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Non-market Valuation of Natural Resource Amenities: Assessing their Effects on Human Values, Public Health, and the Economic Growth

Neelam C. Poudyal
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To the Graduate Council:

I am submitting herewith a dissertation written by Neelam C. Poudyal entitled "Non-market Valuation of Natural Resource Amenities: Assessing their Effects on Human Values, Public Health, and the Economic Growth." I have examined the final electronic copy of this dissertation for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy, with a major in Natural Resources.

Donald G. Hodges, Major Professor

We have read this dissertation and recommend its acceptance:

David M. Ostermeier, Bruce E. Tonn, J. Larry Wilson

Accepted for the Council:
Carolyn R. Hodges

Vice Provost and Dean of the Graduate School

(Original signatures are on file with official student records.)

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A Dissertation Presented for
The Doctor of Philosophy
Degree
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Neelam C. Poudyal
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ABSTRACT

Rural landscapes in the United States have changed substantially in recent years due to increased urbanization, and an ever-increasing demand for consumptive and non-consumptive uses of natural resources. At the same time, we are facing new challenges regarding the socio-economic well-being of people and the ecological significance of resources in the landscape. Previous research in natural resources economics and management has failed to recognize the role of natural resources amenities in fostering economic growth, human values, and public welfare. Applying various non-market valuation techniques to real world observations, the findings from the essays in this dissertation add to the valuation aspects of natural resources economics literature, and reveal some policy implications for local, state, and federal governments.

The first essay investigates the potential of promoting natural resource amenities as a rural economic growth engine. The second investigates how the variation, spatial distribution, and configuration of landuse features are valued in urban neighborhoods. The third essay estimates the demand for public lands in urban areas and analyzes the anticipated economic welfare gain of policies supplying such public lands. The fourth essay extends the existing model of the life expectancy production function to evaluate the role of environmental amenities in promoting public health. The final essay assesses the effects of the ongoing landuse changes and urban sprawl on the demand for wildlife hunting and related nature-based recreation in rural America.

Since the recent approaches of conservation and development emphasize passive employment of natural resources for sustainable development; the essays in this dissertation present some insights into recognizing the value of natural resources in economic growth, human values, public health, and recreational prospects in the United States. In addition to providing policy implications, essays in this dissertation extend or improve some of the existing models and methodological frameworks of non-market valuation.

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CHAPTER 1
INTRODUCTION

1.1 Background

Societal values and, as a result, management directions regarding natural resources in the United States, changed dramatically during the last century. Natural resource management during the first half of the 20th century was guided primarily by the idea of providing "the greatest good to the greatest number" (Cortner and Moote, 1999). Forests were managed primarily for timber products to fuel construction, railroad expansion, and household energy consumption. Conversely, early natural resources management efforts paid little, if any, attention to the environmental and human values of those resources.

During the same period, most of the population was migrating to urban areas in search of jobs, education, and other opportunities. Vast amounts of forest and wildlands were cleared for human settlement and agricultural expansion. The country's economic growth and industrial expansion in the late 1900s also led to landuse conflicts and the pollution of air and water resources. More recent urban development has also occurred at the expense of traditional rural landscapes (Reynolds, 2001). In sum, the pattern of intensive natural resource consumption has consistently resulted in environmental degradation and numerous natural resources problems.

More recently, we have observed, however, a shifting pattern of both demand and consumption of natural resources. The means and approaches to manage them have changed as well. Most importantly, the non-timber values of forests are gradually being recognized as playing an important role in human development and economic growth. As a result, the primary values of forest resources in the U.S. are changing from traditional utilitarian to modern aesthetic, recreational, and environmental. For example, the recent migration trends in the U.S. illustrate that people are moving from the urban to rural areas in search of a better quality of life (Reeder, 1999; Deller et al., 2001). Markets that once relied exclusively on the sale of timber products are now beginning to trade ecosystem services such as carbon offsets, watershed protection, and recreational use (Heal, 2000; Pagiola et al., 2002). Increasing demand for such resources and recently established markets are now opening new avenues for research supporting the effective management of those resources.

Similarly, the management and governance of natural resources have shifted recently, due in part to the realization that local conservation efforts are critical, as well as the increased global pressure to join coordinated initiatives at the regional or global level. Cortner and Moote (1999) described this as a paradigm shift in natural resource management. They characterized the observed transition in management approaches in three different phases. It started with the regulation-free consumption of the early period (before the 1800s), to some government initiatives for regulation (1800s and early 1900s), followed by conservative, sustained yield management in the middle age (1930s-40s), and finally the landscape-scale management of today. After the world's largest intergovernmental institution, the United Nations, introduced the global agenda of *Sustainable Development* (Brundtland Commission, 1987), agencies have began to work in an integrated framework, regardless of scale and jurisdiction. As a result, planning efforts have been gradually modified to encompass a more holistic view. Sustainable use and conservation have been emphasized as being critical to economic growth and development. For example, the concept of “New Regionalism” (Wheeler, 2002) adopts a more inclusive, holistic, and sustainable approach to planning and development. The modern and postmodern landscapes, being massive in extent and mostly polycentric and politically fragmented, were characterized by sprawl, traffic congestion, environmental damage, and placelessness. To overcome these issues, refined planning approaches like “new regionalism” seek to adopt integrated approaches to balance economic development, environmental conservation, human values, and social equity. Doing this is essential if development is going to be economically viable, socially acceptable, and ecologically sustainable.

Managing natural resources has, however never been free of challenges. With increasing tensions between social, economic, and ecological interests, managing natural resources has become more dynamic. This limits the scope of existing tools to deal with new problems, and hence warrants their reconsideration and revision according to changing scenarios. This obviously requires new research that not only tests whether the existing management options will work in changing scenarios, but also explores new opportunities to guide policy decisions. This is perhaps why we have observed increased emphasis on “adaptive management” in natural resource use and development. Adaptive management is a process which guides societies to learn from experiences and develop improved, as well as new, methods of coping with environmental problems (Holling, 1978; Walter, 1986).

1.2 Problem Statement

The rural-urban fringe has become America's most contested landscapes; due in large part to the ecological, social, and cultural costs associated with sprawl and suburban development. A significant number of people, however, view such development patterns as a result of market choice and a matter of individual freedom (Daniels, 1999). Regardless of the current debate, rural America will likely continue to transition into more rural-urban interface conflicts, due primarily to the fact that such interfaces represent the perfect blend of nature and "urbanness" or a geographical balance among town-country magnets like the landuse architecture illustrated in the early concepts of the garden city (Howard, 1902). In order to design smart planning and development policies, it is essential to know why the current patterns of natural resource use and developments are the way they are. However, we still lack sufficient information on the interrelationship between natural resources, human values, and economic growth.

The sustainability of human life and natural resources in the fringe ecology that results from the rapid urbanization has become an important question. Socioeconomic changes can bring changes in landuse patterns and the use of natural resources, for example, which can eventually alter the lifestyle, culture, and traditions of a society. Knowing how changes in natural amenities and landuse resources would impact economic growth, aesthetic and traditional values, public health, and cultural and recreational opportunities in a landscape would therefore be key to preserving the quality of human life, and promoting sustainable development. Thus, we need to examine the mechanisms that conserve natural resources and improve human well-being and the quality of life, while promoting economic growth and development.

Despite a huge body of literature on natural resource economics and management, some important questions remain. It has been consistently documented in the literature that human activities impact the landuse and condition of natural resources, such as creation of rural-urban interface, urban sprawl, habitat loss, and fragmentation. Studies have also constantly revealed that intensive management of natural resources promotes economic growth, regardless of its impacts to the environment. Most of the previous work in natural resource economics, however, has been focused on exploring economic opportunities through the direct and exhaustive employment of our life support resources such as harvesting trees, using fast-growing exotic species, and practicing intensive cropping.

On the other hand, factors, which have not been explored, yet are the opportunities in the passive employment of natural resources for economic growth, human quality of life preservation, and sustainable development. Sustainable development requires conservation, which certainly would not be possible without the sustainable use of resources. Therefore, future strategies should also emphasize less-intensive use of natural resources for economic growth and human development. As discussed earlier, with increasing societal recognition of environmental values and the resulting increased demand for life amenities, a tremendous potential exists for materializing the passive employment of natural resource amenities for fostering economic growth, public welfare, and human values.

Unfortunately, a serious gap exists in the literature regarding these issues. Prior research, for example, tells us little about the types of conflicts or opportunities in the current pattern of natural amenities demand and consumption, the likelihood of changing landuse patterns and landscape features to affect human values, the degree of correlation between natural resources and public health and welfare, and the effects of changes in migration patterns and social behavior on the potential for economic growth and ecological conservation. It is in this context that this dissertation develops a few of these research questions. The studies address these questions by employing non-market valuation of natural resources to estimate their benefits or economic potential, and also to establish their relationship with human values and public health.

1.3 Non-market Valuation

Non-market valuation has been a common analytical method to study economics of natural resource dynamics. Since most of the non-timber natural resource benefits are not directly traded in the market, non-market valuation offers reliable methodology to estimate their economic value based on the stated or revealed preference of consumers (Champ et al., 2003). Stated preference methods are based on responses to surveys such as contingent valuation, whereas the revealed preference methods derive the value of non-market goods based on value of those which are directly linked with the former goods and have prices in market. Types of research questions to be addressed in this dissertation involve valuing and estimating the benefits of natural amenity and landuse resources.

The literature on "valuation" and "benefit estimation" centered development of natural resource economics indicate an increasing research need in valuation. For example, Deacon et al. (1998) found an overwhelmingly increasing trend of literature development in "valuation" and "benefit estimation", compared to other themes of environmental management during the second half of the twentieth century. Since this dissertation contains essays that employ different types of non-market valuation methods, it contributes to the literature in both the methodological and the management implications perspectives. The revealed preference approach of valuation is preferred to stated preference, because of the complexity of data collection and incentive compatibility issues associated with the latter approach. Therefore, revealed preference approaches such as hedonic price and demand models, and hedonic choice models or production function, have been used in the essays.

1.4 Objectives

The study objectives are to:

1. examine the role of natural resource amenities in promoting rural economic development by attracting retirees,
2. evaluate the spatial configuration and pattern of open spaces in an urban neighborhood,
3. estimate the demand for and welfare effects of public lands in urban areas,
4. explore the relationship between environmental amenities and public health, and
5. investigate the effect of urban sprawl and landuse changes on the demand for hunting.

The objectives were achieved by employing individual study approaches specific to the research questions under consideration. Research details for each objective have been developed in essays, which form the individual chapters of the dissertation. Each essay presents an in-depth discussion of the specific objectives, relevant literature, theoretical framework, methodology, and data used. Findings are discussed, as are the conclusions and policy implications from each study. All studies were based on econometric analyses of empirical data collected from a variety of sources. While extensive discussions on the individual research are contained in the respective chapters, the following paragraphs offer a brief overview of each chapter's focus.

1.5 Essay Overview

The first essay (Chapter 2) examines the residential choice pattern of retirees, the most common type of recent amenity migrants in the U.S. (Oehmke et al., 2007). Examining their recent trend of moving from urban to rural counties in America, the study examines the motivating factors behind retiree immigration. My hypothesis is that retiree migration occurs primarily from the urban centers and regional employment hubs to the rural areas, which are endowed with natural amenities and other historic civic facilities such as art galleries and cultural museums. The existing migration literature (e. g., Carolino and Mills, 1987; Deller et al., 2001; Kim et al., 2005; Nzaku and Bukenya, 2005) focuses on general population movement, which is of less importance from an economic point of view than the movement of prosperous retirees. Thus, the research provides more meaningful policy implications for economic growth and rural development.

Traditional polluting and resource extractive industries in urban areas have come under increasing criticism, at a time of steady decline in farming and mining activities in rural areas (Reeder, 1999; Kusmin, 2006). As a result, policy makers and regional planners are searching for alternative economic growth engines. Attracting retirees could be a sustainable regional development strategy because they could provide a significant positive impact on the local tax base, employment, and local economy while resulting in a relatively low impact on the environment. The results also provide some insights into the specific types of natural amenities that could be preserved to boost local economies by attracting retirees.

The second essay (Chapter 3) is related to preserving landscape values in urban neighborhoods. Investigating landscape values dates back to the work of early regionalists such as Ebenezer Howard (1902), who stressed the value of landscape and place characteristics in urban areas. Previous studies, however, mostly focused on estimating dollar values for the amount of and proximity to open and green spaces in urban areas (Cho et al., 2008). Therefore, very little was understood about the value people place on the varieties, spatial configuration, and pattern of landuse. This research attempts to examine how people living in urbanizing landscapes value different patterns of open spaces and developed lands in their neighborhood.

Using housing sales information from real estate markets and landuse data from satellite imagery in an econometrically robust hedonic framework, this study examines the amenity value of those features. Findings from the study offer insights in designing urban landscapes to enhance the human values, aesthetic beauty and increase residents' overall quality of life.

The third essay (Chapter 4) analyzes the demand for public lands for recreation in urban areas. As the population of U.S. cities rapidly grows, the remaining open spaces and parks are being crowded and shared by increasing numbers of people. This trend is not only exceeding the carrying capacity of the parks, but also deteriorating the recreational experiences and personal satisfaction of the visitors and users of these resources. McPherson (2006) pointed out, for example, that one of the potential constraints in North American urban forestry is the overuse of recreation parks in urban areas.

Effective urban landuse planning and increasing the area of such parks require a clear understanding of their amenity values and demand in our society. However, our current knowledge on the economic value of such parks, especially the welfare effect to the community, is limited. For example, one of the six major strategic goals of the National Research Plan for Urban Forestry, 2005-2015, is focused on properly estimating the economic benefits and real estate value added by the enhanced neighborhood quality from such parks (Clark et al., 2007). This essay attempts to estimate the demand for recreation park acreages in urban neighborhood using a two- stage hedonic framework. It also assesses how the supply of additional acreage of land in such parks will increase economic welfare. Additionally, segmenting a single market into homogenous submarkets for demand identification, and applying the second stage demand estimation, represents two significant methodological contributions to the hedonic literature.

The fourth essay (Chapter 5) investigates the relationship between natural resources amenities and public health. While human life expectancy has been a common metric in measuring public health (Barlow and Vissandjee, 1999; Lomborg, 2002), existing studies of life expectancy present a few limitations. First, most of these studies utilized a macro approach, employing data aggregated at a macroeconomic level (Shaw et al., 2005). This type of model captures the variation among countries, but understanding local variation in life expectancy within a developed country such as the U.S. requires examining differences at a finer scale. Moreover, the life expectancy production function used in previous studies virtually ignores environmental factors and natural resource amenities, which are believed to have a substantial influence on quality of life.

The essay extends the previous models of human life expectancy production function by acknowledging the contribution of natural amenities as a factor of production in life expectancy. By doing so, it evaluates the role natural resource amenities play in improving public health in the United States. It aims to strengthen both the natural resource amenities and life expectancy literature in several ways. First, it employs a more complete set of natural resource amenities, which previous research demonstrates enhances the quality of life. In contrast to earlier studies with macroeconomic data, data disaggregated to the county level were used to reveal the relationship at the local level. Third, improving upon previous studies that used cross-sectional data but failed to address spatial dependence, it adopts a spatial econometric model (Anselin and Bera, 1998) that tests and corrects for any form of spatial autocorrelation in the data.

The fifth essay (Chapter 6) links the changing landuse patterns, urban sprawl, and forces of urbanization with recreational activity (Brown et al., 2000; Katz, 2002). Hunting is one of the major nature-based recreational activities in the U.S. and has ecological, social, and economic benefits for society. First, hunters help control the population of game species (Mehmood et al., 2003; Bhandari et al., 2006). Second, license revenues serve as the major revenue source of conservation agencies (Floyd and Lee, 2002). Third, hunting provides a social platform in some parts of the country to bring people together to enjoy cultural and traditional values (Lamar and Donnell, 1987).

Hunting, however, has experienced a continuous decline in public participation for several decades (Cordell and Super, 2000). Earlier, Putnam (1995) suggested that socio-demographic transformation and the emergence of technical innovations affected public leisure patterns and civic engagement. During this period of decline, many regions in the U.S. have experienced dispersed land development patterns and suburban housing growth, typically referred as "urban sprawl" (Rodrigue, 2006). While urbanization brings changes in socio-cultural settings and landuse resources, our understanding of the effect of urbanization on nature-based recreation, such as hunting, is inadequate. This essay will address this gap by assessing the effect of various forces of urban sprawl on hunting demand.

Conclusions and appropriate policy implications of the findings from these studies will be discussed in detail at the end of respective essays. The final chapter of this dissertation will summarize all essays and their conclusions in a more concise form to highlight the main points that add to the natural resource economics literature and have relevancy in policy guidance.

CHAPTER 2
NATURAL RESOURCE AMENITIES, RETIREE INMIGRATION, AND IMPLICATIONS FOR ECONOMIC GROWTH[1]

2.1 Introduction

Historically, federal resources have been allocated to help rural communities finance their infrastructure development such as roads, schools, electrification, and sewers (Whitener, 2005). Unlike the traditional approach of federal funding for local development, more sustainable and collaborative strategies have been emphasized more recently to focus on rural development through mobilizing local resources (Layzer, 2006). Using local resources for development could gain more local public support, reduce local dependency on federal and state resources, and, therefore, be more sustainable in the long run.

Nevertheless, most local governments are continuing to follow traditional economic development strategies such as raising tax rates or attracting industries or heavy manufacturers for their economic base. These approaches have been criticized, however, for their detrimental impact on the environment and quality of life (Reeder, 1998). With increasing environmental and health awareness of urban and suburban residents, these approaches are not likely to gain public support in the future (Castle, 1993; Buttel, 1995; Kim et al., 2005). This suggests that governments in urban and suburban areas will have limited reliance on such traditional growth engines in the future.

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[1] A similar version of this essay appears as:
Poudyal, N C., D. G. Hodges, and H. K. Cordell. 2008. The Role of Natural Resource Amenities in Attracting Retirees: Implications for Economic Growth Policy. *Ecological Economics*, 68: 240-48.

On the other hand, rural counties that have primarily relied on extractive uses of natural resources such as farming and mining have experienced continuous declines in business during the past few decades (Reeder, 1998; Das and Rainey, 2007). For example, the nation experienced a loss of more than 15% of manufacturing jobs between 2000 and 2003 (Kusmin, 2006). Even though the wage rates within some selected industries are considerably higher or stable in some regions, the employment and real earnings from these industries is decreasing. This can affect the economic dependency of local government in such industries. The Rocky Mountain region observed higher mining wage rates, for example, but declining wages for service and trade industries. The number of farming and mining dependent counties in the region declined by 47 and 18%, respectively, whereas service trade counties in the area increased by about 60% between 1970 and 1995 (Vias, 1999, pp. 19). Given the volatility of these job markets and the citizen demand for a cleaner environment, policy makers and local governmental officials might be interested in identifying resources and innovative income-generating activities that are environmentally friendly and sustainable. This paper reports on a national study using a county-level dataset to examine the role of natural resource amenities to attract retirees, which, as earlier studies suggested, could have important implications for fueling local economies.

Natural resources and nature-based amenities have been considered an integral part of growth and development in previous studies (Carlino and Mills, 1987; Clark and Murphy, 1996; Deller et al., 2001; Green, 2001; Rupashingha and Goetz, 2004; Kim et al., 2005; Nzaku and Bukenya, 2005). These studies employed modern growth or development theory to explain the growth in population, income, and employment in relation to various amenities including natural resources. However, understanding general population growth in relation to county amenities might not be as economically appealing as a way to explain the potential of such amenities to attract economically prosperous retirees. As a consequence, policy makers can draw few implications from earlier studies to adopt any specific economic growth strategy.

Recent studies have suggested that attracting retirees can be a potential growth engine for rural America (Haas and Serow, 1990; Federrick, 1993; Deller, 1995; Keith and Fawson, 1995; Stallman and Siegel, 1995; Reeder, 1998; Shields et al., 2001; Skelley, 2004; Das and Reiney, 2007). The studies revealed that educated and economically prosperous retirees for permanent migration bring a tremendous potential for rural economic development. These economically prosperous retirees provide a substantial multiplier effect to local economies. A few of these benefits include, but are not limited to increased tax revenue, local retail expenditure and cash flow, increased service based jobs, donations, and community services (Haas and Serow, 1990; Fagan and Longino, 1993; Siegel and Leuthold, 1993). A few counties predominantly located in rural settings have already benefited from the retirees (Reeder, 1998), and similar non-metro counties possess great potential to attract retirees in the future for their economic development (Serow, 2003).

The retiree population is projected to increase significantly in the near future, with the aging of the 76 million baby boomers, which account for more than 28% of the U.S. population (Duncombe et al., 2001; US Census Bureau, 2006). LRDC (2006) projects that there will be 72 million people of retiree age nationwide by 2030. A recent paper by Oehmke et al. (2007) argued that there are three different types of migration among the retiree age population. The first type of move is by elderly people who move to their families for daily living assistance. Secondly, the elderly move to a long-term care facility. The third type of move entails physically and financially healthy retirees migrating to amenity-rich locations for a better quality of life. The focus of the current paper is on the third type of retiree migration, which is more important from an economic development perspective.

While not all retirees move to new destinations, there is no clear evidence on what portion of retirees would be mobile (i.e., migrating to new destinations) and what portion of them would be stationary (i.e., remaining in their current locations). Surveys in earlier studies, however, revealed that the portion of retirees who migrate to new destinations could be as high as 38% of total retiree population (Governors Task Force, 1994). Similarly, Park and Clark (2007) suggested that more than 400,000 retirees will choose to migrate out of their state in next two decades, and this number is likely to grow in the future (Skelley, 2004). As these physically and financially healthy retirees search for their retirement destination (Oehmke et al., 2007), attracting them could be an important agenda for local governments to foster economic growth and community services.

