address “boundary effect” of those arbitrary sample areas? Do certain landscape types have intrinsic shapes and how their intrinsic shapes may influence on the result interpretation? And how to address the statistical fault introduced into analysis due to limited availability of all landscape types within each sample area? Further studies are required to clarify these issues before concluding landscape metrics are valuable in social/ecological inferences beyond monitoring changes of landscape pattern.

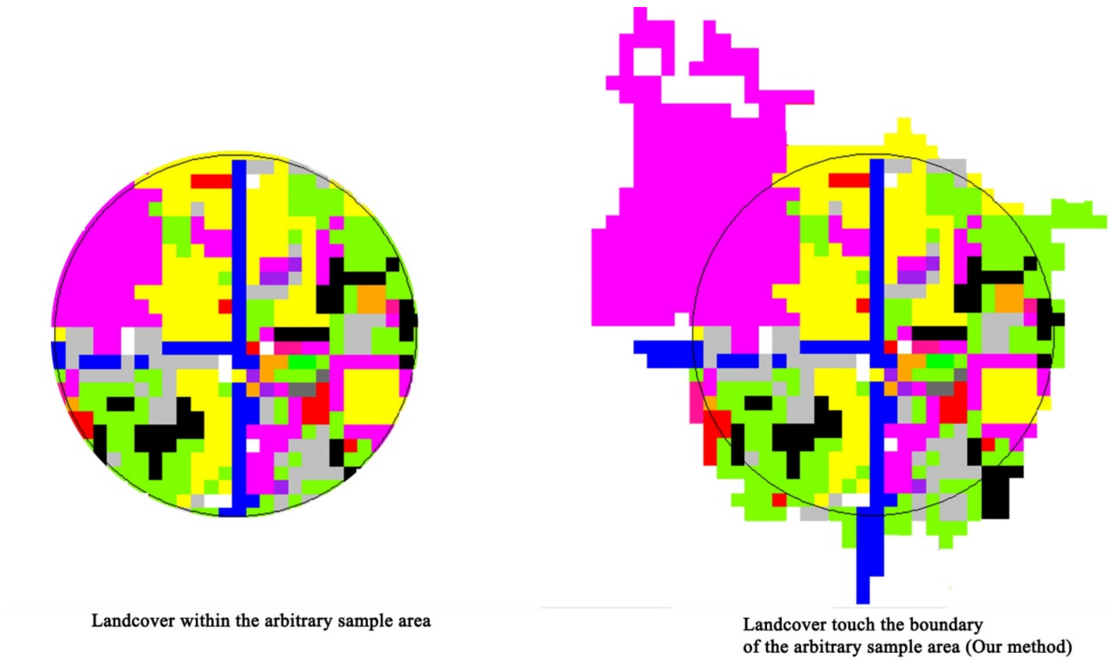


Figure 4.1 Our sample method to reduce boundary effect

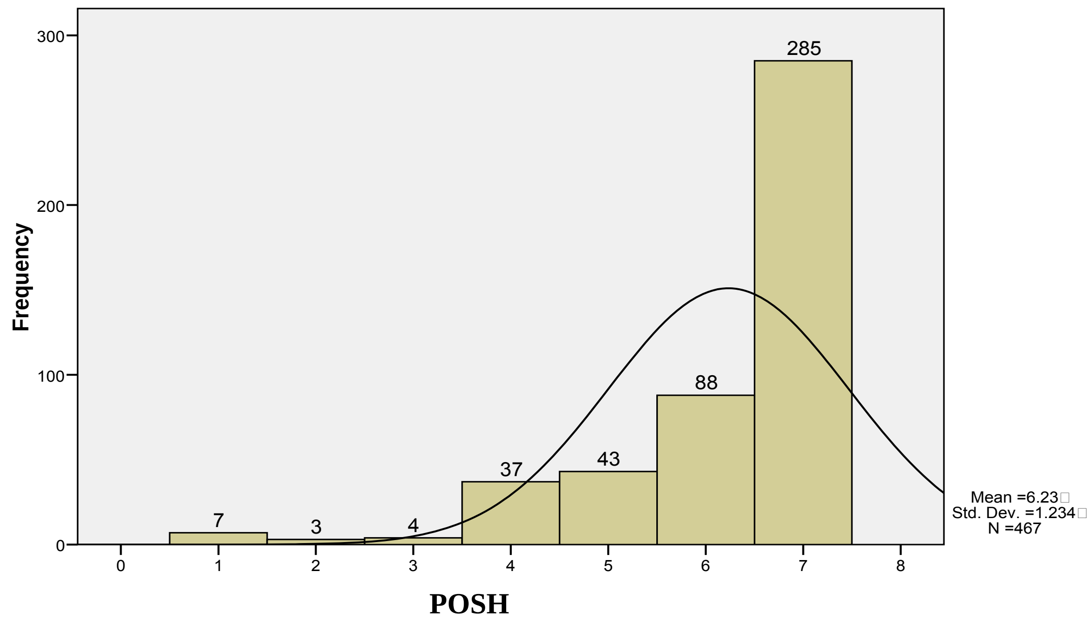


Figure 4.2: Histogram of POSH (preference for having open space adjacent to homes**)**

Table 4.1: Studies investigating the association of landscape metrics with landscape cultural values

