ABSTRACT

Title of Dissertation: THE CONTRIBUTION OF NATURAL CAPITAL TO QUALITY OF LIFE: A MULTISCALE ANALYSIS AT THE COUNTY, REGION, AND GLOBAL SCALES

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This dissertation uses a novel approach to investigate the contribution of the natural environment to quality of life (QOL). The natural environment is important to humans because we need raw materials from nature, we rely on the ecosystem services and functions the environment provides, and we relish the health-related benefits and aesthetic qualities that ecosystems offer.

Using different scales and methods of analysis, the natural environment was found to play an important role in contributing to QOL. Telephone survey data from the Baltimore metropolitan region on life and neighborhood satisfaction were found to have significant, positive relationships with objective environmental variables (canopy cover, water quality) and perceived environment variables (environment satisfaction, number of trees visible from home). Life satisfaction data from national surveys of 50 countries were analyzed at the aggregate country level and found to have significant relationships with natural, human, built, and social capital.

Regression models found that variables representing natural, human, and built capital could explain 72% of the variance in country-level life satisfaction. Finally, a dynamic model of land development in Montgomery County, Maryland, showed that environmentally conscious growth development policies, "Smart Growth" policies, were found to have a positive impact on QOL.

Overall, this dissertation presents new evidence to suggest that the natural environment does have a contribution to make to satisfaction levels and to quality of life as a whole. Specifically, the natural environment has a direct relationship with neighborhood satisfaction and mainly an indirect relationship with life satisfaction. The data presented in this dissertation are novel because there is little if any other literature that combines the use of satisfaction data with objectively measured environmental data. This provides a missing link in determining the level of impact that the natural environment has on subjective measures of well-being.

THE CONTRIBUTION OF NATURAL CAPITAL TO QUALITY OF LIFE: A MULTISCALE ANALYSIS AT THE COUNTY, REGION, AND GLOBAL SCALES

By

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Foreword

Amanda Walker Vemuri made substantial contributions to the jointly authored work presented as Chapter 2 of this dissertation, especially on the topic of quality of life and the model presented. Chapter 2 was published in 2004 in the journal *Ecological Modelling* with a colleague.

In addition, Amanda Walker Vemuri made substantial contributions to chapters 3 and 4, which received input from Dr. Matthew Wilson. Finally, she also made substantial contributions to chapter 5, which was co-authored by Dr. Robert Costanza.

Dedication

Dedicated to my father, William H. Walker Jr., who nurtured my interest in the natural environment all throughout my childhood.

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I wish to thank the many people who supported me, encouraged me, and helped me to complete this dissertation and graduate program. Robert Costanza has been my major advisor throughout my graduate study and has remained involved even after moving to another university. I appreciate his willingness to remain involved and on my committee even with the difficulties of distance. Similarly, I wish to thank Matthew Wilson for being actively involved in many aspects of the research and providing survey and statistical advice when requested. I additionally appreciate his willingness to participate after his move to another university. Herman Daly has been a stable and supportive committee member from the beginning of my graduate study and I have learned a great deal from him, from his writings, and from his classes. I wish to thank Martha Geores and Joshua Farley for being original committee members of mine through my comprehensive exams. I was sorry that circumstances kept them from participating in the dissertation committee but appreciate the ideas and support they provided earlier in my program. I am very grateful to both Glenn Moglen and John Robinson for joining my dissertation committee at a late stage and yet being willing and interested participants.

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Table of Contents

List of Tables

List of Figures

Executive Summary

In this dissertation, I argue that an individual's quality of life (QOL) is significantly impacted by the quality of the natural environment within which he or she resides. Costanza et al. (2002) state that the relationship between QOL and the natural environment is critical since "the laws of thermodynamics ensure that the ultimate source of wealth and resources and the ultimate recipient of the waste products from their use is our environment." Collados and Duane (1999) summarize the importance of the natural environment for humans in the following three relationships. First, environmental goods and services are used as raw materials in the production of human-made goods for the economy. Second, environmental goods and services are required to propagate themselves for the future. Third, environmental goods and services provide humans with positive externalities and benefits that are not available from any other source. Using different scales and methods of analysis, the natural environment was found to play an important role in contributing to QOL.

Chapter one is a literature review that also presents definitions of relevant QOL terms. This chapter delves into the history and development of the field of QOL, with roots in economics, philosophy, psychology and the social indicators movement. The remainder of the chapter further explores the subjective assessments of quality of life, such as subjective well-being, and life and neighborhood satisfaction. I present theories from psychology regarding subjective well-being and its reliability and stability, as well as psychological literature addressing how subjective well-being can be optimized. For life and neighborhood satisfaction, I review relevant literature that has already investigated relationships with the natural environment. Literature on the contribution of the natural environment to life satisfaction is sparse and somewhat inconclusive. There is more literature available on the role of the natural environment in neighborhood satisfaction, however the classification of the natural environment varies widely.

Chapter two describes a dynamic model of development in Montgomery County, Maryland. The model illustrates the process through which select growth management initiatives can impact development patterns, population growth, and QOL in Montgomery County, Maryland. Model analysis suggests that a conservative environmental development approach has the most positive impact on local QOL. The conservative environmental policies, including transferable development rights, reducing detached single-family home lot size, and cluster development, improve economic and environmental health indices and generate the best overall QOL index.

The following two chapters use data from a telephone survey of 1508 respondents across the Baltimore metropolitan region and data on objective environmental variables for the same region to investigate the role of the natural environment in life and neighborhood satisfaction. In chapter three, bivariate correlations and measures of association show that both objective environmental variables (tree canopy cover, water quality) and people's perceptions of their environment (environmental satisfaction, number of trees visible from home) have significant and positive relationships with neighborhood satisfaction. Most of the objective environmental variables and environmental perception variables also have significant and positive relationships with life satisfaction although the relationships are smaller. These data suggest that the natural environment plays a major role in contributing to neighborhood satisfaction and perhaps a minor or indirect role in contributing to life satisfaction. Additional analysis shows that the relationships between neighborhood satisfaction and the environmental variables remain significant even when controlling for socioeconomic and demographic variables.

Chapter four presents logistic regression analyses of both life and neighborhood satisfaction. For both life and neighborhood satisfaction, regression models including a variety of variables, covering the four basic types of capital, were more successful in explaining variation in the dependent variable than regression models using only socioeconomic and demographic variables. Logistic regression analysis did not find the objective environmental variables to be significant predictors of either neighborhood or life satisfaction but the environment satisfaction variable was a significant factor for both. In the main neighborhood logistic regression model, variables representing human, social, and natural capital were all found to be significant factors. Similarly in the main life satisfaction logistic regression model, variables representing built, social, and natural capital were found to be significant factors. The results from these regression models clearly show that the natural environment provides a major contribution to the satisfaction of individuals.

Finally, chapter five investigates the contributions to country-level life satisfaction of the four basic types of capital: human, social, built, and natural. Life satisfaction data were available for respondents from fifty-seven countries from the

World Values Survey over the decade of the 1990's. Data on proxies for human, social, built, and natural capital were available for 171 countries, using data from the 1998 United Nations Human Development Report, Freedom House (1999), and Sutton and Costanza (2002). Regression models show that both the UN Human Development Index (HDI – which includes proxies for both built and human capital) and an index of the value of ecosystem services per km^2 (as a proxy for natural capital) are important factors in explaining life satisfaction at the country level and together can explain 72% of the variation in life satisfaction. There was no proxy for social capital that was a significant predictor in the regression models, due to the inadequacy of available proxy variables for social capital at the national scale and intercorrelation with other variables. Data limitations and other problems with the existing limited data are discussed further in chapter five, along with methods to overcome some of these limitations to improve future analyses. Finally, a National Well-Being Index (NWI) based on the findings is proposed, including a process for improving it over time.

Overall, this dissertation presents new evidence to suggest that the natural environment does have a contribution to make to satisfaction levels and to quality of life as a whole.

Chapter 1: State of Knowledge on the Relationship between Quality of Life and the Natural Environment

Quality of Life Defined

To facilitate understanding throughout the dissertation, some important terms must be defined. Terms to be defined include: natural environment, quality of life, well-being, subjective well-being, happiness, life satisfaction, neighborhood satisfaction, environment satisfaction, social indicators, and welfare. The terms quality of life, well-being, and welfare all indicate similar ideas yet there can be differences in exactly what each term means. It is beneficial, therefore, to review the intended definitions of these and related terms for this dissertation. Finding a generally accepted definition of some of these terms, however, is not an easy task. In fact, some researchers use many of the terms interchangeably (Schuessler and Fisher, 1985; Bramston et al., 2002), however, the definitions listed below will be followed in this dissertation.

Natural environment – The sum of the living plants, animals, and organisms and other non-man made structures (i.e., rivers, rocks, mountains) in one's surroundings.

Well-Being – The state of being healthy, happy, or prosperous (American Heritage College Dictionary, 1993); or "the state derived from the satisfaction of wants or needs evoked by our dealings with scarce means and non-economic factors"

(Van Dieren, 1995). Occasionally, the term well-being is used interchangeably with quality of life (Schuessler and Fisher, 1985).

Welfare – This is an economic term that bases the level of an individual's well-being on income. Van Praag and Frijters (1999) summarize the term as the "evaluation assigned by the individual to income or, more generally, to the contribution to his well-being from those goods and services that he can buy with money." They also state that welfare is different from well-being as it is based on only a subset of the total variables that impact well-being.

Social Indicators – According to Hankiss (1983), these indicators monitor social processes, specifically macro-social processes. These data are generally based on social statistics, and to a lesser degree on surveys. Social indicators aim to analyze the objective conditions of social welfare and well-being, and also the objective consequences.

Objective Indicators – Indicators that can be calculated using available data or be measured directly in the field, but are not based on subjective assessments. These indicators can represent any topic, from social to environmental to economic. Social indicators could be considered a subset of objective indicators.

Life satisfaction – Sirgy (2002) notes that this term is generally considered to be the cognitive evaluation of one's happiness or subjective well-being. This evaluation possibly involves analysis of one's fulfillment of different needs, goals, and wishes perhaps in comparison to some standard.

Happiness – In the quality of life literature this term is generally intended to mean psychological happiness, or the feelings of positive emotions, such as joy, serenity, and affection, that one feels over time (Sirgy, 2002).

Subjective well-being – According to Diener and Lucas (1999), this term refers to individuals' own evaluations of their lives using "both cognitive judgments of life satisfaction and affective evaluations of moods and emotions." One might also consider this term to encompass life satisfaction and happiness into a single item.

Neighborhood satisfaction – A cognitive evaluation of the state of one's neighborhood and one's level of contentment with it.

Environment satisfaction – A cognitive evaluation of the state of the natural environment in one's neighborhood and one's level of contentment with it.

Quality of life – A general concept used by a wide variety of disciplines to represent the measurement of how good or bad the conditions of life are at a specific time and place (Felce and Perry, 1995). It can be measured at the individual level or social level and is a multidimensional assessment using objective indicators.

The term quality of life has a wide diversity of definitions (Pacione, 2003; Sirgy, 2001) and there is very little agreement among researchers on its definition (Bramston et al., 2002). Some researchers define QOL as a subjective assessment of life circumstances and quality (Haas, 1999) but in this dissertation I use SWB, satisfaction, and happiness to refer to subjective assessments and QOL to represent the more general concept and objective evaluation. In addition, the phrase QOL is typically used to title the entire field of study of all of these related concepts. The quality of life (QOL) field is fantastically diverse with relevant disciplines ranging from medicine to economics to marketing and with even more specific study areas including health and disease, social policy, leisure and recreation, services for disabled persons, and planning and development (Seed and Lloyd, 1997; Schuessler and Fisher, 1985).

Theory, Background, and Measures of Well-Being

Quality of life, happiness, and the question of what makes a good life have been topics of contemplation for thousands of years. Different philosophers and different disciplines have approached the topic in different ways and with very different theories of how to attain and judge quality of life, happiness, and the good life. Some of the disciplines that have investigated and written on this topic include philosophy, ecological economics, economics, the social indicators movement, and psychology. I will present ideas on "the good life" from all of these disciplines and then identify how this dissertation approaches the topic.

Each discipline has its own idea of what "the good life" is and especially how to measure and track changes in quality of life. On this level, these disciplines have competing theories of how quality of life should be measured and followed over time to show trends. In addition, there are competing theories within disciplines. Economics and psychology have had most of these intra-discipline competing theories. The historical changes in economic thought on welfare and well-being are presented below, as are the various current competing theories in psychology on subjective well-being.

Philosophy

In the 4th century BC, Aristotle gave great thought to the goal of human life and determined it to be "eudaimonia" or happiness. Aristotle defined happiness as contemplation of truth, a much different meaning than our present day meaning of good mood or satisfaction with life (Aristotle, 1976; Barnes, 1976). Aristotle proposed that all humans worked toward this identifiable supreme good but only some could actually reach it. He defines the happy man as "one who is active in accordance with complete virtue, and who is adequately furnished with external goods, and that not for some unspecified period but throughout a complete life...destined to both live in this way and to die accordingly" (Aristotle, 1976). According to Aristotle, one cannot judge whether a man was happy in life until after his death.

Ecological Economics

The idea of an ultimate end or goal of human life can also be found in ecological economics literature. Daly and Farley (2003) state that an ultimate end or objective value must exist so that we can have a way to evaluate policy alternatives. Without some sense of an objective value, we cannot rank different options as better or worse and therefore we would be unable to have a policy dialogue. Daly and Farley (2003) do not claim to know what this ultimate end is but note that one must exist. In practice, they note that we rank the intermediate ends that we pursue by priority and the one we put in first place acts as an operational estimate of the ultimate end. Daly and Farley (2003) also propose a "working definition of the penultimate end for the ecological economy: the maintenance of ecological life-support systems far from the edge of collapse …and healthy, satisfied human populations free to work together in the pursuit and clarification of a still vague ultimate end—for a long, long time." This definition provides a general framework for generating quality of life but not a method for identifying or judging quality of life in individuals.

Economics

The economics discipline has had many different approaches toward the concept of "the good life," generally thought of as welfare, utility, or well-being in this discipline. Going back to the late 1800s, the marginalist revolution claimed that consumers seek to maximize their utility, which allowed economics to progress mathematically, using the concept of marginal utility (Ackerman, 1997). Next, the material welfare school proposed that there were both material and nonmaterial aspects of welfare but that economics only covered the material aspects. However, the material welfare school did believe that the average utility experienced by large groups could be compared and interventions in the market could be justified when there were conflicts between the material and nonmaterial aspects of welfare (Ackerman, 1997). Interventions would generally benefit the poor or improve the efficiency of competition. The ordinalist revolution of the 1930s, however, moved the discipline away from measurement of welfare by claiming that it was not necessary or possible to compare people's utility or to assign numbers to utility. They claimed that only an ordinal ranking was needed to show consumer preferences. The ordinalist revolution was successful at that time largely because logical positivism was fashionable in philosophy and behaviorism was popular in psychology

(Ackerman, 1997). These concepts basically shun any subjective or mental assessments of welfare. Interestingly, neoclassical economics has held on to positivism and behaviorism even as philosophy and psychology have not. After the ordinalist revolution, Samuelson's theory of revealed preferences took hold, which claimed that consumer preferences could be determined by behavior and no additional utility information was needed (Ackerman, 1997). In this way, neoclassical economics denies the existence of an ultimate end, basing their model of homo economicus on the idea that each person determines their own ends through revealed preference theory. Using the assumptions that people are rational and their choices reflect their preferences, neoclassical economists were able to claim that individuals maximize their utility through their choices. In fact, "revealed preference theory assumes that the satisfaction of a person's actual preferences must improve her welfare" (Kiron, 1997). However, evidence shows that people's choices do not always improve their utility, especially if preferences are irrational, malevolent, or based on inaccurate or incomplete information.

Considering well-being on a national level within the economics discipline, national measures of economic prosperity come to mind. Namely, one may think of the Gross National Product (GNP). The GNP, however, was not originally created to be a measure of well-being (Miles, 1992; Van Dieren, 1995). It was simply intended to measure the scale of the output of the economy, particularly to provide data to help mobilize for World War II (Cobb and Cobb, 1994; Miles, 1992). Even before the collection of data leading to the development of the GNP, economic thinkers disagreed with the developing economic ideal of consumption as the final goal (equivalent to revealed preference theory at the individual level). John A. Hobson was one of these dissenters. He thought that there should be a wide assessment of the output of the economic system, something he termed "organic welfare" (Smith, 1993). He thought that consumption should only be valued for the contribution it provided toward organic welfare or well-being (Smith, 1993). Tawney also disagreed with the idea of making economic wealth its own end and justification (Smith, 1993). Even Simon Kuznets, who participated in the development of national income accounts, thought the accounts were becoming too rigid as early as 1947 and thought that they should also measure social welfare not just economic output (Cobb and Cobb, 1994).

Beginning in the 1970s, people again began to question this measure of economic progress and its use as a general indicator of national well-being (Cobb and Cobb, 1994). Some of the criticisms were that the GNP included "bads" (i.e., national defense, pollution clean up, etc.), that the GNP did not treat natural capital depletion (i.e., unsustainable forestry) as a cost but rather as an income, and that the GNP did not incorporate non-market activity (i.e., household work) (Offer, 1996; Cobb and Cobb, 1994). Another criticism was that prices are not necessarily an accurate measure of well-being (Offer, 1996). Suggestions for revisions and prototypes were made to show how the GNP could be improved as a measure of well-being or at least of welfare. First, Nordhaus and Tobin in 1972 developed the Measure of Economic Welfare (MEW). The MEW made three major changes to the GNP. First, GNP was reclassified into consumption, investment, and intermediate goods. Second, the value of leisure, housework, and the annual services of durable goods were estimated. Third, wage differentials were used between cities to account for urban disamenities (Cobb and Cobb, 1994). Although Nordhaus and Tobin focused on the finding that both the MEW and the GNP grew simultaneously between 1929 to 1965, when the data were analyzed over shorter time periods, the two measures did not always grow together (Cobb and Cobb, 1994). In fact, the MEW did not show anywhere close to the increases over time that the GNP did (Cobb and Cobb, 1994).

Daly and Cobb revisited the MEW in order to take distribution issues and environmental costs into account. They created the Index of Sustainable Economic Welfare (ISEW). The ISEW starts with personal consumption and then makes the following changes: 1) grants an income distribution adjustment, 2) records changes in the stock of reproducible capital excluding land and human capital, 3) estimates the cost of air, water, and noise pollution, 4) estimates costs of various environmental and social bads (i.e., depletion of non-renewable resources, commuting time, auto accidents, etc), 5) omits value of leisure, and 6) includes value for unpaid household work (Costanza et al., 2000; Van Dieren, 1995). The ISEW was found to follow the GNP initially but then shift away in the 1970s and 1980s. One hypothesis to explain this finding is from Max-Neef who suggested that economic income can only increase well-being until the costs of the growth in income become greater than the benefits received (Costanza et al., 2000).

Even with these improvements in the measuring tools, the GNP, MEW, and ISEW all remain indicators solely of economic welfare. A more comprehensive conception of well-being would have to come from an entirely different discipline or possibly incorporate an economic indicator with other indicators of well-being.

Human Needs and Human Advantage Theories

A couple of researchers that do not fall directly into the economic, social indicators, or psychology realms include Manfred Max-Neef, and Amartya Sen. Max-Neef developed the theory of human needs for development. This theory classifies human needs into an interaction of existential and axiological categories (Max-Neef, 1992). The existential needs include Being, Having, Doing, and Interacting. The axiological needs include Subsistence, Protection, Affection, Understanding, Participation, Creation, Leisure, Identity, and Freedom. Individual actions or items that fulfill these needs are called satisfiers. For example, shelter can satisfy the need for Subsistence, while attending classes may satisfy the need for Understanding (Max-Neef, 1992). Satisfiers may satisfy one or more needs and a need can require more than one satisfier to be fulfilled. With this framework, Max-Neef is able to propose that human needs are finite and that they remain the same over time and through cultures. The only variation is in how the needs are satisfied. Max-Neef also states that needs are satisfied on three levels, with respect to oneself, one's social group, and one's environment (Max-Neef, 1992). He categorizes satisfiers into groups as well, violators and destroyers, pseudo-satisfiers, inhibiting satisfiers, singular satisfiers, and synergic satisfiers. Violators and destroyers appear to satisfy a need but actually make it impossible to satisfy that need and others (i.e., arms race to satisfy need of Protection). Pseudo-satisfiers also appear to satisfy a need but do not truly satisfy that need (i.e., prostitution for need of Affection). Inhibiting satisfiers fulfill a specific need but do so to the extent that other needs cannot be satisfied. Singular satisfiers satisfy only one need and do not impact other needs at all. Synergic satisfiers satisfy one need while also contributing to the satisfaction of other needs. Max-Neef's theory is useful for its recognition of human needs beyond basic physical needs and for its insightful analysis of types of satisfiers. While the theory is quite interesting, it is difficult to implement and actually measure or analyze the well-being of a single person using this theory, not to mention a community or nation.

Amartya Sen developed his human advantage theory to "assess a person's ability to achieve valuable functionings" (Kiron, 1997; Crocker, 1995). In Sen's view, it is important that people have many desirable and feasible choices available to them and that they succeed in achieving their goals and personal happiness. He calls the freedom to achieve one's goals and happiness a capability set (the choices available to them). Success in achieving one's goals and happiness is called functionings. Therefore, human advantage is a result of both a person's capability set and a chosen combination of functionings (Kiron, 1997; Crocker, 1995). In other words, a person's well-being is dependent on the set of choices available as well as the ability to reach one's goals. Sen goes on to describe three types of human advantage, standard of living, personal well-being, and agency. He defines standard of living as that which impacts the individual only, not including the emotions that are tied to relation with others. Sen views personal well-being as including standard of living as well as one's emotions or "sympathy-based affect". Agency is the success one has in achieving a desired objective regardless of the impact that achievement may have on one's personal well-being. Human advantage theory acknowledges that people have goals that are not self-interested (Crocker, 1995). Again, the theory is interesting but would be difficult to implement and measure since capability sets and functionings are not easily determined.

Social Indicators Movement

The term "quality of life" did not enter regular usage until the 1960s (Schuessler and Fisher, 1985; Costanza et al., 2002). At that time it was used in connection with the need to address rising crime and violence during a time of economic prosperity (Haas, 1999). This specifically showed that the concepts of quality of life and economic well-being were not equivalent evaluations of national well-being. This reduction in QOL during economic prosperity highlighted the need for non-economic indicators and social indicator work began (Milbrath, 1982; Van Dieren, 1995). Since then, the lack of a relationship between economic status and general well-being has been further investigated. For example, it has been determined that the association of an increase in happiness and an increase in consumption is not very substantial (Bliss, 1996). Hankiss (1983) shows that over the period 1949 – 1965, income per capita grew about 40 percent but the percent of Americans describing themselves as “very happy” on a three point scale declined by 20 to 30 percent. Similarly, one's level of income or affluence has little impact on subjective well-being once one's basic needs are met (Myers and Diener, 1995; Etzioni, 2001; Dodds, 1995; Pacione, 2003; Easterlin, 2003). At the state level, Liu (1975) found that some states with high quality of life ratings did not have high economic indicators such as income per capita. In fact, Liu’s (1975) findings “indicate that the major disparities in quality of life are neither in the economic or political component; rather they are in social, health and education and to a lesser degree in environmental concerns."

In the 1960s, social indicators were initially pursued including crime rates, education levels, and housing type (Haas, 1999). These studies were often limited in scope (by domain or region) but then tried to apply their findings to broader populations such as the entire United States (Haas, 1999). However, these social indicators were found to correlate poorly with subjective well-being assessments (Milbrath, 1982). Therefore, beginning in the 1970s, researchers began to focus more on subjective well-being (Haas, 1999; D'Antonio et al., 1994). Details on subjective well-being are discussed in the next section.

Some current literature has returned to the use of social and objective indicators, however. The Calvert Henderson Quality of Life Indicators are all objective measures of well-being within the United States (Henderson et al., 2000). The Calvert-Henderson indicators, however, attempt to track the quality of life of the nation and not of individuals. The United States has even come up with an experimental set of indicators for sustainable development, published in a progress report entitled: "Sustainable Development in the United States: An Experimental Set of Indicators" (U.S. Interagency Working Group on Sustainable Development Indicators, 1998). In his book, "The Wellbeing of Nations," Prescott-Allen (2001) used objective indicators to rate the well-being and sustainability of most nations as well. Each of these examples intended to track the quality of life and sustainability of the nation and not individuals. It appears that objective indicators are more regularly used in the analysis of populations and subjective assessments in the analysis of individuals. However, this may not be the best policy for the future as subjective assessments could be useful in the analysis of national progress and objective indicators can provide additional information on the individual. Cummins (2000) finds that both objective and subjective indicators can provide significant information regarding an individual's well-being (Cummins, 2000). Andrews and Withey (1976) as well as Milbrath (1982) note that thorough research projects should evaluate both objective and subjective indicators. Pacione (2003) states that policy makers are beginning to accept that both objective and subjective indicators of life quality are useful for measuring well-being.

Psychology and Subjective Well-Being Assessments

Subjective well-being assessments focus on personal experiences and concepts including happiness and life satisfaction (Haas, 1999). To measure subjective well-being (SWB), researchers ask people to rate their feelings of happiness and satisfaction with life. One of the pioneering social surveys that measured happiness, satisfaction, and well-being was based out of the University of Michigan in the 1970's and published by Andrews and Withey (1976) as Social Indicators of Well-Being: Americans' Perceptions of Life Quality. This study generated a great deal of data on Americans' feelings and also became a main source for questions and response scales for the topic. Some of the questions commonly borrowed from the survey were the following (Andrews and Withey, 1976):

- How do you feel about your life as a whole? (Delighted – terrible scale)
- Which face comes closest to expressing how you feel about your life as a whole? (seven faces shown with differing smiles or frowns)

- Here is a picture of a ladder. At the bottom of the ladder is the worst life you might reasonably expect to have. At the top is the best life you might expect to have. Of course, life from week to week falls somewhere in between. Where was your life *most of the time during the past year*?
- How satisfied are you with your life as a whole these days? (seven point satisfaction scale)
- Taking all things together, how would you say things are these days – would you say you're very happy, pretty happy, or not too happy these days?

After collecting data on respondents' subjective well-being, researchers began to analyze the data to draw some basic conclusions. One concern was the test-retest reliability of subjective well-being questions and their stability over time. Atkinson (1982) reviewed the reliability and stability of these subjective well-being measures and concluded that these measures are both reliable and stable over time. In addition, Andrews and Withey (1976) reported high measures of validity (.7 and .8) for many of their well-being measures. Atkinson also looked at whether such measures were sensitive to major life changes over a long period of time (2 years) and he found that they were sensitive to change when it occurred. Neuroscience has even confirmed the idea that people can accurately report happiness levels, "brain scans now prove that people's reported happiness levels are remarkably accurate, as easy to measure as decibels of noise" (Toynbee, 2003). Self-reports of life satisfaction also correlate highly with reports of life satisfaction provided about individuals by family members and close friends (Diener and Lucas, 1999).

One theory for why subjective well-being measures are very stable over time is because they are determined to some extent by personality traits. Diener and Lucas (1999) state that “one of the most consistent and robust findings in the field of subjective well-being (SWB) is that the components of SWB are moderately related to personality.” Easterlin (2003) also notes that subjective well-being and happiness are affected by personality and genetic factors but that life events can also substantially impact subjective well-being. Brekke and Howarth (2003) suggest that subjective well-being is related to psychological disposition, quality of social relationships, degree of self-actualization, physical health and other factors. While many researchers agree that personality traits play a substantive role in determining one’s subjective well-being along with other factors (Easterlin, 2003; Brekke and Howarth, 2003), there are still a number of different models of how personality is related to SWB. Some of these models of the relationship between personality and SWB are described below and include temperament models, homeostasis, congruence models, cognitive models, goal models, and emotional socialization.