Earlier studies such as Schneider and Green (1992), and Duncombe et al. (2001, 2003) revealed the effect of place characteristics on residential choice among the retirement age population. The focus of their study was more on state and local fiscal factors and government expenditures rather than the natural amenities, which may also have significant influence on retirees' relocation decisions. Importantly, many local government agency officials may not be aware of the specific natural resources or amenities they have to attract retirees (Reeder, 1998; LRDC, 2006). Identifying such valuable and attractive amenities is important for the local agencies. As Duncombe et al. (2003) suggested, marketing such amenities would be even a better strategy for attracting retirees than providing fiscal incentives such as tax exemptions. Further, lacking specific information, many local agencies might waste their efforts to attract retirees even though they do not have such amenities to offer (Reeder, 1998). All of these facts provided the motivation for a study that explores the specific amenities that retirees value (Gustafson et al., 2005). The objective of our study was to examine the role played by specific natural resources amenities on retiree population growth in U.S. counties. We hypothesized that counties with high levels of natural amenities and man-modified nature-based recreational amenities possess a significant advantage in attracting retirees. The findings from this study will provide policy insights to local government and regional planners to identify their potential for economic growth by attracting retirees and also justify the efforts to preserve natural amenities.

Previous studies used both the stated and revealed preference-based assessments to study the migration pattern of retirees. For instance, some of the studies used stated preference approaches in which individual retirees were surveyed about their relocation decisions (Bennett, 1993; Haigood and Crompton, 1998; Haas et al., 2006). Alternatively, Graff and Wiseman (1990); Duncombe et al. (2001) and (2003); and Oehmke et al. (2007) used the revealed-preference approach in which the migration of retirement age population was analyzed with respect to variables of interest. The current study also used the revealed preference approach to examine the retirement immigration pattern in relation to the availability of natural amenity resources. A revealed-preference approach was used because: 1) it avoids the possible errors and bias involved in the survey process,

2) it is easier and much faster to analyze and can incorporate a broader geographical coverage, and 3) the developed model can easily be used to predict future migration pattern of retirees.

2.2 Empirical Model

The increase in retiree numbers in a county was explained as a function of the socioeconomic characteristics and availability of natural as well as other life amenities. Following the definition of the USDA Economic Research Service (ERS), the dependent variable, which is the retiree population growth[1] in a county between 1990 and 2000, was measured as a percentage increase in the population of age 60 and older due to in-migration during the period. Following Deller et al. (2001), it was assumed that the households are free to migrate and, in doing so, they maximize utility that is derived from the consumption of market goods, services, and natural resource amenities. As some of the explanatory variables can be endogenous to retiree growth, we jointly estimated the following model in a simultaneous equation approach (Greene, 2003).

$$Y_i = aX_i + \beta P_i + \varepsilon_i \tag{2.1}$$

$$P_i = \lambda Y_i + \delta R_i + \upsilon_i, \tag{2.2}$$

where the term Y_i represents percentage growth in the number of retirees in county i, and X_i is the vector of exogenous socioeconomic factors, natural amenities and human-modified recreational amenities. P_i is the vector of endogenous variables in the model and the term R_i represents the vector of factors that influence the endogenous variables. Terms ε_i and υ_i are the terms capturing errors whereas a, β, λ, and δ are the parameters to be estimated.

The Durbin-Wu-Hausman test (Wooldridge, 2003, pp. 483) was used to check endogeneity of suspected explanatory variables. In a theoretical manner, two variables (i.e., housing value and hospitals) were considered highly likely to be interdependent with or influenced by the retiree growth, and hence checked for endogeneity. For example, housing affordability can affect retirees' locational choice, but at the same time counties can experience a considerable boom in housing market following the initial in-migration of prosperous retirees into the area. Another basic feature retirees may consider in their migration decision is the availability of medical facilities in a new destination. On the other hand, an increase in the retiree population might require more health care facilities in the area, as well as more hospitals. In the first stage, equation (2.2) was estimated using the instruments. Distance to a nearby city, median household income, percentage of college graduates in the county, vacancy rate of housing, median age and rent of houses, percentage of population under poverty level were chosen as unique instrumental variables for housing value and hospital equations.

Although it is fairly common to use two-stage least squares to estimate the above defined system of equations, the estimates would not be efficient if the error terms among the equations were correlated. In such a case, the estimates would be unbiased and consistent, but not efficient. The model was estimated with a three-stage least square estimator (Zellner and Theil, 1962), which was essential in this study for three reasons. First, the correlation among the error terms across the equations in our model was significant at the 1% level; second, the equations in the system were over-identified (Witte et al., 1979); and third, the study used several thousand observations. Using a three-stage least square in such case ensures the asymptotic efficiency of the estimates (Greene, 2003).

The retiree growth equation (2.1) included variables measuring the socio-demographic and economic factors, neighborhood quality, taxation, and other policy effects. A variable capturing the proportion of retirement age population in the county at the base year (1990) was included in the retiree population growth equation. This was assumed to control for situations where counties already consisting of large numbers of retirees may not be capable of receiving more retirees. Following Duncombe et al. (2001), the median housing value, population density, property tax per unit of property, and percentage of African-Americans were included to capture the socioeconomic characteristics and policy factors in the county. Availability of seasonal homes was also included to capture the availability of housing in the area that might attract outside recreationists (Beale and Johnson, 1998).

Similarly, following Duncombe et al. (2001), the number of hospitals per thousand population was included to capture the medical services in the county, whereas the reported crime incidents per thousand population was included to take into account of general neighborhood quality. A dummy variable measuring whether or not the county was rural, but adjacent to a metropolitan area in 1990 was included to determine if retiree migration differs from typical population spillover in metro surroundings. Distances to the interstate and state highway networks and nearest airport were also included to capture effects of various transportation facilities on retiree growth. Access to such transportation and transit resources might be important factors in a retiree's relocation decision. Regional dummy variables were also included to control for variation in the retiree's locational choice for migration, i.e., Northeast (reference), Midwest, South, and West.

Two sets of variables capturing the natural amenities and man-modified natural amenity in the county were added following earlier literature on retiree migration (Haigood and Crompton, 1998; Reeder, 1998; Duncombe et al., 2001). The natural amenity variable set comprised of the climatic factors including average annual temperature and mean daily sunlight hours (Oehmke et al., 2007), land-based amenities including percentage of county area under forests, cropland, pastureland and water-based amenities including percentage of the county under water bodies, mileage of scenic river weighted by the county area, and whether or not the county was coastal. Likewise, a topographical index that represents the topographical variation within the county was also included. Topographical variation is considered a natural landscape attraction in the landscape and is believed to attract nature-based recreationists (Whitener, 2005) and retirees (Pampel et al., 1984).

Human-modified natural and recreational amenities included attractions that are either based on natural resources but developed with some human investment, or recreational and entertainment attractions connected in some way with the outdoor and cultural values of the locality. The variables in this category included the number of fishing camps, number of amusement places, a dummy capturing whether or not the county has a sports attraction, and a dummy capturing whether or not the county has arts and cultural attractions. Also included in this category were the distances to national parks, the presence of state recreation parks, and golf courses per thousand residents. Golf courses are not natural amenities in themselves, but they are popular human-built recreation facilities for retirees, of which the open space, scenic quality, and natural landscape, are integral elements. A detailed definition, descriptive statistics, and data sources of explanatory variables are presented in Table 2.1. Variables included in the retiree growth equation were checked for multicollinearity using the variance inflation factor (VIF). A common rule of thumb is that multicollinearity is a problem if the VIF index for any variable exceeds 10 (Gujarati, 1995). Computed VIF for variables in our model were far less than this threshold (Table 2.2), suggesting that multicollinearity was not a problem.

2.3 Study Area and Data

The geographical coverage of this study was the conterminous United States, with counties serving as the individual unit of analysis. A few counties from the conterminous U.S. were excluded from the analysis, however, due to data limitations, thereby reducing the total number of counties in the analysis to 3,064.

Data used in this study came from a variety of sources. Data on retiree population growth were obtained from the Inter-University Consortium for Political and Social Research, and were originally derived from US Census data of 1990 and 2000 (Voss et al., 2005). Demographic and housing value data were drawn from the 1990 US Census. Tax data and number of hospitals were obtained from the US Census Bureau's City and County Data Book for 1998. The crime incidence data for 1991 were from the Federal Bureau of Investigation's Uniform Crime Report. The distance from counties to national parks, inter/state highways, and the airport were computed in the ArcGIS 9.2 using a dataset from the Environmental and Scientific Research Institute (ESRI, 2006). The

Table 2.1 Definition, descriptive statistics, and data sources of variables used in retiree growth model

Variables	Description	Mean (Standard Deviation)	Data Sources
Socioeconomic Factors			
Retiree age population	Population of 60 and more years age as a proportion of county population in 1990	0.19 (0.05)	US Census
Median housing value♦	Median value of all type of county housing in dollars in 2000	80,478.49 (41,677.60)	US Census
Population density	Number of people per square mile	206.70 (1,489.46)	US Census
Tax rate	Collected property tax sum divided by the number of properties in county	1.43 (1.22)	US Census
African-American	Percentage of African-American in county population in 2000	8.56 (14.34)	US Census
Seasonal house	Percentage of seasonal and recreational housing units in county in 2000	6.39 (8.98)	US Census
Crime	Number of reported crime incidence of all kinds per thousand populations in 2000	27.00 (126.28)	FBI
Hospital♦	Number of hospital per thousand populations in 2000	0.05 (0.08)	US Census
Metro adjacency	Binary variable, if the county is rural and shares border with a metro county 1, 0 otherwise	0.32 (0.46)	USDA-ERS
Distance to highways	Distance in kilometers to inter/state highway from county center	38.67 (37.45)	ESRI
Distance to Airport	Distance in kilometers to airport from the county center	53.9673 (31.45)	ESRI
Northeast	Binary variable, 1 if county is in north eastern region, 0 otherwise (reference type)	0.07 (0.25)	US Census
Midwest	Binary variable, 1 if county is in mid western region, 0 otherwise	0.34 (0.47)	US Census
South	Binary variable, 1 if county is in southern region, 0 otherwise	0.44 (0.49)	US Census
West	Binary variable, 1 if county is in western region, 0 otherwise	0.07 (0.25)	US Census
Natural Amenities			
Temperature	Average annual temperature in Fahrenheit degrees	54.67 (8.25)	NOAA
Sunlight hours	Average number of sunlight hours in January	151.51 (33.29)	NOAA

Table 2.1. Contd.

Variables	Description	Mean (Standard Deviation)	Data Sources
Forestland	Forestland acres as a percentage of county area	29.28 (35.04)	NORSIS
Cropland	Cropland acres as a percentage of county area	28.22 (26.44)	NORSIS
Pastureland	Pastureland acres as a percentage of county area	9.93 (10.88)	NORSIS
Water area	Water body acres as a percentage of county area	5.60 (9.17)	NORSIS
Scenic river miles	Mileages of scenic river within county weighted by county area	0.02 (0.04)	NORSIS
Coastal	Dummy variable, If county shares border with coast 1, 0 otherwise	0.09 (0.29)	NORSIS
Topographic index	Continuous categorical index for topographical steepness of county land, starting from 1 for flat plains to 21 for high mountains	8.89 (6.59)	NORSIS
Man-modified Natural and Recreational Amenities			
State park	Dummy variable, if the county has a state park 1, 0 otherwise	0.48 (0.49)	NORSIS
Fishing camps	Number of fishing camps in the county	0.07 (0.76)	NORSIS
Amusement	Number of Amusement places in the county	2.24 (6.09)	NORSIS
Sports	Dummy variable, if the county has a sport attraction 1, 0 otherwise	0.07 (0.26)	NORSIS
Arts and culture	Dummy variable, if the county has a historical, heritage arts or cultural attractions, 0 otherwise	0.09 (0.29)	NORSIS
Distance to national park	Distance in kilometers from the county center to the national park entrance	59.08 (53.63)	ESRI
Golf courses	Number of golf courses per thousand populations in county	0.01 (0.06)	NORSIS

♦ indicates an endogenous variable. * Data are at county level.

Table 2. 2 Three-stage least square estimates from the retiree growth equation

Variables	Coefficients (Std. Errors)	Elasticity	VIF
Intercept	-195.313*** (11.204)	---	---
Socioeconomic Factors			
Retiree age population	46.319*** (4.953)	1.847	1.57
ln(Median housing value)	18.078*** (1.115)	3.658	2.64
Population density	-0.001*** (0.000)	-0.038	1.23
ln(Tax rate)	-5.626*** (0.573)	-1.138	1.95
African-American	-0.136*** (0.019)	-0.232	2.04
Seasonal house	0.300*** (0.028)	0.388	1.65
ln(Crime rate)	-0.012 (0.011)	-0.002	1.80
Hospital	50.790*** (14.448)	0.571	1.38
Metro adjacency	1.240*** (0.444)	0.081	1.10
ln(Distance to highways)	-0.379** (0.171)	-0.076	1.30
ln(Distance to airport)	-0.599* (0.348)	-0.121	1.60
Midwest	8.636*** (1.028)	0.601	6.01
South	8.151*** (1.104)	0.741	7.73
West	10.870*** (1.221)	0.295	3.97
Natural Amenities			
Temperature	0.315*** (0.041)	3.491	3.28
Sunlight hours	0.033*** (0.007)	1.037	1.64
Forestland	0.076*** (0.012)	0.437	3.31

Table 2.2. Contd.

Variables	**Coefficients (Std. Errors)**	**Elasticity**	**VIF**
Cropland	0.028**	0.151	3.39
	(0.013)		
Pastureland	0.098***	0.197	1.58
	(0.020)		
Water area	0.095***	0.108	1.91
	(0.026)		
Scenic river miles	7.933*	0.038	1.18
	(4.454)		
Coastal	-0.929	-0.018	1.73
	(0.781)		
Topographic index	-0.008	-0.015	2.66
	(0.045)		
Man-modified Natural and Recreational Amenities			
State park	1.254***	0.123	1.15
	(0.378)		
Fishing camps	0.433*	0.005	1.14
	(0.248)		
Amusement	-0.172***	-0.078	1.68
	(0.037)		
Sports	1.280*	0.019	1.27
	(0.742)		
Arts and culture	-0.047	-0.000	1.30
	(0.668)		
ln(Distance to national park)	-0.160*	-0.032	1.48
	(0.088)		
Golf courses	13.889***	0.227	1.21
	(2.069)		
Chi Square Statistic	1662.47***		
R-Square	0.31		
No. of Observations	3064		

Note: ***, ** and * indicate the significance of parameters at 1, 5 and 10% level respectively.

dummy variable for rural counties adjacent to metropolitan areas in 1990 was created using the USDA-ERS county typology and ESRI dataset in ArcGIS 9.2. A non-metro county was marked as rural-adjacent to a metro area if it shared a border with a metro area of at least 250, 000 population. Information identifying whether or not a given county belongs to one of the four U. S. geographic regions (Northeast, South, Midwest, and West) came from the standard classification by the US Census Bureau.

Average annual temperature and mean sunlight hours in January, originally developed by National Climatological Data Center of NOAA based on long-term observations, were obtained from USDA-ERS (McGranahan, 1999). Topographical index was obtained from U. S. Geological Service. The index value increases with general steepness of the county land surface. Measures of landuse and water-based amenities were obtained from the National Outdoor Recreation Supply Information System (NORSIS) of the USDA Forest Service (Betz, 1997). NORSIS maintains periodic information about outdoor recreation amenities in the U.S. at various levels of geographical aggregation. The county level land cover data managed by NORSIS were originally developed from National Land Cover Dataset of the U.S. Geological Service. The total mileage of designated national and state scenic rivers was obtained from NORSIS and weighted by county area to obtain a measure of density stated as miles per unit of county area. Similarly, the data for all the variables in man-modified natural and recreational amenities set were obtained from the NORSIS dataset as well.

2.4 Results and Discussion

The Wald test suggested that the Chi-square statistic of 1662.47 (critical value 135.80), which is significant at less than 1%, justified the simultaneous estimation of model using the three-stage least square estimator. Moreover, the Durbin-Wu-Hausman test of endogeneity rejected our hypothesis at the 5% level that median housing value and hospitals per thousand capita are exogenous. Therefore, the model treated these variables as endogenous to retiree population growth. Regression results revealed that most of the variables (26 out of 30) were statistically significant, including 19 at the 1% level, 2 at 5%, and the remaining 5 at the 10% level. The coefficient, standard error, and elasticity of each variable on retirees' choice of counties are reported in Table 2.2. The variable capturing the proportion of the retiree age population in 1990 was positively related at the 1% level, corroborating the earlier findings of Doncombe et al. (2001); Fuguitt and Beale (1996). As expected, most of the other socioeconomic variables, including population density, proportion of African-American residents, and property tax rate were negatively related to retiree population growth and were significant at the 1% level. Since, the higher population density indicates a higher congestion that negatively affects the local environment and transportation, its negative effect is quite intuitive. It reveals that retirees prefer low-density residential counties (Duncombe et al., 2001) and they are very sensitive to property tax rate at potential destinations (Duncombe et al., 2001; 2003). This supports some states' policies to provide tax breaks for seniors in order to retain or attract them as residents (Mackey and Carter, 1994; Reeder, 1998).

Although crime rate per thousand residents was found to be negatively related, it was not statistically significant. As expected, hospitals per thousand residents had a positive and significant effect on retiree growth, suggesting that health care and medical facilities are important considerations for retirees in selecting their destinations (Oehmke et al., 2007). Consistent with our expectations, adjacency of county to a metropolitan was positively and significantly related to retiree population growth, corroborating the argument of Reeder (1998) that the rural areas adjacent to urban areas experienced greater than average retiree growth during the 1990s. This may be because the retirees want to live in close proximity to regional shopping centers, and other social and health amenities, while finding a place to live that also has natural and open areas. It revealed that some metropolitan areas located next to naturally rich communities might have an advantage from the influx of retirees. This is consistent with some earlier observations such as Siegel and Leuthold (1993) study, which found that the Knoxville metropolitan area in Tennessee benefited from the economic impact of retirement growth in nearby communities including Tellico Village, and Renkow's (2003) study that the economic growth and development in the urban-rural fringe areas are influenced by the spatial spillover of population and employment growth in adjacent urban and rural counties. Further, coefficients on distance to highways and airport suggested that the counties with immediate access to major transportation facilities might have an advantage in attracting retirees.

Among the natural resource amenities, climatic variables, including average annual temperature and mean January sunlight hours, were positively and significantly related to retiree migration at the 1 % level. Clearly, warmer climates and relatively long sunny winter days offer a more desirable environment and more outdoor opportunities (Reeder, 1998). The estimated elasticity indicates that a 1 % higher average annual temperature in the county can increase retiree growth by 3.5%, ceteris paribus. In a similar interpretation, the ceteris paribus effect of a 1 % increase in mean sunlight hours in January was a 1% increase in the county's retiree population growth. Among the land-based natural amenities, percentage of forestland, cropland, and pastureland were positively and significantly related with retiree growth at the 1% level. Elasticity estimates revealed that a 10% increase in the percentage of county area under forest increased retiree growth by 4.3%, ceteris paribus. Assuming all other things constant, a similar increase in cropland and pastureland would separately contribute to retiree growth in the county by 1.5 and 1.9 %, respectively. The strong relationship of these natural landuse types might be explained by open and green space, which provide more recreational and amenity values in the area. Further, such landuses might have important indirect benefits to maintain a stable microclimate or offer invaluable ecosystem services, such as aesthetic beauty and quality of life. Importantly, the size of the marginal effects of these three landuse types reflect an ordering of importance of open space types, with highest for natural and wild forest areas, followed by pastureland, and lowest for cropland, which is often considered an intensive landuse practice. Although we expected that mountains, vistas, and valleys as captured by topographical index could typically add scenic value in the landscape (Pampel et al, 1984), the effect was insignificant.

The water resource amenities, including the percentage of county area in water bodies and scenic river miles per unit of land area also exhibited positive and significant relationships with retiree population growth. The results indicated that a 10% increase in percentage of county land area in water bodies such as lakes, and streams contributed to an increase in retiree population growth by 1%, ceteris paribus. Similarly, assuming other things constant, a 10 % increase in designated river miles per square mile area contributed 0.3% growth in retiree in-migration. The positive effect of these resources is understandable because water-based amenity resources provide scenic values and recreational opportunities (e.g., boating, rafting, and swimming). The insignificant effect of coastal locations, however suggested that retiree growth during 1990s occurred in the inland counties. It may reflect a movement away from coastal counties due to excessive property values, increasing insurance costs due to hurricanes and flooding, and the general trend for retirees to leave coastal areas and move to more seasonable climates. Also, the counties on east and west coasts might have already been crowded and may no longer be the preferred destination for retirees.

Most of the variables among the human-modified natural and recreational amenities were significantly related with the retiree population growth. The presence of a state park in the county was positively related and significant at the 1% level, suggesting that the local agencies could invest in such recreational parks to attract retirees. Likewise, the number of fishing camps, and the number of sports attractions in the county were positively and significantly related with the retiree population growth at the 10% level. Apparently greater availability of fishing opportunities and also other sporting events in a county is likely to attract retirees. Similarly, the golf courses in the county had a positive relationship that was significant at the 1% level, indicating a strong attraction to retirees. Contrary to our expectations, the availability of amusement places was negatively related with the retiree population growth in the county. One explanation behind this, however, is that the amusement attraction might be more popular for family vacation destinations, where the primary recreationists are children rather than the elderly people.

Distance to national parks was negatively and significantly associated with the retiree population growth in the county at the 10% level. It revealed that counties in closer distances to a national park entrance are associated with higher retiree growth rate.

The casual observation behind this is that such counties are advantaged with many outdoor opportunities, wilderness attractions, and environmental qualities. This is consistent with Johnson and Beale (2002) who mentioned that the counties around national park counties experienced higher than average in-migration recently. Although this observation may be encouraging evidence for economic growth in counties near national parks, it is also possible that greater concentrations of retirees and others in the vicinity of national parks may threaten the natural integrity of a park in the long run.

2.5 Conclusion

Extending the earlier studies that focused on general population growth and heavily relied on complex amenity measures, this study examined retiree population growth specifically and identified more direct measures of natural amenities that might attract and retain retirees. While much of the retiree population growth in recent decades has occurred in rural counties close to metropolitan areas and transportation corridors, it has occurred in rural counties endowed with natural amenities as well. While recent studies in regional economics suggest that a growing retiree population offers potential economic growth, this study has revealed that warm and sunny climates, open lands, scenery, and water are important natural resource amenities to attract retirees. Retirees place a great deal of value on the varieties of undeveloped landuses in the countryside such as forest, farmlands, and pasture. Not as attractive to retirees are highly populated and congested areas, coastal areas, and areas with high property tax rates. Our findings suggest that policies specifically encouraging nature-based recreational facilities, natural parks and wilderness areas, fishing spots, along with golf facilities and sporting events, can add to the amenity attractiveness of a locality for retirees.