Studies	Study context	Metrics found to be relevant	Sample area	Data resolution
(Zube et al., 1974)	-A study investigating the scenic resources of the southern Connecticut -fifty-six views -as respondents	Relative relief ratio Absolute relative relief Mean slope distribution Topographic texture Ruggedness number Spatial definition index Mean elevation Land use diversity Naturalism index Percentage tree cover Land use edge density Land use edge variety Land use compatibility Height contrast Grain contrast Spacing contrast Evenness contrast Naturalism contrast Water edge density Percentage water area Area of view Length of view View position	Physical variables within view dimension	N/A
Dearden (1980)	- The scenic values of the Saanich Peninsula, British Columbia, an area of around 300km^2. - 43 sites	Industrial and/or institutional buildings Coastline: % of undeveloped Airport, cemetery, firing range Greenhouses Residential: modern Power-line right-of-ways Highway: 4-lane Coastline: rocky Roads: unpaved Rivers, streams, watercourses Parkland, recreational areas	30 variables were measured per 1km square	1:25000 topographic maps and aerial photographs

		Orchard Lakes: man-made Scattered trees Scrub Mudflats Relative relief Residential: traditional Freshwater shore: developed Freshwater shore: undeveloped Lakes: natural Quarries, garbage site, auto wrecking Hedges		
(Bishop and Hulse, 1994)	-A study predicting landscape's scenic beauty of Oregon. -25 sites analyzed -39 students as respondents	Visible foreground orchard Visible foreground steep slope Visible foreground river Visible forest Range of visible relief	- A 6 km square -In each of the three distance zones (near, middle, and far)	the cell size of 1 ha
(Franco et al., 2003b)	-The effects of both local level and landscape level variables to the scenic beauty of a specific kind of landscape, agroforestry. -12 images -196 locals and students as respondents	Sky Agroforestry network Enclosure Shannon-Wiener visual diversity Connectivity	Landscape pattern metrics were generated within 1km*130^{o} radius area centered in the visual point	N/A
(Palmer, 2004)	-Respondents' perception of scenic beauty in the Cape Cod community of Dennis, Massachusetts - 55 views -68 locals in 1976 and 25 locals in 1996	Forest Waste Naturalism index Largest patch index Edge density	Viewshed from viewpoint	30 m*30m grid
(Dramstad et	-The association of	Shannon's diversity	The area	10m*10

al., 2006)	preference with landscape configuration - A total of 24 Norwegian agricultural images 53 locals and 38 students as respondents	Index Heterogeneity index Number of land types Number of patches Percent open area Total area Area of open land types Length of edge	covered by each photograph as a viewshed	m grid
(Geoghegan et al., 1997)	Residential values in a region within a 30-mile radius of Washington DC.	Diversity index(both 0.1 and 1km buffer) Fragmentation index(0.1km buffer) Wood structure % of open space (1.0 buffer) % of residential use (0.1 km buffer)	Both a 0.1km and 1.0km radius surrounding each housing transection	N/A
(Acharya and Bennett, 2001)	A hedonic property value analysis of over 4000 houses for an urban watershed in New Haven County, Connecticut.	percentage of open space, diversity, Richness, Development (richness* population density)	Area within ¼ and 1 mile of each house	N/A
(Kong et al., 2007)	in predicting the prices of in Jinan City, China -124 housing clusters	land-use patch richness, size–distance index of scenery forest accessibility to park and plaza green space types percentage of urban green space.	a “moving window” with window sizes of 300 and 500m radius	10m*10 m grid

Table 4.2: Description of landscape metrics

Landscape metrics	Description*	Ecological significance
Composition		
Percentage of landscape	Percentage of total area occupied by each LULC type	Availability of varied habitats and land-cover heterogeneity a major cause of declining biodiversity (Noss and Cooperrider, 1994).
Naturalism index	The area-weighted mean "naturalness" rating of land use types (Zube et al., 1974)	N/A
Class-level configuration		
Core area index	The percentage of a patch that is core area. CAI = 0 when the patch contains no core area.	Supports for core-area species and services some species are adversely affected by edges and are more closely associated with patch interiors (Temple, 1986).
Landscape Shape index	LSI = 1 when the landscape consists of a single square or maximally compact (i.e., almost square) patch of the corresponding type; LSI increases without limit as the patch type becomes more disaggregated.	The amount of edge for a habitat patch relates to potential predation in avian species and Plants species richness (Moser et al., 2002). There is an association between edge density and both nest predation (Wilcove, 1985) and nest parasitism (Yahner, 1988).
Patch density	The number of patches per unit area	An area-normalized measure of fragmentation, may relate to dispersal capability probability of occupancy and persistence of an organism in a patch may be related to patch insularity (Kareiva, 1990).
Mean patch size		Many vertebrates require suitable habitat patches larger than some minimum size (Johnson et al., 1992). Patch size is considered as positively correlated to species and/or habitat diversity (Burgess and Sharpe, 1981).
Landscape-level configuration		
Core area index	Same as class-level core area index	Same as class-level core area index
Simpson's Evenness Index	Evenness is expressed as the observed level of diversity divided by the maximum possible	Aldo Leopold noted that wildlife diversity was greater in more diverse and spatially heterogeneous landscapes (Leopold, 1933). Systems

	diversity for a given patch richness.	with lower diversity tend to be more easily invaded by exotic species and more fragile to pollution regarding their nutrient cycles and ecosystem functioning (Schindler, 1990).
Largest Patch Index	LPI equals the area of the largest patch in the landscape divided by total landscape area, multiplied by 100.	Lower level of disturbance. Potential to support more habitats. Patch size is considered as positively correlated to species and/or habitat diversity (Burgess and Sharpe, 1981).
Landscape Shape Index	Same as class-level landscape shape index	Same as class-level landscape shape index