Personality and Subjective Well-Being

The first set of models regarding personality and SWB are temperament models, which suggest that people are born with a certain baseline level of happiness. Basically, one’s level of happiness is largely biologically determined. The first of these models is set-point theories, which propose that “individuals have emotional set-points to which they return after experiencing positive or negative events” (Diener and Lucas, 1999). Another theory, called reactivity theory, posits that individuals differ in their reactions to positive and negative events because of their personality.

For example, “an extravert may be happier than an introvert because the extrovert reacts more strongly to positive stimuli than does the introvert” (Diener and Lucas, 1999). Behavior theory is another temperament model, which suggests that different personality types are able to extract more or fewer rewards from their environment than other types. For example, it has been found that extraverts actually experience more positive events than introverts (Diener and Lucas, 1999).

A theory similar to the temperament models, regarding the stability of well-being over time is homeostasis. In a study evaluating the results of 16 studies of life satisfaction in western nations, Cummins was able to determine that there is a reliable, national-level, average life satisfaction value of 75.0 $\pm$ 2.5 % of the measurement scale maximum score for Western nations (Cummins, 1995). In a later study, Cummins used a similar procedure to develop an international standard of 70.0 $\pm$ 5.0 % of the measurement scale maximum score, which includes all major geographic regions (Cummins, 1998). From these empirical data, he presented the idea that life satisfaction is held within a specific range by homeostatic control even as objective life conditions vary. Cummins (1995) describes homeostasis as “a highly adaptive device on a population basis ensuring that, under relatively stable but diverse living conditions, most people feel satisfied with their lives, thereby conferring a non-zero sum benefit on the population as a whole.” He found there to be a ceiling on life satisfaction of about 80%, reached mainly in Western nations, and that there also seems to be a floor on life satisfaction of about 50%, reached by the lowest ranking nations (Cummins, 1998). Cummins (2000) does note, however, that if the objective life conditions exceed a person's ability to adapt then SWB may suffer, and therefore the satisfaction levels of individuals can fall outside of the ranges presented for the national average. He states that the level at which objective life conditions begin to impact subjective life quality must certainly be influenced by cultural and personal values.

Congruence models present another idea of how personality is related to subjective well-being. These models suggest that the fit between one's personality and one's environment is responsible for determining one's level of subjective well-being (Diener and Lucas, 1999). According to this theory, people are only able to have a high level of subjective well-being "when their personality fits with their environment" (Diener and Lucas, 1999). However, the evidence suggests that extroverts are happier than introverts whether they are in social situations or not and whether they live alone or not, which suggests that something more than just personality-environment fit is responsible for levels of subjective well-being (Diener and Lucas, 1999).

Cognitive models suggest that one's personality determines how positive and negative information is processed. People have different abilities to recall pleasant events over negative events and to focus on positive self information versus negative self information. People who are generally happy will tend to focus on positive events and information while people who are less happy or depressed will not bias their focus on one versus the other (Diener and Lucas, 1999).

Another set of models for the relationship between personality and subjective well-being are goal models. These models suggest that "personality comprises not simply traits but also the goals for which individuals typically strive" (Diener and

Lucas, 1999). One researcher in this field, Emmons, found that personality predicted aspects of subjective well-being in different ways. For example, "life satisfaction was related to striving importance, expectations for success in strivings, and a lack of conflict between different strivings" (Diener and Lucas, 1999). Therefore, if a person had important strivings, reachable expectations, and no conflict between different strivings, he/she would be expected to have high life satisfaction. Other researchers have used goal theory to explain why subjective well-being often has poor correlation with resources such as wealth and health. They suggest that resources (i.e., health, wealth) only correlate with subjective well-being when those specific resources are "relevant to a person's idiographic personal strivings" or goals (Diener and Lucas, 1999). However, none of the evidence specifies a causal relationship and the relationships between personality traits, goals, and resources must be investigated further before causal relationships can be determined.

Emotion socialization models take a very different approach and suggest that mothers teach their children what emotions are appropriate and preferred while they are infants. The infants learn through classical conditioning, instrumental learning, and imitation. Therefore, differences in emotional socialization may explain long-term differences in positive and negative affect among individuals and cultures (Diener and Lucas, 1999).

Optimization of Subjective Well-Being

Aside from innate factors that impact subjective well-being, researchers have also suggested numerous theories of how people are able to optimize their subjective well-being. Optimization theories can help explain why subjective well-being levels are usually on the upper end of the scale as detailed by Cummins (1995) in his generation of a "gold standard" for subjective well-being. One example is gap theory, such that people tend to determine their own SWB by comparing themselves to a reference group or ideal standard (Haas, 1999). This finding is interesting because both low-income and high-income communities or cultures often rate their SWB the same and sometimes, low-income groups rate their SWB higher than a high-income group seemingly because they are comparing themselves to a more accessible standard (Schuessler and Fisher, 1985). Sirgy (2002) groups the remaining strategies for subjective well-being optimization into 1) "inter-domain" strategies, including bottom-up spillover, top-down spillover, horizontal spillover, and compensation; 2) "intra-domain" strategies, including re-evaluation based on personal history, re-evaluation based on self-concept, re-evaluation based on social comparison, goal selection, goal implementation and attainment, and re-appraisal; and 3) balance, which manipulates psychological aspects both across and within life domains.

The inter-domain strategies "focus on the interrelationships among the life domains" (Sirgy, 2002). Bottom-up spillover is a strategy where positive feelings in specific aspects of life (domains) are transferred to increase positive feelings regarding overall life. Basically, positive feelings in specific domains are allowed to compensate for any negative feelings in other domains in one's overall evaluation of life. In top-down spillover, positive feelings regarding one's overall life spills over to increase the positive feelings about specific aspects of life. Allowing positive feelings to spill over into specific domains of life reduces negative energy associated with that aspect of life and in turn feeds back into overall life. Horizontal spillover is when positive feelings in one specific domain are able to influence negative feelings in another specific domain (i.e., satisfaction with friends and family influence negative feelings about one's health). Compensation is a slightly different strategy, which involves reprioritizing all of the life domains such that those that provide the most satisfaction are made most important. Therefore, the satisfaction derived from the more important domains is emphasized while any negative feelings from other specific domains are minimized, especially in the generation of overall life satisfaction.

The intra-domain strategies focus on re-evaluating and manipulating aspects within specific life domains. Re-evaluation based on personal history allows one to modify expectations based on actual progress to date. For example, a person may be frustrated with how long it took to get through college but after re-evaluation recognize that he had not been a good student in high school and he had to pay his own way through college so it is truly a significant achievement to have graduated. Re-evaluation based on self-concept can enhance well-being by changing what one can expect based on concepts such as the ideal self, the deserved self, the competent self, the aspired self and others. In this situation, a person may be unhappy about not getting a promotion at work but then realize that in comparison to those who did get a promotion, she did not work as hard and does not truly deserve the promotion. She can re-evaluate the domain and compare her actual self with her deserved self and realize that she is in the position that she most deserves, which will increase her satisfaction in that domain. Re-evaluation based on social comparison is when a person changes their basis of comparison for a specific life domain. For example, a person may be dissatisfied with his health due to an ongoing struggle with annoying allergies. Then he may compare himself to people he hears about on TV who are struggling with cancer and other life threatening illnesses and he then feels very thankful for his health which increases his level of satisfaction. Goal selection is a way to increase subjective well-being by changing one's personal goals to those that will be able to generate a great deal of satisfaction. A person may have planned to be making a six-figure salary by a young age but is always unhappy with work, working more hours than she would like. By changing her goal to simply being able to live comfortably while working in a job she enjoys, her satisfaction will increase dramatically. Another strategy is goal implementation and attainment in which a person must determine exactly how they can attain their goals so that they do not set themselves up for failure in selecting a new goal. If the woman, who was unhappy in her job above, quits before lining up a new job, she could become very dissatisfied if she determines that there are no jobs available in the line of work that would make her most happy. Re-appraisal is a strategy that allows a person who experiences a negative event to take a second look at the event to draw positive meaning from it. A person who loses his job realizes that he was hoping for a change and is now able to try out the new career he had been too scared to investigate.

The final strategy for subjective well-being optimization is balance. Balance indicates that both positive and negative events are necessary to keep subjective well-being constant over time. Positive events and feelings keep one satisfied in the current situation while negative events and feelings motivate one to make changes, plan ahead, and attain future goals. The potential for positive future events brings additional satisfaction and improves chances of satisfaction in the future.

In general, researchers in the field of psychology have determined that subjective well-being is somewhat biologically determined and in addition, we use strategies to create the highest level of SWB possible using various techniques.

Interdisciplinary

Not all QOL researchers feel that a single theory is sufficient to explain the data on subjective assessments of well-being. Easterlin (2003) argues that "neither the prevailing psychological nor economic theories are consistent with accumulating survey evidence on happiness". He argues that because of hedonic adaptation (people's aspirations adapt to their changing circumstances) and social comparison (people judge their happiness relative to social peers rather than on an absolute scale), the set point theories in psychology and Samuelson's theory of revealed preferences in neoclassical economics both fail.   Instead, Easterlin (2003) suggests that a combination of theories and optimization strategies are needed to explain the available survey data on subjective well-being. Specifically, he thinks that people allocate too much time toward improving their financial status and not enough time focusing on and improving their non-financial aspects of life such as health and family. Easterlin (2003) finds that adaptation and social comparison minimize improvements in the economic life domains such that those improvements (i.e., pay increase) do not transfer into improvements in satisfaction levels or happiness. Adaptation and social comparison do not negatively impact the non-financial domains in the same way, but when people become consumed with improving their financial status, these other domains suffer. Easterlin goes on to discuss the policy implications of his analysis, especially the idea that individuals are not aware of the impacts of adaptation and social comparison and therefore are not able to make informed decisions regarding their well-being, as is assumed in revealed preference theory.

Summary and Measures of Well-Being in this Dissertation

Throughout history, suggestions of how to define quality of life and related concepts have been quite varied as shown above and include: Aristotle's "eudaimonia", ecological economics' penultimate end, neoclassical economics' revealed preference theory, and psychology's subjective well-being, among others. These different ideas and theories about quality of life helped me to determine which specific measures to use in my dissertation research. In chapter 2 of this dissertation, I use objective indicators to represent QOL but only because no subjective assessments were available. However, chapters 3-5 focus on measures of satisfaction to determine people's levels of well-being. The concept of satisfaction should be thought of as a person's mental state based on the knowledge that he or she has about his or her life (Kiron, 1997). My feeling was that the use of subjective assessments was necessary since we are only able to measure these current mental states and not theoretical end states. We are not able to look at the culmination of people's lives and use that knowledge to affect the present, nor are we able to act as an all-knowing outside observer in each person's life. Instead we must rely upon the ratings provided by individuals about their own lives in order to have information by which to judge the well-being of people in the present time. In addition, there has been substantial research on satisfaction and subjective well-being, much of which was presented earlier in this chapter. Here it is simply useful to reiterate that measures of life satisfaction and levels of happiness have been verified using statistical methods and are accepted as “understandable and measurable” (Kiron, 1997). These measures provide unique and useful information that can help focus legislation and policy on topics that are shown to directly relate to the satisfaction of individuals.

Measures of Satisfaction

Composition of Life Satisfaction

While some researchers view life satisfaction as a single idea best assessed using a single global satisfaction question such as "How do you feel about your life as a whole?", other researchers think life satisfaction is composed of multiple aspects and they assess life satisfaction by asking questions about specific domains of life (Cummins, 1996). Researchers have investigated numerous different topics to determine their importance to overall life satisfaction. Michalos (1986) identified ten main areas of interest after reviewing 518 abstracts from Social Indicators Research, these are job satisfaction, life as a whole, marriage, old age, housing and neighborhood, health and human services, politics and social relations, family, crime and justice, and education. Argyle (1996) suggests that while demographic variables can account for 10 to 15 percent of the variance in happiness, the most important aspects of life for happiness are “marriage, employment, occupational status, leisure, and the competencies of health and social skills.” Cummins and others have suggested the use of seven domains to evaluate life satisfaction. These domains are material well-being, health, productivity, intimacy, safety, community, and emotional well-being (Cummins, 1996). Through a review of many life satisfaction studies, Cummins was able to discern that the domain of intimacy had the highest rating of satisfaction across all groups and that the domain of health also consistently fell above the mean satisfaction score (Cummins, 1996). All other domains generally fell below the mean satisfaction score (Cummins, 1996). He was also able to determine that the use of his seven domains could incorporate most of the study data and that his results were not different than single-item global life satisfaction measures (Cummins, 1996). Some researchers feel that domain-specific studies can provide more pertinent information for public policy (Schuessler and Fisher, 1985). However, studies testing the effects of domain satisfactions on life satisfaction have had varying results (Moller and Saris, 2001). Some studies found that domain satisfactions do impact life satisfaction while others found that life satisfaction was more attributable to personality characteristics than domain satisfactions and still other studies found that life satisfaction and domain satisfactions both are based on personality characteristics (Moller and Saris, 2001; Diener and Lucas, 1999). These effects may vary by country or by the domain satisfaction being evaluated.

Notably, none of the domains identified by Cummins, Michalos, or Argyle encompass the natural environment.

Life Satisfaction and the Environment

Costanza et al. (2002) state that the relationship between quality of life and the natural environment is critical since "the laws of thermodynamics ensure that the ultimate source of wealth and resources and the ultimate recipient of the waste products from their use is our environment." Bubolz et al. (1980) state "humans are dependent on their environment to satisfy needs and desires." They go on to note that human behavior often consists of attempts to cope with, adapt to, or change one's environment in order to improve one's situation (Bubolz et al., 1980). The importance of the natural environment for humans can be seen explicitly in three relationships outlined by Collados and Duane (1999). First, environmental goods and services are used as raw materials in the production of human-made goods for the human economy. Second, environmental goods and services are required to propagate themselves for the future. Third, environmental goods and services provide humans with positive externalities and benefits that are not available from any other source. Dodds (1997) also concludes that "important aspects of social, economic and environmental systems are codetermined." These brief statements highlight the relevance of the natural environment to quality of life and express why this relationship deserves attention.

There is reason to believe that the state of the natural environment has an impact on the subjective well-being of humans. We evolved with all other animals relying on the natural environment for our basic needs, such as subsistence and shelter. E.O. Wilson even suggests that the natural environment played a role as important as that of social behavior in shaping human history (Fawcett and Gullone, 2001). Wilson also proposes that humans have an "innate tendency to focus on life and lifelike processes" (Wilson, 1984; Fawcett and Gullone, 2001; Gullone, 2000). As partial evidence of this innate relationship, Wilson and other researchers point to self-reported feelings of comfort and awe in natural settings as well as the relationships that humans form with animals. Wilson uses Darwin's expression of feelings after first encountering the tropical forest near Rio de Janeiro to show the impact that nature can have: "wonder, astonishment and sublime devotion, fill and elevate the mind" (Wilson, 1984).

However, Wilson's biophilia hypothesis really seeks to show that humans have this innate relationship with nature because it has been selected for during millennia of evolution (Fawcett and Gullone, 2001). Those ancestors with this innate relationship, it is argued, had enhanced fitness and their genes are the ones we still carry. Whether there is truth to Wilson's hypothesis of gene transfer is still debated but it is inconsequential here. For the purposes of this study it is simply useful to note the results of the supporting research studies in which people are found to have positive reactions to natural environments and animals.

For example, Fawcett and Gullone (2001) state that human "observation of animals has been shown to result in reduced physiological response to stressors and in increased positive moods." In a study by Ulrich et al. (1991) subjects were exposed to a stressful video of workplace accidents followed by a second video of either a natural or urban scene, including sound. Subjects were found to recover from stress faster and more completely when the second video was of natural settings rather than urban settings (Ulrich et al., 1991). Studies of people in hospitals found that people with window views of nature recovered faster than those overlooking urban scenes (Ulrich, 1984). Similarly, prisoners in cells with windows overlooking nature had fewer reports of illness and stress symptoms (Moore, 1981). Another study looked at the importance of views of nature in the workplace. Kaplan and Kaplan (1989) found that people who had a view of trees or flowers from their office were more satisfied with their job than people who could only see built environments from their window. Overall, Kaplan and Kaplan (1989) suggest that observing and viewing nature, even from a distance or through a window, provides pleasure and allows one to rest and reflect.

Hartig et al. (1991) also found evidence that experiences in nature had greater restorative effects on subjects. By comparing groups of people that either went on a backpacking trip, a non-wilderness vacation, or had no vacation, Hartig et al. (1991) found that the wilderness trip had restorative effects identified through self-reports of affect and seen in improved restoration of mental fatigue. In a second study, Hartig et al. (1991) compared groups of people that went on a nature walk, went on an urban walk, or relaxed in a comfortable chair. This study found that the natural setting experience is more restorative based on self-reports of mood and general affect, as well as measures of recovery from mental fatigue (Hartig et al., 1991). Kaplan and Kaplan (1989) also note that people with access to nearby nature or parks tend to be healthier, and over the long-term, they have increased levels of life, job, and home satisfaction. In general, studies show that being in nature has positive impacts on people although the exact processes and benefits are unclear (Maller et al., 2002).

Quality of life researchers have generally not included an environmental aspect in investigations of subjective well-being (Schuessler and Fisher, 1985). For example, Schuessler and Fisher (1985) noted that environmental conditions are usually considered as "fostering or facilitating QOL, and not as constituting or creating it."

Shin et al. (1983) would agree that SWB is a complex, multi-faceted idea and would go on to add that the components of SWB are not equally affected by different environmental conditions. In addition, not all people perceive the environment in the same way, such that environmental conditions may interact with personality attributes or other experiences to result in the specific perception of the environment by an individual (Shin et al., 1983).

In a study in Benin, Nigeria, the quality of housing was found to impact reports of life quality, such that poor housing conditions detracted from quality of life (Muoghalu, 1991). Respondents in this study also complained of a lack of open and recreational space for children (Muoghalu, 1991). These findings begin to show that quality of life and subjective assessments of life quality are impacted by external environmental conditions, although possibly only in extreme circumstances. Shin et al. (1983) support this finding, noting that US studies have found that SWB is negatively correlated with the size of community and degree of urbanization, such that people in smaller, more rural areas have greater well-being. Similarly, a study of SWB in Korea, found that people in rural communities have greater levels of SWB and that rural communities contribute toward happiness and satisfaction to a greater degree than urban communities (Shin et al., 1983).

Bubolz et al. (1980) in a study of a rural sample in northern Michigan, found that items "related to self-concept and self fulfillment were significantly related to overall satisfaction with life" while items more distant and impersonal (i.e., government) were not large determinants of SWB. Their study did not find a significant relationship between the natural environment and SWB although they had expected one (Bubolz et al., 1980). They did find that people were satisfied with their natural environment and they even ranked it moderately high in importance (Bubolz et al., 1980). Objectively, the quality of the natural environment of the sample would be considered very high in terms of beauty, air quality, and accessibility of outdoor recreational areas (i.e., forests, lakes). The authors suggest that these resources might be taken for granted and therefore not included in a judgment of quality of life (Bubolz et al., 1980). Inglehart and Rabier (1986) support this idea that people may come to take the quality of their natural environment for granted; "and for those who have always lived in an environment where water is plentiful, it may seem virtually valueless, so that the quantity available is completely unrelated to subjective well-being." Another idea might be that the natural environment is not typically included in one's analysis of SWB. Instead, people associate the natural environment as something distant from themselves and more impersonal, characteristics of items that are not highly correlated with people's SWB. Supporting this argument, are the findings of a study by Van Praag et al. (2003), which looked at the role of six domains on German's general satisfaction (job, financial, house, health, leisure, and environment) and found that the three main determinants of life satisfaction were finances, health, and employment. The environment appeared to be one of the least important domains for life satisfaction, especially for those in Western Germany. However, the use of questions at the community or country level regarding the natural environment could bring this discrepancy between importance and impact on SWB into focus.

Neighborhood Satisfaction and the Environment

More recently, researchers are realizing the usefulness of subjective assessments in measuring the quality of social life, whether that is at the neighborhood, community, or national level. People tend to be much more negative in their responses about their satisfaction with society than they are about their satisfaction with their own lives, which seem to be somewhat buffered in a narrow range (Eckersley, 2000). Since the results of questions about life and national-level satisfaction are quite different, researchers conclude that questions about national-level satisfaction do measure people's common life experience (Eckersley, 2000). The Australian Unity Well-Being Index asks citizens about their level of satisfaction with specific aspects of their life and their life as a whole, as well as their satisfaction with specific aspects of life in Australia and life in Australia as a whole (Cummins et al., no date; Cummins et al., 2001). Australian's life satisfaction was found to be 74.2% of scale maximum, which is within the expected range of 70 to 80% for Western Nations (Cummins et al., 2001). Australian's national satisfaction was found to be 58.9% of scale maximum, showing substantially less satisfaction with national-level satisfaction than life satisfaction. Other studies find similar data, with the majority of Australian's feeling that quality of life is declining (Eckersley, 2000). These sentiments are also felt in the United States where the majority of people think life is getting harder and life is not likely to improve (Eckersley, 2000). One suggestion about why people are more negative regarding national satisfaction than their life satisfaction is because wars, environmental destruction, and crime are not always experienced personally by the general public and therefore are not included in evaluations of life satisfaction (Eckersley, 2000). This may make subjective assessments of national satisfaction very useful in tracking national policies and programs since these assessments appear to measure these societal issues best.

While it is agreed that social-level satisfaction tends to be lower than life satisfaction, there is no consolidated and agreed upon domain list for social well-being. Using the neighborhood as our example, there are some common domains that are usually included in an evaluation of neighborhood well-being, including physical features (housing, location characteristics), social features (social embeddedness, sense of community), economic features, and safety (Sirgy and Cornwell, 2002; Amerigo and Aragones, 1997; Martinez et al., 2002; Christakopoulou et al., 2001; Cook, 1988). It is important to note that the domain of physical features does include aspects of the natural environment in some but not nearly all neighborhood well-being studies.

I propose that the quality of the natural environment in the neighborhood does contribute to the overall sense of neighborhood well-being and should regularly be included in domain assessments of neighborhood well-being. I base this assertion on previous empirical studies that strongly suggest that the quality of the natural environment may play an important role in perceptions of neighborhood well-being (Amerigo and Aragones, 1997; Sirgy and Cornwell, 2002; Christakopoulou et al., 2001; Kaplan, 1985). For example, Sirgy and Cornwell (2002) found that satisfaction with neighborhood physical features (i.e., upkeep of homes and yards, landscape in neighborhood, street lighting, crowding and noise, nearness to needed facilities, and perception of the quality of the natural environment) contributed significantly to an individual's feelings regarding their neighborhood and housing. More generally, Sirgy and Cornwell (2002) found that satisfaction with neighborhood social and physical features contributed to an individual's sense of neighborhood well-being. Similarly, Christakopoulou et al. (2001) found that items related to environmental quality and greenery and parks were important factors to be included in their community well-being questionnaire based on the results of factor analysis. Open natural space was identified as an important dimension of residential well-being in one of the studies cited by Amerigo and Aragones (1997). In a more direct look at the role of nature in neighborhood satisfaction, Kaplan (1985) found that "the strongest forces in predicting positive neighborhood satisfaction were trees and natural areas". Milbrath and Sahr (1975) found that 36% of their sample specifically mentioned that the ideal [residential] location would have ready access to nature. Similarly, Fried (1982) found that out of the residential environment factors, the strongest predictor of residential satisfaction using multiple regression analysis was 'ease of access to nature'. Ease of access to nature accounted for 10% of the variance in residential satisfaction, out of the 41% that was accounted for by the residential environment (Fried, 1982). In an outdoor recreation study, people who said that they lived in neighborhoods with many trees, clean air, not much traffic, safe streets, and that were not crowed, were more likely to evaluate their neighborhoods as favorable (Marans and Rodgers, 1975). Mesch and Manor (1998) found that aspects of the natural environment, such as the presence of open space and the lack of air pollution and noise, help create attachment to place. In a study of neighborhood satisfaction among elderly men, Jirovec et al. (1984) found neighborhood satisfaction to be positively correlated with the environmental characteristics of safety, beauty, quietness, space, and pleasantness. Kuo and Sullivan (2001) found that people living in neighborhoods with vegetation close by experienced fewer incivilities, less fear, less crime and violent behavior, than did people living in neighborhoods without nearby vegetation. Finally, in a study by Parkes et al. (2002), respondents who labeled the appearance of their neighborhood as 'less than very good' were more than four times as likely to say they were 'less than very satisfied' with their neighborhood than those who labeled their neighborhood appearance as 'very good'. Maller et al. (2002) summarize that "residents who have nature nearby, or who regularly pursue nature related activities, have greater neighborhood satisfaction, and have better overall health than residents who do not."

At the national level, Welsch (2002) finds that average happiness in a nation "moves systematically with their nation's per capita income and environmental conditions." This may largely be due to the fact that generally "the effect of lower pollution is largely attributed to higher per capita income." But, as an illustration using nitrogen dioxide to represent environmental pollution, Welsch calculates that a change from the level of nitrogen dioxide in Germany to the level in Japan would shift 8.25 percent of German urban residents down one happiness level.

<u>Importance of the Topic and Need for Additional Research</u>

As is apparent from the various studies on the impact of the environment on neighborhood satisfaction, additional focused research on the topic is worthwhile. Clues point to the natural environment as being critical for neighborhood well-being and also a factor in personal well-being. Additional research would be able to more closely determine the nature of these relationships and their level of importance. In chapters 3 and 4 of this dissertation, I present some new research on the topic, which supports the finding that the natural environment has a direct role in contributing to neighborhood satisfaction and an indirect role in contributing to life satisfaction. This research is only the beginning of what is planned to be a long term monitoring of these relationships in the Baltimore, Maryland region.

Already these data along with the literature reviewed here suggest to policy makers and urban planners that they must be mindful of the natural environment in all future plans and legislation. Considerations for the natural environment can have significant and substantial impacts on levels of life and neighborhood satisfaction. Decisions that impact natural lands and undeveloped lands must take into account the impact it will have on nearby residents and residents of future housing. As Kaplan and Kaplan (1989) have stated before, parks and landscaping are critical components of urban design and not optional amenities.

Chapter 2: "Smart Growth" and Dynamic Modeling: Implications for Quality of Life in Montgomery County, Maryland[1]

Introduction

The popularity of growth management initiatives in Maryland and country-wide illustrates the political and cultural interest in improving quality of life while protecting ecological systems and the potential for future development. An idea generally known as "smart growth." Yet, this relatively recent change in planning perspectives has not been in place long enough for the public and policymakers to understand the long-term effect of new initiatives on development patterns and quality of life.

Montgomery County, Maryland was one of the few jurisdictions that began planning in this manner long before smart growth was popularly named. Starting in the 1960's, Montgomery County began to direct growth into concentrated development and to protect agricultural lands. In 1979, about 91,000 acres were zoned as an agricultural reserve area (M-NCPPC, 1993a). Other initiatives such as the Wedges and Corridors program and transferable development rights (TDRs) have been adopted, mostly since 1980, to help protect open spaces and improve efficient land use in the county. Extensive data were collected by the county over this time period, but indicators to test the success of these initiatives are only being established now.

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Dynamic modeling provides the capacity to examine these initiatives and their effects on development patterns and quality of life over the long-term. By using historical data from 1970 to 2000, and projecting through 2050, our model depicts a simple development process that is affected by economic trends, growth management initiatives, and quality of life in Montgomery County.