There are several implications from this study for local and regional economic development policy, real estate marketing, outdoor recreation and tourism providers, and natural resources conservation. First, our results offer fresh empirical evidence on migration patterns of retirees in relation to natural amenities. Local and state agencies can better identify the potential to attract retirees as a stimulus to a county economy. At the same time, counties without natural amenities can assess and perhaps limit their level of effort toward a retiree economy strategy. For amenity rich counties, identifying natural land and water based amenities and their long-term protection may be needed before they are over developed. Local agencies may see benefits in preserving natural amenities and also by introducing other nature-based recreation facilities, such as natural parks, golf courses, fishing camps, and other recreational sites.

Second, in addition to careful management of natural amenities, local agencies may benefit by adopting creative complementary initiatives that would also contribute to quality of life for retirees. These might include tax restructuring favoring the retiree-age population and strengthening health care. However, attention should be paid to avoid any detrimental effects of such tax restructuring on education and other public services. Further, as our findings support that retirees like amenity-rich counties adjacent to metro areas, it supports any policy that establishes regional cooperation among adjacent metro and non-metro governmental agencies to attract retirees in their territories by jointly marketing each other’s amenities (Reeder, 1998). Third, this study used variables describing natural amenities that are periodically updated. Thus the models resulting from use of these variables (from sources such as NORSIS, NRI, US Census) can also be periodically updated, allowing regional planners, economists, and social scientists to update estimates of the retiree growth effects of natural amenities and forecast possible future concentrations of retirees and likely economic growth effects.

Fourth, as the retiree's locational choice seems heavily motivated by the availability of natural amenities, its direct and indirect effect on the natural integrity of rural America is critical with the impending retirement of baby boomers. Specifically, our study revealed that counties close to national parks and containing natural areas and recreation parks experienced a significant growth of retiree population in recent decades, and that growth is likely to continue with the seemingly endless desire of people to live close to nature. Further concentration of retirees, particularly in and around parks and other natural areas, may be problematic in that one of their unique aspects is that they are undeveloped. Too many people wishing to live near public lands may eventually become a threat. Even in counties far from the national parks, the mounting demand for open space and natural areas, housing sites, outdoor recreation, and expansion of utility services can result into ecological issues such as habitat fragmentation (Ritters et al., 2000). With the increasing concentration of new immigrants and development around the wilderness areas, policies regarding buffer area management should be given serious consideration. Managing buffer areas around national parks and other protected areas will allow restricting the landuses around those parks, and help preserve the integrity of flora and fauna inside the parks.

In addition to providing guidance for stimulating economic growth for local and state policy makers, this study also can provide some information on the drivers of growth. Growth is not simply determined by proximity to highways and shopping. As far as retirees are concerned, their choice of residence location is also driven by natural amenities---forests, open land, water, scenery, and recreation opportunities. In addition to providing stimulus to local rural economies, perhaps strategies to provide close substitutes for nature-based outdoor recreation opportunities in metro counties may be needed. A balance toward what Reeder (1998) suggested as making retirement in metro counties equally desirable. Those counties that have already experienced a substantial growth of retirees may need to focus on devising variants of equity-based policy instruments to mitigate or prevent environmental damage or pollution.

Possible deterioration of environmental amenities due to overuse or enjoyment should be given serious consideration. Moreover, as they get older, immigrant retirees may have less discretionary income to spend and become more dependent on public resources such as health care and security. In such cases, they can be a drag on the economy. For example, Reeder (1995) suggested that the influx of retirees in a community might drive up housing prices and property tax rates, thereby forcing existing residents to move elsewhere. Others have found that retirees are often less supportive of community development, as they fear development, which would come at the expense of the quality of life for which they immigrated (Bennett, 1993). Poor public policies favoring economic development can often create decline in amenity value. That not only makes the potential of such engines to drive the economy questionable, but also damage the sustainable development of a community in long run. Therefore, sound planning and reliable public finance efforts should be designed to enhance the feasibility and sustainability of such economic growth policies. Nonetheless, compared to some other alternatives, the “retiree economy” seems to be a viable option to drive rural economic development while limiting environmental and social impacts. At least initially, retiree immigration is a more passive employment of natural resources. It seems that a collaborative regional approach is needed to account for local interests while minimizing the ecological effects of growth on natural amenities.

CHAPTER 3
VALUING DIVERSITY, SPATIAL PATTERN, AND CONFIGURATION OF LANDUSES IN URBAN NEIGHBORHOODS

3.1 Introduction

With increasing population density and congestion in American cities, there is a rising demand for ecosystem services and overwhelming citizen support for open space protection. While federal, state, and local governments are currently planning to preserve more open spaces to ensure a sustainable supply of ecosystem services and environmental benefits (Kline, 2006), our understanding of the economics of open space is inadequate to properly justify investments in open space. With some notable exceptions, most of the previous open space studies have focused on the amenity benefits of living close to open space only. But, the amenity value of their spatial pattern and appearance in neighborhoods has remained under studied.

A number of researchers have scrutinized open space in various non-market valuations frameworks over the past decade. These studies applied the hedonic method to estimate the dollar value of open space in the neighborhood as reflected by housing prices (Bolitzer and Netusil, 2000; Luttik, 2000; Acharya and Bennett, 2001; Irwin and Bockstael, 2001; Lutzenhiser and Netusil, 2001; Irwin, 2002; Anderson and West, 2006; White and Leefers, 2007). Other studies have focused on specific types of open spaces, such as wetlands (Mahan et al., 2000), farmland (Bowker and Didychuk, 1994), and forest land (Tyrvainen and Miettinen, 2000; Kim and Johnson, 2002; Thorsnes, 2002). Some researchers have utilized contingent valuation surveys to estimate willingness to pay for the protection of open space or for living near an open space (e.g. Peiser and Schwann, 1993; Breffle et al., 1998).

Ecosystem services and aesthetic values also depend on spatial pattern and arrangement of landuses in a local area. Open space containing higher levels of biodiversity, for example, may be more productive in terms of providing environmental benefits. Similarly, forests in fragmented and isolated patches may contribute little to ecosystem functioning compared to those in contiguous blocks. Two neighborhoods with similar amounts of open space might produce different levels of aesthetic values and ecosystem benefits due to variations in the spatial pattern and configuration of open space. Therefore, evaluating the effect of such features quality is equally important. The literature on valuing the quality of open spaces as measured by the spatial pattern and diversity of landuse has been developed only recently. Bockstael (1996), Geoghegan et al. (1997); and Acharya and Bennett (2001) reported that the spatial pattern of landuse affects nearby residential house prices. Geoghegan et al. (1997) found that value of landuse diversity depends on the location and level at which the landuse attribute is measured. Geoghegan (2002) concluded that amenity value of open space depends on whether those are permanently preserved or not, and Chesire and Sheppard (1995) scrutinized the effect of open space ownership on nearby property prices. A more recent study by Cho et al. (2008) concluded that the amenity value of spatial pattern of open space varies according to the level of urbanization.

The compositional variety in open space, however, has not been the focus of previous studies. A recent study by Acharya and Bennett (2001) in an urban watershed revealed that both landuse diversity and richness are not desired factors in the neighborhood, regardless of location in the watershed. However, they measured landuse diversity combining all types of landuses such as developed and undeveloped, making it difficult to interpret the diversity value of open space. Their findings do not answer questions such as whether the residents want a neighborhood with a mixture of low-density residential use and industrial use, a mixture of forests and high-density development, or a mosaic of grassland, hardwood forest, and pastureland. In order to better understand the benefits arising from the quality of open space, separate indices should be used to measure the diversity within the undeveloped land or open space (McConnell and Walsh, 2005).

Previous open space studies also assumed that the effects of open space variables are exogenous to housing price and ignored the identification problem in the hedonic framework. Irwin and Bockstael (2001) and Smith et al. (2002) argued that measured open spaces, except those under public ownership, could be endogenous to the housing value. Since the diversity and spatial arrangement of the landuse under various categories are subjected to market forces in a residential neighborhood, those can indeed be endogenous to housing price (Cho et al., 2008). As a result, estimation under an assumption of exogeneity can result into biased estimates.

The present study measured the spatial pattern of open space with a more complete set of variables to capture the variety, spatial configuration, and pattern of open space and to assess their effect on property price. This study attempts to evaluate resident preferences for the open space features in their neighborhood. The objectives were achieved by using separate indices of diversity within the natural or undeveloped open spaces as well as developed spaces. In addition, the spatial pattern and configuration of open space were measured using shape and plot density indices that were borrowed from landscape ecology concepts. These measures were evaluated in a typical hedonic model, which moves beyond the existing hedonic models of open space, by endogenizing the landuse variables.

3.2 Model

Following Rosen (1974), we started with a typical hedonic model based on the conceptual model presented in Equation (3.1):

$$P_h = f\,(S_h, N_h, O_h) \tag{3.1}$$

where, the equilibrium sales price of the *h*th house P_h, is explained as a function of

S_h = structural variables,

N_h = characteristics of neighborhood where the house is located, and

O_h = landuse amenities in the neighborhood.

A Durbin-Wu-Hausman test of endogeneity (Wooldridge, 2003, pp. 483) was used to check the endogeneity of open space or landuse variables. Following Irwin and Bockstael (2001), endogenous variables were instrumented, and the following equations were simultaneously estimated if endogeneity was detected.

$$P_h = \alpha X_h + \beta O_h + \varepsilon_h \tag{3.2}$$

$$O_h = \varphi P_h + \lambda R_h + \upsilon_h \tag{3.3}$$

where, P_h is the real sales price of house *h*, X_h is a vector of factors that affect the price of the house and typically included the structural and neighborhood variables; O_h is a vector of open space and landuse variables in the neighborhood; and R_h is a vector of factors that influence the open space and landuse variables in the neighborhood of house *h*. Similarly, terms α, β, φ, and λ are the parameters to be estimated and ε_h and υ_h are the vectors capturing stochastic error.

In addition, a White test of heteroscedasticity (White, 1980) was used to detect heteroscedasticity, which if present can violate the assumption of homoscedasticity (i.e., the constant variance of the error term) resulting into inefficient estimates of parameters. If heteroscedasticity was detected, robust standard errors were computed using White's method. Further, the Variance Inflation Factor (VIF) was used to check the multicollinearity among variables included in the model (Greene, 2003).

The structural variables included the size of living area, number of stories, age of house, number of bedrooms, and size of parcel on which the house was located. Dummy variables were used to capture the presence of exterior brick walls, central air conditioning (AC), masonry fireplace, and a garage. A seasonal dummy variable was included to control for seasonal difference in sales price of houses.

The neighborhood variables included the percentage of African-American population, percentage of residents with college degrees, and percentage of neighborhood residents below the poverty level. Since location is important in defining neighborhood quality, some distance variables were used to capture the house's proximity to different dis/amenities. Those included distances from the house to public bus routes, nearby parks, regional airport, and railroad. Size of the nearest park was also included to capture the size of publicly available open space in the neighborhood. Definitions of each variable are reported in Table 3. 1.

Table 3.1 Definition and descriptive statistics of variables used in the hedonic model

Variables	Definition	Mean	Std. Deviation
Housing Structure and Neighborhood Variables			
Living area	Square footage of the living area in house	1,388.20	608.54
Brick exterior	Dummy variable, 1 if the exterior is brick, 0 otherwise	0.51	0.49
Central AC	Dummy variable, 1 if the house has a central AC, 0 otherwise	0.69	0.45
Masonry fireplace	Dummy variable, 1 if the house has a masonry fireplace, 0 otherwise	0.46	0.49
Season	Dummy variable, 1 if the house was sold in months 4-9, 0 otherwise	0.55	0.49
Age	Age of house in year 2006	54.84	27.12
Bedrooms	Number of bedrooms in house	3.01	0.42
Stories	Number of stories in the house	1.25	0.57
Parcel	Square footage of the parcel	11,872.71	13,652.44
Garage	Dummy variable, 1 if the house has a garage, 0 otherwise	0.24	0.42
Hip-roof	Dummy variable, 1 if the house has a Hip-roof structure, 0 otherwise	0.134	0.340
African-American	Percentage of African-American population in the census block group	20.85	28.21
College degree	Percentage of residents with college degree in the census block group	9.17	8.17
Poverty	Percentage of residents under poverty level in the census block group	12.50	10.71
Park	Distance in meters from house to the nearest urban forest park	684.30	673.48
Park size	Size in square meter of the nearest urban forest park	2,32,491.45	5,06,364.04
Airport	Distance in meters from house to the regional airport	4301.40	2247.00
Public bus	Distance in meters from house to the nearest public bus route	371.70	435.00
Railroad	Distance in meter from house to the nearest railroad track	1181.40	943.50
Open Space variables			
Open space diversity	Diversity index of open space category in the neighborhood	0.295	0.268
Developed land diversity	Diversity index of developed land category in the neighborhood	0.862	0.157

Table 3.1 Contd.

Variables	Definition	Mean	Std. Deviation
Open space MPFD	Mean plot fractal dimension of open spaces in the neighborhood	1.303	0.007
Opens space Plot Density	Number of plots in which per hectare of open space is distributed in the neighborhood	1.324	1.423

A set of open space and landuse variables, the primary variables of interest in this study, were included in the model. Following Geoghegan et al. (1997), and Acharya and Bennett (2001), the diversity index originally proposed by Turner (1990) was used to two create separate indices of diversity for open space, or undeveloped landuses, and developed landuse. Specifically, the diversity indices were calculated using Equation (3.4).

$$DI_n = -\sum_{l} p_l . \ln p_l \qquad (3.4)$$

where, DI_n is the diversity index in *n*th neighborhood, and P_l is the proportion of landuse type *l* in undeveloped or developed space. The magnitude of this index represents the degree of dominance by few or many landuse types in the neighborhood and depends not only on the diversity but also on the evenness of the landuse type distribution. The interpretation of the index is that larger the index value, greater the diversity (Geoghegan et al., 1997; Acharya and Bennett, 2001). Figure 3.1 and Figure 3.2 compare two neighborhood areas with open spaces of different level of diversity. The first neighborhood contains open space plots of different varieties, and therefore has a higher diversity index, whereas the second neighborhood comprises of open space plots of a single type only, and therefore has a lower diversity index. Eight landuse types were identified within the open space or undeveloped category in the study area, and three within the developed land category. Detailed definitions of these types are presented in Table 3.2.

Similarly, the concept of habitat mean patch fractal dimension (MPFD) was borrowed from landscape ecology (McGarigal and Marks, 1995) to compute the open

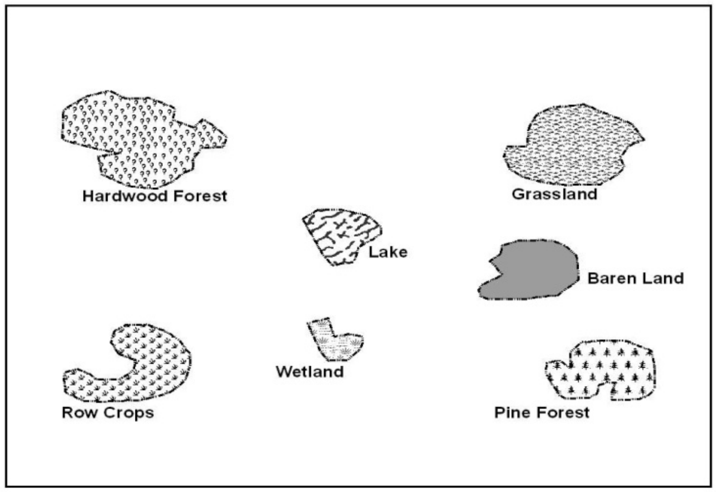

Figure 3-1 A neighborhood area with high level of open space diversity

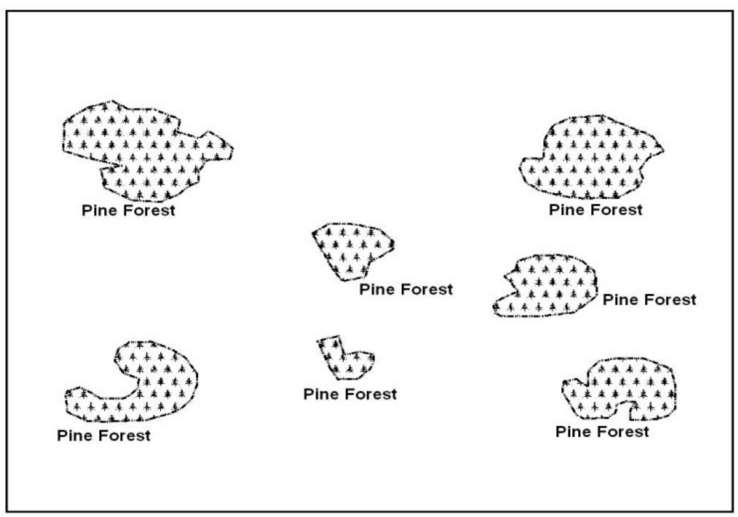

Figure 3-2A neighborhood area with low level of open space diversity

Table 3.2 Brief description of landuses in the city of Roanoke, Virginia, in 2001

Landuse type	Description
Open space or undeveloped lands	
1. Open water	Open water area containing less than 25% of vegetation or soil
2. Barren lands	Barren lands of rock, sand and clay, where vegetation accounts for less than 15%
3. Deciduous forest	Areas dominated by 5 meter or taller trees where 75% of tree species shed their foliage seasonally
4. Evergreen forest	Areas dominated by 5 meter or taller trees where 75% of tree species maintain their foliage in all seasons
5. Mixed forest	Areas where deciduous and evergreen forest trees of 5 meter or taller are mixed but neither of them dominates.
6. Open spaces	Open space (recreational grounds, erosion control plots, golf, etc.)
7. Shrub/Scrub	Areas dominated by shrubs that are shorter than 5 meter
8. Pasture/Hay	Areas of grasses and legumes or mixed for livestock grazing and production of seed or hay crops.
9. Cultivated crops	Areas used for production of annual crops
10. Wetlands	Areas of wetlands where shrub or tree vegetation account for more than 20%
Developed lands	
1. Low intensity developed	Land containing single family housing units and constructed materials, where impervious surfaces that account for up to 50% of total cover
2. Medium intensity developed	Land containing single family housing units and constructed materials, where impervious surfaces account for 50 to 80% of total cover
3. High intensity developed	Highly developed areas with commercial and industrial uses, where impervious surface account for 80 to 100% of total cover

Source: NLCD in Homer et al. (2005)

space mean plot fractal dimension. MPFD captures the shape complexity of the open space plots and is computed using equation (3.5).

$$MPFD_n = \sum_{i=1}^{m} \frac{2 \ln B_i}{\ln A_i} \Big/ m \qquad (3.5)$$

where, $MPFD_n$ is the mean plot fractal dimension of open spaces in neighborhood n; B_i is the perimeter (boundary length) and A_i is the area of the ith plot whereas m is the total number of distinct open space plots in the nth neighborhood. A MPFD value of 1 indicates plots of square shapes with simple, smooth, and straight boundaries, whereas a value of 2 indicates more complex plot shapes with convoluted, rougher edges. Figures 3.3 and 3.4 compare two neighborhood areas with open spaces of different shapes. Open space plots in the first neighborhood are more like square or rectangular shaped with smooth and straight edges whereas those in second neighborhood are of convoluted shapes and irregular edges.