**Descriptions are modified from Fragstats (McGarigal et al., 2002)*

Table 4.3: ANOVA analysis of POSH among respondents with different social/demographic background

Socioeconomic variables	Categories (n)	Df	Mean Square	F	Sig.
kids	Having kids (217) not having kids (251)	1	0.17	0.11	0.74
Age	<=40 (104) >60 (48) <=30 (36) <=50 (149) <=60 (127)	4	2.64	1.74	0.14
Employment	Full time (233) Part time (62) Not employed (168)	2	3.04	1.99	0.14
Marriage	Single, never married (33) Married (352) Separated/divorced/widowed (57) Domestic partnership (21)	3	0.53	0.34	0.79
Income	<$20,000 (27) $20,000 - $29,999 (34) $30,000 - $39,999 (37) $40,000 - $49,999 (56) $50,000 - $59,999 (47) $60,000 - $74,999 (62) $75,000 - $99,999 (62) $100,000 - $149,999 (88) $150,000+ (21)	8	0.83	0.56	0.81
Education	Doctorate, law or professional degree (4) College degree (115) Master's degree (39) Completed some college (193) Completed some postgraduate (32) High school graduate (74) Completed some high school(5)	6	1.55	1.02	0.42
Gender	Male (100) Female (364)	1	3.15	2.07	0.15

Table 4.4: Correlation of POSH with selected landscape metrics for each LULC type for all respondents (n=468)

LULC types	Percentage of landscape	Core area index	Landscape shape index	Patch density	Mean patch size
Developed/developable LULC types					
Low Intensity Urban	-0.25*	-0.23*	-0.19*	-0.23*	-0.23*
High Intensity Urban	-0.19*	-0.12*	-0.11*	-0.19*	-0.16*
Roads / Paved	-0.17*	-0.13*	-0.18*	-0.08	-0.12*
Agriculture	0.17*	0.17*	0.13*	-0.04	0.17*
Open space LULC types					
Herbaceous Openland	-0.10*	-0.06	-0.07	-0.01	-0.10*
Parks / Golf Courses	0.02	0.05	0.02	0.03	0.02
Deciduous forests	0.10*	0.10*	0.18*	-0.14*	0.15*
Coniferous forests	-0.05	0.03	-0.08	-0.08	-0.03
wetlands	0.08	-0.01	0.05	0.11*	0.02
Water	-0.03	-0.05	-0.04	-0.04	-0.03
shrub	0.10*	0.10*	0.06	0.07	0.09

**Correlation is significant at the 0.05 level (2-tailed).*

Table 4.5: Correlations of POSH with selected landscape metrics for each LULC type considering the availability of that LULC type nearby respondent homes

LULC types	Percentage of landscape	Core area index	Landscape shape index	Patch density	Mean patch size
Developed/developable LULC types					
Low Intensity Urban (n=437)	-0.26*	0.18*	-0.16*	**0.05**	**-0.14***
High Intensity Urban (n=377)	-0.14*	-0.09*	-0.13*	**0.06**	**0.02**
Roads / Paved (n=457)	-0.19*	-0.14*	-0.19*	-0.09	-0.14*
Agriculture (n=394)	0.15*	0.11*	0.07	-0.04	0.05
Open space LULC types					
Herbaceous Openland (n=467)	-0.09*	-0.06	-0.07	0.02	-0.09*
Parks / Golf Courses (n=24)	**0.27***	**0.14***	**0.38***	**0.48***	0.07
Deciduous forests (n=467)	0.12*	0.09*	0.11*	-0.14*	0.16*
Coniferous forests (n=445)	-0.05	0.03	-0.06	-0.08	-0.02
Wetland (n=385)	0.09	-0.02	**0.12***	0.14*	-0.01
Water (n=138)	0.05	0.05	0.03	0.02	0.04
Shrub (n=456)	0.12*	0.10*	0.09	0.06	0.08

**Correlation is significant at the 0.05 level (2-tailed).*

Table 4.6: Correlation of POSH with landscape configuration

	Landscape evenness index	Core area index	Landscape shape index	Largest patch index	Naturalism index
POSH	-0.06	0.18*	-0.15*	0.09	0.19*

**Correlation is significant at the 0.05 level (2-tailed).*

Table 4.7: Regression model of POSH*

Model	Beta	metrics entered in the stepwise regression model	R^2
Model 1	-0.199	% of low density urban lands	0.158
	-0.134	landscape shape index of herbaceous openland	
	-0.109	total core area index of high density urban lands	

** n=468. POSH (exurban homeowners' preference for having open space adjacent to their homes) is the dependent variable. Both landscape metrics and social/demographic variables are in the pool of explanatory variables.*

Table 4.8: Standard deviation of selected landscape metrics for each LULC type considering the availability of that LULC type near respondent homes