Major Issues and Scenarios

A simplification of the complex development process, through necessity, our model extracts the relevant elements of the process to illustrate the changes in land development caused by different planning scenarios. We looked at three primary scenarios in our modeling process:

1. Business as Usual – Control Scenario, shows the impact of continuing the status quo policies and provides a baseline for comparison.
2. Environmental Focus – Environmental Development Scenario, shows the impact of making the development policies more environmentally friendly.
3. Build-Out – Development Scenario, shows the impact of reducing the use of growth management initiatives.

These scenarios are dictated by changes in the policies impacting land area for our three primary modeling sectors: natural space, residential land, and non-residential land (retail, office and industry, and paved area). The model's structure, major assumptions, and scenario constructs are discussed in later sections.

Literature Review

This model was created in the context of other literature and planning work in order to understand development dynamics and quality of life. Research on issues such as urban growth modeling and quality of life indicators are pertinent to this study.

Urban Modeling

Over the past thirty years, the process of modeling dynamic urban development has changed dramatically. From Forrester's Urban Dynamics to cellular automata and Geographical Information Systems (GIS), these attempts illustrate that urban changes are both challenging and complex to define.

One of the first contemporary works that attempted to model urban development was Jay Forrester's Urban Dynamics in 1969. Forrester creates a dynamic model of the growth and decay of a city. Starting from open land, the model illustrates the development of businesses and housing, and the growth of a population, and then represents its decline with the aging of its industry and population. Forrester's model lends insight into the construction of such a system and the importance of a multi-leveled model for shared understanding. Although our model focuses on land area consumed and the effects on quality of life, rather than the life cycle of the city as in Forrester's model, his contribution helps direct new dynamic development models.

More recently, researchers have looked towards cellular automata and GIS to create urban dynamic models. The use of cellular automata (Batty, 1997) allows the modeler to use a matrix of cells whose characteristics change from the repetitive application of simple rules. The cell's characteristic is dependent on the change in function of its neighboring cell. This process can be used to mirror the spatial development of a city, its land use, and its form. Through the rule making, different patterns of urban development are created. Similarly, GIS provides the modeler with a basis through which the graphic analysis of a city can be incorporated with multiple layers of data and characteristics to instigate urban change. The systems may be programmed to model dynamic changes, using the base information of analysis (Landis, 1995).

Quality of Life Indicators

The concept of "quality of life" (QOL) is part of a relatively new trend that evaluates country, state, or local health using multiple factors rather than focusing on a limited view of monetary or economic health.[2] There is growing consensus that measures of monetary health as they are calculated now and monetary measures in general are not adequate to assess the quality of life or sustainability of an area (Eckersley, 2000; Wismer, 1999; Giannias, 1997; Adams, 1998; Wiant, 2000; Henderson et al., 2000). Starting in the 1980's, revisions of and alternatives to GNP began to appear, including the Index of Sustainable Economic Welfare (ISEW) and the Physical Quality of Life Index (PQLI). The ISEW attempts to calculate GNP net all environmental and social costs caused by the generation of the national income (Henderson et al., 2000; Costanza et al., 2000; Ekins and Max-Neef, 1992). The PQLI incorporates measures of infant mortality, literacy, and life expectancy to generate an index of welfare (Ekins and Max-Neef, 1992). The United Nations combined the ideas of the ISEW and PQLI for ranking the health of nations in their Human Development Index (HDI; Ekins and Max-Neef, 1992). The HDI looks at

[2] Traditionally, countries have been rated or ranked according to their Gross National Product (GNP), which is the total market value of all the goods and services (available in the market) produced by a nation over a specified time period.

purchasing power parity, education levels, and life expectancy of countries and therefore is not only a measure of economic welfare.

As yet there is no consensus on exactly how quality of life should be presented either. The indices mentioned above combine various pieces of information into a single index, however, others such as Calvert-Henderson leave their indicators separate (Henderson et al., 2000). Because of this discrepancy in opinion, we present our quality of life evaluation in a transparent manner. We show the model user each of our individual indicators and allow him or her to determine how each of the indicators should be weighted for inclusion in the summary indices and the final overall quality of life index.

Study Area

Location

Montgomery County is located in Maryland, northwest of Washington, DC. The county is bordered by the Potomac River on the west and the Patuxent River on the east. The county consists of 497 square miles of land and ten square miles of water. About 45,349 acres of county land was parkland as of 1993 (M-NCPPC, 2000a). As a member of the Washington, DC metropolitan area, the county is part of a larger economic system. Flows of population and jobs occur across the state border with Virginia and DC, as well as with neighboring Maryland counties of Prince George's and Frederick.

Population and Development

Montgomery County is the most populous and affluent county in Maryland (M-NCPPC, 1993a). Over the past 20 years, the county has grown at a faster pace than the nation, 2.1 percent versus one percent. As of 2000, the county contained an estimated 873,341 people (US Census Bureau, 2000). The median household income in the county was $71,614 in 1999 as compared to $40,816 nationally (M-NCPPC, 2000b; US Census Bureau, 1999). Although the balance between in-county jobs and the resident workforce is strong, only 58 percent of residents work in the county (M-NCPPC, 2000a).

Table 2.1: Montgomery County Demographics at a Glance

	1990	2000	At Build Out*
Population	757,027	873,341	
Jobs (At-place)	465,970	536,000	1,000,000
Housing Units	295,723	334,632	480,000

*County estimation using existing zoning.
Source: M-NCPPC 1993a, U.S. Census Bureau, Census 2000; Research & Technology Center, M-NCPPC.

Model Description

The model simulates land use change in Montgomery County, MD using population growth simulation and factors affecting land development. It then evaluates the impact of these land use changes on quality of life indicators. Model design is based on five main sectors: natural space, residential land area, non-residential land area, population growth, and quality of life indicators. Land use is broken down into residential, non-residential, paved area, protected natural space, and agricultural reserve. Acreage information from the county was available by land use type, not zone type. Because of this, our model refers to capacity by land use acreage, not zoned area. The county estimated that existing zoning will reach maximum housing unit capacity by 2013 and job capacity before 2040 (M-NCPPC, 1993a). Given the limit to development with existing zoning, we assume that zoning would be variable for all uses over the fifty-year horizon.[3] The quality of life indicators will be discussed further in a later section.

The model was created with the simulation package STELLA running on an IBM compatible Windows computer. The model has five distinct but interacting sectors that calculate over a time frame of 1970 to 2050. The model uses a time step of one year using the Euler integration method.[4] A time step of one year was determined to be most appropriate because of the long-term time horizon of the analysis. Neither smaller time steps nor different integration techniques changed model response. Detailed equations and parameters of the model are available for review in Appendix A and at http://www.uvm.edu/giee/DMEES/Arch/.

Natural Space Sector

The natural space sector models the change in classification of non-developed land into either protected natural space or the agricultural reserve and tracks the loss of developable land into other land uses (Figure 2.1). The shift from non-developed land into protected natural space is based on county and state investments in land acquisition. State investments are based on an average annual investment. County

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[3] Currently, land in the County's Agricultural Preserve Zone can be developed at one unit per twenty-five acres. We assume that over the fifty year horizon of the analysis, this would be variable, along with the other zones.

[4] Euler integration is one of the most straightforward and simple methods for solving differential equations and is a common method used in STELLA modeling (Haefner, 1996).

investments before 2000 are based on historical data, but after 2000, investments are determined from the average annual investment impacted by the national economic condition and the remaining developable land. Movement of land into the agricultural reserve is based on the sale of TDRs and the amount of land preserved per unit sold, when TDRs apply (1980 and after).

Figure 2.1: Natural Space Sector

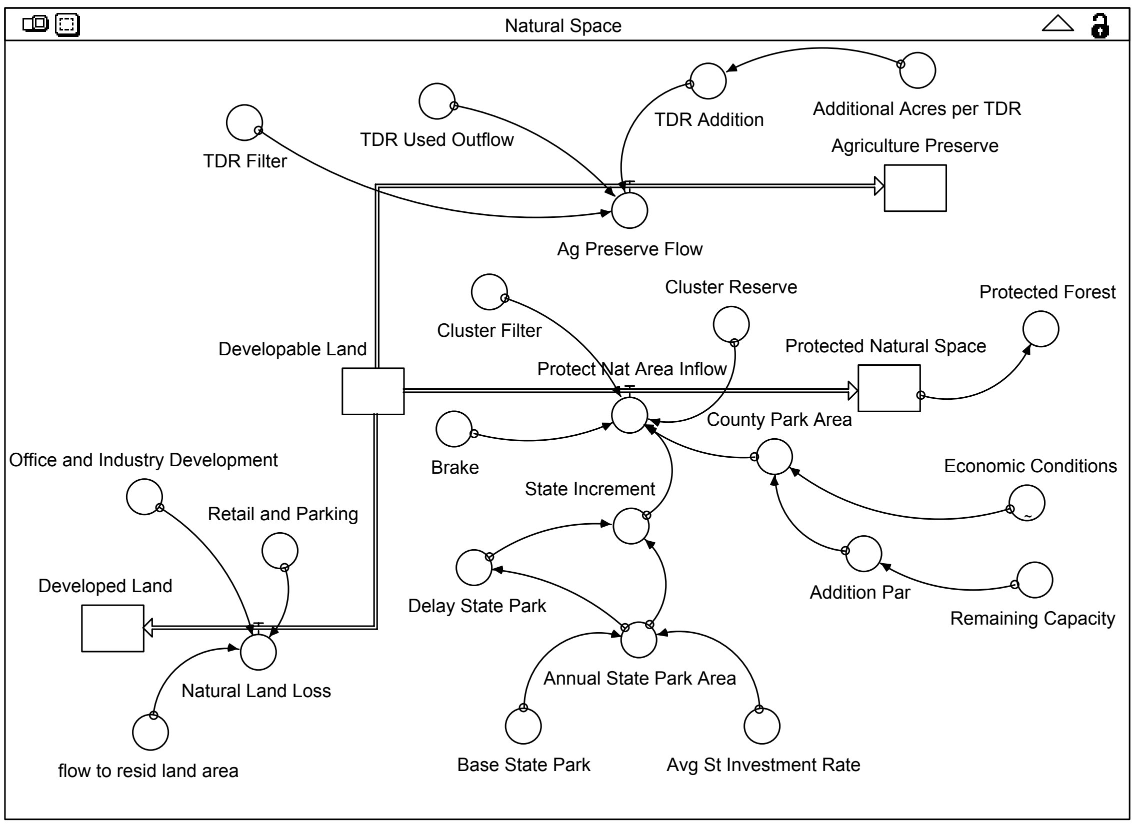
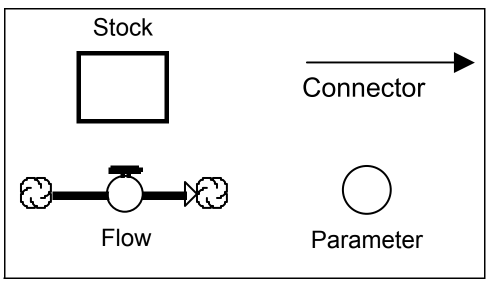


Figure 2.2 below presents the individual model components seen in the figures of the STELLA model sectors. Stock variables or accumulations are represented by a rectangle in the model. These variables collect what flows in net what flows out (High Performance Systems, 2001). The flow variables are represented by the

complex arrow with control icon. Flows fill and drain stocks and the arrow shows the direction of flow (High Performance Systems, 2001). The parameter variables represented by circles in the model hold values for constants, defining external inputs to the model. They can also calculate algebraic functions or be a graphic function (High Performance Systems, 2001). Finally, the simple arrows in the model represent connectors. Connectors simply connect model elements so that they can be included in the same model calculations and functions (High Performance Systems, 2001).

Figure 2.2: Legend of STELLA Model Components



Residential Space Sector

The residential sector models the conversion of non-developed land into residential units, as illustrated in Figure 2.3. On the most basic level, the annual development of residential land is based on the number of new households in the county and the number of TDRs used for development. TDRs can be used to increase densities of residential land use from single family detached (SFD) to townhouses or from large lot SFD to small lot SFD (applied as transition from one acre to quarter acre average lot sizes). As population density increases, a larger portion of TDR housing units are converted from SFD to townhouse units because of a decrease in developable land availability.

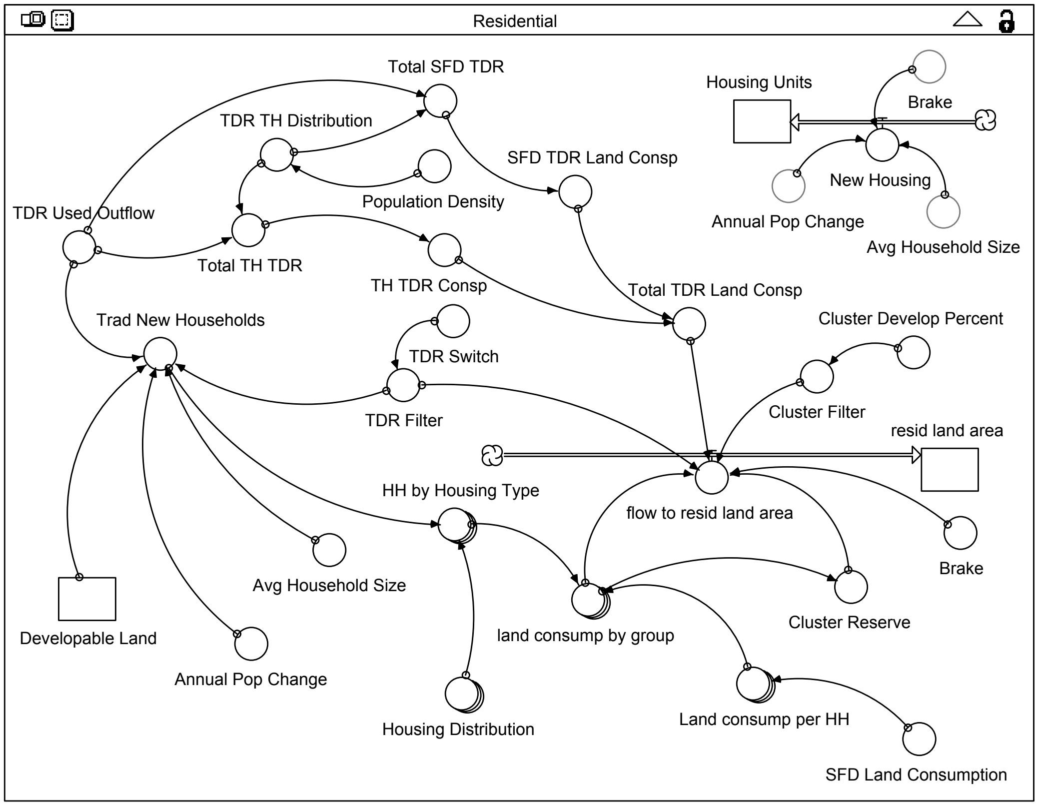
The traditional housing needs are determined based on the number of households still needing housing after TDR housing development. Traditional housing development is then distributed between multifamily housing (30.6 percent), townhouses (17.4 percent), and single family detached (52 percent) based on 1990 US Census figures for Montgomery County.

The number of TDRs bought in any year is based on the ratio of sending[5] to receiving[6] TDRs, not in my backyard (NIMBY) tension, and the annual TDR potential (maximum annual sale). The ratio of sending to receiving TDRs is important because TDRs are more likely to be used when there are proportionately more receiving TDRs than sending. The NIMBY feelings are impacted by remaining development capacity such that people are more likely to object when the higher density areas will be built close to them. Therefore, public pressure against increased densities and the potential to apply TDRs to the land chosen for development may limit their use. In addition, the development process and community pressure introduce some random variation in TDR potential use.

[5] Sending TDRs are the number of TDRs that can be bought from relevant agricultural land.

[6] Receiving TDRs are non-developed lands that have been designated by the county as capable of absorbing additional residential units above the original zoned density.

Figure 2.3: Residential Space Sector



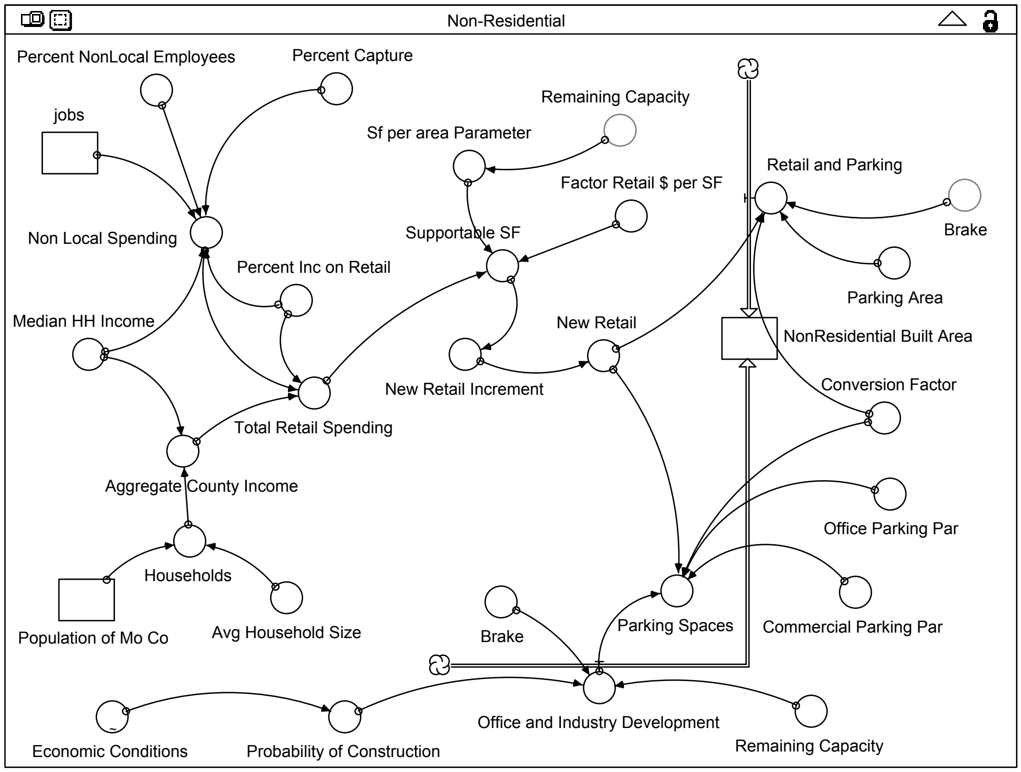
Non-residential Space Sector

The non-residential built sector includes the development of commercial or retail space, office space, industrial space, and paved area (Figure 2.4). We calculate the development of commercial and retail space separately from office and industrial space. The development of paved area is included in the non-residential built sector total and is determined by the amount of single story parking needed for commercial and office/industrial space. Road area is considered static in our model. The development of commercial space is based on the retail square footage supported by consumer spending and the land capacity pressure to build commercial space as single story space or at increased densities (multiple story buildings). Consumer spending from people living in the county is calculated from median household income and percent of income spent on retail as listed in the Consumer Expenditure Survey, 1997-1998 (M-NCPPC, 2000b; Bureau of Labor Statistics, 1998). Consumer spending from county non-resident employees is based on the number of jobs in the county, median household income, percent of people commuting to the county for work (US Census Bureau, 1990), percent of income spent on retail, and percent of spending captured within the county. If spending can support new space then commercial space is developed in the model.

Office and industrial development is based on available land and the probability of construction, which is based on the national economic condition. As the economic condition of the nation improves, new office and industrial space is more likely to be constructed.

The amount of both commercial and office/industrial acreage developed are then used to determine the number of new jobs in the region. This is a feedback loop in commercial development since new jobs add to the consumer spending and consumer spending creates new jobs.

Figure 2.4: Non-Residential Space Sector

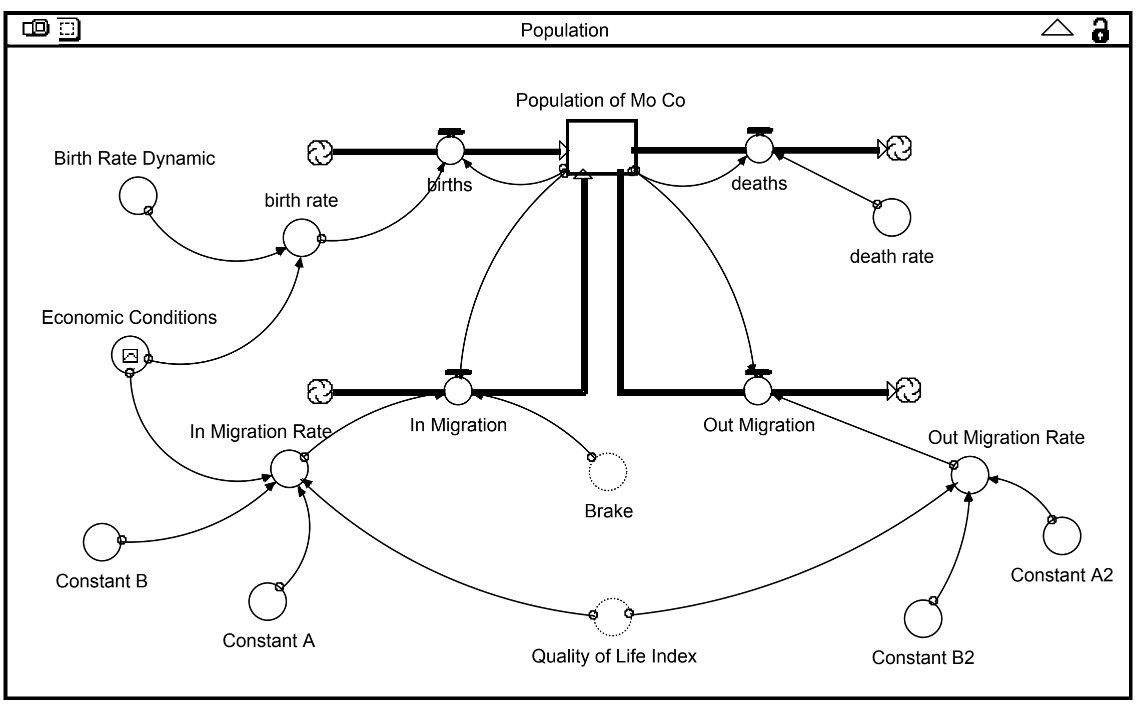


Population Sector

The population sector drives the residential and non-residential sectors whereby an increase in population causes an increase in new households and spending. This sector also incorporates a feedback from the quality of life index, which increases or decreases the desire to move into or out of the county. In addition, the national economic condition is an integral part of the population sector. The national economic condition is modeled as a graph ranging from 0 to 1, rating the health of the national economy. It follows historic economic health through the year 2000 and continues the cyclic pattern that developed to estimate future economic conditions. This is a rough estimation of economic conditions but was the best way to model the typical upward and downward swings in the health of the economy. The values on the graph for each year are used as the actual inputs to the model for each year and represent an economic health index value.

Population is modeled using births, deaths, immigration, and emigration (Figure 2.5). The birth rate is based on historical data but is also impacted by national economic conditions, noted above. The death rate is only based on historical data because it was virtually static over the period from 1970 to 2000. Immigration and emigration are impacted by the quality of life in the county, while immigration is also impacted by the economic condition. These impacts are defined with different parabolic curve equations that are tested in the sensitivity analysis described later.

Figure 2.5: Population Sector



Quality of Life

This aspect of the model calculates a variety of indicators based on different parameters from throughout the model. We use these individual indicators to create three grouped quality of life indices: environmental health, economic health, and social health. These three indices are then used to create an overall quality of life index. Each index and its indicators are weighted, allowing each user to determine which aspects of the index are most important to his or her analysis. An interface page is available to change the weights. Our overall quality of life index combines the three grouped indices, each weighted equally for the purposes of this analysis.

The specific indicators listed in Table 2.2 and detailed below were chosen for the following three reasons: ability to calculate using parameters simulated in our model, they are mentioned in other quality of life literature or in the State of Maryland's draft list of Smart Growth Indicators, and likelihood of public interest (subjective selection). There is significant literature on quality of life indicators and much discussion of which ones may be best to evaluate the health or well-being of an area (Henderson et al., 2000; Wiant, 2000; Wismer, 1999; Ekins and Max-Neef, 1992; Terleckyj, 1975; MDP, 2000).

Table 2.2: Quality of Life Indices and Indicators

Environmental Index	Economic Index	Social Index
Ecosystems Indicator Water Quality Indicator Energy Indicator Percent Open Space Indicator	Percent Capacity Indicator Tax Ratio Indicator Job Growth Indicator Land Conversion Indicator	Residential Density Indicator Job Ratio Indicator Agricultural Land per Capita Indicator

We reviewed the literature and incorporated many of those indicators, but found that our model places some limitations on the actual indicators that could be measured. First, because our model is not spatial, we are unable to model indicators such as air quality, amount and disposal of solid waste, levels of congestion, commuting time, use of mass transit, auto accidents, noise levels, and crime. All of these indicators require some information regarding location of residents within the county and varying levels of density within the county. Our model operates at the aggregate level and is not based on spatially populating the county. Second, some parameters that would be relevant indicators are used as inputs for the model. Due to this structure, we are unable to include them as valid indicators of quality of life. For example, change in median household income is calculated as an input to the model and therefore cannot be used to measure the health of the county. Third, the ratio of property and income tax collected to county services provided was not used as an indicator because it seemed likely that the ratio would not be extensively dynamic but rather that services provided would change as the amount of property and income tax collected changed. Therefore, this ratio would not provide an interesting addition to the economic health index. We do agree, however, that future research should incorporate more of these quality of life indicators that are of interest to the public and policymakers whenever possible.

We also make assumptions regarding the calculation and weighting of our indicators. To date, no comprehensive surveys have been implemented in the county to evaluate the public's opinion regarding the priorities between quality of life issues. Without such information, we attempt to weight each group of indicators according to our idea of public opinion and also to minimize the impact of indicators that have little variation across the scenarios. Obviously, additional research is needed to substantiate the weights used. Due to this limitation, the interface page of the model allows the user to change the weighting of each indicator. Changing the weighting of the indicators could change the value and pattern of the different QOL indices. Interested parties may download the model and adjust the indicator and index weighting as they wish. All equations and model visuals for the quality of life indicators can be found and downloaded at http://www.uvm.edu/giee/DMEES/Arch/.

Environmental Health Index

The environmental health index attempts to combine major indicators from the model that are affected by increased development. Environmental health is defined as the weighted average of the ecosystems indicator, energy indicator, percent open space indicator, and water quality indicator. Each of these individual indicators is briefly described below.

- The ecosystems indicator represents the economic value of ecosystem and social services provided by the forest and water areas within Montgomery County. These economic values are from Costanza et al. (1997), which provided economic values for the services provided by ecosystems and natural capital.
- The energy indicator calculates the amount of electricity consumed by the residential and non-residential built areas. Residential electricity consumption is based on total households per residence type, while non-residential electricity consumption is based on the average electricity consumption per

square foot value by land use type (EIA, 1995). Since total energy consumption increases with development, this factor is subtracted from one in order to reflect its negative impact on the environment.

- The percent open space indicator shows how much of the county is still non-developed open land or preserved natural and agricultural land.
- The water quality indicator is calculated by determining the proportion of total county land area used for agriculture or covered by an impermeable surface (residential and non-residential space). It has been shown that agricultural and urban run-off can have a negative impact on water quality, therefore the greater the proportion of land with these uses, the worse the water quality (Costanza et al., 2001; Castelle et al., 1994; Hessen et al., 1997; Correll et al., 1994).