A plot density measure was included to capture the spatial pattern of open space distribution within neighborhood. Unlike the diversity index, open space plot density was measured by aggregating open space acres of all types in a single category. The plot or patch density represents the number of distinct open space patches per hectare of open space area (McGarigal and Marks, 1995). This captures the extent to which a given amount of open space is scattered in numerous plots within a neighborhood. A higher plot density indicates a more fragmented or scattered pattern (Nelson et al., 2004). A positive (negative) value for this variable indicates that residents prefer fragmented (aggregated) opens spaces. Figures 3.5 and 3.6 compare two neighborhoods with the

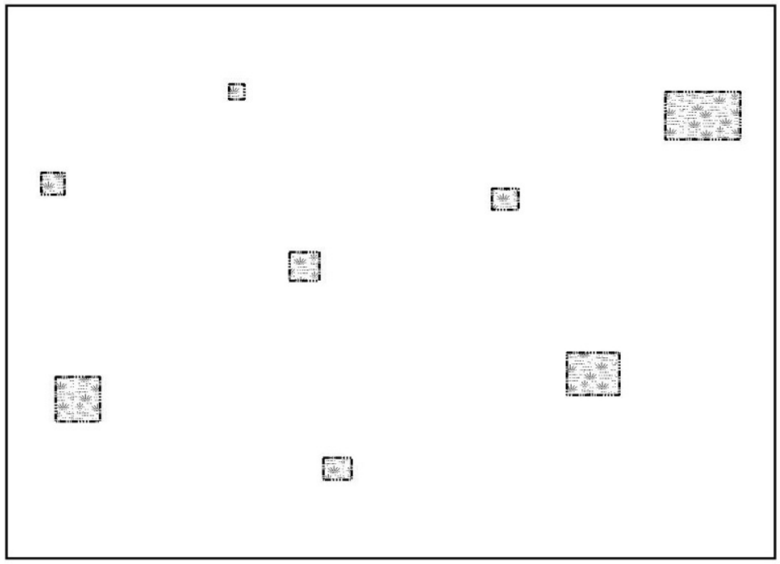

Figure 3-3 A neighborhood area with MPFD close to 1

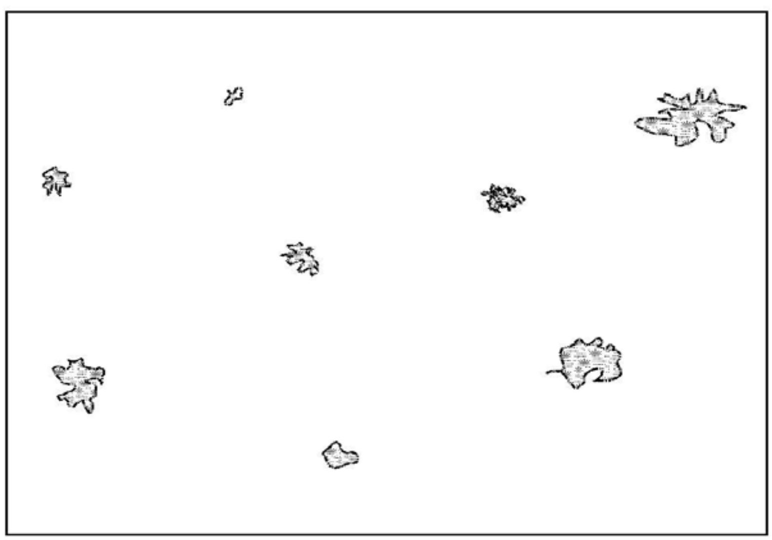

Figure 3-4 A neighborhood area with MPFD close to 2

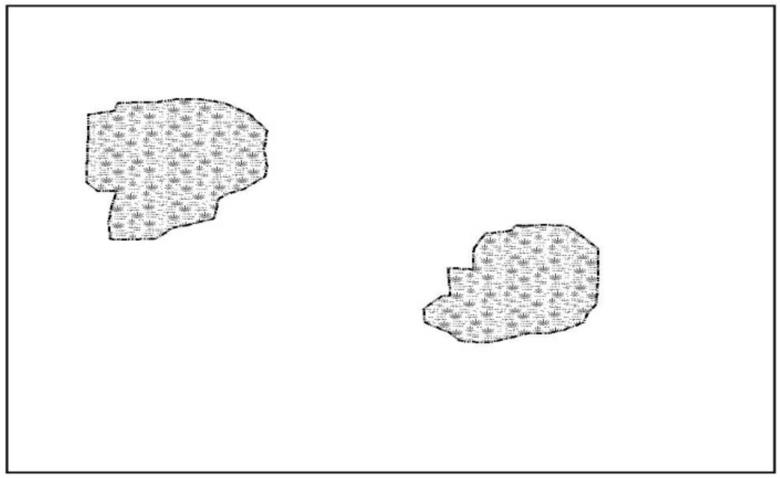

Figure 3-5 A neighborhood area with open space plot in few larger blocks

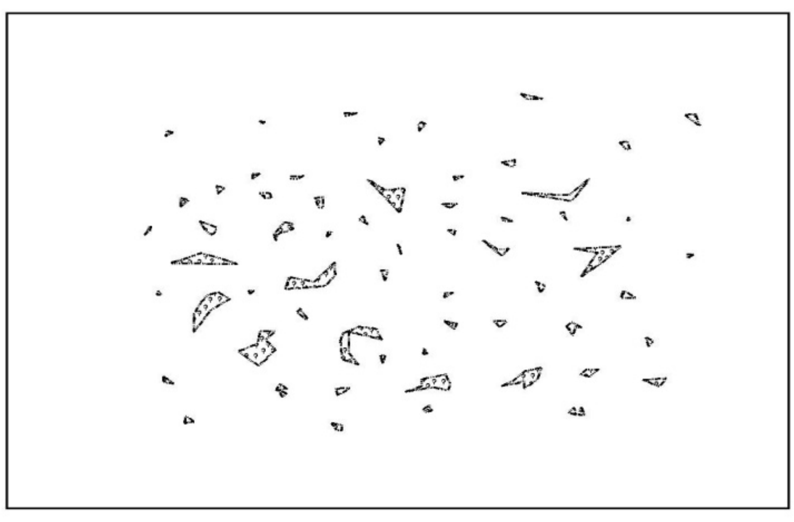

Figure 3-6 A neighborhood area with open space plots in many smaller blocks

same amount of open space, but in different configuration. Open spaces in the first neighborhood are aggregated in a few large plots, whereas open spaces in the second neighborhood are fragmented and scattered in numerous smaller plots around the neighborhood.

3.3 Study Area and Data

The study area for this research was the City of Roanoke, a fast growing and large urban area in southwest Virginia. Since there are more than 100 mid-sized cities in the nation with similar population and urbanization levels, findings from this study may be useful for numerous other cites as well. The above-discussed model was applied to arms-length transactions and complete information of 11,125 houses that were sold within the city limits from January 1997 to December 2006.

Housing price data along with the structural variables were obtained from the Geographic Information System (GIS) database of the city's real estate valuation department. Using the annual housing price index for Roanoke area (OFHEO, 2006), all house sale prices were converted to 2000-dollar values to account for the real estate market fluctuation in the city, and to make them compatible with the Census and landuse data. Another source of data was the U.S. Census Bureau (2000), from which the socioeconomic variables at the census block group (CBG) level were obtained as a proxy for neighborhood descriptors. Further, the distance variables were computed in ArcGIS 9.2 using the GIS shape file of park locations, regional airport, railways, and bus routes obtained from the city's real estate department.

Data on landuse diversity and open space were obtained from the citywide Satellite Imagery of Landsat 7 classified and developed by National Land Cover

Database 2001 (Homer et al., 2005). The database classifies land cover at 30 meter by 30-meter spatial resolution into 29 distinct landuse categories. According to the database, open spaces or undeveloped land are sub-classified into 10 varieties according to cover compositions, and developed lands are sub-classified into three varieties according to level or intensity of development (Table 3. 2).

There is no universal standard in defining neighborhood for measuring the open spaces. Previous studies relied on political boundaries such as census block group, census tract (e.g. Schultz and King, 2001), or a circular area of *ad-hoc* radius around the house (e.g. Geoghegan et al., 1997; Acharya and Bennett, 2001). However, neither of these are without problems. The census block group approach does not capture the neighborhood because houses across the street will technically belong to a different neighborhood because a street lies between them. Likewise, the circular buffer also is not an appropriate measure of neighborhood because it considers everything within a certain distance (i.e., one mile) even though there are distinct neighborhoods with different level of amenities, quietness, cultural and social ties, and other characteristics. The selection of proper radius to define neighborhood has rather been an *ad hoc* choice in previous studies.

Bourossa et al. (2003), however, argued that small neighborhoods defined by the local tax assessor and real estate developers based on their experiences are appropriate measures of neighborhood, and are useful in hedonic modeling and prediction purpose. The real estate department in the City of Roanoke also defines local neighborhoods for citywide housing information modeling purposes. As local officials who have first-hand knowledge and a deeper understanding of locality delineate these neighborhoods, the neighborhoods might better represent the sense of neighborhood for the local residents.

This study measured open space and landuse variables in those intuitively defined neighborhood levels, which are more practical and justified in terms of residents' daily consumption of social, cultural, and environmental amenities. The landuse diversity indices were computed in ArcGIS 9.2, whereas the plot density and mean plot fractal dimensions were computed using Patch Analyst program (Elkie et al., 1999). Patch Analyst 3.1 is a FRAGSTAT-based program and is a compatible extension of ArcView 3.2 to quantify landscape structure.

3.4 Results and Discussion

The Durbin-Wu-Hausman test rejected the null hypothesis of exogeneity for open space and landuse variables at the 1% level (F-Statistic = 55.71, p value = <0.001). This indicates the appropriateness of using two-stage estimation of equation (3.2) and (3.3). Even though, the choices of instrumental variables were subjective decisions, exogeneity was a desired criterion in selection of an instrument variable. The vacancy rate of houses, distance to central business district, distance to nearest school, and median household income were used as instruments. Similarly, the White test of heteroscedasticity rejected (Chi-square Statistic = 1419.04, p value = < 0.001) the null hypothesis of homoscedasticity at the 1% level, hence robust standard errors were calculated using White's heteroscedasticity consistent covariance matrix (White, 1980). Computed VIF index for the variables (Table 3.3) were far less than critical threshold of 10, suggesting that multicollinearity was not a problem in our model.

The results from the hedonic equation regression are reported in Table 3.3. Out of 23 variables, 21 were statistically significant at the 5% level or better. Most of the structural variables were significant and had signs consistent with the literature. The

Table 3.3. Estimates from the two-stage least square regression of hedonic price model

Variables	Coefficients (Standard Error[θ])	VIF[~]
Intercept	49.997***	---
	(9.166)	
Housing Structure and Neighborhood Variables		
ln(Living area)	0.575***	3.24
	(0.027)	
Brick exterior	0.087***	1.28
	(0.014)	
Central AC	0.188***	1.34
	(0.011)	
Masonry fireplace	0.086***	1.78
	(0.013)	
Season	0.048***	1.00
	(0.008)	
Age	-0.006***	1.89
	(0.000)	
Bedrooms	0.040***	1.57
	(0.007)	
Stories	-0.039***	1.91
	(0.010)	
ln(Parcel)	-0.000	1.40
	(0.013)	
Garage	0.045***	1.20
	(0.010)	
Hip-roof	-0.031**	1.23
	(0.015)	
African-American	-0.001**	2.14
	(0.000)	
College degree	0.022***	2.56
	(0.001)	
Poverty	-0.016***	2.46
	(0.002)	
ln(park)	-0.047***	1.38
	(0.012)	
ln(park size)	-0.019***	1.26
	(0.005)	
ln(airport)	0.013	2.28
	(0.026)	
ln(public bus)	-0.040***	1.66
	(0.012)	

Table 3.3. Contd.

Variables	**Coefficients (Standard Error$^{\theta}$)**	**VIF$^{\sim}$**
ln(railroad)	-0.050***	1.77
	(0.011)	
Open Space variables		
Open space diversity	0.537***	1.97
	(0.180)	
Developed land diversity	-0.508**	1.91
	(0.249)	
Open space MPFD	-31.705***	1.85
	(6.813)	
Opens space plot density	-0.033**	1.86
	(0.014)	
F-Statistic	507.17***	
R^2	0.50	
No. of observations	11,125	

Note:
****, **, and * indicate the significance of parameters at 1%, 5% and 10% respectively.*
θ White's robust standard errors.
~ A rule of thumb is that a variable with VIF exceeding 10 causes multicollinearity.

square footage of living area, brick wall dummy, central AC dummy, masonry fireplace dummy, presence of a garage dummy, and number of bedrooms were positively related and significant at the 1% level, indicating all of them were positively related to increasing real sales price. A positive and significant relationship was estimated for the season dummy, indicating that houses sold in spring and summer for higher prices than those sold in fall and winter; the negative effect of age indicated lower prices for older houses. The negative effect of stories and presence of hip-roof was counter to our expectation, whereas parcel size was not statistically significant.

The neighborhood variables were significant at the 5% or better level, most of them with the *a priori* signs. Percentage of African-American population and poverty rate were negatively and significantly related to house price. The percentage of population with college degrees was positively and significantly related, probably indicating their level of income and neighborhood quality. The distance to various amenities including public parks and public bus routes were negatively related at the 1% level, indicating that close proximity to those increase house price.

Importantly, all of the open space and landuse variables in the model were significant at 5 % level or better, suggesting that the open space and landuse features are important predictors of housing price. The diversity index for open space type was positively and significantly related to housing price at the 1% level, suggesting that a variety of open space in the neighborhood increases housing price. Proper interpretation of this index reveals that the urban residents prefer a neighborhood with a more diverse and heterogeneously composed open spaces (Fig. 3.1A) to a neighborhood with less diverse and homogenously composed open spaces (Fig. 3.2A). To be more specific, a neighborhood with a mixture of forest, wetland, and pasture is preferred to a neighborhood with only one type of open spaces.

Conversely, the diversity index for developed land was negatively and significantly related to housing price, suggesting that people do not prefer a neighborhood where residential landuse is mixed with industrial or commercial landuses. This result is also consistent with Stull, (1975) and is very understandable because intermixing industrial landuses and impervious surfaces in a residential neighborhood would create negative externalities. The high-density development and industrial uses often result in air, water, noise, and even visual pollution in the neighborhood, which might downgrade the nearby residential property values.

Even though Acharya and Bennett (2001) found that diversity in landuse is an undesired feature, our result confirms that diversity within open space or undeveloped land is a desired feature, but the diversity within developed landuse is not. This clearly shows that people value the varieties of open space. With this in view, the landuse diversity measured in previous studies on landuse diversity did not properly explain the relationship between open space diversity and housing price, because the diversity they measured also included developed lands. For this reason, McConnell and Walsh (2005) suspected that evaluating the diversity for undeveloped and developed land separately might provide better insight on value of open space variety. Importantly, our analysis answers that question by revealing the underlying contrasting effects.

Similarly, mean plot fractal dimension (MPFD) of open space was negatively and significantly related to housing price at the 1% level. It should be noted that a higher value of this index indicates more complex and irregular shapes of open space plots, whereas the smaller value indicates simpler shaped plots with smoother, straight edges. The negative effect of this index is very intuitive and reveals that the people prefer open spaces in more even and square/rectangular shape (Fig. 3.3A) than those in crooked or convoluted shapes (Fig. 3.4A). This result agrees with findings of a similar study by Nelson et al. (2004) that the managed edges of forest landscape increase house price.

The coefficient on spatial distribution of open space plots as measured by plot density was negative and significant at the 5% level. This indicates that an open space of a given amount increases house price in the neighborhood, if it is aggregated into few larger assemblages, and decreases house price if it is fragmented and spatially distributed in numerous plots throughout the neighborhood. In other words, residents prefer a neighborhood with few bigger plots of open space (Fig. 3.5A) than a neighborhood with many smaller plots (Fig. 3.6A). This could be attributed to the fact that sizeable open space plots might be better for the community from ecological functioning and environmental quality point of view, whereas tiny isolated plots in a fragmented pattern might not have that advantage. For instance, fragmented forests may not have as much capacity as contiguous forests to maintain good microclimate and environmental qualities. Also, from the recreational and aesthetic point of view, a given amount of open space might be better in a single chunk at a location than in several small and disconnected patches, because bigger plots have higher carrying capacity of visitors, and possess more potential for parks, gardens, or other uses. This is very understandable because Central Park of New York might not have the same value it has now, if broken into hundreds of small pieces and scattered around the metropolitan area.

3.5 Conclusion

Extending previous research, this study evaluated diversity and spatial configuration and pattern of open space, using a more meaningful set of landscape matrices in a hedonic framework that also was corrected for the identification problem induced by endogeneity of landuse variables. The findings from this study have several policy implications in urban landuse planning, open space preservation, and real estate management. We confirmed that residents value variety in open space in their neighborhood; hence any open space protection efforts should consider preserving diversity in its composition. Preserving various types of open spaces might not only increase biodiversity and productivity of local ecosystems, but also raise the local tax base capitalized through increased house prices. In contrast, any growth policy that mixes industrial or commercial landuse with low or medium density residential landuse is not a desirable feature in urban neighborhoods.

In addition to the variety, resident care about the spatial appearance and pattern of open space plots in their surroundings. Our analysis shows that square-shaped open space plots, with smoother and more managed boundaries are preferred[2] to those with complex and convoluted shaped plots with unmanaged boundaries. This might be encouraging to

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[2] It should be noted that I am using a revealed-preference approach of valuation. Therefore, the correlations estimated in this analysis reveal people's preferences, but in an indirect way. That means that I use the estimated correlations to draw conclusions on how homeowners would have shown their preference, had they been surveyed in a stated preference approach. As our analyses indicate, people are willing to pay different prices for houses that are otherwise identical but contain different patterns of open spaces around them, indicating that they prefer one to another. The correlation parameters have been interpreted along this line throughout this dissertation.

local agencies that need justification for investment in landscaping and gardening of natural areas and open spaces in urban areas. Likewise, people preferred few larger plots of open space to numerous tiny plots spatially disaggregated around the neighborhood. This is consistent with the “bigger the better” principle, and reveals that smart open space protection polices should favor protecting fewer but sizable amount of plots, rather than protecting numerous tiny plots randomly located around the neighborhood. As our analysis reveals that urban residents are likely to pay significant price premiums for carefully configured open space plots and their spatial arrangement in the neighborhood, real estate developers may see benefit in considering them in their development plan to increase the housing value.

As the increasing urban population in U.S. cities will increase the pressure on the remaining open spaces, effective design and management of those spaces will be crucial to derive the best human value from these amenities. In addition, several local and federal agencies are currently acquiring new open space plots and protecting remaining plots. The findings from this study will provide a useful guide to increase the aesthetic quality that resident value and maximize the returns from open space conservation efforts through increased property tax. More importantly, this study offers additional insights into urban residents’ preferences for open space quality, which is key to designing citizen funded open space protection plans and making open space valuation calculus more complete. Further research may focus on the survey of residents to validate these results and assess their actual willingness to pay for configuration and spatial distribution of open spaces in their neighborhood.

CHAPTER 4
A HEDONIC ANALYSIS OF DEMAND FOR AND BENEFIT FROM URBAN PUBLIC RECREATION PARKS

4.1 Introduction

Open spaces and public recreation lands enhance the economy and quality of life in cities by improving the air quality, providing the recreational opportunities and aesthetic values, among many other benefits (Nowak and McPherson, 1993). However, as cities grow, open spaces are paved over to make room for new buildings and roads needed to accommodate the increasing urban population. McPherson (2006) pointed out that one of the likely threat into in North American urban forestry is the overuse of recreation parks in urban areas. As the population grows rapidly prompting urban expansion, the remaining small forest patches and open spaces in urban territories are being shared among an increasing number of people (Kline, 2006). The sizes of open spaces not only affect the recreational potential and aesthetic values, but also determine to some extent the quantity and quality of ecosystem services provided to the nearby community (Metropolitan Design Center, 2004).

Public support for open space protection has also increased substantially in recent years. For instance, public referenda on open space have passed in at least 39 states in the US after 1999 (Trust for Public Land, 2005). In addition to population growth, the demand for urban parks and open space is likely to grow in future with citizen awareness of environmental issues and demand for ecosystem services. Effective urban landuse planning and supplying additional acreage of such parks will require a clear understanding of its amenity values and demand in our society. However, our current knowledge on economic value of such parks, especially the welfare effect to the community is limited. For example, one of the six major strategic goals of the National Research Plan for Urban Forestry, 2005-2015, is focused on properly estimating the economic benefits and real estate value added by the enhanced neighborhood quality from such parks (Clark et al., 2007). This paper attempts to estimate the demand for recreation park acreages in urban neighborhood using a two-stage hedonic framework. It will also assess how the supply of additional acreage of land in such park will increase the welfare in our society.

Estimates of the economic values or amenity benefits of urban parks and public open spaces have recently emerged (Tyrvainen, 1997; Bolitzer and Netusil, 2000; Tyrvainen and Miettinen, 2000; Lutzenhiser and Netusil, 2001; Geoghegan, 2002; Hobden et al., 2004; Salazar et al., 2007). A review of the open space and urban park literature by McConnell and Walls (2005) analyzed the results from studies focusing on different kinds of open spaces. Most of the studies focused on either the distance to the urban parks or the proportion of open spaces in some defined level of neighborhood to measure their amenity values in dollar terms. With some notable exceptions (e.g., Bolitzen and Netusil, 2000), most of them have ignored the acreage effect of the urban parks on property values.

Earlier research revealed that housing price increases with its proximity to (Tyrvainen, 1997; Tyrvainen and Miettinen, 2000; Thorsnes, 2002), and size of the nearby urban parks (Tyrvainen, 1997). Salazar et al. (2007) estimated the willingness to pay for proximity to the planned urban parks in Spain. Likewise, Bolitzen and Netusil (2000) considered the size of different natural areas on property values in Portland, Oregon, and noted that public parks significantly increase housing prices in the neighborhood but private parks do not. Lutzenshiser and Netusil (2001) concluded that the size of natural areas and parks have the largest effect on property prices compared to any other kind of open spaces.

Likewise, Anderson and West (2003) and Morancho (2003) reported that the size of the urban parks or green areas did not have a significant amenity effect. In a recent hedonic study, Mansfield et al. (2005) concluded that the trees in the lot or immediate neighborhood could serve as substitutes for living near large woodlots. Despite the substantial amount of research, little information is available on how increasing acreage of urban recreational park will be capitalized in the real estate market and local property tax base. Understanding how the economic welfare changes by supplying more recreational open spaces in the urban landscape and how the residents respond to such policies is important before taking initiatives on open space protection and smart park designing.

One of the limitations of previous studies is that they relied on the implicit price from the first stage hedonic regression to explain the economic benefit from the proximity of open spaces. However, policy changes are often non-marginal and those implicit prices cannot measure such benefits *ex-ante* (Taylor, 2003). Also, proper estimation of demand requires a second stage estimation (Rosen, 1974), which combines the observed quantity of urban park acreage with the implicit prices from the first stage hedonic regression to estimate the demand function. For the non-marginal changes, however, the identification problem arises to estimate the demand (Taylor, 2003). The identification problem is addressed either by estimating the hedonic regression from multiple markets (Palmquist, 1984; Boyle et al., 1999; Brasington and Hite, 2005) or by using the marginal rate of substitution approach (Chattopadhaya, 1999). Due to some questionable assumptions in the latter approach, the multiple market approach is preferred (Freeman, 1993; Boyle et al., 1999). The idea behind the multiple markets is that the marginal implicit price of attribute of interest varies with the estimated parameters across those markets.

Most of the previous studies relied on data from multiple markets or metropolitan area to identity the demand (Taylor, 2003), and ignored the existence of submarkets within a single city (Palmquist, 2005). Literature on housing and real estate economics has revealed that the segmented submarkets exist even within a single city where the dwellings within a submarket serve as substitutes (Bourassa et al., 1999). Recent studies utilizing hedonic methods on the other hand used some statistical clustering techniques to identify submarkets (Lipscomb and Farmer, 2005, Day et al., 2007; Cho et al., 2008 etc.). However, estimating the second-stage demand function to evaluate the urban parks or open space has not been a focus of previous studies.

This study attempted to fill the above-discussed gaps in hedonic valuation of urban recreation park acreage. In particular, this study evaluated the amenity value of urban recreation park and estimated the demand for park acreage based on a second-stage hedonic demand that employed the implicit price of park acres from various submarkets within an urban area. It also evaluated the welfare effects from non-marginal changes in park size. Findings from this study would be useful in urban landuse planning and understanding the public demand for and welfare effects of recreational open space projects.