LULC types	Percentage of landscape	Core area index	Landscape shape index	Patch density	Mean patch size
Developed/developable LULC types					
Low Intensity Urban (n=437)	0.10	5.05	0.17	8.98	1.57
High Intensity Urban (n=377)	0.07	6.01	0.14	6.31	0.14
Roads / Paved (n=457)	0.10	4.12	0.46	4.49	1.68
Agriculture (n=394)	0.25	21.71	0.53	2.75	9.59
Open space LULC types					
Parks / Golf Courses (n=24)	0.14	18.18	0.40	3.15	2.28
Deciduous forests (n=467)	0.14	9.59	0.34	5.15	2.34
Coniferous forests (n=445)	0.06	6.46	0.13	4.94	0.30
Wetlands (n=385)	0.04	3.42	0.19	3.69	0.19
Water (n=138)	0.13	25.35	0.31	1.18	5.36
Shrub (n=456)	0.03	2.89	0.12	3.67	0.16
Herbaceous Openland (n=467)	0.08	6.18	0.14	5.61	0.63

Table 4.9: Standard deviation of selected landscape metrics for each LULC type (all respondents, n=468)

LULC types	Percentage of landscape	Core area index	Landscape shape index	Patch density	Mean patch size
Developed/developable LULC types					
Low Intensity Urban	0.099	4.911	0.333	9.354	1.517
High Intensity Urban	0.062	5.482	0.469	6.397	0.429
Roads / Paved	0.102	4.082	0.508	4.584	1.669
Agriculture	0.241	22.25	1.385	2.986	9.0494
Open space LULC types					
Parks / Golf Courses	0.047	6.954	0.333	1.126	0.737
Deciduous forests	0.136	9.592	0.351	5.202	2.341
Coniferous forests	0.060	6.331	0.287	5.197	0.303
wetlands	0.035	3.150	0.491	3.835	0.251
Water	0.081	17.54	0.638	1.033	3.337
shrub	0.031	2.854	0.218	3.762	0.160
Herbaceous Openland	0.085	6.173	0.159	5.686	0.627

References:

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

Andrén, H. (1994). Effects of habitat fragmentation on birds and mammals in landscapes with different proportions of suitable habitat: a review. *Oikos* **71**, 355-366.

Appler, D. R. (2004). America's converging open space protection policies: evidence from New Hampshire, Virginia, and Oregon. *Urban Lawyer* **36**, 341-374.

Atash, F. (1994). Redesigning suburbia for walking and transit: emerging concepts. *Journal of Urban Planning and Development* **120**, 48-57.

Balling, J. D., and Falk, J. H. (1982). Development of visual preference for natural environments. *Environment and Behavior* **14**, 5-28.

Baudry, J., and Tatoni, T. (1993). Changes in landscape patterns and vegetation dynamics in Provence, France. *Landscape and Urban Planning* **24**, 153-159.

Benedict, M. A., and McMahon, E. T. (2002). Green infrastructure: smart conservation for the 21st century. *Renewable Resource Journal* **20**, 12-17.

Bishop, I. D., and Hulse, D. W. (1994). Prediction of scenic beauty using mapped data and Geographic Information Systems. *Landscape and Urban Planning* **30**, 59-70.

Bureau of Land Management, U.S. Department of Interior (1986). "Visual Resource Inventory, Bureau of Land Management Handbook 8410-1," U.S. Government Printing Office, Washington, D.C.

Brown, G. G., Harris, C. C., and Reed, P. (2002). Testing a place-based theory for environmental evaluation: an Alaska case study. *Applied Geography* **22**, 49-76.

Burchell, R., Lowenstein, G., Dolphin, W., Galley, C., Downs, A., Seskin, S., Still, K., and Moore, T. (2002). "Cost of Sprawl-2000," Rep. No. TCRP Report 74. National Academy Press, Washington, DC.

Burchell, R. W., and Mukherji, S. (2003). Conventional development versus managed growth: the costs of sprawl. *American Journal of Public Health* **93**, 1534-1540.

Burgess, R. L., and Sharpe, D. M., eds. (1981). "Forest Island Dynamics in Man-dominated Landscapes: Analysis and Synthesis." Springer, New York.

Calthorpe, P. (1989). Pedestrian pockets: new strategies for suburban growth. *In* "The pedestrian pocket book: A new suburban design strategy" (D.Kelbaugh, ed.), pp. 7-20. Princeton Architectural Press, New York.

Cantrill, J. G. (1998). The environmental self and a sense of place: communication foundations for regional ecosystem management. *Journal of Applied Communications Research* **26**, 301-318.

Carruthers, J. I., and Ulfarsson, G. F. (2002). Fragmentation and sprawl: evidence from interregional analysis. *Growth Change* **33**, 312-340.

Corry, R. C., and Nassauer, J. I. (2005). Limitations of using landscape pattern indices to evaluate the ecological consequences of alternative plans and designs. *Landscape and Urban Planning* **72**, 265-280.

Dearden, P. (1980). A statistical technique for the evaluation of the visual quality of the landscape for land-use planning purposes. *Journal of Environmental Management* **10**, 51-68.

Dearden, P. (1984). Factors influencing landscape preferences: an empirical Investigation. *Landscape Planning* **11**, 293-306.