To create the environmental health index, we assume that open space is most important with a weight of 40 percent, water quality next important with 35 percent, energy use at 15 percent, and ecosystem value at 10 percent of the total index. The ecosystems value indicator does not vary widely in the model scenarios described below. Therefore, this factor is weighted less to highlight the variations in the other indicators.

Economic Health Index

The economic health index reflects the positive impacts of development on economic well-being while incorporating long-term capacity constraints. This index is the weighted average of the tax ratio indicator, percent remaining capacity for development indicator, annual conversion of open land to developed land indicator, and annual job growth indicator. These indicators are each briefly described below.

- The tax ratio indicator is the calculation of annual sales tax collected divided by total possible sales tax at build-out. This provides a sense of consumer confidence and level of disposable income.
- The percent capacity indicator calculates the percent of remaining development capacity in the county. Capacity reaches zero at build-out and is considered to negatively affect economic health as it decreases.
- The land conversion indicator calculates the rate of natural land loss (conversion) per year. This evaluates the efficiency in land development to use less land for development each year. To reflect a process of limiting sprawl, development would still take place but use fewer acres.
- The job growth indicator portrays economic health by looking at the rate of job growth per year.

We weight the percent development capacity at 50 percent, the job growth indicator at 30 percent, the conversion indicator at 10 percent, and the tax ratio indicator at 10 percent of the total economic index.

Social Health Index

The social health index combines factors that reflect resident satisfaction with the county and enjoyment of their living environment. The index is the weighted average of job ratio per housing unit indicator, residential density indicator, and agricultural land per capita indicator. The individual indicators are presented below.

- The job ratio indicator presents the number of jobs per housing unit in the county, indicating the likely employment level within the county. This can reflect issues of accessibility to jobs and resident choice to reduce time spent commuting to work.
- The density indicator is calculated as the population per residential acre and provides a way to track urbanization. As development reaches maximum densities, the indicator decreases.
- The agricultural land per capita is the total agricultural land in the county divided by the county population. This ratio is important to people who desire the proximity of agricultural land.

The job ratio indicator is considered most important at 60 percent, the density indicator is weighted 25 percent, and the agricultural land per capita is weighted 15 percent.

Management Scenarios

The onset of smart growth in the planning field during the last decade and its effects on ecosystem preservation and quality of life seem to be momentous. Attempting to promote growth for efficient use of jurisdictional resources, while preserving open space and improving community cohesiveness, these policies combine universal interests for successful development. The Maryland Department of Planning created initiatives in Maryland in 1997 to help attain these goals throughout the state. Since then, numerous states have modeled their own development programs after the initiatives created in Maryland. Some overarching programs and the specific initiatives portrayed in this model are subsequently explained along with the specific model variables that are affected.

The management options include four scenario variables: TDRs, cluster development, forest versus agriculture development, and average SFD lot size. These variables, along with the indicator weights, are interactive inputs for the user to define. This allows the user to test the effects of different policy decisions and priorities on QOL and land development patterns. Each variable reflects an aspect of development policy in Montgomery County over the past 40 years.

Cluster Development and Forest Preservation

In 1961, county officials and residents recognized the importance of disappearing open space and created a guiding policy to protect these land types. The Wedges and Corridors plan promoted growth that focused on Washington, DC as the regional center and expanded development along major transportation corridors radiating from the city in all directions (M-NCPPC, 1993a). Each corridor would be separated by wedges of open space and serviced by multiple transportation options. M-NCPPC was the only planning authority in the metropolitan area to officially adopt this proposal in the 1960's.

Today, this program helps guide zoning and densities throughout the county (M-NCPPC, 1993a). Two of the major policies instigated through this plan include cluster development and forest preservation. Cluster development encourages development with smaller lot sizes (one-quarter acre, in general) or townhouses, allowing the developer to conserve one-third of the parcel for open space. It reduces developer costs for roads and sewage, decreases the amount of impervious surface, and increases the amount of open space (Church, 2000; Mega et al., 1998). The model's cluster development variable determines what percent of SFD development will be in cluster-type development.

Forest preservation became a priority, simultaneously, as an important characteristic of the Wedges area. For our model, development on open space may be directed towards forested or agricultural lands, depending on the policy preferences of the county leadership. The forest development rate parameter determines what portion of forested land will be developed before agricultural land is used, or vice versa.[7]

Transferable Development Rights and Lot Size

Another one of the successful programs to come out of the Wedges and Corridors program is TDRs. In 1980, the county began to protect the Wedge of agriculture in the northern part of the county by selling development rights from agriculture land. This program allows developers to purchase development rights from agriculture landowners for added residential density in the central and down-county area (Daniel, 1999). Each right is connected to five acres of agricultural land. The program gives farm owners an economically viable alternative to selling their land for residential development and attempts to minimize residential sprawl in the agricultural region. The use of TDRs to support agriculture has been extensively implemented to date and continues to be used. In this model, the TDR variable allows the user to end TDR use or to vary the number of agricultural acres associated with each TDR bought.

[7] Maryland's Forest Conservation Act of 1991 may reduce the effect of development on forested land, but the viability of newly planted trees and environmental services provided is questionable.

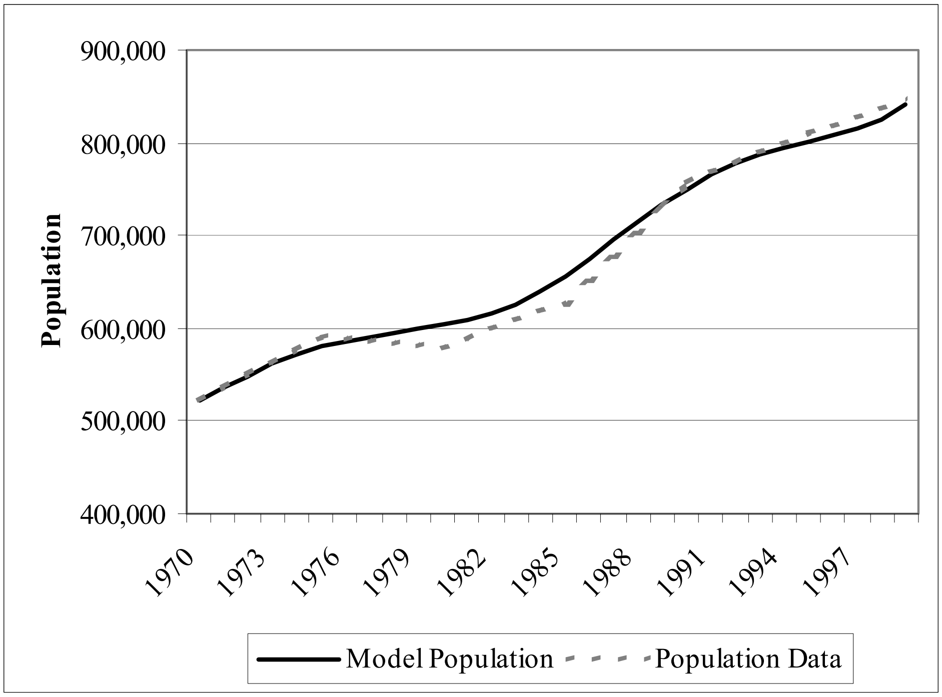
The SFD lot size is also affected by the use of TDRs in development projects. TDRs increase development density and reduce the lot size per unit. This parameter is also chosen for user input because of the incredible effect that a change in average lot size can have on development in the county.

Results

Calibration Results

To calibrate our model, we compare our model output to county data available on the Montgomery County website (www.mc-mncppc.org). The best data set available for calibration was county population between 1970 and 2000. We are able to simulate population growth similar to their data using birth rate, death rate, immigration, and emigration factors and the parameters that impact them. Percent error in our population simulation between 1970 and 2000 never exceeds 4.6% and is at or below 1.0% for the majority of the time period, showing our model's ability to reproduce past population trends (Figure 2.6).

Figure 2.6: Population Calibration



We also calibrate to benchmark data on land use acreage, number of housing units, and number of jobs in the county. M-NCPPC provided data on land use acreage for the years 1960 and 1991. Data for 1970 was estimated by applying the average annual growth rate from 1960 to 1991. The calculated values for 1970 were used as the starting acreage values for the model. The summary of land uses does not follow the same breakdown as our model so we aggregated our numbers for comparison. As you can see in Table 2.3, our model output comes close to matching the 1991 benchmark data on land use acreage.

Table 2.3: Land Area Calibration Data

Year	Residential Land			Non-residential Land			Park Land		
	Model (acres)	Data (acres)	% Error	Model (acres)	Data (acres)	% Error	Model (acres)	Data (acres)	% Error
1991	81,450	93,500	12.9	17,766	18,473	3.8	36,378	33,954	7.1

Source: M-NCPPC 1993b. 1970 data were estimated from average growth rate between 1960 and 1991 from Fact Sheet information.

We also obtained data on jobs in Montgomery County and our model estimation came close to the data in 1989 and 1999. For 1989, our model estimation of county jobs is a bit low, 432,000 versus 450,848. However, for 1999, our model estimation is quite close, 508,000 versus 503,000. This parameter further substantiates the skill of the model to reproduce past trends, on average.

County data on the number of housing units proved to be the hardest data to match. Our model seems to underestimate the number of housing units created while matching residential land use quite well. This may be because of the omission of a vacancy rate. Although our parameters concerning distribution of residential unit types constructed and amount of land used per residential type are based on county data, it seems some change in these values might be appropriate. For 1990, the model generates 235,000 housing units while county data lists 296,000 housing units (M-NCPPC, 2000a). Neither benchmark nor annual data are available for any other model parameters.

Sensitivity Analysis

We evaluate the sensitivity of our model to select parameters to help us understand model behavior. We look at sensitivity to economic condition, two constants that affect how QOL impacts immigration, forest development rate, acres per TDR, and acres per SFD lot.

The economic condition is used as a variable in the calculation of immigration, birth rate, office and industrial development, annual county parkland additions, and median household income. Economic condition has the greatest impact on the immigration rate and was one of the main factors involved in calibrating our model to population data. However, the impact of the economic condition on birth rate, office and industrial development, annual county park additions, and median household income does not prove to be substantial. The sensitivity analysis conducted on the economic condition parameter was somewhat informal due to the fact that the parameter was a graph. We methodically raised and lowered relative economic peaks and recessions until the simulated population growth followed the same historical peaks and valleys that the data presented.

To further calibrate the population, we perform sensitivity analyses on two constants that shape the relationship between QOL and immigration.

Equation 2.1:

$$In\_Migration\_Rate = \frac{(Constant\_A \times QOL\_Index)}{(Constant\_B + QOL\_Index)} \times Economic\_Conditions$$

Equation 2.1 generates a parabolic saturation curve that allows the immigration of people to Montgomery County to increase as quality of life improves but it does not exceed a maximum threshold. We vary constant A between 0.15 and 0.2 finding the best value for population calibration to be 0.165. We vary constant B between 0.8

and 1.1 finding the best value to be 0.9. With these parameter values, the simulated population growth matches the population data sufficiently, with percent error never exceeding 4.6%.

We also conduct sensitivity analysis on some of our policy variables to determine the realistic range for these factors. Forest development rate values below 0.4 (40 percent) usually cause the model to develop all available agricultural land before the end of the simulation, with developable agricultural land running out anywhere from 2005 to 2040. With no remaining agricultural land to exchange for TDRs, this also stops any further use of TDRs. For values above 0.4, the model results are very similar, depending more on the randomness in TDR use than on the percent of forest land developed before agricultural land. The environmental health index, however, does show some sensitivity to variation in this parameter. Although the ending values are quite similar (0.36 to 0.38), there is significant variation in the index between 1990 and 2020, from 0.44 to 0.55 at the widest point in 2004.

The model is also sensitive to the parameter, acres per TDR, which causes the model to run out of developable agricultural land for higher values of agricultural acres preserved per TDR. At values of 19 acres per TDR (14 additional acres per TDR), the agricultural reserve reaches a maximum around 2020 of about 66,000 acres. It reaches its maximum size at lower values of acres per TDR too but only later in the simulation.

Finally, we also conduct sensitivity analysis on the average SFD lot size, ranging from 0.5 to 3 acres. This results in residential land area developed ranging from 133,000 to 175,000 acres and final population values of 1,097,000 to 830,500.

As is obvious, the model proves to be rather sensitive to this parameter since it drastically impacts the residential land area developed and also limits population growth. Population begins to drop off in the last 20 years for runs of average lot size greater than 1.75 acres because of the lack of developable land for construction of new housing. Our sensitivity analysis also determined that the final environmental health index value ranges from 0.41 to 0.33, decreasing as the average lot size increases. The reason for this decrease is because larger lot sizes result in more land developed for residential use, which has a negative impact on the water quality indicator as described earlier in the section on the environmental health index.

Scenarios

Here we present and compare the results of the different scenario runs of our model: control, environment, and development. As described earlier, the control run is the best estimate of policies currently being used in Montgomery County and sets a baseline of the status quo. Past the year 2000, the control run assumes no change in policies and presents a view of the future with no changes. The environment scenario presents the outcome of enacting more environmentally-friendly policies after 2000. The development scenario shows the impact of ending the current growth management policies after 2000. Table 2.4 compares policy variables between the different scenarios. These are the only model parameters that change between simulations and they only vary for the time period 2000 to 2050.

Table 2.4: Comparison of Policy Use Across Scenarios

Policies	Control Scenario	Environment Scenario	Development Scenario	Variable Range
TDR use	Yes	Yes	No	Yes/No
Additional TDR acres	None	5 acres	None	0 - 20 acres
Cluster development	10%	50%	0%	0% - 100%
SFD lot size	1 acre	0.75 acres	3 acres	0 - 5 acres
Agriculture vs. forest land	50% on forest land	25% on forest land	100% on forest land if possible	0% - 100%

In the control scenario, the majority of land is developed into residential land during the model simulation and reaches 146,482 acres in 2050. The next greatest land use is protected natural space and then the agricultural reserve (Table 2.5). Non-residential land use requires the least amount of land, only 23,196 acres by 2050. In this scenario, population grows to about one million people and then plateaus, fluctuating around one million from 2020 to 2050. County job availability grows with non-residential land area, reaching about 800,000 jobs in 2050.

The results of the environmental scenario are similar to that of the control scenario. In terms of land area, the environmental scenario results in less residential area but more protected natural space and agricultural reserve and about the same amount of non-residential land area (Table 2.5). The environmental scenario also reaches a population of about one million with number of county jobs at just under 800,000 in 2050.

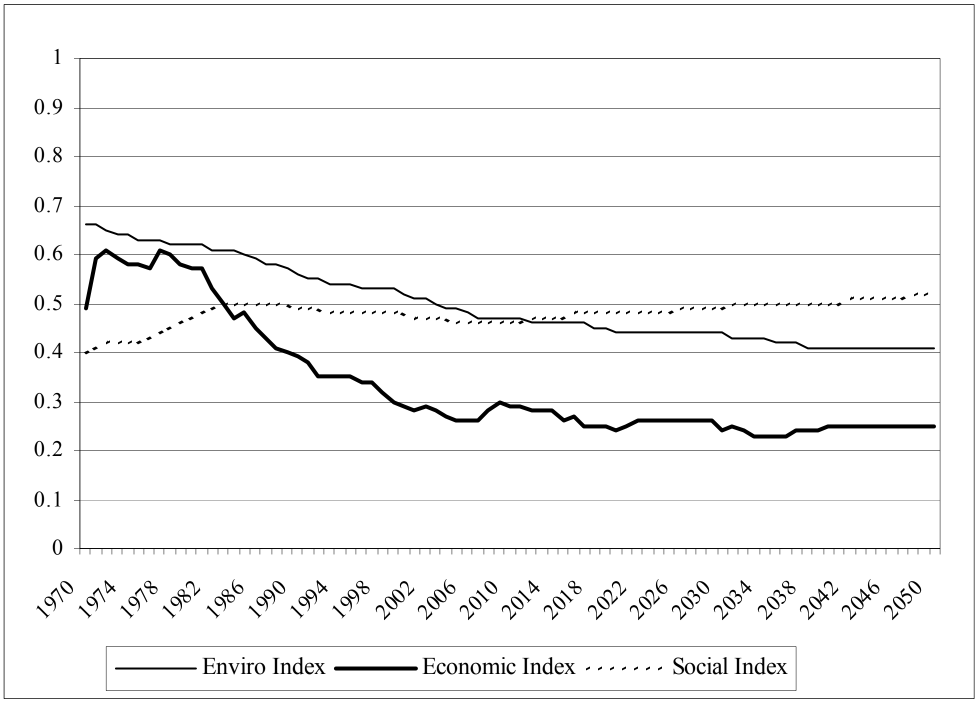
The development scenario results in much greater residential land use but less protected natural area and agricultural reserve. However, about the same amount of non-residential land use results in the development scenario as in the control and environmental scenarios (Table 2.5). The development scenario also results in the smallest county population, reaching an asymptote around 850,000 people rather than close to one million like the other two scenarios because of limited developable land near the end of the modeling simulation. With the smaller population, fewer county jobs are created as well, only reaching about 730,000 jobs in 2050.

Table 2.5: Land Area Comparison Across Scenarios

	Residential (acres)			Non-Residential (acres)		
Time	Control	Environment	Development	Control	Environment	Development
1970	37,500	37,500	37,500	13,210	13,210	13,210
2000	98,796	99,941	96,880	18,600	18,607	18,601
2030	135,269	129,369	162,530	21,538	21,609	20,882
2050	146,482	139,195	174,305	23,196	23,345	22,151
	Protected Natural Space (acres)			Agricultural Preserve (acres)		
Time	Control	Environment	Development	Control	Environment	Development
1970	20,054	20,054	20,054	0	0	0
2000	43,632	43,671	43,574	27,976	26,413	25,381
2030	54,712	58,760	53,061	40,842	45,999	25,381
2050	62,331	67,747	60,086	43,314	45,999	25,381

Figure 2.7 displays the quality of life indices for the control run. This graph shows the variation in the environmental, economic, and social indices. The environmental index ranges from 0.66 to 0.41, decreasing over time. The social index increases slightly over time from 0.40 to 0.52. The economic index decreases from a height of 0.60 and then asymptotes around 0.25. The overall quality of life index is an average of these three and as a result decreases slightly from about 0.55 and then asymptotes at about 0.39 with slight variation.

Figure 2.7: Quality of Life Indices, Control Scenario



The environmental scenario remains close to the control values for the QOL indices (Table 2.6). Table 2.6 shows that the environmental and economic indexes for the environmental scenario are slightly higher but that the social index in the environmental scenario ends slightly lower than the control. Finally, for the overall quality of life index, the environmental scenario is highest, ending at 0.40.

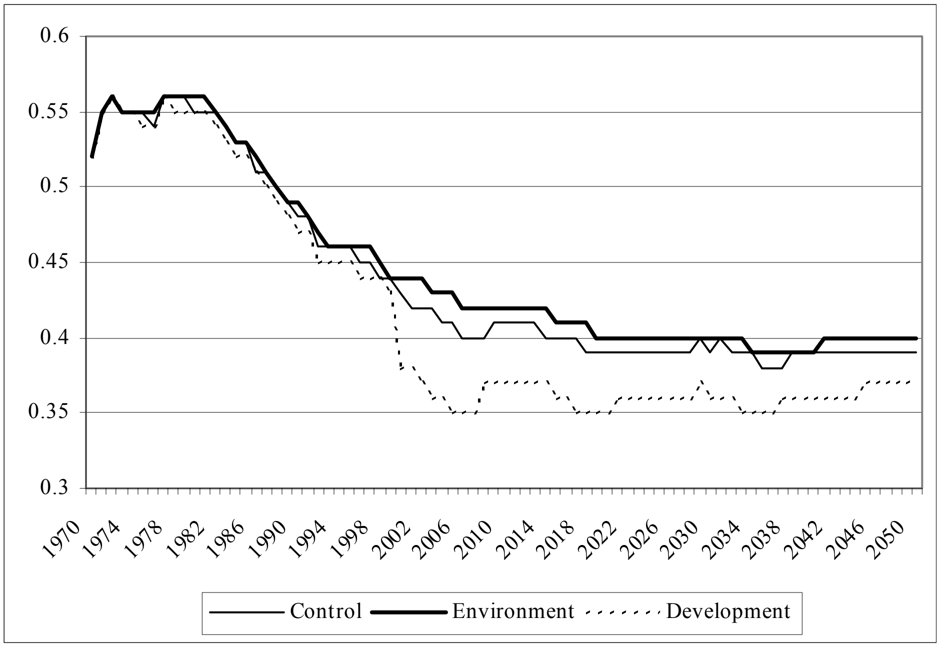
All the quality of life indices except the social index are lower in the development scenario (Table 2.6). The environmental index is substantially lower, ending at 0.35. The economic index ends only slightly lower at 0.24, and the social index in the development scenario is equal to the control, ending at 0.52, only 0.01 higher than the environmental scenario. Finally, the overall quality of life index for the development scenario is lowest, ending at 0.37 and reaching a low point of 0.35.

Table 2.6: Quality of Life Comparison Across Scenarios

	Overall Quality of Life Index			Environmental Health Index		
Time	Control	Environment	Development	Control	Environment	Development
1970	0.52	0.52	0.52	0.66	0.66	0.66
2000	0.43	0.44	0.38	0.52	0.55	0.46
2030	0.39	0.40	0.36	0.44	0.47	0.37
2050	0.39	0.40	0.37	0.41	0.43	0.35
	Economic Health Index			Social Health Index		
Time	Control	Environment	Development	Control	Environment	Development
1970	0.49	0.49	0.49	0.40	0.40	0.40
2000	0.29	0.31	0.17	0.48	0.47	0.49
2030	0.24	0.24	0.23	0.49	0.49	0.49
2050	0.25	0.26	0.24	0.52	0.51	0.52

Figure 2.8 shows how the overall QOL index changes over time for the three model scenarios. The control and environment scenarios have very similar patterns and values for the QOL index while the development scenario falls a bit lower after the year 2000. The overall QOL index for the development scenario is lower because of two of the indices that make up the overall QOL index, the environmental index and the economic index. Variations in those indices are discussed below.

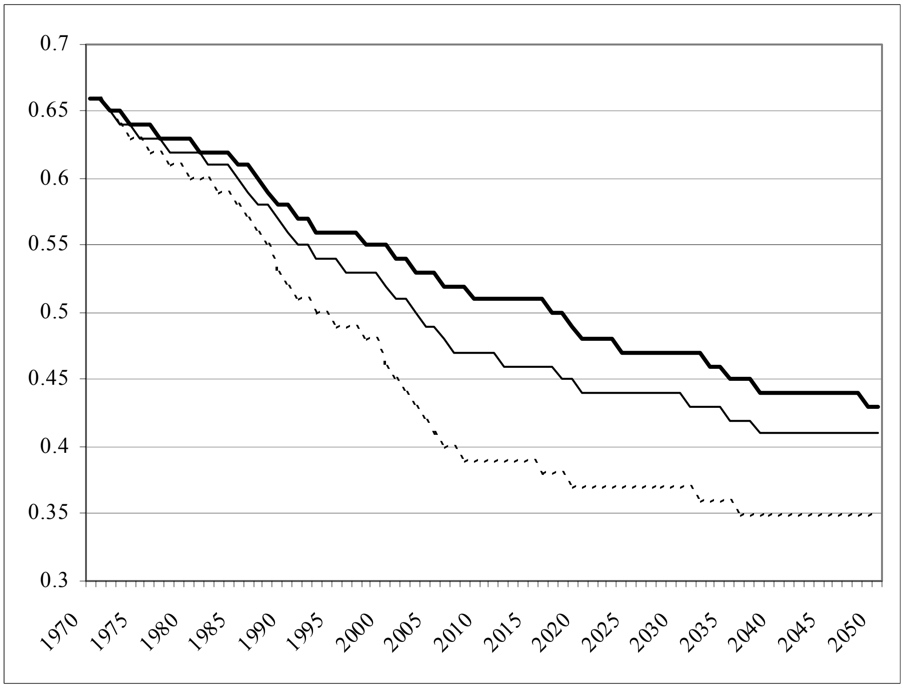
Figure 2.8: Quality of Life Index Comparison Across Scenarios[8]



Variation in the environmental index across the three model scenarios can be seen in Figure 2.9. This index had the greatest variation among the three model scenarios. This variation is largely due to the different amounts of developed land in the three scenarios and what type of land was chosen for development. The environmental index is based on open space, services provided by ecosystems (on undeveloped land), water quality (which is best when impervious surface is limited and agricultural land is limited), and amount of energy used (less energy use is better and more energy is used when more land is developed). As a result, the environmental scenario has the highest environmental index value, followed by the control scenario and the development scenario has the lowest value. The index has a downward trend in general since land continues to be developed in all the scenarios.

[8] The legend provided in Figure 2.8 should also be used for Figures 2.9 – 2.11.

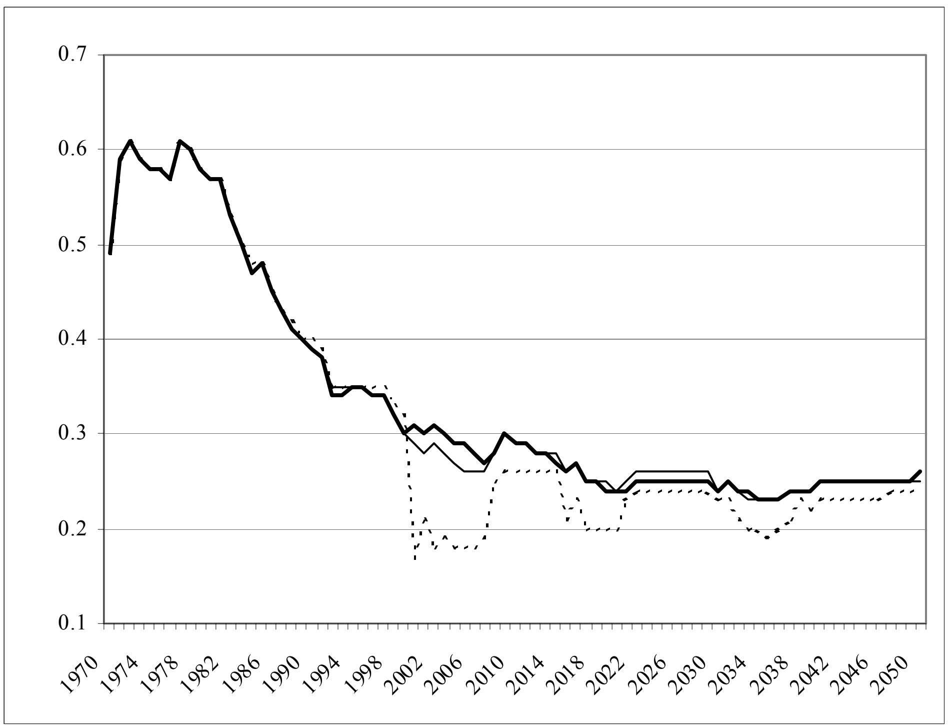
Figure 2.9: Environmental Index Comparison Across Scenarios



The economic index is presented for the three model scenarios in Figure 2.10. The values for this index for the control and environmental scenarios are almost identical. This is probably because these scenarios have similar population and job levels and similar amounts of developed land, as these are all important factors contributing to the indicators within the economic index. The economic index is based on the tax ratio, percent development capacity, land conversion, and job growth. The development scenario stands out in this graph due to the significant dips in the index for three time periods. These fluctuations, visible only in the economic index for the development scenario, are a result of periods of rapid residential development in that scenario. The first and most drastic event occurs right at year

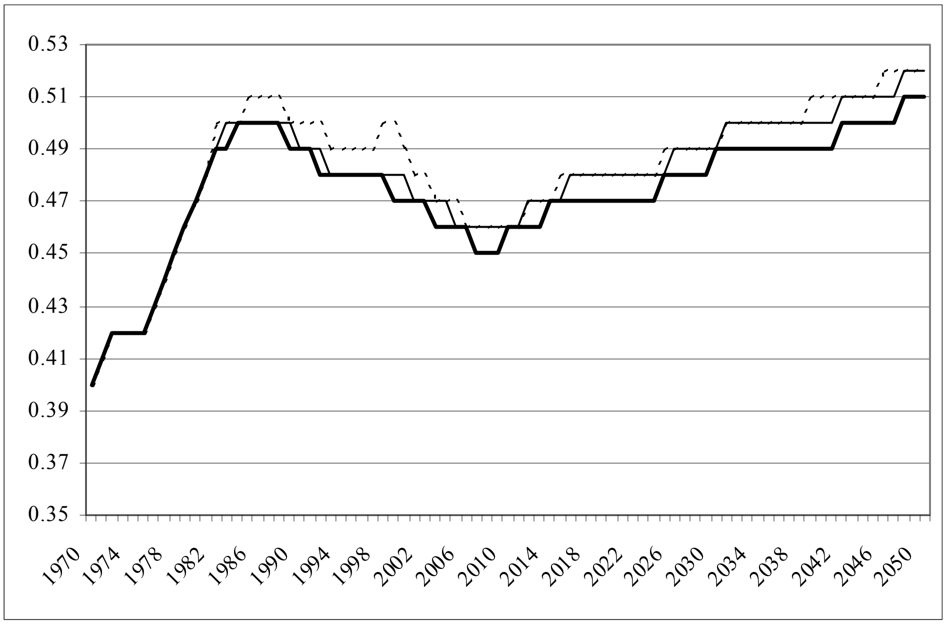
2000, when the 'smart growth' policies are repealed in that scenario and rapid residential development occurs as a result. The other two time periods of rapid residential development occur after periods when no developable land is available. This unstable development pattern in the development scenario causes the land conversion indicator to drop and this pattern to appear in the graph.