4.2 Methods

4.2.1 Study Area

The study was carried out in the City of Roanoke, Virginia. Roanoke was chosen because: 1) it is the largest and fastest growing urban area in the southwestern Virginia region, 2) it has been listed among the top three most livable small cities in the nation for its amenity attractions including urban parks (PLC, 2004), and 3) it contains several urban recreation parks of varying size, uniformly distributed throughout the city area and hence provides an ideal place for the study of urban park benefits. The city area includes 46 different urban parks. In addition to green open space and urban trees, these parks are supplemented with additional man-made attractions such as greenways and playgrounds.

4.2.2 Hedonic model

This study used a typical hedonic equation of housing price in a semi-logarithmic form as shown in equation 4.1.

$$\ln P_i = \beta_0 + \sum \beta_j S_{ij} + \sum \beta_k N_{ik} + \sum \beta_l U_{il} + \varepsilon_i \qquad (4.1)$$

where, a $\ln P_i$ is the natural log of real sales price of the ith house, S_{ij} represents the jth structural variable, N_{ik} is the measure of the kth neighborhood characteristic, and U_{il} represents the lth attribute of urban park. Similarly, β_0, β_j, β_k, β_l, represent the corresponding parameters to be estimated whereas ε_i captures the stochastic error term. Although, it is common to estimate the above model with ordinary least squares (OLS), estimating equation (4.1) using OLS assumes that the variance of the error term is constant i.e., homoscedastic. But if this assumption is violated, the error terms will be heteroscedastic, thereby undermining model estimation. A White test of heteroscedasticity was used to test for the homoscedasticity of the error term. If heteroscedasticity was present, consistent estimates of the standard errors were obtained using White's approach of robust standard error (White, 1980). Presence of multicollinearity was tested using the Variance Inflation Factor (VIF), which is a scaled version of the multiple correlation coefficients among independent variables in the model (Greene, 2003).

As expressed in the hedonic function above, three sets of explanatory variables were used. These included a set of structural variables of the house, a set of neighborhood characteristics, and a set of variables explaining the attributes of the urban park. Key structural variables included size of the living area, number of stories, age of house, and size of the parcel on which the house is located. In addition, dummy variables were included to indicate whether or not the house has a brick exterior, central air conditioning (AC), and hip roof design. Other dummy variables were included to capture the presence of masonry fireplace, enclosed porch, and garage. A seasonal dummy was also included to control for the price differential in houses sold in the spring-summer and fall-winter seasons.

Variables capturing the neighborhood characteristics included population density, percentage of population below poverty level, and vacancy rate of houses. Population density captured the relative congestion and level of development in the neighborhood. Percentage of population below poverty level reflected the economic condition and prosperity of the neighborhood. The vacancy rate captured the housing occupancy and residential consumption in the neighborhood.

Distance variables were included to capture the proximity of the neighborhood to several amenity and disamenities. Those included distance to the central business district (CBD), distance to airport, distance to nearest school, distance to public bus route, distance to railway track, and distance to riverside. These distance variables were expected to control for the locational effects and bring useful information in submarket identification, which will be discussed later. Distance to CBD measures the proximity to employment and business hub in the area. Goodman and Thibodeau (1998) mentioned that the quality of public education is the major predictor of neighborhood quality and can explain the housing segmentation. By the same token, the distance to school was also included. Other distance variables mentioned above were expected to control for other amenity and disamenities in the locality.

The size of the nearest urban recreation park was included as well, which is the focus variable in the study. In addition, the distance from the house to the nearest urban park was also included to account for the accessibility of the park from the house. A positive and significant relationship to the size of urban parks was expected. That means the larger (smaller) the size of the park, the larger (smaller) the sales price of nearby houses. In addition, distance to the park was expected to have a significant and negative effect. Detailed definitions of the variables used in this study are presented in Table 4.1.

Table 4.1 Definition and descriptive statistics of variables used in the hedonic equation

Variables	Definition	Mean	Std. Deviation
Structural and housing variables			
Living area	Square footage of the living area in house	1,388.20	608.54
Brick exterior	Dummy variable, 1 if the exterior is brick, 0 otherwise	0.51	0.49
Bedrooms	Number of bedrooms in house	3.01	0.42
Central AC	Dummy variable, 1 if the house has a central AC, 0 otherwise	0.69	0.45
Garage	Dummy variable, 1 if the house has a garage, 0 otherwise	0.24	0.42
Masonry fireplace	Dummy variable, 1 if the house has a masonry fireplace, 0 otherwise	0.46	0.49
Parcel	Square footage of the parcel	11,872.71	13,652.44
Age	Age of house in year 2006	54.84	27.12
Season	Dummy variable, 1 if the house was sold in months 4-9, 0 otherwise	0.55	0.49
Stories	Number of stories in the house	1.25	0.57
Enclosed porch	Dummy variable, 1 if the house has an enclosed porch, 0 otherwise	0.17	0.38
Hip roof	Dummy variable, 1 if the house has a hip roof structure, 0 otherwise	0.13	0.34
Neighborhood and urban recreation park variables			
Population density	People per square miles in the census block group	3,088.89	1,668.02
Poverty	Percentage of residents under poverty level in the census block group	12.50	10.71
Vacancy rate	Proportions of vacant houses in the census block group	0.06	0.03
African-American	Percentage of African-American population in the census block group	20.85	28.21
Median age	Median age of the residents in the census block group	38.51	5.65
Median household income	Median household income of the residents in the census block group	35,174.10	15,500.05
College degree	Percentage of residents with college degree in the census block group	9.17	8.17

Table 4.1. Contd.

Variables	Definition	Mean	Std. Deviation
School	Distance in feet from the house to the nearest school	3,128.55	2,052.87
Public bus	Distance in feet from the house to the nearest public bus route	1,239.16	1,450.83
Airport	Distance in feet from the house to the regional airport	14,338.34	7,490.71
CBD	Distance in feet from the house to the central business district	13,307.11	5,542.85
Railroad	Distance in feet from the house to the nearest railroad track	3,938.55	3,145.32
River	Distance in feet from the house to the nearest river or stream side	2,704.48	2,042.04
Park size	Size in square footage of the nearest urban recreation park	2,527,081.00	5,503,957.00
Park proximity	Distance in feet from the house to the nearest urban recreation park	2,281.72	2,244.95

In order to identify the demand, the above-discussed hedonic model was estimated for different submarkets (to be discussed in the next section) within the city. The partial derivative of the estimated hedonic equation (eq. 4.1) with respect to the attribute of interest (i.e., size of urban forest park) was used to calculate the implicit price of the park per acre. The implicit prices of such attributes from each submarket were then combined to estimate the demand in the second stage.

4.2.3 Market Segmentation

Following Lipscomb (2005), Day et al. (2007), and Cho et al., (2008), we used a statistical technique to identify the submarkets and estimate separate hedonic price functions in them. A commonly-used statistical technique to identify market segmentation within a city is a *k*-means clustering (Bourassa et al., 1999; Lipscomb, 2005; Cho et al., 2008), in which the housing and neighborhood variables forming the hedonic function are used to group the houses into different clusters. The houses belonging to a particular cluster share the same structural and neighborhood characteristics and are substitutes for each other (Bourassa et al., 1999). Hence, these clusters are commonly referred to as submarkets (Bourossa et al., 1999 and 2003; Day, 2003; and Cho et al., 2008). However, use of *k*-means clustering is challenging because it needs *a priori* information on the number of possible clusters or submarkets before segmentation can occur. What *k*-means clustering cannot do is identify the optimal number of clusters or submarkets (Bourossa et al., 1999).

In contrast, a more-recently developed clustering technique called Two Step Clustering (McGarigal et al., 2000) is capable of identifying the optimal number of clusters based on the housing and neighborhood characteristics entering the hedonic function. The first step of the Two Step Cluster method begins with pre-clustering observations for individual houses by constructing a likelihood distance measure function. A matrix containing distances between all pairs of pre-clustered observations is created. In the second step, these pre-clustered groups of original observations are treated as individual observations and re-grouped by selecting the optimal number of clusters using either the Bayesian Information Criterion (BIC) or the Akaike Information Criterion (AIC). Because the first step groups a large number of original observations into a much smaller number of pre-clusters, the second step uses an agglomerative hierarchical clustering to re-group the pre-clusters (Green and Salkind, 2003). Following McGarigal et al. (2000) and Strong and Jacobson (2005), this study used Two Step Clustering techniques. Even though the clustering techniques group the properties of similar characteristics, we do not know whether those clusters represent the submarkets. Therefore, an ANOVA test was performed to compare the statistical differences among the submarket properties based on sample means and variances (Moore and McCabe, 2003). In addition, following Allen et al. (1995) and Day (2003), a series of Chow tests were used to confirm the existence of submarkets by checking whether the hedonic price functions among those clusters differed significantly.

4.2.4 Demand for Urban Recreation Park

The implicit prices of different attributes estimated from separate hedonic regressions for individual submarkets were combined to estimate a citywide-pooled model. Following Palmquist (1984), Boyle et al. (1999), Brasington and Hite (2005), a semi-log demand model was estimated:

$$\ln Q_u^i = P_u^i + P_{sc}^i + Z_i + \nu_i \tag{4.2}$$

where, $\ln Q_u^i$ represents the natural log of acres of urban recreation park that is closest to the *i*th house, P_u^i is the implicit price of the park acres. Likewise, P_{sc}^i is a vector of implicit price for substitutes and/or complements and Z_i is a vector of exogenous demographic and economic factors that are related to tastes and preference of the residents and are expected to influence the demand. Although there is not a common standard in selection of goods that are substitutes/complements to natural amenities, previous studies have used prices of living area and some attributes of the amenities under study. For instance, Boyle et al. (1999) used the price of living area and price of view of the lake to evaluate demand for water clarity in the lake. By the same token, implicit prices of living areas and proximity to the park (in miles) were included in vector P_{sc}^i. The implicit price for park acreage and living area were log transformed due to a substantial variation in them.

The exogenous demand shifters in Z_i were taken from the corresponding census block group information. As these socioeconomic characteristics were measured at the census block group scale, these might not be perfectly exogenous. However, for the hedonic analysis, they are valid demand shifters (Brasington and Hite, 2005; Mahan et al., 2000) and have been used in several hedonic demand models. These included the income of the home purchaser as measured by natural logarithm of the median income of the households, tastes and preferences of the homebuyer as measured by median age of residents, race defined as the percentage of the population in the census block that are African-American, and education as measured by the percentage of residents with a college degree.

Similarly, following Clark and Cosgrove (1990), squares of some of these variables including median age and percentage of African-American population were also included. Palmquist (1984) and Boyle et al. (1999) argued that the implicit price of the park size and the income of the home purchaser are endogenous to the demand function in equation (2). Thus, the endogeneity of implicit price and median household income were addressed using instrumental variables in a Two Stage Least Square approach. Following Palmquist (1984), the per capita income and the unemployment rate were chosen as instruments.

We also estimated a welfare effect due to change in acres of urban recreation park. Results from the estimation of eq (4.2) were utilized to estimate the marginal implicit price of the park acres at its current mean level and at a 20% higher level. Using the MAPLE 9 program, consumer surplus was then calculated by integrating the demand function with respect to predicted prices at these two price levels, whereas the other variables were kept constant at their mean level.

4.2.5 The Data

Data used in this study came from a variety of sources. Housing prices and their structural characteristics were obtained from the Geographic Information System (GIS) database of the real estate department at City of Roanoke, Virginia. A total of 11,334 single-family houses were sold between 1997 and 2006. However, 209 of those either did not have complete information or had sales price of only a few dollars and did not seem to involve arms-length transactions. Following Bolitzer and Netusil (2000), such observations were omitted from the analysis. This resulted in a final dataset consisting of 11,125 houses with complete information. All the housing prices were adjusted to year

2000 dollars to control for real estate market fluctuations in the city, and to make them compatible with the neighborhood data of Census Year 2000. For this, we used the annual housing price index for the City of Roanoke, which was obtained from the Office of Federal Housing Enterprise Oversight (OFHEO, 2006). Since the month in which sales occurred was also recorded along with the transaction price, the month of sales was used to create a season of sale dummy variable.

The GIS files of spatial location of parcels, regional airport, public bus routes, schools, railroad, rivers, urban parks, and central business districts were obtained from the city as well. Distances from each house to those features were computed in ArcGIS 9.3. The neighborhood data on socioeconomic information were obtained from the census block group level data of US Census Bureau data in 2000 (US Census, 2000). Descriptive statistics of the variables used are presented in Table 4.1.

4.3 Results

4.3.1 First Stage Hedonic Model

A White test of heteroscedasticity rejected the null hypothesis of homoscedasticity at the 1% level in citywide hedonic regression (Chi-square Statistic = 1434.61, critical value of 135.81). Computed values of VIF did not exceed the threshold value of 10 except for age and square of age (Table 4.2). Since using the square of age is common practice in hedonic literature to account for declining house price in age, they were not omitted. Results from the citywide hedonic regression along with White's robust standard error are presented in Table 4. 2. Conventional adjusted R-square (0.64) reveals a relatively good fit of the data to the specified model. Coefficients on most of the

Table 4.2 Estimates from the hedonic regression

Variables	Coefficients (Standard errors)	VIF
Constant	4.229***	---
	(0.213)	
Structural and housing variables		
ln(Living area)	0.657***	3.41
	(0.020)	
Brick exterior	0.087***	1.48
	(0.008)	
Bedrooms	0.019***	1.56
	(0.006)	
Central AC	0.183***	1.33
	(0.009)	
Garage	0.059***	1.20
	(0.009)	
Masonry fireplace	0.139***	1.73
	(0.009)	
ln(Parcel)	0.041***	1.57
	(0.010)	
Age	-0.003***	16.53
	(0.000)	
Age squared	-0.000	17.73
	(0.000)	
Season	0.047***	1.00
	(0.007)	
Stories	-0.046***	1.92
	(0.008)	
Enclosed porch	-0.036***	1.11
	(0.010)	
Hip roof	-0.014	1.24
	(0.013)	
Neighborhood and urban recreation park variables		
ln(Population density)	0.013**	1.48
	(0.006)	
Poverty	-0.012***	1.89
	(0.000)	
Vacancy rate	-0.837***	1.69
	(0.150)	
ln(School)	-0.033***	1.31
	(0.005)	

Table 4.2. Contd.

Variables	Coefficients (Standard errors)	VIF
ln(Public bus)	0.015***	1.59
	(0.004)	
ln(Airport)	0.066***	1.75
	(0.005)	
ln(CBD)	0.137***	3.22
	(0.015)	
ln(Railroad)	-0.026***	2.05
	(0.005)	
ln(River)	0.021***	1.53
	(0.004)	
ln(Park size)	0.030***	1.16
	(0.002)	
ln(Park proximity)	-0.016***	1.54
	(0.004)	
Adj. R-Square	0.64	
F-Statistic	563.98***	
Number of Observations	11,125	

*Note: Dependent variable is ln(real housing price); the standard errors are white's robust standard error; ***, ** and * denote the significance of parameters at 1%, 5% and 10% confidence levels respectively.*

variables (22 out of 24) were statistically significant at the 1% or better level and most of them had the expected signs.

Most of the structural variables including square feet of living area, exterior brick dummy, number of bedrooms, central AC dummy, garage dummy, and masonry fireplace dummy were positively related and significant at the 1% level, as expected. Not surprisingly, these are consistent with existing hedonic studies. Likewise, the coefficient on square feet of the parcel and age of the house were significant at 1% level and were positively and negatively related to house price, respectively. Some of the other variables such as number of stories and enclosed porch dummy had negative effects, which is counter to our expectation. Similarly, among the neighborhood variables, population density was positively related with house price, whereas the percentages of population in poverty and vacancy rate were negatively related to house price at the 1% level.

Distance from the house to the nearest school was negatively related to house price, whereas the distance to the closest public bus route and regional airport were positively related to house price, all of them being significant at 1% level. Further, the coefficient on the distance to the CBD was positively related and significant at the 1% level, which is quite consistent with the economic theory that houses farther away from the downtown might have a higher demand for residential purposes than their downtown counterparts due to sound and quality of life. This merely confirms the concentric zone model of urban development proposed by sociologists Robert Park and Ernest Burgess in their 1925 study of Chicago. On the other hand, the observed effect of the railroad was not palpable; the positive effect of distance to rivers might be attributed to the fact that this variable did not distinguish between rivers and small streams or creeks, which might increase the risk of erosion and landslide (MacDonald et al., 1990).

More importantly, the variables associated with the urban forest park, which also is the focus of this study were significant and had expected sign. The size of the nearest urban forest park was significant at the 1% level and was positively related to house price, corroborating the findings of previous studies (e.g., Tyrvainen, 1997; Bolitzer and Netusil, 2000; Lutzenhiser and Netusil, 2001). Since the sizes of parks measured in square feet were log-transformed, as was the dependent variable, the coefficients are interpreted as elasticity. It reveals that a 1% increase in square footage of the urban forest park in the neighborhood increased the real sales price of the house by 0.03%, ceteris paribus. This finding confirms that the size of the nearby urban forest parks has a small but significant and positive relationship to property price.

In the same way, the distance to the nearest urban forest was negatively related to house price at the 1% level. This is consistent with the findings of Bolitzer and Netusil (2000); Tyrvainen and Miettinen (2000); Morancho (2003); Tajima (2003); Anderson and West, (2006) etc. The elasticity indicates that a 1% decrease in distance from the house to these parks increases the real price of the house by 0.016%, ceteris paribus. Combining the mean real housing value and initial distance of 1 mile, the marginal implicit price would be $0.295, suggesting a $295 increase in house price by moving the house 1000 feet closer to an urban recreation park.

4.3.2 Second Stage Demand Model

Two Step Cluster analyses yielded four distinct submarkets within the city of Roanoke. The number of submarkets identified here is comparable with Cho et al. (2008), who found five distinct submarkets within the city of Knoxville, Tennessee, which is similar in size and geographically close to Roanoke city. Differences among characteristics of the property by submarket are reported in Table 4.3. The *P*-values of F Statistic in ANOVA tests indicated that the property characteristics varied significantly among submarkets, suggesting a clear distinction between those submarkets.

In addition, a series of Chow tests showed that F-Statistic were significant at 1% level for each submarket combination (Table 4.4), rejecting the null hypothesis of equivalency of hedonic price functions between those submarkets. This evidence confirmed that Roanoke contains four distinct submarkets, which were utilized to identify the demand. Like our statistical tests proved, the difference in identified submarkets in the area appeared to have economic meaning as well. Submarket 1 contains medium-valued houses located farther away from the downtown and in a less dense area and is in relatively greater distance from the parks, public transportation and schools. Submarket 2 consists of medium valued houses made of brick walls, in densely populated areas with recreation parks and public transportation nearby. Likewise, Submarket 3 includes higher-valued suburban houses occupied by high income and well-educated people, whereas submarket 4 appears to be poorer housing owned by less-educated African-American in the inner city area. As in Day (2003), Lipscomb (2006), and Cho et al. (2008), submarkets in our case are not necessarily contiguous. However, the members of each submarket formed apparent geographical clusters because we take the spatial locational factor (e.g., proximity to various amenities) into account in the cluster identification process. Separate hedonic estimations were used to compute the marginal

Table 4.3 Mean values of property characteristics by submarket and ANOVA results of difference among submarket means

Variables	Submarkets				F-Statistic
	1	2	3	4	
Living area	1,180.12	1,344.24	2,299.04	1,192.92	2032.13†
Brick exterior	0.25	0.94	0.67	0.13	3901.97†
Bedrooms	2.95	3.03	3.52	2.82	356.00†
Central AC	0.91	0.70	0.91	0.45	736.43†
Garage	0.19	0.29	0.48	0.11	307.29†
Masonry fireplace	0.22	0.68	0.95	0.17	1987.71†
Parcel	13,082.29	10,544.25	22,908.94	7,926.33	493.62†
Age	30.75	60.77	47.36	67.30	1281.29†
Season	0.54	0.56	0.59	0.52	8.67†
Stories	0.90	1.31	1.47	1.33	439.69†
Enclosed porch	0.06	0.21	0.15	0.21	94.83†
Hip roof	0.02	0.13	0.16	0.19	131.44†
Population density	1,928.16	3,615.63	2,021.80	3,705.74	1120.10†
Poverty	8.89	8.27	4.65	22.75	2891.05†
Vacancy rate	0.04	0.05	0.04	0.08	838.79†
African-American	17.75	15.10	3.87	36.20	696.76†
Median age	37.09	38.92	46.22	35.78	1854.25†
Median household income	38,104.02	35,005.10	56,414.81	24,587.54	2499.90†

Table 4.3 Contd.

Variables	Submarkets				F-Statistic
College degree	6.53	10.57	22.93	3.63	4553.29†
School	5,322.36	2,603.99	2,683.91	2,446.23	1593.05†
Public bus	2,659.48	760.97	1,874.33	563.53	1827.11†
Airport	14,534.27	12,282.88	23,159.04	12,770.09	1062.67†
CBD	18,209.65	13,203.89	16,215.55	8,993.99	2373.99†
Railroad	6,060.88	4,026.88	3,525.39	2,623.46	666.24†
River	2,080.60	2,800.58	2,520.70	3,085.50	123.40†
Park size	3,865,281.00	1,115,257.00	6,893,779.00	1,365,865.00	563.79†
Park proximity	4,106.21	1,537.90	3,790.23	1,266.15	1582.28†
House price	89,739.22	90,773.50	215,755.30	53,156.13	2468.18†

† Significant at the 1% level

Table 4.4 Chow test statistics for equivalency of hedonic price function among submarkets

Submarket	1	2	3
1			
2	11.34***		
3	13.74***	22.03***	
4	5.46***	15.43***	20.49***

*Note: *** denotes the significance of F-Statistic at 1% level.*

implicit prices of urban park acres for different submarkets, while the second-stage demand function was estimated using the pool dataset.

The results from the Two Stage Least Square estimation of demand function are presented in Table 4.5. Most variables were significant and possessed the expected sign. It should be noted that the standard errors are robust (i.e., corrected for heteroscedasticity using White's method). The own implicit price of park acre, price of substitutes, and exogenous demand shifters explained most of the variation in quantity demanded. In view of the good fit of the model and theoretically consistent estimates, it is reasonable to argue that the proper segmentation of submarkets in fact allows one to identify and estimate the demand function in the hedonic framework even with observations from a single city. In this regard, we improved upon the method used by Mahan et al. (2000) for demand identification in a two-stage hedonic method.