DiBari, J. N. (2007). Evaluation of five landscape-level metrics for measuring the effects of urbanization on landscape structure: the case of Tucson, Arizona, USA. *Landscape and Urban Planning* **79**, 308-313.
Dramstad, W., Tveit, M., Fjellstad, W., and Fry, G. (2006). Relationships between visual landscape preferences and map-based indicators of landscape structure. *Landscape and Urban Planning* **78**, 465 - 474.
Fernandez, L. E., Brown, D. G., Marans, R. W., and Nassauer, J. I. (2005). Characterizing location preferences in an exurban population: Implications for Agent Based Modeling. *Environmental Planning B-Planning and Design* **32**, 799-820.
Flaspohler, D. J., Temple, S. A., and Rosenfield, R. B. (2001). Effects of forest edges on ovenbird demography in managed forest landscape. *Conservation Biology* **15**, 173-183.
Forman, R. T. T., and Godron, M. (1986). "Landscape Ecology," John Wiley & Sons, New York.
Fotheringham, A. S., and Rogerson, P. A. (1993). GIS and spatial analytical problems. *International Journal of Geographical Information Systems* **7**, 3-19.
Francis, M., Cashdan, L., and Paxson, L. (1984). "Community Open Space," Island Press, Covelo, CA.
Franco, D., Franco, D., Mannino, I., and Zanetto, G. (2003). The impact of agroforestry networks on scenic beauty estimation- the role of a landscape ecological network on a socio-cultural process. *Landscape and Urban Planning* **62**, 119-138.
García Pérez, J. D. (2002). Ascertaining landscape perceptions and preferences with pair-wise photographs: planning rural tourism in Extremadura, Spain. *Landscape Research* **27**, 297-308.
Geoghegan, J., Wainger, L. A., and Bockstael, N. E. (1997). Spatial landscape indices in a hedonic framework: an ecological economics analysis using GIS. *Ecological Economics* **23**, 251-264.
Girardin, P., and J. Weinstoerffer (2002). Assessment of the contribution of land use pattern and management of farming systems to landscape quality: a landscape indicator. *In* "NIJOS/OECD Expert Meeting on Agricultural Landscape Indicators, October 7-9," (NIJOS/OECD, ed.), pp. 193-208. NIJOS, Oslo, Norway.
Girling, C. L., and Helphand, K. I. (1994). "Yard, street, park: the design of suburban open space," Joan Wiley & Sons, Inc., New York.
Southeast Michigan Council of Governments. (2003). "Land Use Change in Southeast Michigan: Causes and Consequences." SEMCOG, Detroit, MI.
Griffith, D. A. (1983). The boundary value problem in spatial statistical analysis. *Journal of Regional Science* **23**, 377-387.
Griffith, D. A. (1985). An evaluation of correction techniques for boundary effects in spatial statistical analysis: contemporary methods. *Geographical Analysis* **17**, 81-88.
Gustafson, E. J. (1998). Quantifying landscape spatial pattern: what is the state of the art? *Ecosystems* **1**, 143-156.

Haire, S. L., Bock, C. E., Cade, B. S., and Bennett, B. C. (2000). The role of landscape and habitat characteristics in limiting abundance of grassland nesting songbirds in an urban open space. *Landscape and Urban Planning* **48**, 65-82.

Hall, E. T. (1966). "The Hidden Dimension," Doubleday, Garden City, N.Y.

Hara, Y., Takeuchi, K., and Okubo, S. (2005). Urbanization linked with past agricultural landuse patterns in the urban fringe of a deltaic Asian mega-city: a case study in Bangkok. *Landscape and Urban Planning* **73**, 16-28.

Heath, T., Smith, S. G., and Lim, B. (2000). Tall buildings and the urban skyline - the effect of visual complexity on preferences. *Environment and Behavior* **32**, 541-556.

Heimlich, R. E., and Anderson, W. D. (2001). "Developing the urban fringe and beyond: impacts on agriculture and rural land," Rep. No. Report Number 803. USDA Economic Research Service, Washington, DC.

Herzog, T. R., and Gale, T. A. (1996). Preference for urban buildings as a function of age and nature context. *Environment and Behavior* **28**, 44-72.

Herzog, T. R., and Shier, R. L. (2000). Complexity, age, and building preference. *Environment and Behavior* **32**, 557-575.

Hollis, L. E., and Fulton, W. (2002). "Open space protection, conservation meets growth management." http://www.solimar.org/pdfs/hollisfultonopenspace.pdf Last retrieved on Nov 12,2004.

House, M., and Maureen Fordham (1997). Public perceptions of river corridors and attitudes towards river works. *Landscape Research* **22**, 25-44.

Johnson, A. R., Milne, B. T., Wiens, J. A., and Crist, T. O. (1992). Animal movements and population dynamics in heterogeneous landscapes. *Landscape Ecology* **7**, 63-75.

Kaplan, R., and Austin, M. E. (2004). Out in the country: sprawl and the quest for nature nearby. *Landscape and Urban Planning* **69**, 235-243.

Kent, R. L. (1993). Determining scenic quality along highways - a cognitive approach. *Landscape and Urban Planning* **27**, 29-45.

Kong, F., Yin, H., and 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**, 240-252.

Leitäo, A. B., and Ahern, J. (2002). Applying landscape ecological concepts and metrics in sustainable landscape planning. *Landscape and Urban Planning* **59**, 65-93.