Figure 2.10: Economic Index Comparison Across Scenarios



There is almost no variation in the social index across the three model scenarios (Figure 2.11). The development scenario has the highest values for the social index (occasionally tied with the control scenario) likely because it has a greater job ratio than the other scenarios and it has a lower population density. The control scenario has social index values very close to the development scenario while the environmental scenario lags behind just slightly.

Figure 2.11: Social Index Comparison Across Scenarios



Discussion

Montgomery County's application of growth management policies has greatly affected its land use development. Decisions to implement programs such as transferable development rights, parkland acquisition, and cluster development have conserved more open space than the county would have preserved otherwise. With this model, we try to demonstrate how these policies directly affect land use allocations and indirectly affect quality of life.

Policy Implications

This model was created to be a tool for public officials, planners, and the county's citizens to understand policy effects more clearly. As a decision-making tool to improve quality of life in the county, as a tool to understand long-term impacts of today's decisions, and as a way to understand the more covert effects of these policies, this model lends insight into the complex web of land use development.

As discussed in the results section above, the environmental scenario results in the best values for both the environmental health and economic health indices (Figures 2.9 and 2.10). Environmental health is best in the environmental scenario because of the preservation of open space and forested area, and the reduction of negative effects on water quality due to lower nutrient loading. Economic health is enhanced because developable land still remains in 2050 and conversion of open land to development on an annual basis is reduced.

On the other hand, the social health index reaches its highest values in the development scenario, though not significantly higher than in the other two scenarios (Figure 2.11). This higher result is due to the increasing ratio of jobs per household because of the lack of resources for additional residential development and the reduced residential density caused by large SFD lot size.

We found that our conservative version of the environmental scenario results in the best values for the QOL indices. This included smaller average SFD lot sizes, continued use of TDRs, and increased application of cluster development. Although additional research is certainly necessary to verify the impacts of these types of policy changes, testing such ideas in this model can help direct future county research and policy agendas.

As a decision-making tool, this model can also help interested parties look at long-term effects created by past and present public policies. While the model is not intended to predict population figures or total land use consumption, it can be used to assess future trends. In addition, we can break down the effects of each policy to evaluate both its positive and negative impacts on quality of life in the county.

Covert effects can also be broken down for discussion. For instance, policy suggests that cluster development helps preserve additional open space, but some research suggests that this open space is not always usable for the public (Mega et al., 1998). In this model, one can see the positive land preservation effects of the TDR program, while also recognizing the negative effects that additional agricultural land may have on water quality. This allows policy makers and the public to acknowledge the need for a combination of policies to preserve the county's quality of life.

Quality of Life Index

The decision to apply particular QOL indicators was a challenging part of this research. As noted earlier, research on QOL and indicators of well-being has been substantive, but the decision to apply specific indicators to a jurisdiction or project remains highly subjective. The indicators selected for this project came from a number of sources.

Our goal was to apply indicators that would be meaningful to both public officials and local citizens. We chose issues that are clearly reflected in land use development, and are applicable to environmental, economic, or social issues. We also adopted a number of indicators from the State of Maryland's draft list of Smart Growth Indicators (MDP, 2000). Indicators such as jobs per housing unit and the rate of conversion of resource lands to developed lands were taken from the draft list and added to later versions of this model. We also found that a number of indicators independently chosen by the authors were also included on the State's list, such as the percent of unprotected lands converted (the capacity indicator), and average residential lot size (an input for the model). The other indicators in the model were chosen based on importance to environmental, economic, or social issues and whether the model contained adequate data on that topic.

We found it important to make the weighting of the indicators a transparent process because of the variability created by these proportions. Our weightings attempt to emphasize the interests of the public, but this is also quite subjective. Without public surveys regarding relative indicator preference and quality of life in the county, this is a personal decision. Additionally, this transparency allows different interest groups, such as politicians, developers, environmental groups, or local citizen groups to adapt the QOL weights to their own perspective. We feel this is important for different application uses.

The overall QOL index is obviously dependent on both the individual indicator weights and the three indices' weights. Some combinations will combine strong negative and positive indicators to create a QOL index that is seemingly unchanging around the mid-point. Since combining these factors often hides relevant information regarding changes in the county, we generally evaluate the three indices independently rather than rely on the one QOL index for information.

Future Works

Our model simplifies the land development and preservation processes taking place in Montgomery County. The project does not attempt to model every decision or growth shift in the county, but instead follows the average trends and changes that take place. Additional work can be done to expand this model to include other intricacies of land use changes and new indicators.

New research would contribute additional information for model expansion. Information regarding car use, vehicle miles traveled (VMT), and transit use by housing type or employment would provide data to discuss air quality, accessibility, and mass transit. Surveys concerning membership in community groups and participation rates would contribute to an evaluation of social capital in the county. State or county studies pertaining to the importance of various quality of life indicators to the citizens would also help direct model development. Forthcoming work by the State to survey its Smart Growth Indicators at the state and local levels will provide a vital source of new information. Expansion of this analysis into a spatial model would also create the opportunity to include more detailed information about land use dynamics and local quality of life.

Conclusion

Modeling land development dynamics and population growth can help evaluate the effects of growth management policies on the future quality of life for Montgomery County citizens. Only through research such as this, can we begin to understand the connections between different policy decisions and long-term changes in the county. Public policies, like growth management, need to be modeled and studied to examine their effects on future county trends and citizen satisfaction.

Chapter 3: The Role of the Natural Environment in Neighborhood and Life Satisfaction

Introduction

Few empirical studies have focused on the role of the natural environment in contributing to life satisfaction or neighborhood satisfaction. In investigating the relationship between the natural environment and life satisfaction, researchers have found only minor or indirect relationships, if any (Bubolz et al., 1980; Muoghalu, 1991; Shin et al., 1983; Kaplan and Kaplan, 1989). However, people are entirely dependent on the natural environment for all of the necessities of life such as clean water, clean air, and food (Costanza et al., 2002; Collados and Duane, 1999). Many people also enjoy the aesthetic and relaxing qualities of spending time in parks and green spaces (Ulrich et al., 1991; Hartig et al., 1991). The lack of a clear relationship between the natural environment and life satisfaction is therefore perplexing. But perhaps the importance of the natural environment is not reflected in life satisfaction but instead is reflected in neighborhood satisfaction. It is thought that life satisfaction only reflects those aspects of life that are considered personal and the natural environment may not qualify as personal for many (Eckersley, 2000). Notably, the natural environment is occasionally included as one of many aspects that impacts neighborhood satisfaction in research studies. Generally when the natural environment is included in research studies, it is found to have a positive impact on neighborhood satisfaction (Sirgy and Cornwell, 2002; Milbrath and Sahr, 1975; Fried, 1982; Parkes et al., 2002). In this chapter, I look at the relationships between life and neighborhood satisfaction, objective environmental variables, and perceived environmental variables. I hypothesize that neighborhood satisfaction will be highly correlated with the environmental variables while the relationships between life satisfaction and the environmental variables will be smaller.

Data and Methods

Survey Methodology

The Baltimore Ecosystem Study (BES) began in 1997 as one of two urban Long-Term Ecological Research (LTER) Network sites funded by the National Science Foundation.[9] As an urban LTER site, the impact and role of humans in the ecological system was central to the BES research questions. From the beginning, plans were made to include a social survey as part of the data collection efforts and by 1999, the first BES survey was completed and interviews conducted. This first survey was limited spatially to the Gwynns Falls watershed, an area within the larger Baltimore metropolitan region, and resulted in 801 completed interviews. The survey was designed to be administered via telephone and a survey research firm, Hollander, Cohen, and McBride conducted the interviews using Computer Assisted Telephone Interviewing (CATI). The same telephone survey was administered again in 2000 by the same firm using CATI techniques and resulted in 813 completed interviews from respondents in the Gwynns Falls watershed and across the entire Baltimore

[9] National Science Foundation grant number #DEB – 9714835.

metropolitan region. In 2000, the sample was appended with spatially-explicit classifications called PRIZM® so that the survey data could be analyzed spatially.[10]

All of the survey data presented in this paper are from the most recent BES telephone survey administered in September of 2003, again by Hollander, Cohen, and McBride. Hollander, Cohen, and McBride used CATI techniques to contact sample households and administer the questionnaire. The use of the CATI system 1) facilitated the stratified probability sampling of the metropolitan area using Claritas' PRIZM clusters, 2) increased coverage of the spatially heterogeneous urban population, 3) centralized data collection and standardized interviewer training, and 4) reduced the overall cost of data collection (Groves, 1990; Fowler and Mangione, 1990).

The study area and sampling universe for this project was the Baltimore metropolitan statistical area (Figure 3.1) and the primary sampling unit was residential households stratified by PRIZM neighborhood lifestyle clusters (see Table 3.1). A spatially-explicit sample list was purchased from the professional sampling firm, Claritas, providing geo-coded addresses and telephone numbers for households within the Baltimore metropolitan region in ArcGIS format. PRIZM coding based on census block group identification was appended to each primary sample unit, thereby allowing the research team to employ a stratified random sampling design across 15 PRIZM lifestyle clusters (Sudman, 1983; Frankel, 1983).

[10] PRIZM is a commercially available lifestyle classification approach provided by the market research firm, Claritas. The goal of Claritas' PRIZM classification is to categorize the American population by lifestyle clusters and to associate these clusters with characteristic household tastes and attitudes using Census data, market research surveys, public opinion polls, and point-of-purchase receipts. The PRIZM classification system can be applied at a United States Census Block Group level, providing spatially-explicit information about neighborhoods.

Figure 3.1: Study Area of the BES Telephone Survey

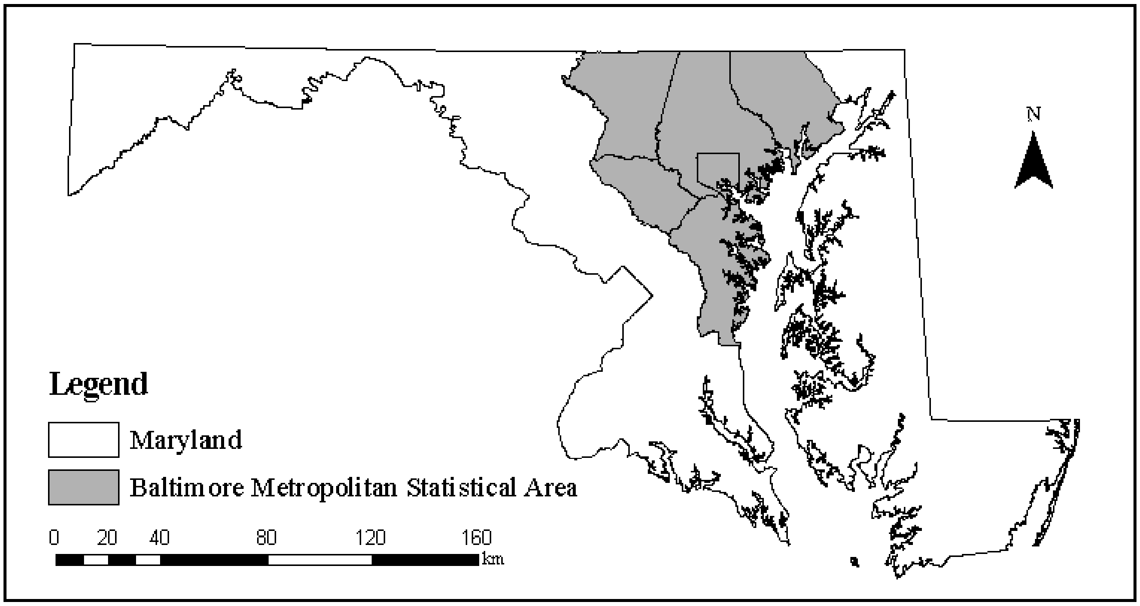


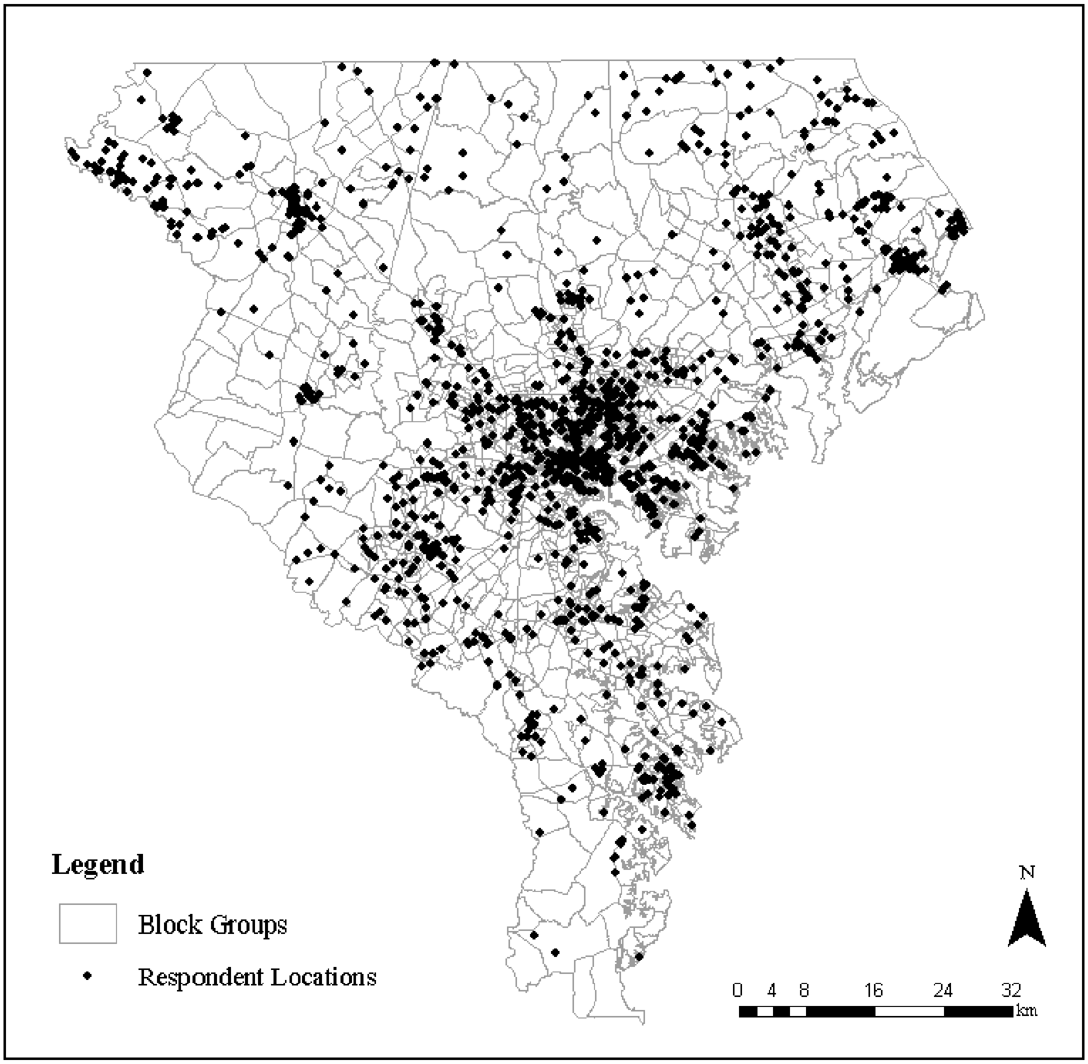
Table 3.1: PRIZM Social Cluster Snapshot

PRIZM	Name	% of Baltimore Pop	% of U.S. Pop	Median Income (U.S.)	% College Grad (U.S.)
U1	Urban Uptown	3.2	4.7	$57,500	37.3
U2	Urban Midscale	13.4	6.6	$36,500	16.7
U3	Urban Cores	11.2	5.4	$18,800	9.6
S1	Elite Suburbs	16.5	10.2	$81,900	40.4
S2	The Affluentials	17.8	7.8	$49,500	23.7
S3	Inner Suburbs	9.3	5.5	$34,800	16.0
C1	2nd City Society	7.1	5.5	$56,800	32.6
C2	2nd City Centers	1.7	7.0	$34,000	23.6
C3	2nd City Blues	2.4	6.9	$20,100	9.2
T1	Landed Gentry	12.3	7.3	$64,600	29.9
T2	Exurban Blues	2.3	6.4	$39,900	15.8
T3	Working Towns	1.0	6.6	$24,400	10.4
R1	Country Families	1.7	6.4	$42,200	14.0
R2	Heartlanders	0.1	4.0	$29,200	9.7
R3	Rustic Living	0.1	9.5	$25,000	8.8

Equal probability for selection was given to households within each of the 15 PRIZM lifestyle strata. We used a target completion rate of 100 interviews for 11 of the lifestyle clusters (n=1100), a target completion rate of 150 interviews for the 2 most populous lifestyle clusters in the Baltimore region (n=300), and a target completion rate of 50 interviews for the 2 least populous lifestyle clusters in the Baltimore region (n=100). A sample list of approximately 9000 primary sampling units was generated in order to complete the specified 1500 interviews. In aggregate data analysis of the Baltimore region, survey responses were weighted to match the natural proportions in the Baltimore population.[11] This allowed us to achieve full coverage of the Baltimore metropolitan region as well as have sample sizes large enough to be able to perform comparisons between PRIZM clusters (Figure 3.2).

[11] Post stratification weights were calculated based on the percentage of the Baltimore metropolitan population in each PRIZM class and the percentage of the sample in each PRIZM class.

Figure 3.2: Respondent Locations



A total of 1508 interviews were completed, with a response rate of 36 percent.[12] Table 3.2 shows that the majority of the nonrespondents were classified as refusals and no contact was made on about half of the total telephone sample.

[12] The response rate was calculated as the percent of completed surveys out of the total number of potential respondents contacted.

Table 3.2: Response Rate

	Count	Percent of Appropriate People Contacted
Completed	1508	36.1
Refusal	2524	60.4
Incomplete	147	3.5
Wrong street	84	
Call back / Appropriate person not available	617	
Contact made with appropriate person to take survey	4179	
Contact made with household	4880	
No Contact with household	4120	

Given observed nationwide declines in telephone survey response rates because of over saturation by marketing research (DeMaio, 1980; Steeh, 1981; Reichhardt, 2004), the investigator team explicitly recognized that the decision to use the telephone required conscious action to ameliorate nonresponse (Schwarz et al., 1991). Two techniques to increase response rates were used, a personalized advance postcard, and repeat callbacks with optimal call scheduling (Biemer et al., 1991; Lyberg and Dean, 1992). First, when the spatially stratified sample frame was generated using PRIZM lifestyle clusters, a geo-coded street address for each primary sampling household unit was generated. Therefore, a short, personalized advance postcard was sent to each household two weeks prior to first contact by the survey firm providing the professional affiliation of the survey team and the purpose of the survey questionnaire (Appendix B; Dillman, 2000; Groves, 1990). Second, the CATI software was programmed for at least three attempted callbacks per telephone number, with an emphasis on pulling available callback sample prior to accessing uncalled numbers (House and Nicholls, 1988). Our response rate of 36% is directly in line with the response rates of other pollsters; Reichhardt (2004) reported that only about 35% of people reached by phone during the 2000 presidential campaign answered pollster's questions. In addition, Keeter et al. (2000) found that attitudes held by easy-to-reach and hard-to-reach survey respondents were very similar. Keeter et al. (2000) obtained a response rate of 36% in their standard (easy-to-reach) study and a rate of 60.6% in their rigorous (hard-to-reach) study, but the statistically significant differences between the two surveys were generally on demographic items only. Respondents' attitudes on the substantive survey questions were not much different between the two studies. These findings suggest that response rates of approximately 35% are not likely to increase error rates.

Questionnaire Design

Significant time and effort were placed on developing a questionnaire that was concise, easy to understand and used no open-ended response questions. To reduce respondent burden, the research team limited the questionnaire so that the average interview length would be no more than 15 minutes. The survey questionnaire was based on the BES telephone survey used in 1999 and 2000. In revising the survey questionnaire, we worked closely with Baltimore community representatives from the Parks and People Foundation (http://www.parksandpeople.org/) to design survey questions that were both meaningful to the community, and effectively tapped the domains of interest. Members of the research team conducted two expert focus groups at the Parks and People Foundation in June of 2003, meeting with community leaders and local 'experts' in Baltimore to test the effectiveness and clarity of questions. A total of 29 leaders and experts contributed time and thought regarding the survey questionnaire, generating useful comments that helped to improve questionnaire wording and flow. Finally, in August of 2003, a pretest with a sub-sample of 15 randomly selected households was conducted prior to final implementation of the CATI system. These pretest interviews were audio taped and highlighted the need for a few final wording changes in the questionnaire, which were made before full implementation of the survey. Largely these were minor wording changes that made the questionnaire easier for the interviewer to read and made it easier for the respondent to understand. The final questionnaire used can be found in Appendix C.

Below is an overview of question wording and response options to facilitate explanation and understanding of the analyses and results. The section of the survey with the satisfaction questions was introduced by the following text and explanation of the scale used.

> For the next few questions, I am going to ask you how satisfied you are with your life and with life in your neighborhood, on a scale ranging from zero to 10. Zero means you feel very dis-satisfied. 10 means you feel very satisfied. And the middle of the scale is 5, which means you feel neutral.

The life satisfaction question is the same as the one used in the Australian Unity Well-Being Index (Cummins et al., 2001) and is very similar to the life satisfaction question used in the World Values Survey (Inglehart et al., 2000), and questions used by Andrews and Withey (1976). The question reads, "Thinking about your own life and personal circumstances, how satisfied are you with your life as a whole?" I chose to use the 11 point scale because 1) Atkinson (1982) showed these scales to be stable over time, 2) scales of this size were used by both the Australian Unity Well-Being Index and the World Values Survey and 3) the 11 point scale has a neutral midpoint of five. Both the neighborhood and environment satisfaction questions also use the same 11 point satisfaction scale. The neighborhood question reads, "Thinking about the situation in your neighborhood generally, how satisfied are you with life in your neighborhood?" This question was based on the national question in the Australian Unity Well-Being Index and is similar to questions in other smaller studies such as the Genesee County Quality of Life survey (Widgery et al., 2002) and a study by Sirgy and Cornwell (2002). The environment satisfaction question reads, "How satisfied are you with the quality of the natural environment in your neighborhood?" This question was based on the national-level environment question in the Australian Unity Well-Being Index (Cummins et al., 2001).

Another perceived environment question was "Approximately how many trees, total, would you estimate are visible from the windows in your residence, none, less than 10, 10 – 50, 51 – 100, or over 100?" This question was based on a question in a residential survey by Kaplan (1985). The question, "If you could, would you move away from your neighborhood?" was based on a question in the Genesee County Quality of Life survey (Widgery et al., 2002) and a question in the Perceived Neighborhood Scale by Martinez et al. (2002). In addition, all of the socioeconomic and demographic variables used in the analysis were from questions in the survey (Appendix C) and the response options for those questions are listed in Table 3.4.

Table 3.3: Socioeconomic and Demographic Variables

Socioeconomic or Demographic Question	Response Options
Own or rent home	Own; Rent; or Other
Type of residence	Townhouse or Rowhouse; Duplex; Apartment Building; or Individual Detached Family Home
Number of people in household	Any number
Marital status	Married; Living with someone as a couple; or Single, Divorced, Separated, or Widowed
Age	Under 35; 35-44; 45-54; 55-64; or 65 or over
Education	Less than high school; High school graduate; Some college; College graduate; or Postgraduate work
Employment	Employed full time; Employed part time; Full time student; or Not employed, retired, or on disability
Ethnicity	White Caucasian; African-American or other Black; Hispanic; Asian; or Some other ethnic group
Income	Under $15,000; $15-$25,000; $25-$35,000; $35-$50,000; $50-$75,000; $75-$100,000; $100-$150,000; or over $150,000
Gender	Male or Female

Objective Environmental Data

I was able to identify three environmental variables that were available for the Baltimore metropolitan area and had a spatial representation so that they could be associated with a census block group or a nearby respondent. Spatial representation was needed so that the survey responses could be matched with the corresponding values of the objective environmental variables.

Water quality was represented by the benthic index of biotic integrity (benthic IBI), obtained from the Stream Waders Program of the Maryland Department of Natural Resources (Boward, 2004). The benthic IBI is a "stream assessment tool that evaluates biological integrity based on characteristics of the …benthic assemblage at a site" (Roth et al., 2004). In general, samples are collected from randomly chosen sites throughout Maryland using a "D" net. The net is placed downstream while the stream bottom is gently rubbed by hand and then disrupted to a deeper level using one's foot. The samples are preserved using ethanol and then counted using randomly selected grid cells until 100 macroinvertebrates have been identified (Roth et al., 2004). The level of benthic IBI is based on a determination of 1) the number of different types of macroinvertebrates identified and the number of each type found, 2) whether the species identified are known to be pollutant tolerant or sensitive to pollutants, and 3) whether there is a presence or absence of certain feeding groups, which could indicate a disturbance (Maryland Department of Natural Resources, no date). The specific benthic IBI scores for each site were "determined by comparing the … benthic assemblage to those found at minimally impacted reference sites" (Roth et al., 2004). Benthic IBI scores can range from 1.0 to 5.0, with 1.0 – 1.9 being very poor, 2.0 – 2.9 being poor, 3.0 – 3.9 being fair, and 4.0 – 5.0 being good. Scores less than 3.0 represent sites that are likely to be degraded (Roth et al., 2004). Benthic IBI values were associated with each of the respondent locations by attributing the benthic IBI value of the closest water quality site to each of the respondent locations. There were approximately 300 water quality sites within the study area and sites were matched with respondent locations usually about two miles away but no further than a distance of 10 miles.