As expected, the own price was negatively related to the acres of park demanded and was significant at the1% level. Since the dependent variable and the price of park acres are in log form, the reported parameter is interpreted as elasticity. The elasticity value of -0.84 reveals that a 1% increase in the implicit price of park acres decreased the demand by 0.84%, ceteris paribus. This indicates that the demand for urban forest park

Table 4.5 Demand estimation from two-stage least square (2SLS)

Variables	**Coefficients (Standard errors)**
Constant	-0.974***
	(0.181)
ln(Price of park acre)	-0.843***
	(0.008)
ln(Price of living area)	0.636***
	(0.010)
Price of park proximity mileage	0.002***
	(0.000)
ln(median household income)	0.431***
	(0.022)
Median age of residents	0.050***
	(0.006)
Square of median age	-0.000*
	(0.000)
African-American	-0.009*
	(0.000)
Square of African-American	0.000
	(0.000)
College degree	-0.002***
	(0.000)
Adj. R-Square	0.94
F-Statistic	4239.62***
Number of Observations	11,125

*Note: Dependent variable is ln(Urban recreation park acres); the standard errors are white's robust standard errors; ***, ** and * denote the significance of parameters at 1%, 5% and 10% confidence levels, respectively.*

acres is inelastic, corroborating Kristrom and Riera, (1996). Following Boyle et al. (1999), the demand function was evaluated for various levels of park size and using a Grand constant, which contained all variables other than, own price in their current mean values. Figure 4.1 reveals a clear downward sloping demand curve for park acres with respect to its hedonic price change. It reveals that urban residents prefer larger parks to smaller ones, but their marginal willingness to pay for extra acreage diminishes.

The coefficient of implicit prices of living area was positively and significantly related to demand for park acreage at the 1% level, confirming that the house was a substitute for the size of nearby parks. As revealed by the cross price elasticity of 0.63, the residents demand bigger park acres if the cost of living space is high, ceteris paribus. Earlier, Thorsnes (2002) found larger lot sizes to be substitutes of open space in forest preserves. The cross price elasticity in case of distance to park was highly inelastic but significant and confirms that the proximity to park is a substitute for size. A similar study by Mansfield et al. (2005) found that trees on a parcel could serve as substitutes for living near big forest blocks. These results might have important implications in real estate design and landuse planning. The exogenous shifters of demand were also significant and had the expected sign. The median household income of the purchaser was positively and significantly related to demand. Although the demand was inelastic on income ($\gamma = 0.43$), it is still the most important predictor of demand for park acres after the price of the amenity itself.

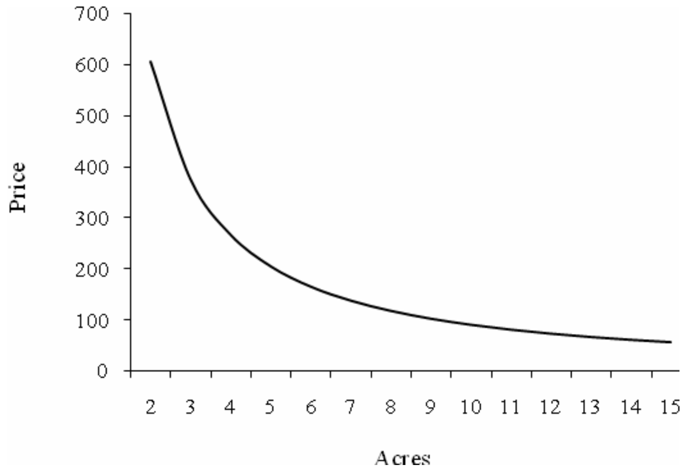

Figure 4-1 Demand curve for acres of urban recreation parks

The median age of the resident were positively and strongly related with the demand, whereas the square of media age was negatively related. A possible explanation of this might be related to the declining mobility of senior citizens to properly consume those resources. The residents demand nearby parks while they remain physically active, but that desire might diminish with aging and physical inactivity. Counter to our expectation, the percentage of residents with a college degree was negatively related to the demand for the park area. That might be, however, associated with the higher opportunity cost of time, higher ability to afford alternative natural amenities within reasonable distances, and other factors that were not accounted for in our demand model.

As expected, race was another predictor of demand for park acres. As the result shows in Table 4.5, the coefficient of percentage of African-Americans residents was negatively related at the 10% level, suggesting that neighborhoods with a higher proportion of non-whites are less likely to demand urban parks. The coefficient on the square of the percentage of residents who are African-American was positive but was not statistically significant.

One of the major benefits of estimating the second stage demand in hedonic framework is to evaluate the welfare impacts of alternative policy interventions. As Boyle et al. (1999) and Brasington and Hite (2005) estimated for other environmental attributes, we estimated consumer surplus per household from a policy that provides more urban acreages under recreation parks. Increasing the current average size of the urban recreation park (35.13 acres) in the city by 20% (42.15 acres) resulted in an increase in consumer surplus of $160 per household. Since the values of parks related natural amenities are localized within the neighborhoods, we estimated the total consumer surplus effect of this size increase on properties those are within a mile[3] from the park boundaries. Total consumer surplus from increasing the current size of parks by 20% becomes $6.5 million for 40,984 properties located within a mile distance of these parks.

Even though there are no other studies on urban park demand with which to compare our results, the estimated figures do not dramatically differ from other related open space studies. For instance, Bolitzer and Netusil (2000) estimated that each additional acre of natural area increases the nearby house price by $28, suggesting a surplus of $196 for an increase that is equivalent to the one we discussed above. A contingent valuation study by Breffle et al. (1998) in Boulder, Colorado estimated $302

[3] Acharya and Bennett (2001) argued that one-mile radius circle represents a typical walkable neighborhood around the house. We used ArcGIS 9.3 to find out the number of properties located within that distance from the park.

as a household's one time willingness to pay to preserve 5.5 acres of open space in the neighborhood. However, the observed difference between our and their results may be because of the estimation method employed, and also the context and level of urbanization between the study areas. In addition, the observed differences could also be attributed to the possible difference in service proved by different types of open spaces.

4.4 Conclusion

As American cities continue to grow, more people are using the available open spaces and urban recreation parks. This means that urban parks will become more congested, possibly to a point, which exceeds the potential of these parks to sustain their recreational and amenity benefits. Using a two-stage hedonic model, this study estimated the amenity value of and demand for urban recreation park acres in Roanoke, Virginia.

Findings from this study suggest that both the proximity to and size of the urban recreation parks have a small but significant positive effect on property values. Further, the hedonic price of an urban park acre was negatively related to the park size. A fairly inelastic demand curve was derived, with an elasticity of -0.84. Although, income was the best predictor of demand after the hedonic price of the park size, the demand was inelastic for income as well. The study also confirmed that the price of the living space and proximity to the nearest park were substitutes for the acres of nearby urban parks. The demand for urban park size increases as the cost of living space increase. This might be a useful implication in landuse planning and urban sprawl management because preserving public open spaces could encourage high-density development and help discourage sprawl. Similarly, residents prefer the residential locations by trading the size of the urban recreation parks with the proximity of those parks.

Welfare analysis in this study also suggests that increasing the current mean size of urban forest acres by 20% in Roanoke would increase the per household consumer surplus by $160. Properties located within an immediate neighborhood of these parks will have an increased consumer surplus of $6.5 million from this policy. This estimated welfare impact might be helpful in justifying investment on open space preservation and park management, and may provide guidance in designing citizen-financed open space preservation or park management for Roanoke, in particular, and hundreds of cities nationwide with similar characteristics.

Results from this study will have several policy implications in real estate design, landuse planning, and urban park management. We also confirmed that the second-stage demand estimation could yield theoretically consistent results, provided the submarkets are identified systematically. As a result, our method offers a useful approach to estimate the demand for other environmental amenities for which data from multiple cities are not available. Given that the federal and local governments are attempting to preserve more open spaces in urbanizing communities, this study provides useful guidance to understand how the residents respond to different level of open space acres and to ensure proposed investment for new acquisitions will be justified by the anticipated welfare gains.

CHAPTER 5
EVALUATING NATURAL RESOURCE AMENITIES IN A LIFE EXPECTANCY PRODUCTION FUNCTION

5.1 Introduction

Life expectancy has been a major metric in measuring long-term human health, social welfare, and development of our society (Barlow and Vissandjee, 1999; Lomborg, 2002). The human development index, which the United Nations uses to measure human development among countries, depends on life expectancy at birth in addition to other factors such as literacy rate and income (United Nations Development Program, 1997). Some even suggest that it is an important determinant of economic welfare calculus (Anderson, 2005). Life expectancy also influences fertility behavior, human capital investment (Shaw et al., 2005), and public funding on some basic human needs such as education and health care (Gradstein and Kaganovich, 2004), thereby determining the overall quality of life.

Average life expectancy has increased globally in recent years. The rate of increase in life expectancy among developing countries, however, was significantly higher compared to the developed countries (Lomborg, 2002). In the United States, the average life expectancy has steadily increased recently, but there is substantial variation across the nation. Ezzatti et al. (2008) found that life expectancy is decreasing in some parts of the United States, for example, including the deep South and the southern portions of the Midwest and in Texas. This pattern is consistent with the basic idea of ecology that species in the northern portion of their territory are likely to live longer than those in the southern. However, the very question of what causes this variation cannot be answered unless we adopt a micro-approach to examine life expectancy patterns within the United States.

Few studies have been focused on life expectancy (Barlow and Vissandjee, 1999; Shaw et al., 2005). Moreover, most have adopted a macro-approach, using countries as the analysis unit. These studies employed a life expectancy production function in which the socio-demographic factors, risk and safety factors, medical facilities and expenditures, and environmental variables were included as function arguments. The idea of a life expectancy production function is that all of these factors jointly determine the average life longevity of the country's population. Even though there is not a common standard among the studies in using specific factors to describe socio-demographic and economic conditions, factors such as literacy rate and income have been commonly used.

Barlow and Vissandjee (1999) reported that income level, education, fertility, and location are strong predictors of national life expectancy. They also noted that health expenditures and urbanization rates are rather weak determinants. Peltzman (1987) compared the effect of government health expenditures and wealth on life expectancy and reported that only wealth increases expectancy. Hertz et al. (1994) regressed country level life expectancy against literacy rate, availability of medical facilities, dietary factors, gross national product, and labor force. Results from their study revealed that literacy rate, animal product consumption, and access to safe water are positively associated to life expectancy.

Some researchers have studied the determinants of life expectancy by breaking down countries according to level of development. Shaw et al. (2005), for example, studied factors affecting life expectancy in developed countries. Their study reveals that pharmaceutical consumption increases life expectancy at various age levels. In another study, Sufian (1989) focused on developing countries and explained life expectancy by literacy rate, energy consumption, per capita gross national product, urban population, access to safe water, and medical resources. He concluded that only literacy rate, family planning efforts, and daily calorie consumption exhibit significant relationships with life expectancy. Rao (1988), in a study using a sample of 51 countries, noted that medical goods and services, literacy rate, and food calories increase life expectancy at birth whereas the amount of meat and poultry in the diet is negatively related to life expectancy.

The existing literature on life expectancy has some limitations. First, most of these studies utilized a macro approach, employing data aggregated at a macroeconomic level (Shaw et al., 2005). This type of model can capture the variation among countries, but understanding local variation in life expectancy within a developed country like United States requires examining differences at a finer scale. With some notable exceptions[4], none of the existing studies examined life expectancy of sub-populations within the United States.

Another limitation is that the life expectancy production function used in previous studies almost ignores environmental factors and natural resource amenities. Ho et al. (2003), however, argue that public health approaches should be holistic and adopt both the medical care and prevention strategies that promote the direct and indirect benefits of

[4] A recent study by Singh and Siahpush (2006), however, looks at the effect of socio-economic deprivation on life expectancy among US counties, and concluded that populations in higher socioeconomic status experienced an increase in average life expectancy.

natural parks and resources. The literature also reveals that environmental qualities and recreational resources enhance quality of life (Deller et al., 2001; Nzaku and Bukenya, 2005). An abundance of natural resources and environmental amenities can maintain clean air and water that are directly associated with human health. In addition, amenities including open space, landuse diversity, scenic beauty, and outdoor resources offer a vast potential for leisure activities that might not only enhance recreational satisfaction and personal experience but also help people remain physically fit and maintain good public health (Kruger et al., 2007). Moreover, areas with a high proportion of farmland, forests, and ranchlands might offer farm produce for daily consumption and engage the local population in physically challenging jobs. All of these could collectively enhance physical health and life longevity. Previous study has revealed an inverse relationship between the number of visits to natural areas and the frequency of illness (Grahn and Stigsdotter, 2003)

Recent studies have also revealed that a vast number of Americans are now moving from urban to naturally rich rural counties for a better quality of life (Deller et al., 2001, Poudyal et al., 2008). Even though earlier studies recognize the role of such resources in life expectancy, they either ignored or failed to properly include them in the production function. Barlow and Vissandjee (1999), for example, utilized a dummy variable to capture whether or not the country is located in tropics to take into account of ecological factors. Shaw et al. (2005) used wealth, education, and safety factors to control for the environmental measures and Rao (1988) used temperature and precipitation.

This study aims to strengthen our understanding of determinants of life expectancy in a few ways. First, we used a more complete set of natural resources amenities, which as the literature suggests, enhance quality of life. In contrast to earlier studies with macroeconomic data, we used data disaggregated to the county level to explain life expectancy variation at the local level. Third, in contrast to previous studies that use cross sectional data but failed to address spatial dependence, we adopted a more robust econometric model that tests and corrects for any form of spatial autocorrelation in the data.

5.2 Methods

5.2.1 Empirical Model

Following Shaw et al. (2005), Sufian (1989); and Barlow and Vissandjee (1999), we used a life expectancy production function which contains county socio-demographic and economic factors, medical facility and risk factors, and natural resource amenities as factors of production. Equation 5.1 summarizes the conceptual model.

Life expectancy = *f* (socio-demographic factors, medical facility and risk factors, natural resource amenities) (5.1)

We began with an ordinary least square (OLS) estimate of this equation. However, since the model uses cross sectional spatial data of counties, residuals from OLS model can exhibit two types of spatial dependence. The first type of spatial dependence is a spatial error, which means the OLS residuals are correlated among counties, which violates the assumption of uncorrelated error terms, leading into inefficient estimates. In such a case, the spatial error model (SEM) as expressed in equation 5.2 is estimated (Anselin and Bera, 1998).

$$\begin{aligned} y &= X\beta + u \\ u &= \rho W u + \varepsilon \qquad where \quad \varepsilon \sim N(0, \sigma^2 I_n) \end{aligned} \tag{5.2}$$

Where vector y *(N X 1)* contains cross-sectional observations on average life expectancy at birth by county, matrix X *(N X K)* contains the observations on a set of independent variables affecting life expectancy. W is a spatial weight matrix[5], whereas β is a vector *(K X 1)* of parameters to be estimated. Similarly, μ is a vector *(N X 1)* of error terms that are spatially auto correlated, and ε refers to vector *(N X 1)* of error terms with N $(0,\sigma^2 I)$, and scalar ρ represent the coefficient of spatial autoregressive error lag term.

The second type of spatial dependence is the spatial lag, which means the dependent variable in a county is affected by independent variables of not only the county itself, but also the surrounding counties. This violates the assumption of uncorrelated error terms as well as independence of individual observations, and can lead to biased and inefficient estimates. In such case, a spatial lag model as expressed in equation 5.3 is estimated (Anselin and Bera, 1998).

$$\begin{aligned} y &= \rho W y + X\beta + \varepsilon \\ \varepsilon &\sim N(0, \sigma^2 I_n) \end{aligned} \tag{5.3}$$

Where y again is a vector *(N X 1)* of observation on average life expectancy at birth by county, Wy is a spatial lag of dependent variable, and scalar ρ represent the spatial lag autoregressive coefficient. Similarly, β is a vector *(K X 1)* of parameters to be estimated, X is a matrix *(N X K)* of independent variables, and refers to error terms with N $(0,\sigma^2 I)$.

We used a spatial regression decision process suggested by Anselin (2005, pp 199) to identify the type of spatial dependence and fit our model to the appropriate form.

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[5] Positive and symmetric spatial contiguity weight matrix *(N X N)*, is used to define the first-order adjacency of counties. Each element w_{ij} of W is given 1 when county i and j are adjacent, otherwise 0, and each row in the matrix W are row standardized. Details of weight matrix is found in Anselin and Bera (1998).

5.2.2 Variables and Data Sources

The dependent variable in the study was the average life expectancy at birth for county residents in 1999. The definition of this variable is the number of years a newborn is expected to live in a county (Singh and Siahpush, 2006). Data for this variable were obtained from the Harvard School of Public Health. County level expectancy as originally estimated by Ezzati et al. (2008), using mortality statistics from the National Center for Health Statistics (NCHS) and population data from the US Census Bureau. Mean life expectancy at the birth in 1999 among US counties was 76.32 years, with 66.63 years as the minimum and 81.31years as the maximum.

The independent variables were grouped into three categories including demographic and socioeconomic factors, medical facilities and risk factors, and natural amenity and outdoor recreation resources. The first category included factors that capture the race, literacy rate, income, occupation, housing condition, and type of residence. Since these factors determine the life style, food consumption pattern, and other tastes and preferences of the population, they could eventually determine life longevity. Following Singh and Siahpush (2006), Sufian (1989), and Barlow and Vissandjee (1999), we included the percentage of African-Americans, percentage of college graduates, median household income, population density, median housing value of the house, and a dummy variable indicating whether or not the county was urban.

We included social security benefits per thousand capita and property tax rate in the county to capture any effect of local governmental support and fiscal factors. Average travel time to work was included to capture effect of commuting pattern and time spent in regular traffic. Data on these variables were obtained from the US Census Bureau City and County data book (1994). We hypothesized that the variables in this category will have a mixed effect on life expectancy. For example, variables capturing education, income, housing value, will be positively related with life expectancy, whereas those capturing the congestion, county urban status, and proportion of African-American populations will be negatively related to life expectancy (Harper et al., 2007).

We also included medical facilities and risk attributes to control for the factors that are likely to affect life expectancy. Following Rao (1988), we included the number of hospital beds per thousand and the number of physicians per thousand. In addition, the number of community hospitals in the county was also included. Shaw et al. (2006) and Barlow and Vissandjee (1999) used per capita pharmaceutical expenditure to control for these facilities, but found them to be weak determinants. Data on those variables were obtained from the US Census Bureau City and County data book (1994) as well. We hypothesized that variables capturing the medical facilities will have positive effect on life expectancy.

We also included variables to capture the potential of human life longevity risks. Estimated risks of respiratory disease were obtained from the Environmental Protection Agency (EPA) for 1999. We also included the percentage of county population in manufacturing jobs, to control for labor or job related life risks (Hertz et al., 1994). Data on manufacturing jobs was obtained from the USDA, Economic Research Service. Crime related effects were controlled, using the number of serious crime incidences per thousand, whereas a distance variable measuring the proximity to interstate and state highways was included to control for traffic and transportation related risks. Crime data were obtained from the US Census Bureau City and County Data Book (1994), whereas the distance from each county to major highways was calculated using the Environmental and Scientific Research Service (ESRI)'s county and highway maps in ArcGIS 9.2. Following Rao, (1988), we also included the average annual temperature to control for the effect of high temperatures, which favor several pathogens and life- threatening disease vectors (Barlow and Vissandjee, 1999). Annual temperature data, which are the average of long-term annual observations, were obtained from the National Climatological Data Center of NOAA. We hypothesized that variables in the risk factor category were negatively related to life expectancy.

The third category included variables describing the county's natural amenities and outdoor recreation resources. These include the percentage of county area in farm, forests, pasture, rangeland, and water bodies. We also included a dummy variable capturing whether or not the county is a coastal. Mean sunlight hours in January were also included to capture the availability of sunny days that favor outdoor mobility and leisure activities. A topographical index was included to capture general surface terrain. Variables describing outdoor recreation resources included a dummy indicating whether or not the county contains a state recreation park, proximity to the national park, number of outdoor sports attractions in the county, and number of golf courses per thousand. Data on these variables were obtained from the National Outdoor Recreation Supply Information System (NORSIS). As a part of the Renewable Resources Planning Act of 2000 (RRPA), NORSIS compiles periodic data of various outdoor recreation goods and services at the county level (Cordell and Betz, 1997). We hypothesized that variables in natural amenities and outdoor recreation resources category were positively related to life expectancy.

Detailed definitions of the variables, their expected signs in the regression, and sources are summarized in Table 5.1. Following Barlow and Vissandjee (1999, pp. 17), we treated all variables as exogenous to life expectancy. Multicollinearity, which if present makes precise estimation difficult, was checked using the variance inflation factor (VIF). As a rule of thumb, variables associated with VIF value of 10 is considered to cause multicollinearity (Freund and Wilson, 1998, 194). Even though previous studies with country level data included variables such as calorie consumption per family and percentage of population with access to safe water in the model, we could not do so here due to lack of such data at the county level. However, we believe that the range of demographic and economic variables included in our model control for such factors. This study covers all the states in the conterminous United States and counties are the individual analysis units. Due to data limitations, however, a few independent cities of Virginia and counties from other states were excluded from the analysis, reducing the total number of counties in the analysis to 3,064.

5.3 Results

A Lagrange Multiplier (LM) test confirms the presence of positive spatial autocorrelation in the OLS residuals (Moran's I = 0.054, p value < 0.01). Moreover, results from a series of LM tests in spatial regression decision process (Anselin 2005, pp 199) revealed that spatial error dependence was present (LM Statistic for error = 23.16, p value <0.01), whereas the spatial lag dependence was not (LM Statistic for error = 0.32, p value = 0.32). This indicates the appropriateness of the spatial error model (SEM) to correct for spatially correlated OLS residuals. Maximum likelihood estimates from the SEM model are presented and compared with OLS estimates in Table 5.2.