Leitao, A. B., Joseph, M., Ahern, J., and McGarigal, K. (2006). "Measuring Landscapes: A Planner's Handbook," Island Press, Washington.

Leopold, A. (1933). "Game Management.," Charles Scribners, New York.

Leung, Y. (1987). On the imprecision of boundaries. *Geographical Analysis* **19**, 125-151.

Li, H., and Wu, J. (2004). Use and misuse of landscape indices. *Landscape Ecology* **19**, 389-399.

Lim, S. (2002). Indicators for agricultural landscape and policy implications: a Korean Perspective. *In* "NIJOS/OECD Expert Meeting on Agricultural Landscape Indicators, October 7-9," (NIJOS/OECD, ed.), pp. 228-241. NIJOS, Oslo, Norway.

Lovaas, D. (2002). Growing up, growing out: some rust belt cities sprawl without population growth. *E: The Environmental Magazine* **13**, 14-15.

Lyons, E. (1983). Demographic correlates of landscape preference. *Environment and Behavior* **15**, 487-511.
Martinuzzi, S., Gould, W. A., and Ramos Gonzalez, O. M. (2007). Land development, land use, and urban sprawl in Puerto Rico integrating remote sensing and population census data. *Landscape and Urban Planning* **79**, 288-297.
McGarigal, K., Cushman, S. A., Neel, M. C., and Ene, E. (2002). FRAGSTATS: Spatial Pattern Analysis Program for Categorical Maps. Pages Computer software program produced by the authors at the University of Massachusetts, Amherst. Available at the following web site: http://www.umass.edu/ landeco/research/fragstats/fragstats.html.
McIntyre, N. E. (1995). Effects of forest patch size on avian diversity. *Landscape Ecology* **10**, 85-99.
Medina, A. Q. (1983). A visual assessment of children's and environmental educators' urban residental preference patterns. Unpublished doctoral dissertation, University of Michigan, Ann Arbor.
Moser, D., Zechmeister, H. G., Plutzar, C., Sauberer, N., Wrbka, T., and Grabherr, G. (2002). Landscape patch shape complexity as an effective measure for plant species richness in rural landscapes. *Landscape Ecology* **17**, 657-669.
Nelson, A. C., and Sanchez, T. W. (1997). Exurban and suburban residents: a departure from traditional location theory? *Journal of Housing Research* **8**, 249-276.
Noss, R. F., and Cooperrider, A. Y. (1994). "Saving Nature's Legacy: Protecting and Restoring Biodiversity.," Island Press.
Opdam, P., Foppen, R., and Vos, C. (2001). Bridging the gap between ecology and spatial planning in landscape ecology. *Landscape Ecology* **16**, 767-779.
Palmer, J. F. (2004). Using spatial metrics to predict scenic perception in a changing landscape: Dennis, Massachusetts. *Landscape and Urban Planning* **69**, 201-218.
Pedlowski, M. A., Dale, V. H., Matricardi, E. A. T., and da Silva Filho, E. P. (1997). Patterns and impacts of deforestation in Rondonia, Brazil. *Landscape and Urban Planning* **38**, 149-157.
Rapoport, A. (1982). "The meaning of the built environment," Sage, Beverly Hills, CA.
Ritters, K. H., O'Neill, R. V., Hunsaker, C. T., Wickham, J. D., Yankee, D. H., Timmons, S. P., Jones, K. B., and Jackson, B. L. (1995). A factor analysis of landscape pattern and structure metrics. *Landscape Ecology:* **10:** 23-40.
Ryan, R. L. (2002). Preserving rural character in New England: local residents' perceptions of alternative residential development. *Landscape and Urban Planning* **61**, 19-35.
Saura, S., and Martinez-Millan, J. (2001). Sensitivity of landscape pattern metrics to map spatial extent. *Photogrammetric Engineering and Remote Sensing* **67**, 1027–1036.
Schindler, D. W. (1990). Natural and anthropogenically imposed limitations to biotic richness in fresh waters. *In* "The Earth in Transition: Patterns and Processes of Biotic Improvement" (G. M. Woodwell, ed.), pp. 425-462. Cambridge University Press, Cambridge.
Shaw, G., and Wheeler, D. (1997). "Statistical Techniques in Geographical Analysis (2nd ed.)," David Fulton Publications.

Slak, M., and Lee, A. (2002). Indicators of landscape dynamics: On-going land cover changes. *In* "NIJOS/OECD Expert Meeting on Agricultural Landscape Indicators, October 7-9," (NIJOS/OECD, ed.), pp. 116-129. NIJOS, Oslo, Norway.

Sperber, C. F. et al. (2004). Tree species richness and density affect parasitoid diversity in cacao agroforestry. *Basic and Applied Ecology* **5**, 241-251.

Stamps, A. E. (2002). Fractals, skylines, nature and beauty. *Landscape and Urban Planning* **60**, 163-184.

Stamps, A. E. (2003). Advances in visual diversity and entropy. *Environment and Planning B-Planning & Design* **30**, 449-463.

Strumse, E. (1994). Perceptual dimensions in the visual preferences for agrarian landscapes in western Norway. *Journal of Environmental Psychology* **14**, 281-292.