The canopy cover variable was based on the tree canopy layer of the 2001 National Land Cover Database, Zone 60 available from the US Geological Survey (http://beslter.org/products/vemuri filename: nlcd01canopy.zip). This database is based on remote-sensing images collected from 1999 – 2001 and has a spatial resolution of 30 meters. The data from the tree canopy layer were clipped to the study area using ArcGIS and then were sectioned to match up with the block group boundaries. For each block group, the percent of block group area covered by tree canopy was calculated.

The protected lands variable was based on three GIS layers, county parks, Maryland Department of Natural Resources (DNR) lands, and federal lands. The state wide county parks data, dated 2001, is from the Maryland DNR, Wildlife and Heritage Division (http://beslter.org/products/vemuri filename: Parks_County_MD.zip). The county parks data includes land areas over 5 acres that are run and maintained by county and municipal authorities. The state wide DNR lands are from 1999 and generated by the Maryland DNR (http://beslter.org/products/vemuri filename: DNR_Lands.zip). These lands represent over 435,000 acres of public land and open space owned by DNR in Maryland. The state wide federal lands are from the MD DNR, Wildlife and Heritage Division in 2002 (http://beslter.org/products/vemuri filename: Federal_Lands.zip). These are lands run and maintained by US governmental authorities although some lands may have been left out due to sensitive data. These layers were joined and clipped to the study area. Then, similar to the canopy cover variable, the percent of block group area that is protected land was calculated.

Variables in Analysis

All three of the satisfaction variables are ordinal categorical variables that are left skewed. Although variable transformations can often improve distributions, no transformations were successful in improving the distribution of the satisfaction variables, especially since the scale is positive and bounded, 0-10.

The number of trees variable is also ordinal although it is not particularly skew; and the move away variable is simply dichotomous. The water quality variable is a bounded continuous variable that can easily be placed into ordinal categories. Since the scale is so short, 1-5, this variable cannot actually be treated as a continuous variable. The canopy cover and protected lands variables are percentage values and therefore function as continuous variables although they are bounded by 0 and 100. It is also relevant to note that both variables are right skewed, although the protected lands variable is more skewed than canopy cover.

Since all of the variables are bounded and most are ordinal or can be transformed into groups to be treated as ordinal variables, I had to determine what the most appropriate statistical tests would be for this analysis. For correlations between ordinal variables, Pearson's r is generally not appropriate since Pearson's requires that the variables be interval and the relationship be linear (Bryman and Cramer, 2001). Instead, it is common to use the nonparametric correlation coefficient of Spearman's rho. However, I found there to be very little difference in the actual correlation coefficient values or significance values for most of the relationships presented below. The larger, more substantial relationships were quite stable across the two coefficients, while smaller less significant relationships were more likely to have differences of .03 or more. Since the differences were so minor, I present the more common Pearson's *r* correlation coefficients here.

Similarly, with crosstabulation analyses, measures of association other than chi-square are preferred when both variables are ordinal because they are able to convey more information about the relationship between the variables (Bryman and Cramer, 2001). Kendall's tau-b and tau-c and Goodman and Kruskal's gamma are all possible choices, which are based on concordant pairs. Somers' d is often used when both variables are ordinal and "the role of the independent and dependent variables is clear" (SPSS, 1999). I present Kendall's tau-b and Somers' d to further explore the relationships in the data.

Results and Discussion

Demographics

The demographics for the weighted dataset are presented below in Table 3.4. Unfortunately, the United States Census Bureau does not compile data on just the Baltimore metropolitan region but instead includes this area in the larger "Washington-Baltimore, DC-MD-VA-WV CMSA". However, it is still worth noting how the survey demographics compare to Census 2000 data on this larger metropolitan area. More females answered the survey than are in the general population, 64.4% versus 51.5%. White Caucasians make up about 63% of the Washington-Baltimore area, but we had a larger percentage of White Caucasians answer our survey. The median household income for the Washington-Baltimore area is $57,291 with 57% of the population making over $50,000. We had a very similar percent of people reporting incomes over $50,000. The level of education of our sample is a bit higher at than that of the Washington-Baltimore area. In the Washington-Baltimore area, 37.1% of people have college or postgraduate degrees while 42.8% of our respondents report those levels of education. The Census Bureau reports 65.3% of people in the area are employed in any capacity. Our survey demographics show that 65.5% of the respondents are employed either full time or part time. Our survey respondents are slightly more likely to be married and own their own home than is the population in the Washington-Baltimore area as a whole, with 52.2% married and 65% owning their home in the Washington-Baltimore region.

Table 3.4: Demographics of the Weighted Dataset Used for Analysis

	% Female	% Income >50,000	% White Caucasian	% College Grad +	% Employed Full Time	% Married	% Own Home
Weighted Dataset	64.4	58.5	72.8	42.8	57.2	56.7	74.1

Correlation Analysis

From the correlation results, it is immediately clear how the environmental variables impact the satisfaction variables. Table 3.5 shows that only the canopy cover variable, out of the objective environmental variables, has any significant and substantial correlation with life satisfaction. This is logical since canopy cover is the environmental variable that is the most obvious to an individual and is most likely to have a personal impact. People might enjoy walking along their shady, tree-lined street but not be aware of whether the water quality in the nearby stream is good or bad and may not be aware of what lands near their home are protected versus simply undeveloped. In fact, there is some correlation between life satisfaction and the number of trees variable, such that people who can see more trees from their home tend to be more satisfied with life. Both the environment and neighborhood satisfaction variables are highly correlated with life satisfaction as well, with neighborhood satisfaction having the highest correlation. People who have high levels of life satisfaction are also likely to have high levels of neighborhood satisfaction, and to a lesser extent, have high levels of satisfaction with the natural environment in their neighborhood. There is also a significant correlation with the survey question of 'would you move away from your neighborhood if you could?'. People who are satisfied with their life are less likely to want to move away.

Table 3.5: Correlations with Life and Neighborhood Satisfaction

Pearson's *r*	Neighbor-hood Sat.	Enviro Sat.	Move Away	Number Trees	Water Quality	Canopy Cover	Protected Lands
Life Satisfaction	.490 .000	.363 .000	.200 .000	.090 .001	.054 .038	.169 .000	.003 .909
Neighbor-hood Satisfaction	1.000	.517 .000	.393 .000	.191 .000	.145 .000	.276 .000	-.045 .079

Both the water quality variable and the canopy cover variable are significantly correlated with neighborhood satisfaction. It is also important to note the very large correlation between neighborhood satisfaction and environment satisfaction. All three of these correlations support the idea that the natural environment is a very important factor in contributing to neighborhood satisfaction. The number of trees visible from one's home is also significantly correlated with neighborhood satisfaction and is even more highly correlated with canopy cover, $r = .494$. The environment satisfaction variable has a greater impact on neighborhood satisfaction than do the objective natural environment variables, which is somewhat expected since the general public may not be aware of the actual level of environmental quality in their neighborhood. Finally, neighborhood satisfaction is highly correlated with the move away variable, such that people who are satisfied with their neighborhood are not likely to say that they would move away from their neighborhood if they could.

Environment satisfaction has the highest correlation with the objective environment variables, canopy cover (.321) and water quality (.234), and both are highly significant. The protected lands variable only had a significant correlation with the canopy cover variable but not with any of the satisfaction variables. Due to the lack of correlation, the protected lands variable is excluded from further analysis.

The correlations between the objective environmental variables and all of the satisfaction variables are not as large as one might expect, but there are a couple of reasons why this may be the case. First, in the survey questionnaire, respondents are given the following definition of neighborhood: "the block or street you live on and several blocks or streets in each direction". Then, respondents are told to only rate their satisfaction with their neighborhood and the environment in their neighborhood, using the definition of neighborhood as provided in the survey. This definition of neighborhood may have limited the respondents' ability to include satisfaction with park areas or larger environments outside their defined neighborhood that they otherwise might have included. It is also important to note that the objective environmental variables were not based on such a small spatial scale and this mismatch may have resulted in smaller correlations. Second, people's perception of their environment is likely to be relative rather than absolute, such that their perception changes as the environment gets better (tree growth or additional planting) or worse (cutting down of trees for development or diseased trees). Measurement at a single point in time cannot account for whether the local environment has improved or worsened in recent years.

Partial Correlation Analysis

To gather some additional information about the relationships between the satisfaction and environment variables, I also reviewed partial correlations while holding socioeconomic and demographic variables constant. The partial correlations are based on Pearson's r and are useful in determining whether the relationships between the satisfaction and environment variables are independent of typical socioeconomic and demographic variables.

In general, the relationships are independent of socioeconomic and demographic variables although a few do have some impact. The income variable has the greatest impact of all the socioeconomic and demographic variables tested. It actually reduces the correlation coefficients between life satisfaction and canopy cover, benthic IBI, and number of trees by 0.05 to 0.07. The correlation between life satisfaction and canopy cover is the only relationship that remains significant while holding income constant. The income variable also has an impact on the relationships between neighborhood satisfaction and the environment variables. The correlations are reduced by about 0.02, but all remain significant. This is also true of the interrelationships of the satisfaction variables.

The education variable has a minor impact on the correlations, reducing the relationships between life satisfaction and the environment variables by approximately 0.02 to 0.03. The relationship with life satisfaction remains significant for number of trees and canopy cover, but is not significant for benthic IBI. The education variable also reduces the relationships of neighborhood satisfaction with the environment variables by close to 0.02, but all remain significant. Relationships with environment satisfaction were reduced by only 0.01 and all remain significant as well. The education variable has no impact on the interrelationship of the satisfaction variables but does reduce the correlations between the environmental variables by about 0.02.

The ethnicity variable has a very minor impact on the correlations, not impacting the interrelationships of the satisfaction variables at all or the relationships with life satisfaction. However, it does reduce the correlations between neighborhood satisfaction and the environment variables and environment satisfaction and the environment variables by 0.01 to 0.02. It also reduces correlations between the environmental variables by roughly 0.02. All of these relationships remain significant, however.

The only other demographic variable that had any impact on the variables was marital status. Marital status has no real impact on the interrelationships between the satisfaction variables; however, it does reduce the correlations between life satisfaction and the environment variables by approximately 0.02. This causes the relationship between life satisfaction and the benthic IBI to no longer be significant. Marital status also reduces the correlations between neighborhood satisfaction and the environment variables by 0.03 and between environment satisfaction and the environment variables by around 0.01 to 0.02, but all remain significant. In addition, marital status reduces the interrelationships between the environmental variables by about 0.02, with no impact on significance.

Employment, age, and gender had absolutely no impact on the correlations between these variables. Overall, the socioeconomic and demographic variables have only a minor impact on the relationships between the satisfaction and environment variables, showing that these relationships are virtually independent of any socioeconomic and demographic factors.

Measures of Association

To further investigate the relationships between the variables, I looked at Kendall's tau-b and Somers' d. These measures fully support the findings of the correlation analysis. Tables 3.6 and 3.7 display Kendall's tau-b and Somers' d for relationships with neighborhood satisfaction and life satisfaction. Again it is clear that the environmental variables, both objective and subjective, are highly associated with neighborhood satisfaction. There is less association of the environmental variables with life satisfaction across the board but especially for the objective environmental variables and the number of trees variable.

Table 3.6: Measures of Association with Neighborhood Satisfaction

	Environment Satisfaction	Life Satisfaction	Move Away	Number of Trees	Water Quality	Canopy Cover
Kendall's tau-b	.461 .000	.425 .000	.353 .000	.167 .000	.142 .000	.201 .000
Somers' d (neighborhood dependent)	.457 .000	.437 .000	.466 .000	.182 .000	.161 .000	.208 .000

Table 3.7: Measures of Association with Life Satisfaction

	Environment Satisfaction	Neighborhood Satisfaction	Move Away	Number of Trees	Water Quality	Canopy Cover
Kendall's tau-b	.294 .000	.425 .000	.194 .000	.063 .004	.028 .194	.109 .000
Somers' d (life sat dependent)	.283 .000	.414 .000	.250 .000	.067 .004	.031 .194	.109 .000

GIS Mapping

Providing additional support for these relationships are maps of the data across the Baltimore metropolitan region, showing where people were more satisfied and what locations had a higher level of environmental quality. Figure 3.3 shows a map of life satisfaction values across the Baltimore region. The block groups are displayed in grayscale to show the mean life satisfaction value for the respondents in that block group.[13] The light shades of gray represent low satisfaction and the darker shades represent higher satisfaction. Figure 3.4 shows neighborhood satisfaction just as life satisfaction was presented.

[13] Note that sample sizes within block groups are not equal and range from just one respondent to many. The inequality of variance prohibited the use of any spatial statistics based on block groups. See Figure 3.2 for actual respondent locations within the study area.

Figure 3.3: Mean Life Satisfaction by Census Block Group

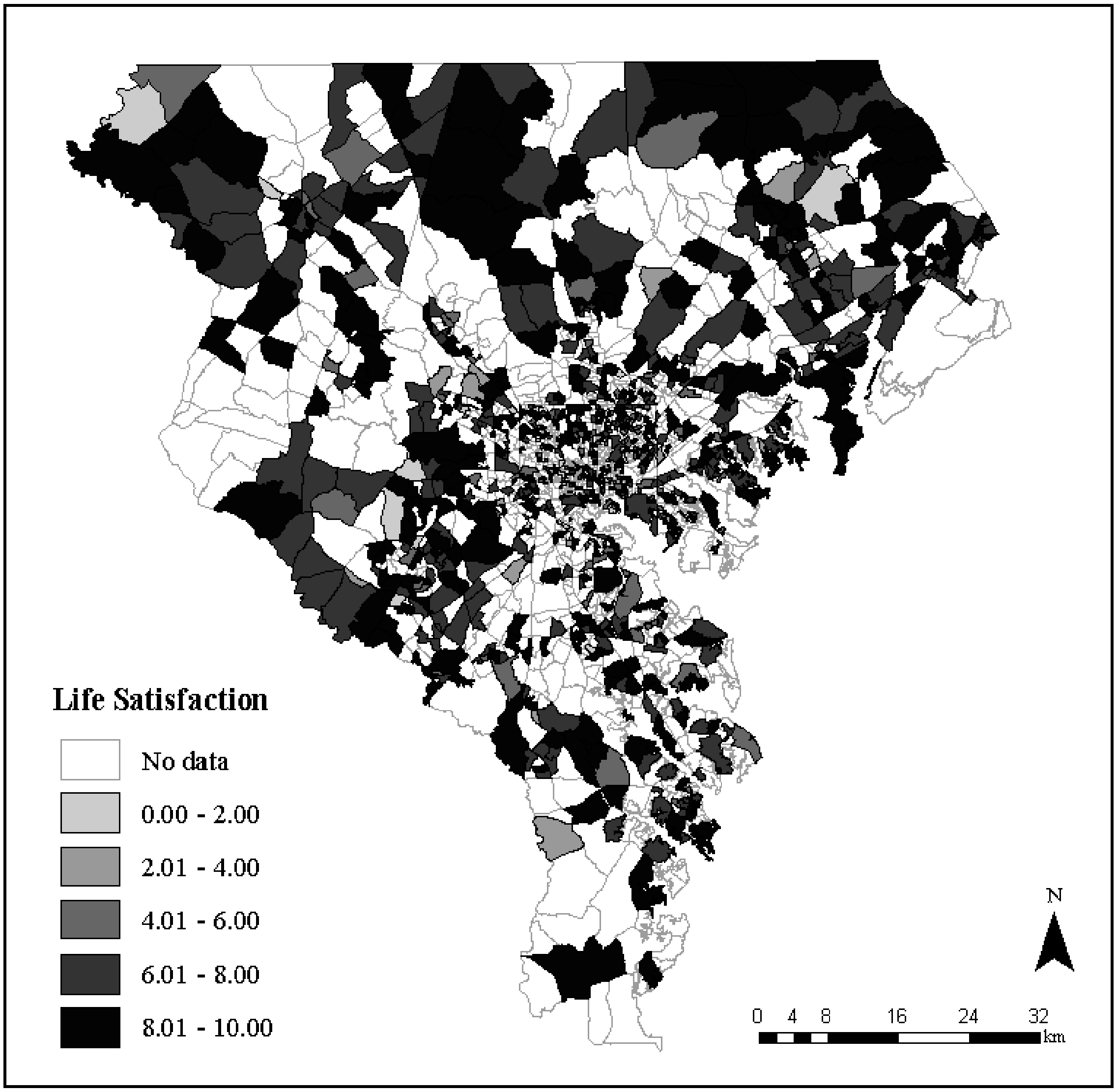
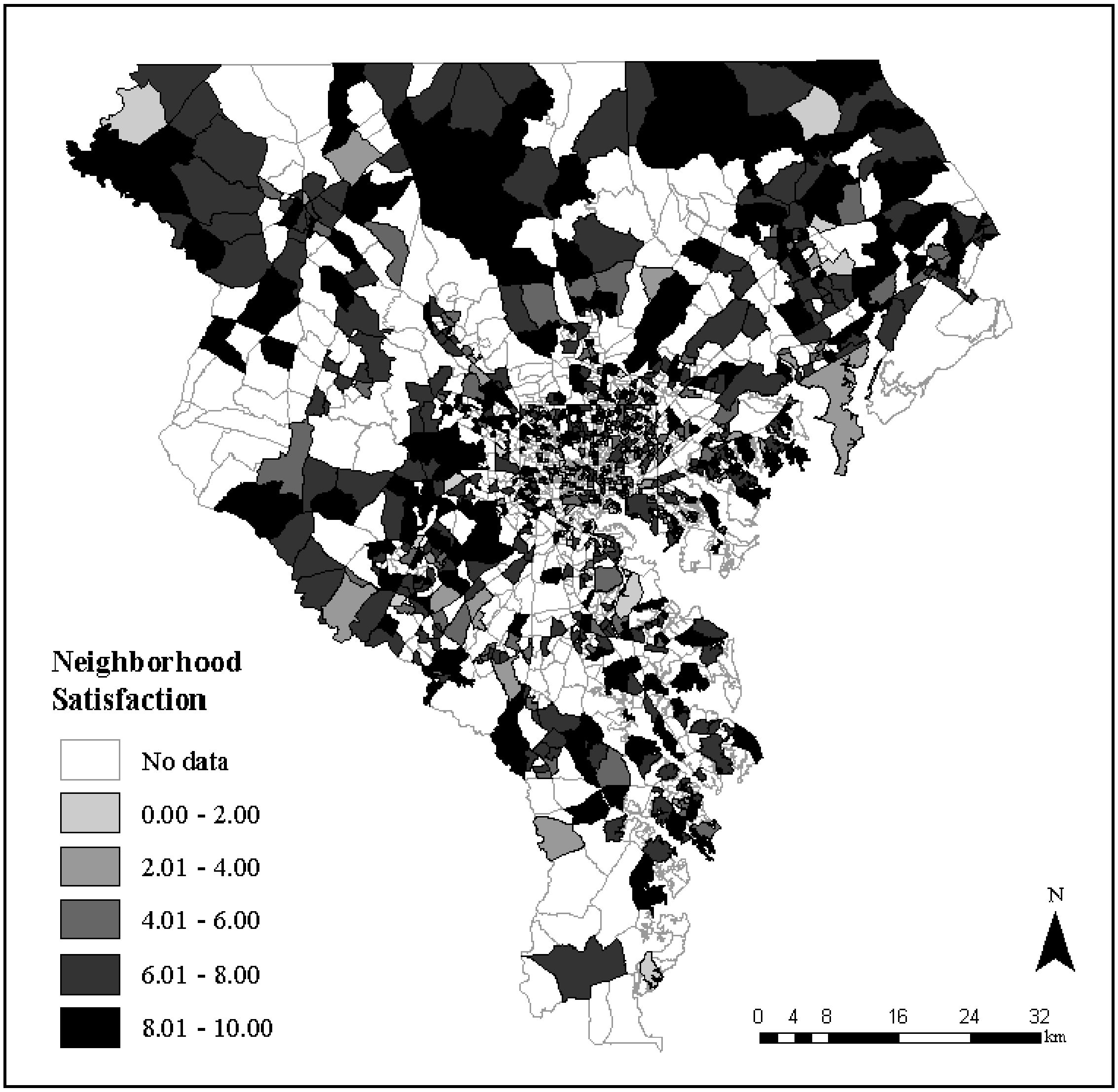


Figure 3.4: Mean Neighborhood Satisfaction by Census Block Group



There is no clear pattern to the geographic location of highly satisfied respondents. The dark gray block groups are somewhat randomly scattered across the region for both life and neighborhood satisfaction. Neither life nor neighborhood satisfaction follow any urban to rural trend. One can see that there are somewhat fewer dark gray areas on the neighborhood satisfaction map as compared to the life satisfaction map, however. This accentuates the lower average neighborhood satisfaction value (7.18) versus the average life satisfaction value (7.88).

There is a much more distinct pattern of geographic variation for the environmental variables. Canopy cover is lacking in much of the downtown Baltimore area and is also reduced in the Northwestern portion of the Baltimore metropolitan region, possibly due to agriculture (Figure 3.5).   The relationship between canopy cover and neighborhood satisfaction is visible in these maps, with the lower levels of neighborhood satisfaction found in central and southeastern Baltimore City, where there are lower percentages of canopy cover.

Water quality has even clearer patterns of geographic variation, with low levels of water quality in Baltimore City, some areas South of Baltimore City, and along the coast East and North of the City (Figure 3.6). High levels of water quality are spread throughout the northern portion of the study area and a few areas to the West of Baltimore City.

Figure 3.5: Mean Percent Canopy Cover by Census Block Group

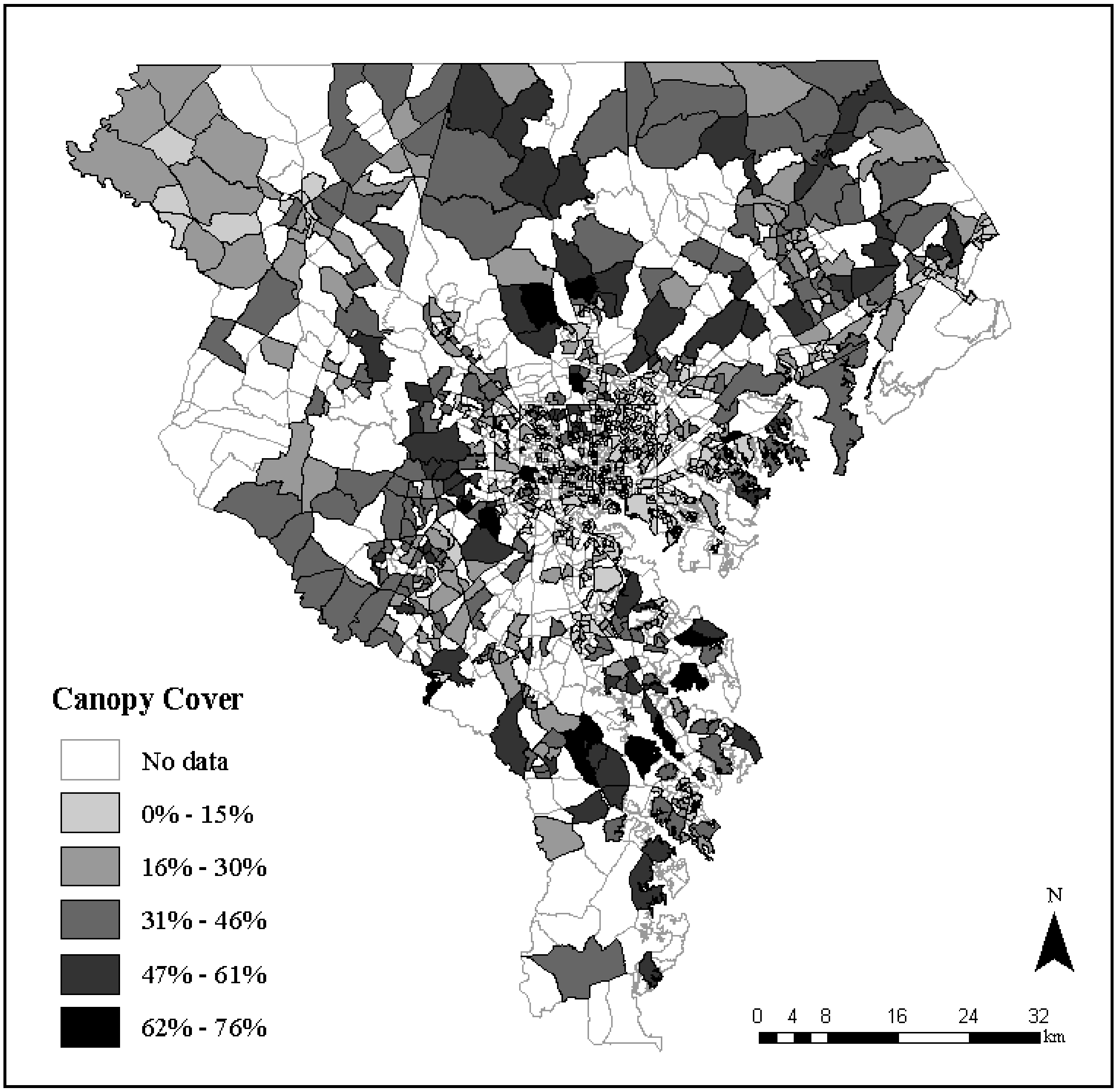
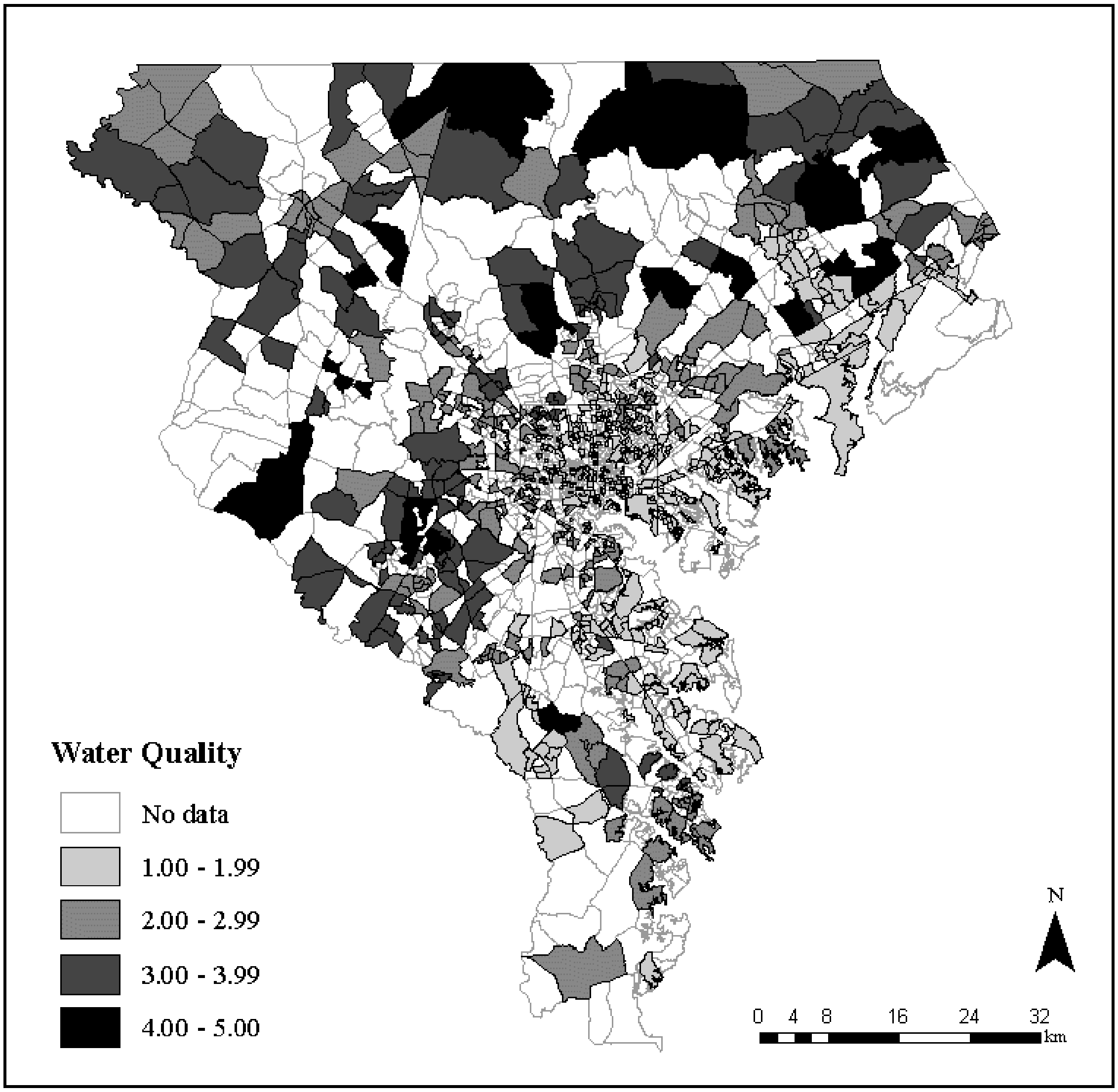