Table 5.1 Definitions, expected signs, and data sources of variables used in life expectancy production function

Variables	Definition	Expected sign	Data Source
Demographic and socioeconomic factors			
African-American	Percentage of African-American in county population	-	US Census Bureau
College graduate	Percentage of college graduate in county population	+	US Census Bureau
Household income	Median household income	+	US Census Bureau
Population density	Number of people per square mile	-	US Census Bureau
Median housing value	Median value of owner occupied housing units	+	US Census Bureau
Urban	Dummy variable, 1 if the county is urban, 0 otherwise	-	USDA-ERS
Social Security Benefit	Social security program beneficiaries per thousand population	+	US Census Bureau
Tax rate	Property tax rate per housing unit	+/-	US Census Bureau
Travel	Average travel time to work	+/-	US Census Bureau
Medical facilities and risk factors			
Physicians	Number of active nonfederal physicians per hundred thousand population	+	US Census Bureau
Hospital beds	Hospital beds per hundred thousand population	+	US Census Bureau
Community hospitals	Number of community hospitals	+	US Census Bureau
Respiratory disease risk	Average respiratory disease risk per million population	-	EPA
Manufacturing jobs	Percentage of county population in manufacturing jobs	-	USDA-ERS
Crime rate	Number of crime incidence of all kinds per thousand population	-	FBI, Uniform Crime Report
Proximity to highways	Distance in mile to the nearest state or interstate highways from county centroid	-	ESRI
Temperature	Average annual temperature in Fahrenheit degrees	-	NOAA
Natural amenities and outdoor recreation resources			
Farmland	Percentage of county in agriculture cropland	+	NORSIS

Table 5.1 Contd.

Variables	Definition	Expected sign	Data Source
Forestland	Percentage of county in public forestland	+	NORSIS
Pastureland	Percentage of county area in pastureland	+	NORSIS
Rangeland	Percentage of county area in rangeland	+	NORSIS
Water bodies	Percentage of county area in water bodies such as lakes, rivers, streams	+	NORSIS
Coastal	Dummy variable, 1 if the county is coastal, 0 otherwise	+	NORSIS
Winter sunlight	Mean daily sunlight hours in January	+	NOAA
Topography	A continuous index measuring topographical steepness of county, starting from 1 for flat plains to 21 for high mountains	+	USGS
State recreation park	Dummy variable, 1 if county contains a state recreation park, 0 otherwise	+	NORSIS
Distance to national park	Distance in mile to the nearest entrance of national park from the county centroid	-	ESRI
Amusement and sports	Number of outdoor sports or amusement attraction in county	+	NORSIS
Golf course	Number of golf course per thousand populations	+	NORSIS

Note: abbreviations include: USDA-ERS, United States Department of Agriculture-Economic Research Service; EPA, Environmental Protection Agency; FBI, Federal Bureau of Investigation; ESRI, Environmental and Scientific Research Institute; NOAA, National Oceanic and Atmospheric Administration; NORSIS, National Outdoor Recreational Survey Information System; USGS; United States Geological Service

Table 5.2 Regression estimates from the ordinary least square and spatial error model of life expectancy

Variables	OLS	SEM	VIF
Intercept	59.928 (43.612***)	60.307 (44.026***)	---
Demographic and Socioeconomic factors			
African-American	-0.043 (-20.582***)	-0.044 (-20.736***)	2.08
College graduate	0.182 (18.610***)	0.183 (18.831***)	2.23
ln(Household income)	0.927 (4.975***)	0.916 (4.955***)	5.05
Population density	-0.000 (-0.805)	-0.000 (-0.834)	1.18
ln(Median housing value)	0.446 (4.206***)	0.916 (4.955***)	4.94
Urban	-0.107 (-1.649*)	-0.091 (-1.416)	1.86
Social Security Benefit	0.000 (0.768)	0.000 (0.716)	1.22
Tax rate	0.300 (6.462***)	0.298 (6.365***)	2.08
Travel	0.009 (1.910*)	0.007 (1.516)	1.33
Medical facilities and risk factors			
Physicians	-0.000 (-0.761)	-0.000 (-0.555)	1.37
Hospital beds	0.000 (1.715*)	0.000 (1.495)	1.33
Community hospitals	-0.010 (1.547)	-0.008 (-1.216)	1.40
Respiratory disease risk	0.013 (1.376)	0.012 (1.254)	1.55
Manufacturing jobs	0.003 (0.827)	0.002 (0.611)	1.07
Crime rate	-0.005 (-4.574)	-0.005 (-4.761***)	1.53
Proximity to highways	0.032 (1.955*)	0.029 (1.806*)	1.27
Temperature	-0.047 (-11.758***)	-0.047 (-11.546***)	2.51
Natural amenities and outdoor recreation resources			
Farmland	0.015 (12.141***)	0.015 (12.127***)	2.55

Table 5.2 Contd.

Variables	OLS	SEM	VIF
Forestland	0.001	0.001	1.62
	(2.198**)	(2.280**)	
Pastureland	0.010	0.011	1.63
	(4.387***)	(4.514***)	
Rangeland	0.006	0.006	2.69
	(4.080***)	(3.999***)	
Water bodies	0.006	0.006	1.88
	(2.094**)	(2.049**)	
Coastal	0.335	0.333	1.62
	(3.762***)	(3.721***)	
Winter sunlight	0.005	0.005	1.62
	(6.381***)	(6.535***)	
Topography	0.005	0.006	2.48
	(1.028)	(1.237)	
State recreation park	0.156	0.154	1.13
	(3.506***)	(3.121***)	
Distance to national park	-0.039	-0.039	1.58
	(-4.090***)	(-4.073***)	
Amusement and sports	0.032	0.028	1.08
	(1.849*)	(1.606)	
Golf course	1.052	1.014	1.14
	(5.128***)	(4.995***)	
Spatial autoregressive parameter (Lambda)	---	0.131	
		(4.740***)	
Residual Moran's I	0.054***	-0.002	
R Square	0.661	0.665	
AIC	9644.780	9622.790	
N	3,064	3,064	

*Note: Numbers in parenthesis are t-ratio for OLS model, and Z-value for SEM model. ***, **, and * indicate significance of parameters at the 1%, 5% and 10% respectively.*

Even though the R^2, which is a conventional measure of goodness of model fit, does not improve much, comparison of Akaike Info Criteria (AIC) statistics suggests that the spatial error model (9626.05) performed better than OLS (9626.88) on our data. Also, by using SEM model, we eliminated spatial autocorrelation in the residuals (Moran's I = -0.002, p value = 0.40).

The computed VIFs were well below the threshold of 10 (Freund and Wilson, 1998, pp. 194), and suggest that multicollinearity was not a problem. Altogether 22 of the 30 variables were significant at the 10% or better level in OLS model, whereas only 18 of them were significant in the SEM. However, most exhibited the expected sign. It should be noted that our discussion here focuses on estimates from the SEM model, unless mentioned otherwise. Importantly, lambda, which is a coefficient of spatial autoregressive error lag term, was strongly significant and positive, suggesting a positive spatial dependence. A lambda value of 0.13 indicates that a county experienced a 1.3% increase in average life expectancy if expectancy in surrounding counties increased by 10%, ceteris paribus. Among demographic and socioeconomic variables, median housing income, percentage of college graduates, and median household income exhibited positive and significant relationships to life expectancy at the 1% level. This is consistent with Singh and Siahpush (2006) who in a recent study reported that people in higher socioeconomic groups are likely to have a longer life expectancy.

Similarly, the percentage of African-American population was negatively related and significant at the 1 % level, corroborating the findings of Harper et al. (2007). Population density, average travel time to work, and the urban status of county possessed the expected signs but were not statistically significant. Travel time was significant at the

10 % level in OLS, but appeared insignificant in SEM. Even though the social security benefits per thousand capita exhibited a positive sign, the effect was not statistically significant. Property tax was positive and significant at the 1% level, which can be explained by the fact that high tax revenues might have been invested in public goods and services that enhance health and life resources.

Among medical facility and risk factors, hospital beds were positively and significantly related at the 10 % level in OLS Model, but were only marginally significant in SEM model. The number of community hospital and number of physicians per thousand populations were not significant in either model. Even though, a positive effect was expected in those variables, it is not completely surprising given the fact that Barlow and Vissandjee (1999) found little impact of health expenditure on life expectancy. Similarly, Sufian (1989) found that variables capturing number of hospital bed and number of physician did not have significant effect on life expectancy.

Counter to our expectations, the average risk of respiratory diseases was insignificant. However, there may not have been adequate variation among counties, in regard to risk factors estimated in terms of per million populations. Since none of the previous studies used these variables in the model, we could not verify their relationship. The percentage of county population in manufacturing jobs was not significant. As expected, crime rate per thousand population and proximity to major highways were negatively related and significant at the 1 and 10 % level, respectively. The effect of temperature was negative and significant at the 1% level, and is consistent with earlier observations of Barlow and Vissandjee (1999).

The primary variables of interest are natural resource amenities and outdoor recreation resources. An F test for the significance of natural resource amenities variables in life expectancy production function rejected the null hypothesis that these variables are not related to life expectancy (F statistic = 24.61, p value <0.001). In both the OLS and SEM model, variables for mild weather, landuse, and recreation resources were consistently significant and exhibited the expected signs. Percentage of cropland, percentage of pastureland, and percentage of rangeland were positive and significant at the 1% level. These observations suggest that counties with a higher proportion of area in such uses are likely to have a higher life expectancy among residents. Similarly, the percentage of area in public forest also was positively related and significant at the 5% level. These observations are consistent with earlier findings of Maas et al. (2006), who reported that people living in neighborhoods with a large amount of green space are likely to generally healthier than those who do not.

Importantly, as the analysis in this study show, there is a relationship between longevity and the proportion of landuses because the model being used here controls for all other factors that affect the longevity. In an earlier study by Grahn and Stigsdotter (2003) reported that a more frequent visitor to natural areas would less frequently experience illness. Likewise, Ewing et al. (2003) concluded that landuse patterns, particularly those associated with urban sprawl, significantly influence the physical activity of residents, and to some extent determine the health outcomes such as obesity and hypertension. While results from the current study corroborate the findings of those previous works, there is a room for scrutinizing the issues of causality vs. correlation, as revealed by this analysis.

The percentage of water bodies in a county was positively related to life expectancy, and significant at the 5% level. Similarly, the dummy variable capturing whether or not the county is in a coastal location was also significant at the 1% level, suggesting that counties in close proximity to water bodies are likely to provide a longer life expectancy. Mean sunlight hours in January were positively and significantly (1% level) related. This might be explained by the fact that an abundance of water resources and clearer days may not only maintain the stability of microclimate but also offer opportunities for outdoor mobility and leisure such as fishing, boating, swimming, and similar activities. Engaging in such activities can be beneficial to human health and quality of life. The effect of the topographical index, measuring the variation in surface terrain, was not statistically significant. This is perhaps because the index was too general to properly represent variation in county topography.

As expected, the dummy variable indicating whether or not the county has a state recreation park was significant at the 1% level and exhibited a positive relationship with life expectancy. The number of outdoor sports attractions possessed the expected positive sign, which was significant at the 10% level in the OLS model, but was marginally significant at the 11% level in the SEM model. Similarly, the distance to the national park was negatively related and significant at the 1% level, suggesting that life expectancy in counties closer to national parks are likely to be longer than in those located farther away. Similarly, the number of golf courses in the county was positively and significantly (1% level) related. This is not surprising because golf is a popular physical and sports activity among adults.

5.4 Conclusion

This study examined the effect of natural resource amenities on human life expectancy in the United States. Extending the existing model of the life expectancy production function with correction for spatial dependence, we assessed the determinants of life expectancy using county level data. The findings from this study have several implications in natural resource economics and management, and public health. First, we established empirical evidence that life expectancy of human population is largely affected by natural resource amenities. Hence, any life expectancy production function will be incomplete and can result in biased estimates if these amenities are not considered to be factors of production.

Additionally, it would be beneficial from a public health and social welfare perspective to preserve existing land resources such as farmland, forests, rangelands, water bodies, and undeveloped open lands. Moreover, agencies may see a benefit in introducing outdoor recreational opportunities such as state recreation parks, golf courses, and parks to enhance longevity in their community. Recent public health literature suggests that viable environmental strategies to improve public health require controlling the physical and social environment of the neighborhoods (Schmid et al., 1995). Local agencies could make their communities attractive to retirees and other amenity demanding population sectors, and help boost their economy (Poudyal et al., 2008), because millions of individuals are seeking communities with such amenities for retirement.

Findings from this study could provide a basis for encouraging people to protect our natural resource amenities, because the evidence directly linking these amenities to longevity may be more compelling than other arguments to conserve nature. The model presented here utilized socio-demographic, medical facilities, and natural amenity variables for which periodic data are available from US Census, NORSIS inventory, EPA and NRI surveys, and can easily be extended to analyze and forecast future life expectancy in U.S. counties. Above all, a more compelling message of our findings is that the traditional approach of public health and human development should be extended beyond just controlling diseases or treating patients (Ho et al., 2003), to a more comprehensive approach that also acknowledges natural amenities as well as nature-based outdoor recreation resources in maintaining good public health, quality of life, and overall human development. The model developed in this study could be extended in the future to evaluate the effects of those amenities on longevity of people with different migration behaviors (e.g., long-time residents vs. recent immigrants)

CHAPTER 6
EFFECT OF URBAN SPRAWL ON HUNTING[6]

6.1 Introduction

In the United States, over 13 million people participated in hunting and related activities in 2001, which accounted for more than $20 billion in direct expenditures (USDI Fish and Wildlife Service, 2002). Hunters' expenditures on license fees, various equipment, transportation, and accommodations have a multiplier effect on local and regional economies (USDI Fish and Wildlife Service, 2002). For example, the economic impact of hunting in Georgia was estimated to be higher than that of peanuts, one of Georgia's major crops (International Association of Fish and Wildlife Agencies, 2002). In addition to its economic impact, hunting helps to maintain and control wildlife populations (Mehmood et al., 2003; Bhandari et al., 2006). Despite these benefits, participation in hunting has declined in recent decades (Cordell and Super, 2000; Mozumder et al., 2007).

During this period of decline in hunting participation, many regions in North America have experienced dispersed land development patterns and suburban housing growth, typically referred as "urban sprawl" (Rodrigue, 2006). Urban sprawl has widespread ramifications for habitat conservation and human safety. Sprawl expands land

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development toward suburban and rural territories, increasing wildland-urban interfaces (WUI) (USDA and USDI 2001; Alavalapati et al., 2005; Radeloff et al., 2005) and increasing human-wildlife conflict (Johnson, 2001; Hussain et al., 2007). Further, urban sprawl can affect hunting and other outdoor recreation opportunities. Sprawl, for example, changes the socio-demographic and cultural characteristics of rural communities (Katz, 2002) and introduces modern indoor recreational opportunities that can eventually replace traditional outdoor activities (Brown et al., 2000). Putnam (1995) suggested that "privatizing" and "individualizing" American culture as a result of the technological innovation (e.g., television, VCR) have transformed leisure patterns in the United States. In addition, urbanization causes ownership fragmentation that results in smaller tracts of land, in which hunting potential may be limited. Similarly, hunters may need to travel farther to find hunting areas, thereby adding to their hunting costs.

A number of studies have assessed the demand for hunting licenses (Heberlein and Thomson, 1996; Teisl et al., 1999; Floyd and Lee, 2002) and have revealed that declining hunting participation is related to demographic changes within the U.S. population and losing accessibility to hunting areas (Mehmood et al., 2003; Mozumder et al., 2007; Poudyal et al., 2008). Heberlein and Ericsson (2005) found that ties to "countryside" are key to attitudes toward hunting. Although decreased access to hunting areas has been directly associated with urbanization, decline in hunting activity relative to urban sprawl has not been a focus of previous studies.

Understanding the factors behind declines in hunting is important because of the ecological and economic impact that the decline could cause. Hunting serves as a management tool to maintain wildlife populations within ecological and social carrying capacities. Sales of hunting license generate substantial revenue for conservation agencies (Floyd and Lee, 2002). Further, hunting-related business has a multiplier effect in rural local economies (International Association of Fish and Wildlife Agencies, 2002). Therefore, our objective was to analyze the effects of urban sprawl on hunting activity in the Southeastern U.S. using a dataset of county-level license sales for the year 2000. Our primary purpose was to isolate and estimate the effect of urban sprawl on hunting demand. The Southeast U.S. was selected for the study because: 1) hunting is one of the major consumptive outdoor recreation activities in this region (Lamar and Donnell, 1987), 2) the region includes some the fastest growing areas in the nation in terms of urban development (Reynolds, 2001), and 3) eight of nation's 20 most sprawling metropolitan areas in 2000 were located in this region (Yin and Sun, 2007).

6.2 Methods

6.2.1 Model

Extending the hunting demand model by Teisl et al. (1999) and Sun et al. (2005), demand for hunting can be expressed as:

$$\ln Y = \beta_0 + \sum_k \beta_k X + \varepsilon \tag{6.1}$$

where, ln Y is an N x 1 vector of the natural logarithm of number of licenses sold in counties; X is an N x K matrix of variables explaining socio-demographic, ecological, and urbanization characteristics of the county. The last term, ε, is an N x 1 vector of random errors. Because our focus was on the effect of urban sprawl on overall hunting demand, we included all types of resident licenses sold in the county to obtain number of hunting licenses sold.

Because our model had heteroscedasticity (χ^2_{169} = 416.1, P $\leq$ 0.001), the feasible generalized least square (FGLS) method (Greene 2003) was adopted. Using FGLS, we estimated parameters with the following equation,

$$\hat{\beta} = (X'\hat{\Omega}^{-1}X)^{-1}X'\hat{\Omega}^{-1}\ln Y \quad (6.2)$$

where Ω is an *N* x *N* diagonal matrix of error terms. The estimated error variance and detailed specification of the FGLS model are discussed in Greene (2003, p.209). Variance inflation factors (VIF) were estimated to detect multicollinearity (Greene 2003) among variables included in the model.

6.2.2 Data Sources, Variables and Study Area

The model assumed that log of quantity of hunting licenses issued in a county is a function of socio-demographic, ecological, and institutional variables (Table 6.1) that have been used in previous studies (Heberlein and Thomson, 1996; Floyd and Lee, 2002; Mehmood et al., 2003). State offices responsible for hunting license sales maintain license sales records at county level. We summed county-level sales data for all type of resident hunting permits in 2000 and calculated the natural logarithm to derive dependent variable (i. e., natural log of resident license sold in county). Details on explanatory variables are presented below.

Urban Sprawl Variables

We used the county proportion of urban population, mean travel time to work, percentage of wildland-urban interface (WUI) area, and average ownership size of private forestland to measure aspects of urban sprawl. County share of urban population is commonly used to estimate degree of urbanization (e.g. Applegate et al., 1984; Brown et

Table 6.1 Variables used and regression estimates to understand impact of urban sprawl on hunting participation in 2000 in the Southeastern U. S.

Variable	Description	Coefficient (Std. error)	VIF
Urban Sprawl Variables			
Urban population	Proportion of urban population in the total population of county in 2000	-0.145** (0.061)	1.139
Mean travel time to work	Average commute time to work in minutes in county in 2000	-0.010*** (0.003)	1.399
Wildland-urban interface	Percentage of county land classified as wildland-urban interface in 2000	-0.026*** (0.006)	3.485
Private forest ownership size	Average size of private forestlands in hundred acres in county in 2000	-0.022 (0.016)	1.393
Socio-demographic, Ecological and Institutional Variables			
License fee	Per hunter capita expenditure in dollars on license fee in the state in 2000	-0.000 (0.007)	1.241
Population	County total population in 2000	0.813 *** (0.019)	3.048
Age 16-65	Percentage of county population aged 16 to 65 in 2000	-0.000 (0.006)	2.400
Below high school	People with less than 9 year of schooling as a percentage of county population in 2000	0.017*** (0.007)	3.229
College graduate	College graduates as a percentage of county population in 2000	-0.045*** (0.006)	5.076
Caucasian	Caucasian population as a percentage of county total in 2000	0.011*** (0.001)	3.308
Employment	Percentage of people in the county holding full time jobs in 2000	-0.012*** (0.003)	3.059
Per capita income	Median per capita income in dollars of the county residents in 2000	1.047*** (0.202)	7.143
Single parent households	Households with underage children but single parent as a percentage of total county households in 2000	0.002 (0.002)	1.323
Public forest	Public forest area within 100-mile radius buffer around county as a percentage of total in-state area within the buffer in 1998	0.023*** (0.005)	4.383

Table 6.1 Contd.

Variable	Description	Coefficient (Std. error)	VIF
Private forest	Private forest area within100-mile radius buffer around county as a percentage of total in-state area within the buffer in 1998	0.005*** (0.001)	1.949
Wetland	Wetland area within100-mile radius buffer around county as a percentage of total in-state area within the buffer in 1998	-0.014** (0.006)	2.775
Gun club dummy	Binary variable, 1 if county has gun club in 1998, 0 otherwise	0.483*** (0.074)	1.628
Amusement	Number of outdoor amusement and sports attractions in the county in 1998	0.004 (0.002)	4.999
Adj. R- Square		0.84	
F- Statistic		318.52***	
Number of observations		1,066	

**** and ** denote the significance of parameters at 1% and 5 % level respectively. The numbers in parenthesis are the standard errors. ♦ Variables with VIF values exceeding 10 induce multi-collinearity.*

al., 2000). Urban and total populations of each county were obtained from U.S. Census dataset (U.S. Census Bureau, 2000). The mean travel time to work, which defines accessibility to economic opportunities for county residents, was also obtained from this source. We included this because it determines spatial pattern of employment and intensity of development (Gordon et al., 1989; Song, 1996; Bento et al., 2005). Land with a housing density of 6.17 or more per square kilometer and with 50% or less area covered by wildland vegetation was classified as being within the wildland-urban interface (USDA and USDI, 2001).

We obtained the proportion of county land in WUI from Wildland Urban Interface Project 2000 (Radeloff et al., 2005). WUI data are readily available at the county level and have already been used by Haight et al., (2004); Hammer et al., (2005); and Stewart et al., (2007). We obtained mean size of private forestland from the National Agriculture Census of 2002 (NASS, 2002), which maintains number of forest owners and total forestland under private ownership. We included this because urban sprawl can cause ownership fragmentation, which leads to smaller forest tract size in which hunting may no longer be feasible.