T. Pinto-Correia, et al. (2002). Landscape units in Portugal and the development and application of landscape indicators. *In* "NIJOS/OECD Expert Meeting on Agricultural Landscape Indicators, October 7-9," (NIJOS/OECD, ed.), pp. 309-316. NIJOS, Oslo, Norway.

Tahvanainen, L., Tyrväinen, L., Ihalainen, M., Vuorela, N., and Kolehmainen, O. (2001). Forest management and public perceptions - visual versus verbal information. *Landscape and Urban Planning* **53**, 53-70.

Temple, S. A. (1986). Predicting impacts of habitat fragmentation on forest birds: a comparison of two models. *In* "Wildlife 2000: Modeling Habitat Relationships of Terrestrial Vertebrates" (J. Verner, M. L. Morrison and C. J. Ralph, eds.), pp. 301-304. Univ. of Wisconsin Press, Madison, WI.

Theobald, D. M. (2001). Land-use dynamics beyond the American urban fringe. *The Geographical Review* **91**, 544-64.

Turner, M. G., Gardner, R. H., and R.V.O'Neill (2001). "Landscape Ecology in Theory and Practice: Pattern and Process," Springer Verlag, New York, NY.

Vesterby, M., Heimlich, R. E., and Krupa, K. S. (1994). "Urbanization of Rural Land in the United States." AER-673. U.S. Department of Agriculture, Economic Research Service.

Vogt, C. A., and Marans, R. W. (2004). Natural resources and open space in the residential decision process: a study of recent movers to fringe counties in southeast Michigan. *Landscape and Urban Planning* **69**, 255-269.

W. Fjellstad, W. D. a. R. L. (2002). Testing indicators of landscape change in Norway. *In* "NIJOS/OECD Expert Meeting on Agricultural Landscape Indicators, October 7-9," (NIJOS/OECD, ed.), pp. 145-156. NIJOS, Oslo, Norway.

Wilcove, D. S. (1985). Nest predation in forest tracts and the decline of migratory songbirds. *Ecology* **66**, 1211-1214.

Wu, J., Shen, W., Sun, W., and Tueller, P. T. (2003). Empirical patterns of the effects of changing scale on landscape metrics. *Landscape Ecology* **17**, 761-782.

Yahner, R. H. (1988). Changes in wildlife communities near edges. *Conservation Biology* **2**, 333-339.

Yamashita, S. (2002). Perception and evaluation of water in landscape: use of photo-projective method to compare child and adult residents' perceptions of a Japanese river environment. *Landscape and Urban Planning* **62**, 3-17.

Zube, E. H., Pitt, D. G., and Anderson, T. W. (1974). "Perception and Measurement of Scenic Resources in the Southern Connecticut River Valley," Rep. No. Publication No. R-74-1. University of Massachusetts, Amherst.

Chapter V

Conclusions

Exurban development is the result of a complex array of human desires, market forces, and policy choices. The dilemma for open space conservation in exurbia is that, while exurban homeowners move to exurbia for open space experiences and to be closer to environments that they perceive as natural, exurban development occupies open space and impacts the structure, function and dynamics of ecological systems. The aim of this dissertation is to reveal homeowner preferences for open spaces so that future exurban development would maintain long term availability of open space experiences as well as the quality of ecosystem services provided by that open spaces.

Chapter II shows that open space strongly influences exurban homeowners' home-buying choice, ranking second only to home price. Importantly, exurban homeowners do have different preferences for different types of open spaces. Among the seven open space types examined in this study, the most preferred types are forests, lakes and streams, followed by wetlands and prairie. Playing fields and golf courses are least preferred. When we compared the perceptions of exurban homeowners who put more importance on living nearby open space with others, those who considered open space more important had significantly higher preferences for forests, streams, lakes, wetlands and prairie open space types. The results suggest that if forests and water (lakes and streams) are maintained as a part of exurban landscapes, they could be planned to satisfy exurban homeowners' preferences and to enhance ecological quality. Careful design of wetland and prairie is essential to protect these ecosystems while providing preferable living environments for exurban homeowners. As for golf courses and playing fields, their development should be restricted considering their limited ecological values and their locations within a community should be strategically allocated to better satisfy respondent preference for open spaces nearby.

Chapter III is theoretical exploration of potential causal explanations for relationships between *preference* for having open space near one's home and *actually having* open space landuse /landcover (LULC) near one's home. This research has two main findings about how exurban respondents' preference for open space might be related to LULC near their homes. First, in the newly developed exurban landscape of America, exurban homeowners may choose neighborhoods with open space that they prefer, rather than nearby open space inculcating their preference. Second, our study suggests that deciduous forests, wetlands and shrubs are LULC types that exurban homeowners want to live nearby, particularly for those individuals who place a high value on open space in their home-buying choice. As these LULC types are significant elements of the native ecosystems in southeast Michigan, we suggest that maintaining forests and wetlands as a part of exurban landscapes can be part of planning to satisfy respondents' preferences and simultaneously preserve open space as natural habitat. People are generally unwilling to give up their desires and needs, but we can use what we know about human preferences to formulate new landscape patterns (Nassauer, 1993; Nassauer, 2005). A better understanding of the values associated with living near open space will contribute to the development of more sustainable landscape patterns in exurbia.