Figure 3.6: Mean Water Quality by Census Block Group

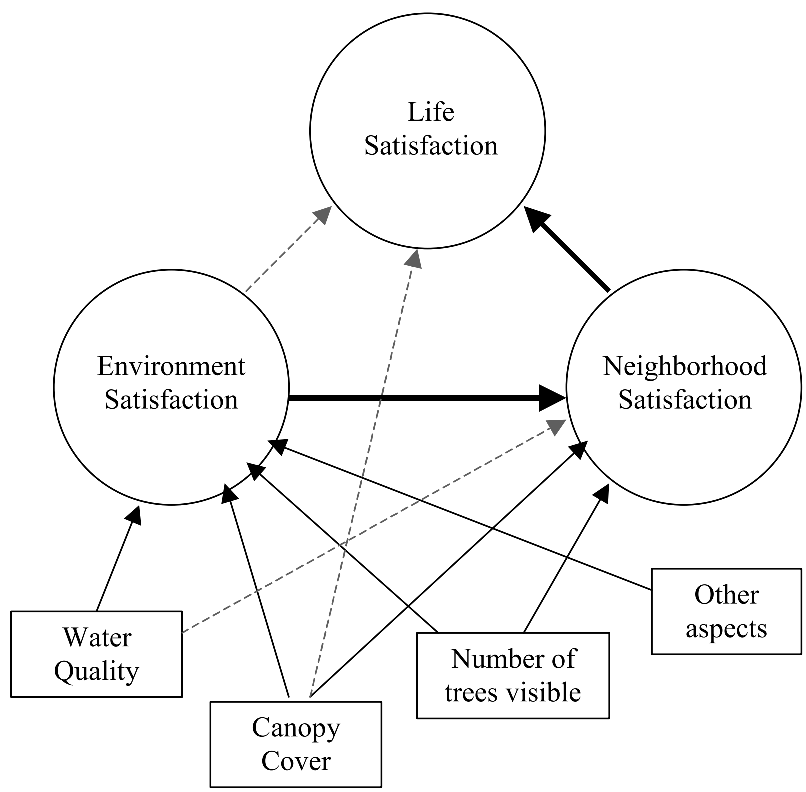


Conclusions

Clearly the natural environment does play a role in people's satisfaction with life and their neighborhood. Objective environmental variables provide important information about the neighborhood studied and high levels of environmental quality are correlated with higher levels of satisfaction. The findings support the idea that the environment has the greatest impact on individuals at the neighborhood level, rather than at the life satisfaction level. Neighborhood satisfaction had larger correlations with the environmental variables than did life satisfaction. The environmental variable that had the largest correlations was environment satisfaction. Perhaps it is people's perception of their environment that is most important, allowing them to interpret their surroundings in a way that is most beneficial to their satisfaction. Or, perhaps, the similarity of the satisfaction scales increased the level of correlation between life, neighborhood, and environment satisfaction. Either way, the following figure, Figure 3.7, is a graphical representation of the most likely path through which the natural environment impacts people's satisfaction. This may vary to some extent for individuals but this is a general representation. Note, however, that this figure excludes all other variables that impact either neighborhood or life satisfaction.

Although not shown in Figure 3.7, the natural environment may also indirectly impact life satisfaction through additional domains that have been found to be important to life satisfaction. For example, the natural environment may impact the domain of health, both by helping to keep the air and water clean (services provided by forests and wetlands) and by providing beautiful areas for relaxation and reflection. These benefits of the natural environment help both physical health and mental health. Other domains that the natural environment contributes to are productivity, since workers are found to be more productive and satisfied when they have a view of nature (Kaplan and Kaplan, 1989), and emotional well-being, since nature can help maintain good mental health (Hartig et al., 1991; Ulrich et al., 1991; Kaplan and Kaplan, 1989). More generally, the natural environment provides underlying support for all domains that impact life satisfaction, through raw materials, ecosystem services and functions, and aesthetic benefits.

Figure 3.7: Natural Environment Impact on Life Satisfaction



Implications for Policy and Planning

These findings are of great use to environmental policy makers and neighborhood planners. From the data, it is clear that living near the natural environment, and trees especially, is quite important to many people. It is correlated with higher satisfaction and a reduced likelihood of moving away from one's neighborhood. Possible policy options include providing funding for tree planting programs to communities that lack canopy cover and requiring a certain percentage of canopy cover and green space in all new neighborhood development plans.

Next Steps

Future analyses should investigate what other aspects of life are also important to the life and neighborhood satisfaction of residents in metropolitan Baltimore, Maryland. A multivariate regression analysis would be a useful method of investigation. A direct comparison of different neighborhood types, using PRIZM classification, on satisfaction and environment variables could also highlight areas in Baltimore, specifically, that could use some special attention and would be the best locations to try tree planting and other greening measures.

Chapter 4: The Role of Human, Social, Built, and Natural Capital in Explaining Neighborhood and Life Satisfaction at the Individual Level

Introduction

The research in this chapter follows up on the analysis in Chapter 3 by using multivariate regression models to further explain variation in neighborhood and life satisfaction. The regression models allow additional analysis of the importance of the natural environment for neighborhood and life satisfaction, and indicate what other aspects of life are crucial for explaining satisfaction. A total of four logistic regression models are presented and used to investigate the relevance of the four types of capital in explaining neighborhood and life satisfaction.

Four Types of Capital

The theory behind the four types of capital comes from the expanded model of the ecological economic system elaborated in Costanza et al. (1997a). The core of this model is the set of four basic types of capital: human, social, built and natural and the notion that there is limited substitutability between these. It hypothesizes that a balance among these four types of capital is necessary to satisfy human needs and generate individual and community well-being (Costanza et al., 1997a). In this chapter I am able to investigate this hypothesis using data on life and neighborhood satisfaction of individuals.

Data and Methods

Survey Methodology

The majority of the variables used in the regression models are from the Baltimore Ecosystem Study (BES) telephone survey described in Chapter 3, pages 83 - 92. As explained in the previous chapter, the data were weighted in the analysis to match the population proportions in the Baltimore metropolitan region. The regression models in this chapter utilize responses from some additional survey questions not mentioned in Chapter 3, however. For reference, the survey questions and responses used in the regression analyses are listed in Table 4.1.

Table 4.1: BES Telephone Survey Variables

Short Name	Survey Question	Response Options
Binary neighborhood satisfaction	Thinking about the situation in your neighborhood generally, how satisfied are you with life in your neighborhood?	Original 0-10 scale recoded as dissatisfied = values 0-5 and satisfied = values 6-10
Binary life satisfaction	Thinking about your own life and personal circumstances, how satisfied are you with your life as a whole?	Original 0-10 scale recoded as dissatisfied = values 0-5 and satisfied = values 6-10
Income	Is the total annual income of all members of your household…	Less than 15,000; 15-25,000; 25-35,000; 35-50,000; 50-75,000; 75-100,000; 100-150,000; or over 150,000
Education	What is the highest grade of school you have had the opportunity to complete?	Less than high school, high school graduate, some college, college graduate, or postgraduate work
Ethnicity	Do you consider yourself to be…	White Caucasian,

		African-American or other black, Hispanic, Asian, or Other
PRIZM 5	Value comes attached to the telephone sample	Urban, suburban, second city, town, or rural
Residence type	Is your current residence an attached single family home such as a townhouse or rowhouse, or is it a duplex, an apartment building, or an individual detached family home?	Townhouse/rowhouse, duplex, apartment building, individual detached
Own or rent	Do you own or rent where you live?	Own, rent or other
Marital status	Are you married, or living with someone as a couple, or are you single, divorced, separated, or widowed?	Married, couple, or single, etc
Live in a watershed	Do you live in a watershed?	Yes or no
Social capital index	How strongly would you agree or disagree with the following statements about your neighborhood: people in the neighborhood are willing to help one another; this is a close knit neighborhood; people in this neighborhood can be trusted; there are many opportunities to meet neighbors and work on solving community problems; and churches or temples and other volunteer groups are actively supportive of the neighborhood?	An index of all five statements using the scale of: 1, strongly disagree to 5, strongly agree
Number of trees	Approximately how many trees, total, would you estimate are visible from the windows in your residence?	None, less than 10, 10 – 50, 51 – 100, or over 100
Environment satisfaction	How satisfied are you with the quality of the natural environment in your neighborhood?	0, very dissatisfied through 10, very satisfied
Move away	If you could, would you move away from your neighborhood?	Yes or no
Problem index	In regard to the following environmental and quality of life issues, I'd like you to tell me if you consider it to be a major problem, somewhat of a problem, or not a problem in your neighborhood: cleanliness of streets and sidewalks; availability of parks and open spaces; quality of parks and open spaces; safety and security; air quality; and water quality?	Not a problem, somewhat a problem, or major problem

Total recreation activities	Thinking about everyone in your household, which of the following outdoor recreational activities has anyone done in the past year: walk for exercise or jog; go biking or play outdoor sports; picnic, barbeque, or camp; drive for pleasure; swim; canoe, kayak, or sail; motor boat or fish?	Summation of all yes responses
Days spent on water	On about how many days out of the past year were you on or in the water of Maryland rivers, streams or lakes, the Bay, the ocean, or used their shores or the areas surrounding them?	Number of days
Neighborhood satisfaction	Thinking about the situation in your neighborhood generally, how satisfied are you with life in your neighborhood?	0, very dissatisfied through 10, very satisfied

A few non-survey variables were also included in the regression models and include: live in city, canopy cover, and the benthic index of biotic integrity (IBI). The live in city variable is a binary variable that notes whether the respondent's location is within the Baltimore City limits. The canopy cover variable was described extensively in Chapter 3 and is a measure of the average percent of canopy cover per census block group. The canopy cover value was assigned to each respondent based on the census block group in which each respondent was located. The benthic IBI is a measure of water quality that is also described fully in Chapter 3. Benthic IBI values were associated with each of the respondent locations by attributing the benthic IBI value of the closest water quality site to each of the respondent locations.

Variables as Types of Capital

Since part of the analysis is to investigate the role of the four types of capital in contributing to neighborhood and life satisfaction, I have identified each of the independent variables in the analysis as belonging to a type of capital when possible.

A few of the independent variables did not fit into any of the four capital types and were classified separately.

The only variable that reasonably represents human capital is education. Social capital is best represented by the social capital index. No other variables address the social interaction of respondents with family, friends, or neighbors. For built capital, the income variable is the best proxy but the residence type and own or rent variables can also be considered representations of built capital. There are four variables that reasonably represent natural capital including number of trees, environment satisfaction, canopy cover, and the benthic IBI. It is relevant to note, however, that the environment satisfaction variable is only a perception of the natural environment and not necessarily an accurate representation of the true quality of natural capital.

The remaining variables were each placed into categories as well. The ethnicity variable simply represents ethnicity, a basic demographic variable. Two variables represent urbanization, PRIZM 5 and live in city. This will let us know whether the level of urbanization in which a person lives plays a role in neighborhood or life satisfaction. Marital status is a representation of the life domain of intimacy (Cummins, 1996). The problem index and neighborhood satisfaction as an independent variable represent community, which is a domain that is found to be important to life satisfaction (Cummins, 1996). I suggest that the total recreation activities and days spent on water variables represent active involvement. The move away variable is a behavioral intent variable and can represent a respondent's level of commitment to their neighborhood (Widgery et al., 2002). Another interpretation of the move away variable is based on a study by Martinez et al. (2002) in which the desire to move away was highly correlated with the respondent's perception of crime in their neighborhood. As a result, the move away variable may also represent the level of crime in the neighborhood to some degree. The most difficult variable to classify was the live in a watershed variable, which basically tests the respondent's knowledge of watersheds. Loosely it can represent knowledge of natural capital.

Choice of Regression Models

The majority of the variables described above and used in the regression analyses were either binary or ordinal. The dependent variables in these analyses are neighborhood and life satisfaction, both bounded, highly negatively skewed variables with nonconstant variance. Transformations of the dependent variables were attempted to improve the distribution and relationship of the dependent variables with the independent variables but none were successful.

A logistic regression model was found to be the best fit for the analyses since the dependent variables violated the assumptions of multiple linear regression and the trial ordinal regression models had limited predictive ability and difficulty accommodating the weighted dataset. For the logistic regression, the response scale of the dependent variable had to be reduced from an 11 point scale to a binary variable. Since most of the respondents fell in the range of 7-10, the mid-point of five was placed with the lower values, creating a 0-5 dissatisfied response and a 6-10 satisfied response. Using the binary version of neighborhood satisfaction, the data did not violate any underlying assumptions of the logistic regression model. Logistic regression models have been used by other researchers when evaluating neighborhood satisfaction as well, which provided added support for this type of analysis (Parkes et al., 2002).

Neighborhood Satisfaction

Correlation Analysis Results

The correlation results clearly show that many variables are significantly correlated with binary neighborhood satisfaction but only a few have substantial coefficient values. Table 4.2 presents the most relevant correlations for this analysis, all of which have significance values of $p \leq .001$. Correlations with social capital, environment satisfaction, and move away are relatively large and highly significant, indicating that these variables are likely to be important factors in the regression models.

Table 4.2: Pearson's Correlations with Binary Neighborhood Satisfaction

	Social Capital	Env. Sat.	Move Away	Income	Educ.	Live in City	Res. Type	Canopy Cover
Neigh. Sat.	.339 .000	.413 .000	.340 .000	.200 .000	.225 .000	-.217 .000	.178 .000	.204 .000

Regression Model Results

I focused on two logistic regression models using binary neighborhood satisfaction as the dependent variable. First, I ran a logistic regression including as independent variables all variables that had a Pearson's *r* correlation greater than 0.10 with binary neighborhood satisfaction. Second, I ran a logistic regression including only traditional socioeconomic and demographic variables from the telephone survey.

The full model presented below in Table 4.3 was found to be significant with a Cox and Snell R square value of .282 and a Nagelkerke R square equal to .417. This model was able to explain between 28% and 42% of the variance in neighborhood satisfaction. In addition, the model was able to improve its overall classification rate of respondents from 74.7% correct to 83.6% correct, and the model was able to accurately predict 52.9% of the dissatisfied respondents. Only four predictor variables were found to be significant with $p < .05$. The significant variables were education, social capital, environment satisfaction, and move away, all significant with $p < .001$ (Table 4.3).

Table 4.3: Full Logistic Regression Model for Neighborhood Satisfaction[14]

Variable	B	Standard Error	Odds Ratio
Income	-.003	.060	.997
Education	.359***	.084	1.432
Ethnicity	-.062	.122	.940
PRIZM 5	-.221	.123	.802
Residence type	-.037	.071	.964
Own or rent	.086	.189	1.089
Marital status	-.153	.102	.858
Live in city	-.438	.262	.645
Live in watershed	-.325	.205	.722
Social capital index	.500***	.090	1.648
Number of trees	-.041	.099	.960
Environment satisfaction	.342***	.040	1.407
Move away	1.157***	.185	3.179
Canopy cover	.000	.007	1.000
Benthic IBI	.096	.134	1.100
Problem index	-.102	.157	.903
Constant	-5.103***	1.265	.006
$X^2 = 358.239$, df = 16, $p < .001$, Nagelkerke R square = .417			

***p<.001

[14] Sample size of the model was 1079.

The reduced socioeconomic and demographic model was also found to be significant. The pseudo R square values were much lower, however, with Cox and Snell = .085 and Nagelkerke R square = .125. The model was only able to explain between 8% and 13% of the variance in neighborhood satisfaction. Looking at classification rates, the model makes almost no improvement, changing from an overall classification rate of 74.4% correct to 74.7% correct, and only 11.1% of the dissatisfied respondents were accurately predicted. This model also had four significant predictor variables, which were education, PRIZM 5, residence type, and own or rent (Table 4.4).

Table 4.4: Socioeconomic and Demographic Logistic Regression Model for Neighborhood Satisfaction[15]

Variable	B	Standard Error	Odds Ratio
Income	.058	.048	1.060
Education	.312***	.066	1.366
Ethnicity	-.095	.100	.909
PRIZM 5	.176*	.077	1.192
Residence type	.153**	.056	1.165
Own or rent	-.333*	.147	.717
Marital status	-.102	.082	.903
Constant	-.173	.586	.841
X^2 = 103.298, df = 7, p < .000, Nagelkerke R square = .125			

*p<.05, **p<.01, ***p<.001

Discussion

Although both neighborhood satisfaction models were found to be significant, only the full logistic regression model is a good fit of the data and is able to explain a

[15] Sample size of the model was 1166.

substantial amount of the variance in neighborhood satisfaction. The results of the Hosmer and Lemeshow Test further support this finding because the socioeconomic and demographic regression has a significant test value (Chi-Square = 20.900, df = 8, p = .007), which indicates that it is not an acceptable model for the data. The full logistic regression model does not have a significant Hosmer and Lemeshow test statistic (Chi-Square = 12.673, df = 8, p = .124) and therefore it is implied that the full model's estimates fit the data at an acceptable level.

Of the four variables found to be significant in the socioeconomic and demographic logistic regression model, only one remained significant in the full logistic regression model, education. The other three variables, PRIZM 5, residence type, and own or rent, completely drop out of the model. PRIZM 5 does remain somewhat of interest with a significance value of p = .072, but it is not quite significant.

Most interesting are the four variables found to be significant in the full logistic regression model. First is the education variable, which was important in both regression models. In the full model, a unit increase in education level is associated with an increase in the odds of being satisfied by a factor of 1.432. Second on the list is the social capital variable, for which a unit increase in the level of social capital corresponds to an increase in the odds of being satisfied by a factor of 1.648. The third significant variable, environment satisfaction, had the highest Wald statistic and a unit increase in environment satisfaction resulted in an increase in the odds of being satisfied by 1.407. Fourth is the move away variable, which has a very large impact on the odds of being satisfied, with a shift from saying you will move away to saying you will not move away being associated with over a three-fold increase in the odds of being satisfied (3.179).

As defined earlier, these four significant variables represent human capital, social capital, natural capital, and neighborhood commitment. Three of the four basic types of capital are found to be very important for neighborhood satisfaction based on empirical data. This is strong support for the ecological economic model that human, social, natural, and built capital are all needed to achieve community or neighborhood satisfaction. It is very interesting to note, however, that built capital, represented here by income, was not found to be a significant factor in determining levels of neighborhood satisfaction. This result does seem plausible though since one's income plays a larger role in determining the neighborhood in which you live but not as large a role in determining your satisfaction with that neighborhood. It is equally important to point out how vital natural capital is for neighborhood satisfaction, even just people's perception of and satisfaction with the quality of their surrounding natural environment. Again it is found that people have a need to be near and have access to the natural environment in order to fully enjoy life. This is a variable that must not be overlooked in future studies of neighborhood satisfaction.

It is noticeable that the objective environmental variables drop out of the full regression model. While this was not an expected result, there are a couple of reasons why this may have happened. These are basically the same reasons why the objective environmental variables were not more highly correlated with the satisfaction variables, as presented in Chapter 3. First, in the survey questionnaire, respondents are given the following definition of neighborhood: "the block or street you live on and several blocks or streets in each direction". Then, they rate their satisfaction with their neighborhood and the environment in their neighborhood, using the definition of neighborhood as provided in the survey. However, this definition of neighborhood may have limited the respondents' ability to include satisfaction with park areas or larger environments outside their defined neighborhood that they otherwise might have included. In addition, the objective environmental variables were not based on this same small, "neighborhood" spatial scale but instead based on census block groups. This mismatch probably minimizes the ability of these objective environmental variables to predict satisfaction. Second, people's perception of their environment is likely to be relative rather than absolute, such that their perception changes as the environment gets better (tree growth or additional planting) or worse (cutting down of trees for development or diseased trees). People's environment satisfaction will be sensitive to these changes and match their satisfaction levels accordingly while objective environmental measures are absolute and cannot account for whether the local environment has improved or worsened in recent years.

Life Satisfaction

Correlation Analysis Results

In general, the correlations between binary life satisfaction and the survey variables and the environmental variables are not as large as those with binary neighborhood satisfaction. Many of the correlation coefficients were still found to be significant but fewer were actually substantial. Correlations with income, environment satisfaction, and neighborhood satisfaction are the largest and therefore most likely to be important factors in the regression models (Table 4.5).

Table 4.5: Pearson's Correlations with Binary Life Satisfaction

	Income	Education	Marital Status	Social Capital	Env. Sat.	Canopy Cover	Neigh. Sat.
Life Satisfaction	.272 .000	.205 .000	-.125 .000	.079 .002	.276 .000	.151 .000	.394 .000

Regression Model Results

When using binary life satisfaction as the dependent variable, I conducted two logistic regressions very similar to the ones for neighborhood satisfaction. The first was a full logistic regression model that mainly included variables that had a Pearson's *r* correlation with binary life satisfaction greater than 0.10.[16] The second logistic regression model was the socioeconomic and demographic model, which included the more traditional socioeconomic and demographic variables from the survey.

I present the full model below in Table 4.6. The Cox and Snell R square value for the model was .209, and the Nagelkerke R square was equal to .359; indicating that the regression could explain between 20% and 36% of the variation in life satisfaction. The classification abilities of the model were somewhat minimal, however, with the overall percentage correct changing from 84.3% to 86.2%. The model was able to predict 31% of the dissatisfied respondents correctly. Four

[16] The only variable included in the full regression that did not have a correlation value with binary life satisfaction greater than .10 was the social capital variable, which had a correlation of .079. This variable was still included in the regression model because it is the only variable that represents social capital.

variables were found to be significant predictors and two other variables were almost significant (Table 4.6). The significant variables were income, social capital, environment satisfaction, and neighborhood satisfaction. The two variables that were almost significant were own or rent and education.

Table 4.6: Full Logistic Regression Model for Life Satisfaction[17]

Variable	B	Standard Error	Odds Ratio
Income	.305***	.069	1.357
Education	.166	.089	1.181
Own or rent	-.369	.197	.691
Marital status	.017	.116	1.017
Social capital index	-.367***	.109	.693
Environment satisfaction	.151***	.042	1.163
Move away	.106	.219	1.111
Canopy cover	-.002	.006	.998
Total recreation activities	.087	.060	1.091
Days on water	-.002	.002	.998
Neighborhood satisfaction	.389***	.047	1.475
Constant	-2.046*	.977	.129
X^2 = 265.653, df = 11, p < .000, Nagelkerke R square = .359			

*p<.05, **p<.01, ***p<.001

The socioeconomic and demographic logistic regression model included the same seven variables as the socioeconomic and demographic model for the neighborhood satisfaction variable. The Cox and Snell R square value was .095 and Nagelkerke R square was .163. Therefore, the model had little explanatory power, only covering between 9% and 16% of the variance in life satisfaction. The model also provided little improvement in classification rates, going from an overall

[17] Sample size of the model was 1135.

classification rate of 84.1% to 84.6% and only able to accurately predict 8.6% of the dissatisfied respondents. According to the model output, only three variables were significant, income, education and own or rent (Table 4.7).

Table 4.7: Socioeconomic and Demographic Logistic Regression Model for Life Satisfaction[18]

Variable	B	Standard Error	Odds Ratio
Income	.279***	.059	1.322
Education	.235**	.080	1.265
Own or rent	-.648***	.169	.523
Marital status	-.061	.101	.941
Residence type	-.107	.070	.898
Ethnicity	.228	.141	1.256
PRIZM 5	.177	.093	1.193
Constant	1.003	.713	2.727
X^2 = 116.091, df = 7, p < .000, Nagelkerke R square = .163			

**p<.01, ***p<.001

Discussion

Both of the life satisfaction logistic regression models were found to be significant but neither of the models provided a good fit of the data. In fact, the socioeconomic and demographic model did not pass the Hosmer and Lemeshow Test (Chi Square = 22.097, df = 8, p = .005), which confirms that it is not an acceptable model for life satisfaction. Although the full model does pass the Hosmer and Lemeshow Test (Chi Square = 12.481, df = 8, p = .131), this model has some minor nonlinearity problems. The Box Tidwell test of nonlinearity showed one significant interaction term in the test model, which was neighborhood satisfaction times its

[18] Sample size of the model was 1162.

natural logarithm. The significance of this interaction term provides evidence of nonlinearity in the logit. When reviewing the data, it appears that there are diminishing increases to life satisfaction as neighborhood satisfaction increases, which is more of a saturation curve than a linear relationship. Another unexpected result was that in the full model the social capital variable is significant but in such a way that a unit increase in social capital is associated with a decrease in the odds of life satisfaction. When evaluated logically, this does not make sense and this was not the case for the neighborhood satisfaction analysis. One explanation might be that since social capital is such an important factor in neighborhood satisfaction, perhaps these two variables cannot be included independently in a model of life satisfaction. More than likely, social capital impacts life satisfaction indirectly through neighborhood satisfaction.

Aside from social capital, there were three other variables that were significant in the full model, income, environment satisfaction, and neighborhood satisfaction. Income was highly significant in the model and a unit increase in income was associated with an increase in the odds of being satisfied by a factor of 1.357. The second highly significant variable was environmental satisfaction; a unit increase in environmental satisfaction increased the odds of being satisfied by 1.163. The third significant variable was neighborhood satisfaction for which a unit increase resulted in almost a 1.5-fold increase in the odds of being satisfied (1.475).

Just as in the full neighborhood satisfaction regression model, the objective environmental variables drop out and are not found to be significant in the full life satisfaction regression model. The reasons presented for the neighborhood satisfaction model again hold true, there is a mismatch in spatial scale between the objective measures and the satisfaction measures, and life and environment satisfaction are relative measures rather than absolute ones like the objective environment variables. In addition, the natural environment, measured objectively, may not be considered personal enough to have significant bearing on one's life satisfaction (Eckersley, 2000).

When comparing the life satisfaction regression results to the available literature on the domains important for individual life satisfaction it becomes clear why the two regression models presented here are not good explanations of the data. The literature identifies seven main domains that are important for individual life satisfaction: material well-being, health, productivity, intimacy, safety, community, and emotional well-being (Cummins, 1996). The full regression model picks out a material well-being variable, income, and three other significant variables (neighborhood satisfaction, environment satisfaction, and social capital), which all relate to the domains of community and safety. Unfortunately, there are almost no questions in the survey that relate to some of the most important domains of life satisfaction including intimacy, emotional well-being, and health. Productivity could be represented by the employment variable but the correlation between binary life satisfaction and employment was not very strong and a person's satisfaction with their employment is likely to be more important to life satisfaction than simply whether they are employed or not. While it is useful and interesting to track life satisfaction in the Baltimore region, the current BES survey does not include enough questions on the domains of individual life satisfaction to support regression analyses that try to explain the components of individual life satisfaction in the Baltimore metropolitan region.