Socioeconomic, Ecological and Institutional Variables

There is no unitary hunting license fee available because different states issue various types of licenses. Because license fees are fixed at the state level, we used state fees to estimate effect of license fees on hunting demand at the county level. The U.S. Fish and Wildlife Service (2003) maintain state-level annual uniform records of licensed hunters and their expenditures on license fees. Using this dataset, we represented license fees by per capita hunter expenditure on licenses, which is equal to statewide resident license sales divided by the number of resident hunters. This is not an exact measure of license price but it does capture variation in license prices among states and is likely the best proxy available. We included the license fee variable because price is an essential component of a recreation demand model (Walsh et al., 1992).

We obtained data on socio-demographic and economic variables from the U.S. Census Bureau (2000). We used total population, age, education, race, employment, per capita income, and family status to control for tastes and preferences of people. We used the natural log of county population to minimize outlier effects of large variations in county population (Teisl et al., 1999). We created an Age 16-65 variable to represent percentage of total county population comprised of residents between the ages of 16 and 65 years. We selected this particular age group because most of the hunters begin hunting at the age of 16 (Heberlein and Thomson, 1996) whereas people in age cohort of 65 years and older are less likely to hunt (Schole, 1973; Manfredo and Zinn, 1996). We also included percent of county residents with less than a high school education and percent of those with at least a college degree. We included percentage of Caucasians in the total county population in the model based on Floyd and Lee, (2002). We included percentage of full-time employed individuals to capture effect of employment status, whereas we used the median per capita income to estimate effect of economic prosperity on hunting. We hypothesized that counties with larger percentages of people with full time employment or higher education would be less likely to hunt, but those with higher incomes would be more likely. We also included percentage of single parent households to allow for differing parental responsibilities, which can affect time available for hunting (Mehmood et al., 2003).

Ecological and institutional variables included percentage of public and private forests, percentage of wetland, presence of a gun club, and number of outdoor amusement and sports attractions. We obtained data for those variables from the National Outdoor Recreation Supply Information System (NORSIS) (Cordell and Betz, 1997). Using these data, we created a 100-mile radius buffer around the county and measured availability of public forest, private forest, and wetland as a percentage of total in-state area within that buffer. We limited the buffer to within the state only because resident hunting permits are not valid outside state of residence. We hypothesized that the larger the percentage of these land cover types within the buffer, the more hunting opportunities there are in a reasonable travel distance from the county. We created a dummy variable to indicate whether or not a gun club was present in the county. Including presence/absence of gun clubs within a county allows for possible effect that sports shooting may have on hunting. Number of amusement and sports attraction at the county level was available in NORSIS dataset and we included this variable in our demand model to control for possible substitute/complementary effects for hunting.

We included counties from ten Southeastern States (Alabama, Georgia, North Carolina, South Carolina, Tennessee, Virginia, Kentucky, Arkansas, Louisiana, and Texas). We excluded three counties in Georgia and Texas due to no sales records. We also excluded all counties in Florida and Mississippi because these states did not have county-level sales records available for 2000. We used 1,066 counties and excluded 197.

6.3 Results and Discussion

Estimates from the FGLS model reveal that 14 out of 18 variables were statistically significant ($p \leq 0.05$), and consistent with the extant literature (Table 6.1). The adjusted R-square of 0.84 reveals that hunting demand model provided a reasonably good fit of the data.

Urban Sprawl Variables

All urban sprawl variables were significant ($p \leq 0.05$), demonstrating the importance of sprawl factors on hunting demand. An increase of 1% in proportion of urban population by itself decreased hunting demand by 12% at the county level. This relatively large elasticity is consistent with results of Applegate et al. (1984) and Brown et al. (2000) suggesting that urbanization is the greatest demographic threat constraining participation in hunting in the U.S. These results also corroborate the finding by Heberlein and Ericson (2005) that an individual's demand for hunting greatly depends on whether or not he or she grew up in a rural setting. The negative coefficient of urban population is consistent with previous studies and indicates the urban share of total county population significantly reduces the demand for hunting (Heberlein and Thomson, 1996; Manfredo and Zinn, 1996; Brown et al., 2000). Exposure to alternative modern indoor leisure activities, such as school sports, television shows, theatres, and electronic media, might have reduced public interest on hunting in urban areas (Brown et al., 2000). Another reason for the negative effect of the urban population share may be that increasing civil and animal rights advocacy could convince more urban than rural residents not to hunt (Brown et al., 2000; Campbell and Mackay, 2003; Heberlein and Ericson, 2005). Additionally, individuals who moved to urban areas may no longer hunt and therefore are not passing on hunting to their children (Purdy et al., 1989; Brown et al., 2000).

The coefficient of commute time was negative ($p \leq 0.01$), with an estimated marginal effect that a one minute increase in average commute time to work decreases demand for hunting in the county by 1.02%. This is consistent with Willett (2002), who concluded longer commute times substantially reduced time spent with family and in other leisure activities. To the extent increased commuting time is associated with increased travel time to any location, this variable incorporates an additional impact that discourages hunting. This implies that availability of time adversely impacts popularity of consumptive outdoor recreation in urbanizing landscapes. The WUI coefficient was negative ($p \leq 0.01$), indicating that an increase in urban sprawl significantly decreased participation in hunting. An increase of 1% in the area of WUI is estimated to decrease demand for hunting by 2.6%. This implies that sprawl development constrains hunting demand as a result of the decline of huntable land and habitat fragmentation. This result may be explained in part by "leap-frog" development patterns associated with urban sprawl, leading to increase WUI. This is consistent with studies, which found that suburban development and fragmentation of rural forestlands have substantially decreased the feasible hunting areas (e.g., Brown et al., 2000; Jagnow et al., 2006). Moreover, these factors can sometimes favor habitat for early successional species, whose population growth, if not hunted, is likely to result in nuisance wildlife problems. Average ownership size of private forestlands did not have a significant ($p = 0.17$) effect on hunting demand. This might be explained by the fact that ownership size that is based on parcel size may not capture the actual size of the forest tracts in the parcel, which might have more relevance in explaining hunting opportunities. While data on mean size of private forest tracts is not available at a county level, we believe that our WUI variable and forest variables take into account any effects that average forest tract size may have on hunting.

Socioeconomic, Ecological and Institutional Variables

License fee was found to have an insignificant effect ($p = 0.90$) on license demand (Table 6. 1), which may be explained by the fact that license fees comprise a negligible share of total expense for hunting. This is consistent with Teisl et al., (1999); and Sun et al. (2005) who concluded that resident hunting demand is price inelastic. The coefficient for the log of total population was positive and significant ($p \leq 0.01$), and the elasticity estimate (Table 6.1) indicated that a 1% increase in county population increased demand for hunting by 0.81%. As expected, the coefficient for Caucasian was positive ($p \leq 0.01$), which is in agreement with Floyd and Lee (2002). Percentage of the county population between 16 and 65 years was not significant ($p = 0.88$). Distribution of this particular age group may not have possessed significant variation in the study area. A test of variance estimate also supported this speculation (F-Statistic = 0.01; $p = 0.92$). Counties with higher proportions of their populations with full time jobs had smaller hunting demand ($p \leq 0.01$). Percentage of households with single parents was not significant ($p = 0.43$). The coefficient of per capita income was positive ($p \leq 0.01$). The estimated income elasticity of 1.03 suggests that a 1% increase in per capita county income increases the demand for hunting by 1%. This income elasticity is similar to income elasticity among Maine residential hunters (Teisl et al., 1999).

Our result indicates that education level of residents also affects demand for hunting. That means that less educated people are more likely to hunt. This may be explained by the fact that hunting is a part of culture and tradition in rural areas in the Southeast, where the average level of education is lower than in urban areas. The negative effect of higher education level may be also attributed to the larger opportunity cost of time for physical and time-consuming outdoor trips. Variables capturing proportion of public and private forests were positive and significant ($p \leq 0.01$). Thus, proximity and availability of forest areas increased demand for hunting. Comparing estimated marginal effects of two different forest types revealed that availability of public forestland could have a larger effect than private forestland. This may be due to the fact that hunting in private forests often involves an extra cost of leasing, potential liability, and other legal costs (Mozumder et al., 2007). Effect of wetland availability was significant ($p \leq 0.05$), but had an unexpected sign. However, this effect could be positive for other consumptive outdoor recreation such as fishing and boating. As expected, the presence of gun clubs in the county had a positive effect ($p \leq 0.01$), supporting the argument of Green et al. (2004) that membership in such clubs generates social capital and increases hunters' welfare. Availability of alternative outdoor amusement activities did not have a significant effect ($p = 0.06$) on demand for hunting.

6.4 Conclusion

Our results reveal that sprawl development and associated urban influences constrain hunting demand. In particular, urbanization of the population and loss of habitat and hunting ground due to increases in WUI area is deterring hunting in the region. An implication for forest and wildlife managers is that feasibility and effectiveness of hunting as a wildlife management tool may decrease in the future, if the current urbanization trend persists. If hunting participation decreases, one of the most significant non-timber benefits from forestlands (i.e., lease hunting) may be limited. Decreased hunting is partially responsible for problems related to public safety such as highway-collisions and crop depredation, and ecological issues such as overpopulation and smaller predator-prey ratios. Likewise, the decline in public participation in such group leisure activities might result in a gradual loss of social capital such as public networking or civic engagement (Putnam, 1995). Moreover, loss of license revenue will further constrain operating budgets and conservation efforts of state agencies. As the urban proportion of the U.S. population is likely to grow in future, efforts could be directed toward encouraging hunting among urban residents. Also, because decline in hunting is likely to be mitigated by sprawl management, conserving natural areas and discouraging sprawl-like development may be needed to maintain hunting.

Forestland needs to be protected from urban sprawl because rural areas and forest in the region are being converted to wildland-urban interface zones at unprecedented rates (Cordell and Macie, 2002), and our analysis shows that an increase in WUI areas and loss of hunting areas in forestland can significantly affect hunting demand, regardless of land ownership. While local governments are unlikely to support policies that discourage development, providing landowners compensation for easements would motivate some to resist market demand for their property to be developed. Specifically, promoting smart growth efforts to increase housing density and decrease forest fragmentation may help preserve hunting opportunities in urbanizing neighborhoods. Comprehensive landuse plans, along with incentives that reduce landowners' property tax burdens, might be needed to slow down sprawl and preserve habitat, where opportunities may exist for hunting and other outdoor activities. Forest managers and planners working in WUI areas could encourage and assist nonindustrial private forest landowners to pursue lease hunting, which could be helpful in increasing public access to private land that currently are unavailable. State agencies may see benefits in increasing public hunting land, because our model indicates a far greater effect of public land on license sales compared to private land.

CHAPTER 7
SUMMARY AND CONCLUSIONS

Rural landscapes in the United States are changing due to increased amenity-led in-migration such as retirees or second homes, urbanization, and intensive use of natural resources. Despite a decades-long history of research in natural resources economics and management, a number of literature gaps exist regarding the role of natural resource amenities in fostering economic growth and in enhancing human values and public welfare. In this context, the analyses presented in this dissertation shed some light on a few of the previously unanswered questions. Applying various non-market valuation techniques to real world data, findings from the essays included in this dissertation add to the natural resources economics literature, and derive some implications of policy relevance.

The first essay highlighted how passive ways of employing natural resources may help meet the economic objectives of rural communities. As recent retiree migration patterns reveal, their residential preference is influenced by natural resource amenities such as landuse diversity, wilderness, and open spaces. Given the fact that retiree immigration often boosts local economies (Reeder, 1998), attracting retirees appears to be an opportunity for economic growth through a less intensive use of natural resources. A key implication of this study is that local communities with abundant amenities may adopt a 'retiree economy' to fuel their local development. This is because attracting an amenity-demanding prosperous population may be a less exhaustive approach to achieving the goal of sustainable development, compared to farming, mining, manufacturing, or other intensive industries.

Moreover, the results indicate that building highways, opening shopping malls, or attracting manufacturing companies are not the only options to grow an economy. Nor do we need to clear our woodlots or drain wetlands to fuel economic growth. But we can identify the natural resource amenities with which our communities are endowed and market them to potential consumers who place a great deal of value on the amenity, aesthetic, and recreational benefits. Even though the analyses presented in this study only considered retiree populations, there might be a larger population of amenity consumers, who might choose to live in natural amenity-rich communities. With rising income levels and increasing citizen awareness of environmental issues, the coming decades are likely to see an increasing trend in urban-rural migration. Therefore, the scope of materializing natural amenities for the economic benefit may become even larger.

The findings from this study could guide amenity-rich communities and local agencies in identifying their latent potential to attract retirees and adopt a retiree economy strategy. Conversely, it may reveal to other areas that lack such resources the futility of expending time and resources, and encourage them to look for alternative economic engines. Some evidence, however, warn of a possible over-use and development of ecologically fragile areas in rural America. Since too many people moving towards amenity-rich landscapes will create fringe ecology, such as rural-urban interfaces, that threaten the existence of natural flora and fauna, this study cautiously calls for collaborative regional efforts to ensure that ecological effects are considered while promoting natural amenity-based economic growth such as “retiree economy”.

The most significant result of the second essay is that it draws attention to some important issues in landuse economics that have been largely ignored in the hedonic literature until recently. Most importantly, this study has established an empirical relationship between landscape patterns and human values. Even though geographer Kevin Lynch in his influential book “*The Image of the City”,* attempted to uncover the ways that individuals perceive and navigate the urban landscapes (Lynch, 1960), few researchers have pursued this idea. Part of the reason behind this may be the challenges one would face in quantifying landscape features. This essay has successfully filled this gap by borrowing some metrics from landscape ecology to measure and then evaluate landscape patterns in a hedonic model.

While previous hedonic studies on open spaces stressed only the quantity, findings from this study bolster the argument that quality also matters. Open spaces heterogeneous in composition, larger in size, and smoother in shape are the desired aesthetic features in urban landscapes. This conclusion is consistent with the theory of ecology as well. For example, one would expect different supply of ecosystem services from two neighborhoods containing the same amount of open space but arranged in different spatial pattern or configuration. This observation, coupled with theory of economic rationality, suggests that people’s willingness to pay to live in these neighborhoods will be different as well.

Another implication is that developed landuses, which are allocated for industrial and business purposes, depreciate aesthetics and human values, if mixed within the residential zones. This defines the economic theory of externality, and could have relevance in urban planning and landuse design. As Lynch (1960) argued, knowing the values of landscape features and patterns that people care about helps in making cities and neighborhoods attractive to its residents. Findings of this study possess a great deal of potential to assist local agencies to justify funds for maintaining open space and landuse features in metropolitan areas. Moreover, since the urban residents will be willing to pay a premium for such services, local governments will realize the benefit of preserving landscape features, because such efforts are likely to increase property tax revenue capitalized in real estate values.

As American cities continue to grow, limited open spaces are available to a growing population. Maximizing aesthetic and human values from the remaining spaces will be critical to open space management. In this context, the study offers insights on quality aspects of open space values.

The third essay, which focused on public parks, emphasized the implications for urban planning, park design, and landuse management. Given the fact that only a handful of previous studies utilized second stage hedonic estimation in natural resource valuation (Taylor, 2003), this study presented practical methodological implications for future hedonic research. Some important results of this essay include developing a demand schedule for park acres in relation to various economic parameters such as price and income, and estimating the welfare effects of landuse policies that aim to supply more public land and recreation parks.

As this study concludes, residents consider the availability of lands in nearby public parks as a substitute to living space. Considering this, it would be reasonable to expect an increase in demand for more park acres with increases in the cost of living space within a city. This is a very important implication for landuse planning and urban sprawl management because supplying more acres in public parks could encourage high-density development and prevent or mitigate urban sprawl. In addition, as revealed by the conclusion of previous essay, allocating open space in larger patches would result in a higher level of aesthetic value to residents and economic returns in the form as tax revenue to local government. Since the federal and local governments are currently attempting to preserve more open space in urbanizing communities, this study is useful in understanding how residents respond to different levels of open space area. Additionally, it also will help ensure that proposed investments in new acquisitions will be justified based on the anticipated welfare gains.

This essay further offers some constructive points in designing citizen-financed open space preservation and public land management. As long as allocating more acres for public recreation increases resident welfare, and provided the urban homeowners are willing to pay for this amenity, urban landuse planners in conjunction with neighborhood associations (Lipscomb, 2003) can establish cooperative funds to establish new parks or expand existing public lands. Alternative citizen finance approaches could include one-time matching funds in partnership between local government agencies and residents for the outright purchase of public land easements. For example, Lipscomb (2003) suggested the concept of a “neighborhood bank”, as a financial platform to use a revolving low-interest fund for landscaping and amenity improvement in neighborhoods. Similar other cooperative bonus schemes could be promoted to encourage paid public recreation and ecosystem service consumption on private lands as well (Goldman et al., 2007), particularly in areas where a shortage of public lands is already an issue.

The fourth essay delves into one of the previously unexplored aspects of public health. While public health literature mostly explains human health and life longevity as a function of medical facilities, income and education level, food habits, and other demographic and health factors, it falls short of identifying the effects of natural resource amenities. For the first time, this study recognizes the fact that there exists a direct relationship between natural resource amenities and human longevity. This is a pioneering work in both natural resource and public health studies. The implication of the findings from the study goes beyond this, however. Protecting the existing natural resources such as undeveloped land resources, and preserving air, water, and climatic quality would be advantageous for public health and social welfare. Conclusions drawn in this essay also could provide a basis for encouraging the protection of natural resources. By directly linking such amenities with their longevity, the public may be more willing to engage in nature conservation. The most compelling message of the study, however, is that the traditional approaches of public health and human development should be extended beyond just controlling disease or treating patients (Ho et al. 2003) to acknowledge the role of natural amenities in maintaining public health.

The fifth essay assessed how changing landuse patterns and urbanization can affect human traditions and cultural activities, particularly those directly related to natural resources. Since rural areas and forests in the region are being converted to wildland-urban interface zones at unprecedented rates (Cordell and Macie 2002), the evidence presented in this essay indicates a potentially diminishing scope of hunting as a wildlife management tool. Although hunting or outdoor recreation may not be the only endeavor to benefit from sprawl management, this study provides an additional justification. This justification may be appealing to our society in both ecological and economic grounds.

As the urban proportion of the U.S. population is likely to grow in the future, efforts could be directed toward encouraging hunting among urban residents. Even though checking demographic changes are beyond the control of conservation agencies, some policy instruments may mitigate the likely decline in hunting. Promoting wildlife hunting as a college sport, revising or adjusting hunting days, and changing the schedules of full-time urban workers might increase the number of hunters in urbanizing communities.

This essay suggests that preserving wild lands and hunting areas may require controlling land development. While local governments may not support such policies, comprehensive landuse plans, couples with incentives to reduce property tax burdens, may help control sprawl and preserve wildland. In addition, forest managers and planners working in interface areas could encourage nonindustrial private forest landowners to pursue lease hunting. This will increase hunter access to wildlands, where availability of hunting ground has already been an issue.

Alternatively, state agencies may see benefits in increasing public hunting land. Resulting increases in hunting license sales may compensate such investments, and the policy may help preserve hunting as a game management tool and a cultural tradition. Even though the conclusions in this essay are based on the analysis of hunting only, the implications may be relevant to other outdoor recreation activities that are directly or indirectly dependent on nature-based resources.

The essays presented in this dissertation have addressed some of the issues previously unanswered in the natural resource economics literature. In addition to providing policy implications, techniques adopted in some of these essays have extended or improved the existing models and methodological frameworks in non-market valuation. Hypothesis testing with empirical analyses boost the arguments that natural resource amenities are integral parts of human values, public health, quality of life, and economic growth. Since recent approaches to conservation and development have emphasized passive employment of natural resources for sustainable development, essays in this dissertation provide some insights in this direction.

Furthermore, topics addressed in this dissertation have opened new avenues for research in natural resource economics and management. For example, the first essay puts forward ideas for promoting retiree-based economic growth through the marketing of natural resource amenities. But further research could adopt an economic input-output analysis approach to estimate the cost of preserving such amenities, and the benefits in terms of job creation and increased tax revenue.

A contingent valuation survey could be designed to assess residents' willingness to pay for configuration and spatial pattern of landuse features, which were found to have amenity value in the second essay. That would help verify how the results from the hedonic analysis of revealed preference would match with public behavior revealed by the stated preference data. Similarly, the methodology used in the third essay in segmenting market for demand identification could be applied to assess the demand for other non-market goods, for which data from multiple markets are not available.

The current analysis in the fourth essay uses the life expectancy of the county population in general. But further studies could disintegrate the county population according to different age cohorts or different geographic regions within the country and determine variation in the relationship. Even though the last essay was focused on wildlife hunting only, it offers a useful empirical framework to explore the effects of urban forces and landuse change on other types of nature based activities. Forecasting how the projected change in landuse resources, particularly hunting areas, would constrain license sales and revenue flow in the future would be of interest to state conservation agencies, whose operating budget and work performance largely depend on continued hunting.

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APPENDIX

ACRONYMS

AIC	Akaike Information Criterion
ANOVA	Analysis of Variance
BIC	Bayesian Information Criterion
CBD	Central Business District
CBG	Census Block Group
EPA	Environmental Protection Agency
ERS	Economic Research Service (of the USDA)
ESRI	Environmental and Scientific Research Institute
FBI	Federal Bureau of Investigation
FGLS	Feasible Generalized Least Square
GIS	Geographic Information System
LM	LaGrange Multiplier
LRDC	Louisiana Retirement Development Commission
MPFD	Mean Plot Fractal Dimension
NCHS	National Center for Health Statistics
NOAA	National Oceanographic and Atmospheric Administration
NORSIS	National Outdoor Recreation Supply Information System
NRI	National Resource Inventory
OFHEO	Office of Federal Housing Enterprise Oversight
OLS	Ordinary Least Squares
RRPA	Renewable Resources Planning Act
SEM	Spatial Error Model
USDA	United States Department of Agriculture
USDI	United States Department of the Interior
USGS	United States Geological Survey
VIF	Variance Inflation Factor
WUI	Wildland-Urban Interfaces

Vita

Neelam C. Poudyal was born on September 9, 1978, in Nepal. He graduated with an undergraduate degree in forestry in 2001 from the Institute of Forestry, Tribhuvan University, Nepal. He later earned a Masters Degree in Geography in 2005 from the Western Illinois University, Illinois, USA.

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