Chapter IV is an exploratory study using landscape metrics to infer one aspect of landscape social values, open space preference. This research contributes to understanding of the linkage between landscape metrics and landscape cultural values by examining the association of landscape metrics with one cultural value: exurban homeowner's preference for their living environment. Particularly in exurbia, where societal desires for open space experiences may impact these very open space characteristics and their ecological service, landscape planning and management could be greatly enhanced by a better understanding of the relationship between landscape-scale factors and homeowner's preference for their living environment. The study finds that preference for having open space nearby is not predicted by landscape metrics measuring

LULC composition and spatial configuration of physical open spaces nearby respondent homes, but is weakly predicted by landscape metrics measuring the surrounding built up environment. These results lead to two alternative conclusions. 1) Open space may be most valued for simply not being developed rather than for its particular LULC composition and composition. This seems inconsistent with the conclusions from Chapter II and III, which find that exurban homeowners have significantly different preferences for different open space types, and those who considered open space nearby to be more important in their home buying choice live in areas that match their open space preferences. However, the inconsistency is not a total contradiction because Chapter IV initiates the question of why open space is valued while Chapter II and III only explore the associations. 2) Landscape metrics may not validly measure LULC characteristics that are related to some landscape cultural values. This lack of validity could occur for many possible reasons including: inherent limitations of metrics tested, construct differences between planimetric data and landscape experience, data resolution, data LULC types. The lack of relationship between metrics and stated preference suggests a series of questions that should be asked when considering use of landscape metrics to infer landscape values or landscape functions are summarized.

There are several ways in which the research can be extended or improved.

One limitation of this research is about agricultural LULC, which is not considered as a type of open space in our questionnaire design because agriculture in general is not protected from development in southeast Michigan and can be encroached easily by residential development (Heimlich and Anderson, 2001; Vesterby et al., 1994). Studies have shown that agriculture is attractive to people and can have positive influences to surrounding house prices (Klinea and Wichelns, 1998; Roe et al., 2004; Rosenberger and Loomis, 1999). Meanwhile, agriculture is the dominating LULC in some exurban areas (Heimlich and Anderson, 2001), including our study area. Agriculture is “developable open space” as discussed by Geoghegan (2002). And in this categorization, farmland with conservation easement should be separated from other agricultural landscape since farmland with conservation easement is permanent open space (Geoghegan, 2002).

Furthermore, only nearby LULC within 400 meter circle of respondent homes is examined in this research. It is possible that the relationship between open space preference and nearby LULC extends to a broader area. Future study examining LULC at different scales would further the understanding of the relationships between open space preference and LULC nearby. Similarly, a study examining the respondent use frequency of surrounding open space would provide more insight about a potential environmental cause of preference.

Lastly, the LULC data used in this research is from 2001, while the image-based web survey was conducted in 2005. Because of landscape change, respondents may have experienced different nearby LULC than our data showed. When measuring the effect of experience, we did not factor in the amount of time people have lived in their neighborhood.

A better understanding of the values associated with living near open space is essential to successful open space conservation efforts, because of the critical role that human preference can play in exurban planning and the future shape of broader landscape patterns. This dissertation examines exurban homeowners' open space preference and demonstrates that exurban homeowners have varied preferences for different types of open spaces, sorting in home-buying choice is the main cause for homeowners' preference for open space nearby and there are many challenges of using landscape metrics to infer open space preference, one aspect of landscape cultural values. It also suggests some research questions for further exploration of the values associated with living near open space. People are generally unwilling to give up their desires and needs, but we can use what we know about human preference and need to formulate new landscape patterns (Nassauer, 1993; Nassauer, 2005). A better understanding of the values associated with living near open space will contribute to the development of new sustainable landscape patterns in exurbia.

References:

Cheshire, P., and Sheppard, S. (1995). On the prices of land and the value of amenities. *Economica* **62**, 247-267.

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

Heimlich, R. E., and Anderson, W. D. (2001). "Developing the urban fringe and beyond: impacts on agriculture and rural land," Rep. No. Report Number 803. USDA Economic Research Service, Washington, DC.

Klinea, J., and Wichelns, D. (1998). Measuring heterogeneous preferences for preserving farmland and open space. *Ecological Economics* **26**, 211-224.

Kopits, E., McConnell, V., and Walls, M. (2007). "The tradeoff between private lots and public open space in subdivisions at the urban-rural fringe," Rep. No. RFF DP 07-33. Resources for the future, Washington, DC.

Nassauer, J. I. (1993). "Ecological function and the perception of suburban residential landscapes," Rep. No. NC-163. USDA Forest Service North Central Forest Experiment Station General Technical Report, St. Paul, MN.

Nassauer, J. I. (2005). Using cultural knowledge to make new landscape patterns. *In* "Issues in Landscape Ecology" (J. A. Wiens and M. R. Moss, eds.), pp. 274-280. Cambridge University Press, Cambridge UK.

Roe, B., Irwin, E. G., and Morrow-Jones, H. A. (2004). The effects of farmland, farmland preservation, and other neighborhood amenities on housing values and residential growth. *Land Economics* **80**, 55-75.

Rosenberger, R. S., and Loomis, J. B. (1999). The value of ranch open space to tourists: Combining observed and contingent behavior data. *Growth and Change* **30**, 366-383.

Vesterby, M., Heimlich, R. E., and Krupa, K. S. (1994). "Urbanization of Rural Land in the United States." AER-673. U.S. Department of Agriculture, Economic Research Service.