Discussion and Conclusions

The regression analyses presented here add to the ever-expanding research on life and neighborhood satisfaction. The neighborhood regression analyses clearly show that traditional socioeconomic and demographic variables do not do an adequate job of identifying the most satisfactory neighborhoods nor are they the aspects of neighborhoods that are most likely to improve the experience of the people who live in them. While numerous studies have shown that housing quality and safety are critical components of neighborhood satisfaction (Sirgy and Cornwell, 2002; Cook, 1988; Amerigo and Aragones, 1997), here I am able to add the natural environment and social capital as additional critical components of neighborhood satisfaction. In this study, human, social, and natural capital were all found to be important for the achievement of neighborhood satisfaction. It is important to note that the natural environment component need not be a pristine or perfect environment. Instead, it simply needs to be a green space that is satisfactory for the nearby residents. For example, in inner city Baltimore, even a small lot with trees and / or flowers may make a difference and change a person's perception of their natural environment and consequently their satisfaction with their neighborhood.

In general, since the life satisfaction regression analyses had little explanatory power, it is not possible to draw too many conclusions. However, if one does look at the variables that are shown to be significant or almost significant in the full life satisfaction regression, all four types of capital are represented. Social, built, and natural capital are all highly significant and human capital is almost significant. The regression model may need some work and additional data but there is evidence that all four types of capital do have an impact on life satisfaction. And, the lack of explanatory power of these regressions provides some support for the individual life satisfaction literature which finds that much of life satisfaction is dependent on personal aspects of life that were not addressed in the BES survey.

A critic might ask, ‘If I am a fairly wealthy white person living in a neighborhood with lots of tree cover, am I satisfied because of the natural environment around me or is the high quality environment around me because of my wealth, etc. which is what actually makes me satisfied?’ The analysis presented here suggests a middle ground. Wealth and other socioeconomic and demographic variables are not sufficient to explain people’s life or neighborhood satisfaction levels. Regression models using solely socioeconomic and demographic variables had minimal explanatory power and were found to be unacceptable models for the data. They were much worse than the full models at explaining variance in the satisfaction variables. However, a high quality natural environment alone would not be sufficient to keep people fully satisfied with their life or neighborhood and would not be able to explain all the variance in the satisfaction variables. A combination of key variables is needed to explain the variance in life and neighborhood satisfaction and different variables are needed for the two types of satisfaction. I suggest that the data presented here show the importance of including a natural environment variable and a social capital variable along with other more traditional variables at least for neighborhood satisfaction. Without additional data, it is not possible to say for certain what variables would be needed for a life satisfaction regression, although it is likely that both the natural environment and social capital are important whether they impact life satisfaction directly or indirectly through a variable such as neighborhood satisfaction.

Implications for Policy and Planning

The main point here is to emphasize the inability of socioeconomic and demographic factors to predict neighborhood or life satisfaction and highlight the usefulness of concepts such as social capital and the environment. Policy makers and neighborhood planners need to find ways to incorporate these factors into the planning process and make them an integral part of neighborhood development plans. Neighborhoods and housing can be designed to provide inviting natural areas and areas that support positive interactions between neighbors.

The natural areas within and near residential developments only need to be satisfactory to the residents in order to increase environment satisfaction and therefore neighborhood satisfaction. However, in order for the natural areas to provide environmental goods and services, more care may be needed in the design. For example, a neighborhood retention area that absorbs rapid rain runoff could be connected to a wetland, which naturally provides disturbance and water regulation, storage and retention of water, gas regulation, waste treatment, and also is habitat for wildlife (Costanza et al., 1997b). This type of nearby natural area would also allow residents to observe wildlife such as ducks, rabbits, deer, fox, beavers, birds, and frogs. Residents would feel as though they had a park in their backyards with such a lush and vibrant ecosystem. A design such as this would be best if the goal was to not only provide a natural area to increase neighborhood satisfaction but also to provide additional ecosystem services where they may be needed.

Next Steps

Future work might include adding additional questions to a future BES survey that try to address, 1) social capital between respondents and family or close friends, not just neighbors, 2) personal aspects of life, such as time spent with partner, health, and religion, and 3) safety. These are all aspects of life satisfaction according to the literature that were lacking in this analysis. For neighborhood satisfaction, time series analysis would be quite interesting and useful for monitoring the effects of policies or programs implemented within the study area. The BES survey will likely be conducted again in 2006 and at that time it would be interesting to see whether there has been much change in levels of satisfaction compared to data from the 2003 survey. The changes in levels of neighborhood satisfaction could even be analyzed geographically and one could try to match large jumps or declines in satisfaction with corresponding revitalization efforts, problems, development, or other events.

Chapter 5: The Role of Human, Social, Built, and Natural Capital in Explaining Life Satisfaction at the Country Level: Towards a National Well-Being Index (NWI)

Introduction

How does one assess the "well-being" of nations and the individuals that make them up? The answer to this question is critical to national and international development policy, as the explicit goal of these policies is to "make things better". How one measures "better" is thus obviously a key question. There have been several approaches to this question, including:

(1) traditional economic measures such as Gross National Product (GNP) or Gross Domestic Product (GDP);

(2) the UN's Human Development Index (HDI) which combines an index based on GDP with indices of education and health (UNDP, 1998);

(3) broader "economic welfare" indicators that combine components of GDP with wealth distribution adjustments, and natural, social, and human capital adjustments, such as the Index of Sustainable Economic Welfare (ISEW – Daly and Cobb, 1989) and the more recent Genuine Progress Indicator (GPI – Anielski and Rowe, 1999);

(4) indices based on a broad range of factors such as the Human Welfare Index (HWI), which includes over 87 specific sub-indices, and the

Wellbeing Index, which combines the HWI with the Environmental Welfare Index (Prescott-Allen, 2001) ; and

(5) measures of subjective well-being (SWB) derived by interviewing individuals and asking them to evaluate their overall well-being, happiness, or life satisfaction.

Subjective Well-Being

Subjective well-being (SWB) analysis studies individuals' own evaluations of their lives using "both cognitive judgments of life satisfaction and affective evaluations of moods and emotions" (Diener and Suh, 1999; Diener et al., 1995a). In the 1960s and 1970s, it became apparent that the common measures of economic well-being did not adequately capture the actual well-being of individuals or nations (Milbrath, 1982; Daly and Cobb, 1989; Cobb and Cobb, 1994; Easterlin, 1974; Easterlin, 1995). Even social indicators were not found to be sufficient to portray individual or national well-being (Milbrath, 1982; Haas, 1999). Much of the research in this field has focused on the individual and what may cause differences in the subjective well-being of different people. However, researchers have also investigated the differences in national levels of mean subjective well-being (Inglehart and Rabier, 1986; Diener et al., 1995a; Diener et al., 1995b; Diener and Suh, 1999).

Aims of This Study

This study aims to combine data on national levels of mean SWB with data on objective measures of built, human, social, and natural capital in order to better explain the determinants of national SWB. This should help to build better objective indices of national well-being that can be extended to countries and for years for which SWB has not been measured. In this study, SWB was simplified to the measure of life satisfaction, or just the cognitive evaluation of one's subjective well-being (Sirgy, 2002). In some other studies, subjective well-being has been defined as a combination of life satisfaction and a measure of happiness, or both the cognitive and affective judgments of subjective well-being (Diener and Lucas, 1999). The decision to use life satisfaction to represent subjective well-being at the national level is supported by Diener et al.'s (1995a) finding that national predictors of well-being more strongly influence cognitive assessments of well-being (satisfaction) than affective assessments of well-being (happiness).

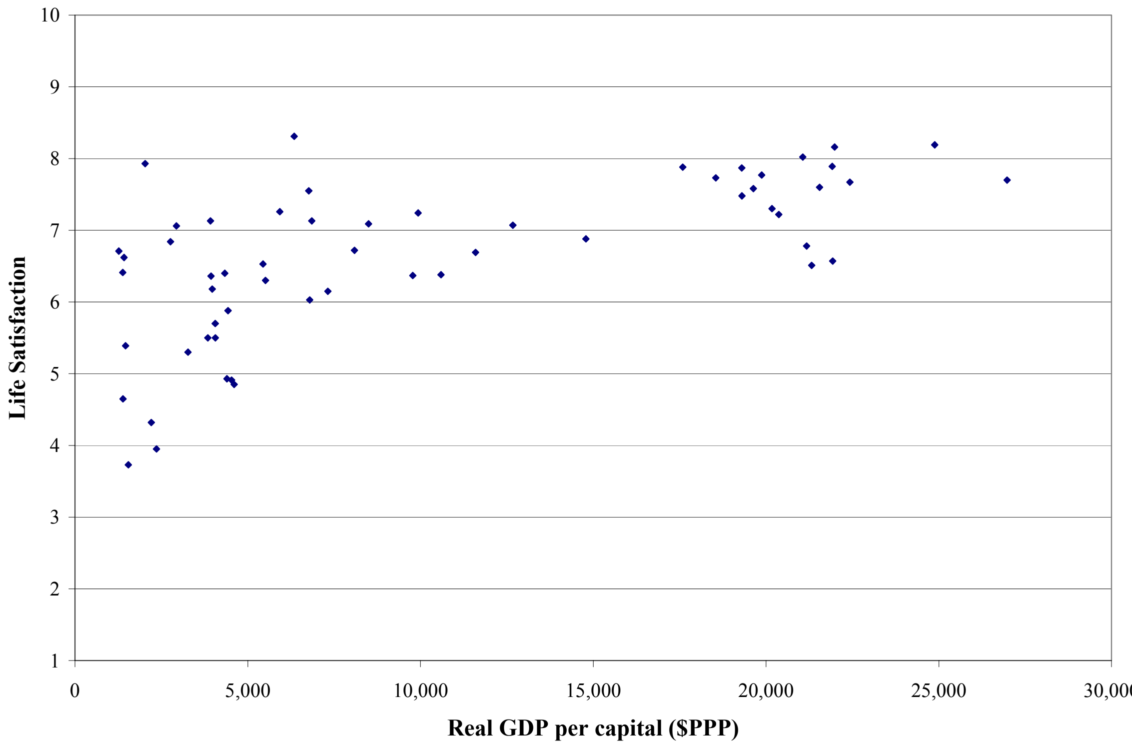
Background

Efforts to explain well-being have a long history, but there has been an explosion of interest and activity in recent years. Easterlin (2003) identifies two main strands of prevailing theory in psychology and economics. The dominant theory in psychology has been the "set point theory" (Lucas et al. 2003 is a good recent review). This theory hypothesizes that each individual has a happiness set point determined by genetics and personality to which one returns after relatively brief deviations caused by life events or circumstances. At the international level, this theory would imply that the level of SWB across countries should not be affected at all by factors such as income, health, education, environmental amenities, etc., but should be purely a function of the genetic make-up of the population.

The dominant theory in economics has been that "more is better" (Samuelson, 1947; Varian, 1987). This theory implies that levels of income across countries should correlate with SWB. Easterlin (2003) argues that "neither the prevailing psychological nor economic theories are consistent with accumulating survey evidence on happiness". He argues that because of hedonic adaptation (people's aspirations adapt to their changing circumstances) and social comparison (people judge their happiness relative to social peers rather than on an absolute scale) that both the "set point" and "more is better" theories fail. Easterlin shows that SWB tends to correlate well with health, level of education, and marital status, and not very well with income. The lack of a linear relationship with income is visible in a graph of life satisfaction versus GDP per capita ($PPP), which illustrates the diminishing returns to satisfaction of increases in GDP per capita (Figure 5.1). Easterlin concludes that

> "people make decisions assuming that more income, comfort, and positional goods will make them happier, failing to recognize that hedonic adaptation and social comparison will come into play, raise their aspirations to about the same extent as their actual gains, and leave them feeling no happier than before. As a result, most individuals spend a disproportionate amount of their lives working to make money, and sacrifice family life and health, domains in which aspirations remain fairly constant as actual circumstances change, and where the attainment of one's goals has a more lasting impact on happiness. Hence, a reallocation of time in favor of family life and health would, on average, increase individual happiness."

Figure 5.1: Life Satisfaction versus GDP per capita ($PPP)



Previous international comparisons of subjective well-being have focused on cultural differences in the acceptance of positive and negative emotion, income, individualism, human rights, societal equality, political stability, and interpersonal trust (Diener and Suh, 1999; Diener et al., 1995a; Diener et al., 1995b; Welsch, 2002; Cummins, 1998; Helliwell, 2003; Oswald, 1997). Diener et al. (1995b) focused on income and the acceptance of positive and negative emotion to explain national differences in SWB. They found that 1) income did not impact SWB, 2) differences in SWB are not due to unfamiliarity with the concept, and 3) the frequency of reporting positive or negative emotions is related to the acceptance of those types of feelings in the culture. Diener and Suh (1999) found that people in wealthy countries report higher levels of SWB than those in poorer countries, but that national wealth is strongly correlated with human rights, equality, fulfillment of basic biological needs, and individualism. Therefore, the effect of each of these variables individually is difficult to determine. They also found interpersonal trust and political stability to be strongly correlated with higher SWB. Diener et al. (1995a) found SWB to be correlated with high income, individualism, human rights, and societal equality. However, individualism was the only variable to correlate with SWB when other variables were controlled. They found low or inconsistent relationships between SWB and cultural homogeneity, income growth, and income comparison. Welsch (2002) investigated how happiness was impacted by income, rationality, freedom, and pollution. He found that income had a positive impact on happiness and the pollutant nitrogen dioxide had a negative impact on happiness, while rationality and freedom had more indirect effects on happiness. Cummins (1998) found that life satisfaction correlates strongly with national wealth and individualism but that these two variables only account for about 35 percent of the variance across the nations in the study. In conclusion, Cummins gives two suggestions, 1) that life satisfaction is held under homeostatic control since life satisfaction falls into such a narrow range (70 ± 5 percent of scale maximum), and 2) that one must be cautious in interpreting international rankings of life satisfaction or SWB as implying some desirable population state. Helliwell (2003) based his international comparison on international samples of individual respondents, rather than national average levels of life satisfaction. He found links between life satisfaction and education and social capital but acknowledges that his findings can only show linkages and not establish the existence or direction of causation. Oswald (1997) reviews the happiness and satisfaction literature and finds that in developed nations, happiness is only minimally impacted by economic progress. In addition, Eckersley (2000) examined personal and social satisfaction measures to determine their possible use in providing "insights into the state and fate of nations." He suggests that subjective measures of social-level satisfaction are best used for evaluating national progress because there is evidence that life satisfaction is most influenced by personal and intimate aspects of life and is kept under homeostatic control which buffers it against shifts in personal circumstances and social conditions. Eckersley (2000) does acknowledge, however, that most analyses of national subjective well-being have been based on personal well-being questions, not social questions. Due to lack of international data on social-level satisfaction, this study follows the past trend in analyzing life satisfaction averages at the national level. Specifically, this research investigates international comparisons in a new theoretical framework, which incorporates the role of the natural environment, a variable that has been excluded from most other international subjective well-being comparisons.

Theoretical Foundation

This work is based on the expanded model of the ecological economic system elaborated in Costanza et al., (1997a). The core of this model is the set of four basic types of capital: natural, human, social, and built and the notion that there is limited substitutability between these. It hypothesizes that a balance among these four types of capital is necessary to satisfy human needs and generate individual and community well-being (Costanza et al., 1997a). This investigation tests this hypothesis by using national scale data on the four types of capital (and more importantly the services they provide) as determinants of SWB as measured by the World Values Survey via surveys of individuals.

Data and Methods

This study investigates the relative impact of the four types of capital on mean, national-level life satisfaction. Single proxy variables were selected to represent each type of capital and life satisfaction data were used to represent individual well-being.

Subjective Well-Being Data

The life satisfaction data were obtained from the 1990 and 1995 World Values Surveys (WVS). In 1990, there were 41 countries with life satisfaction data.[19] Forty-two countries had 1995 life satisfaction data.[20] Twenty-six countries had life satisfaction data for both 1990 and 1995, for those countries, an average value across the two years was used. The World Values Survey was conducted within each country with domestic funding using either national random, stratified multi-stage

[19] The national-level life satisfaction averages were calculated as basic means of all respondents from each nation surveyed. Note: sample sizes were not the same in each country and ranged from 588 respondents in Finland to 2792 respondents in Belgium, but the majority of countries had sample sizes of about 1000 respondents. Standard error of the mean for life satisfaction ranged from a high of 0.088 in Austria to a low of 0.030 in Spain with the majority around 0.062.

[20] The national-level life satisfaction averages were calculated as basic means of all respondents from each nation surveyed. Note: sample sizes were not the same in each country and ranged from 95 respondents in Ghana to 6004 respondents in Colombia, but the majority of countries had sample sizes of about 1000 respondents. Standard error of the mean for life satisfaction ranged from a high of 0.219 in Ghana to a low of 0.026 in Colombia with the majority around 0.055.

random, or quota sampling.[21] All surveys were conducted using face-to-face interviews in the national language with adults over the age of 18 (Inglehart et al., 2000). The life satisfaction question used in the 1990 and 1995 WVS was "All things considered, how satisfied are you with your life as a whole these days?" and it was rated on a scale from 1, dissatisfied, through 10, satisfied.

Human and Built Capital Data

Human and built capital were represented together as the 1995 UN's Human Development Index (HDI) obtained from the United Nations Human Development Report 1998. The HDI is a measure of achievements in human development and is comprised of a longevity index, an education index, and a standard of living index. The longevity index is based on life expectancy. Adult literacy and the combined enrolment ratio are combined into the education index. The standard of living index is based on the adjusted per capita income in PPP$. Index values are used in order to normalize the values of the variables that are included in the HDI, so that all values fall between 0 and 1 (UNDP, 1998). The three indices are averaged to obtain the HDI. Additional details on the calculation of the HDI are available in the technical notes of the Human Development Report, 1998.

The human and built capital variables were represented together because all of the possible human capital variables available were highly correlated with all of the possible built capital variables. The following human capital variables were tested: combined education enrolment ratio, life expectancy, adult literacy, and female adult

[21] Inglehart, et al. (2000) note that the "populations of India, China, and Nigeria, as well as rural areas and the illiterate population, were undersampled". Stratified multi-stage random sampling was generally used in the 1990 WVS (Inglehart et al., 2000).

literacy, with both the real GDP per capita ($PPP) and the adjusted real GDP per capita ($PPP). All combinations of the human and built capital variables were highly correlated, which can confound regression analysis. In fact, regression models were run using the separate human and built capital variables but these models suffered from intercorrelation errors. For example, in a regression using the separate variables, the combined education enrollment ratio was found to have a negative impact on life satisfaction, which was only because of the intercorrelation of this education term with the GDP variable. Confounding errors such as this inhibited the use of the separate human and built capital variables. No other data on human capital were available for a large number of the countries included in the analysis; nor were there any other logical built capital variables to use.

Natural Capital Data

The natural capital variable was based on the ecosystem services product (ESP) obtained from Sutton and Costanza (2002). ESP was estimated using the IGBP land-cover dataset and unit ecosystem service values from Costanza et al. (1997b). The amount of each type of land-cover was estimated for each of the countries and multiplied by the corresponding unit ecosystem service values to obtain a total dollar value of ecosystem services per country (Sutton and Costanza, 2002). Using data provided by Sutton and Costanza (ESP values and land area for each nation)[22], the ESP per square kilometer was calculated. Then, for this analysis, the log of ESP per square kilometer was normalized as an index between 0 and 1. The original distribution of the ESP variable was highly right-skewed, with a skewness value of

[22] Some of the land area values were not included in the dataset provided by Sutton and Costanza and instead were obtained from the CIA World Factbook (2003).

47. The original distribution of the ESP variable also had a large kurtosis value (234), which indicates tails longer than those found in a normal distribution. The distribution of the log of ESP per square kilometer index is significantly better, with a normal bell curve and virtually no skewness or kurtosis, with values of -1.3 and 0.82 respectively.

Social Capital Data

The best social capital proxy available was based on Freedom House's press freedom rating for 1995 (Freedom House, 1999). Freedom House assesses the freedom of the press within a nation by focusing on four categories: the laws, political factors, economic factors, and degree of actual violations. The influence of laws and administrative decisions on the content of news media is rated 0 to 15, low numbers meaning greater freedom. Political influence or control over news media content is also rated on the 0 to 15 scale. The influences of economic factors from either government or private entrepreneurs are again rated from 0 to 15. Actual violations against the media, however, are rated on a scale of 0 to 5. All of these categories are assessed for both broadcast and print media. Finally, Freedom House may add between 1 to 5 points to a country's score to reflect the frequency and severity of actual violations against the media. The Freedom House rating was transformed by subtracting the value from 100 (100 – Press Freedom rating), to make the score match the direction of positive results of all the other variables in the model. This way, greater freedom is a larger number, just as a larger number represents higher life satisfaction.

Initial Analysis

To begin the analysis, bivariate correlations between all of the variables were conducted (Table 5.1). The combined human and built capital, natural capital, and social capital variables were all significantly and positively correlated with life satisfaction. It is also important to point out that there was some intercorrelation between the social capital variable and the other capital variables. The press freedom variable had a highly significant correlation with both the HDI variable (human and built) and the log ESP/km^2 index variable (natural capital). This type of intercorrelation between variables can cause problems in regression analysis.

Table 5.1: Bivariate Correlations between Variables

		Average Life Sat.	HDI	Log ESP per km^2 Index	Press Freedom
Average Life Sat.	Pearson cor. Significance	1			
HDI	Pearson cor. Significance	.463 .000	1		
Log ESP per km^2 Index	Pearson cor. Significance	.358 .007	.071 .353	1	
Press Freedom	Pearson cor. Significance	.502 .000	.502 .000	.295 .000	1

A review of partial correlations reveals that it is the HDI and press freedom variables that are most intercorrelated. When controlling for HDI, the correlation between press freedom and life satisfaction is reduced to 0.2703 and is barely significant. Similarly, when controlling for press freedom, the correlation between HDI and life satisfaction is reduced to 0.1779 and is not significant. Regression analyses were conducted with the press freedom variable included but it was not found to be a significant factor; however, the HDI variable was found to be significant. Since HDI is the more important variable to include, the press freedom variable was excluded from the regression analysis. The press freedom variable does not add enough unique variation to the description of life satisfaction to warrant inclusion in the analysis, especially since it could cause intercorrelation errors in the regression. Next, an ordinary-least-squares (OLS) regression model was used to examine the effect of natural capital and the combined human and built capital on life satisfaction. The results of the regression model are presented both before and after deleting six outlier countries.

Results and Discussion

Basic Regression Model

In the basic regression model no countries were excluded from the analysis. Overall, the country-level regression model was found to be significant, with an R^2 value of .349. The independent variables representing natural capital, and human and built capital were able to explain almost 35% of the variability in life satisfaction.[23] Both the natural capital and the combined human and built capital variables were highly significant in the regression (Table 5.2). The data for all of the countries used in the analysis is presented at the end of the chapter in Table 5.5.

[23] Using the less optimistic adjusted R^2 value for the basic regression model (.324), we were able to explain about 32% of the variability in life satisfaction.

Table 5.2: Basic Regression Model Coefficients for National-level Analysis[24]

	Unstandardized Coefficients		Standardized Coefficients		
	B	Std. Error	Beta	t	Significance
Constant	1.857	.900		2.063	.044
HDI	3.524	.832	.470	4.234	.000
Log ESP/km^2 Index	3.498	1.021	.380	3.427	.001

A number of diagnostic statistics were conducted on our basic regression model to test for influential cases and violations of OLS assumptions. Tests of collinearity using tolerance and the variance inflation factor (VIF) showed no signs of collinearity, with a tolerance value close to one and a low VIF value (Draper and Smith, 1981; SPSS, 1999; Berk, 2004). The Durbin-Watson test for detecting serial correlation was conducted and resulted in a non-significant value of 2.169 based on the testing procedures and tables in Draper and Smith (1981).

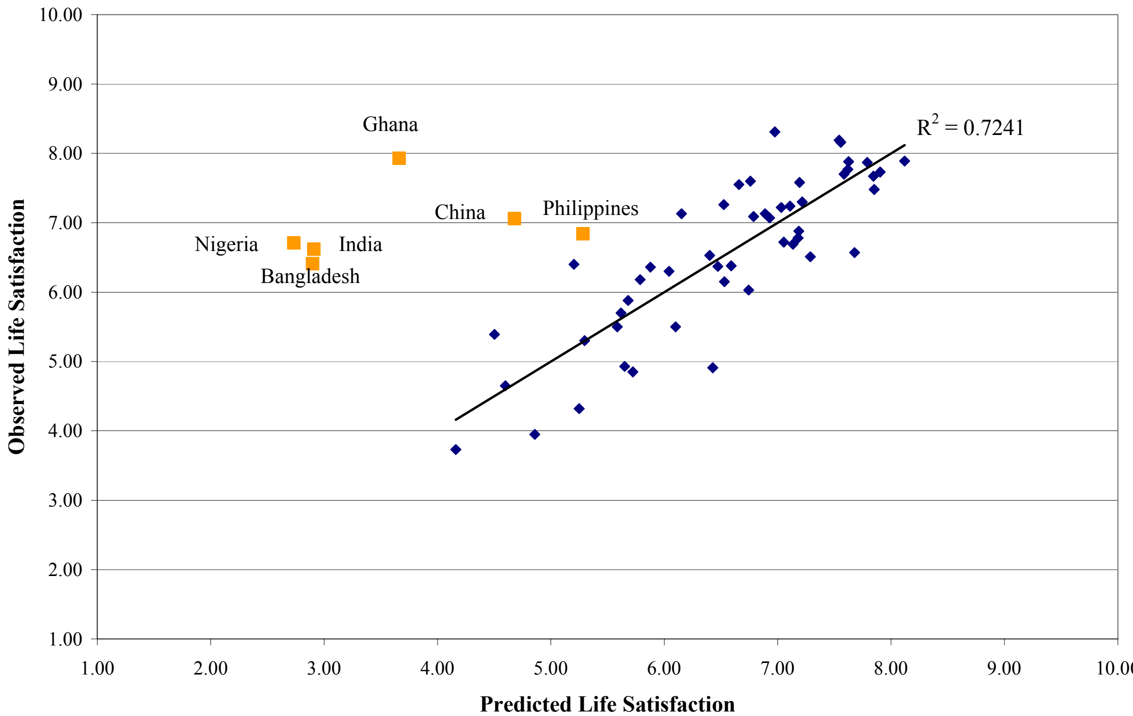
Figure 5.2 shows that a number of countries were consistent outliers in the partial regression plots and in terms of leverage values and Cook's distance statistic. The main outliers were Bangladesh, Ghana, India, Nigeria and China. Since these were almost all of the low-income countries from Africa and Asia in the dataset, it made sense to exclude the Philippines from the analysis as well. These countries all have low HDI values (below 0.7) and are not located in Europe or the Americas. In addition, World Values Survey documentation noted that many of the low-income countries over sampled the urban, educated population and under sampled the illiterate population (Inglehart et al., 2000). Specifically, the samples from China and

[24] Sample size of the regression model was 56.

India were 90% urban and much of the Nigerian sample was also urban or near urban centers (Inglehart et al., 2000). These sampling issues could have biased the life satisfaction levels from these countries, artificially inflating the values since the sample represents people who have had education and other opportunities that are not available to the entire population. The cultures of the low-income nations may also impact the observed levels of life satisfaction. Perhaps people in these countries are more reliant on social networks, which could not be represented in the models presented here. Therefore, the six countries excluded are likely to have a very different life satisfaction regression equation, one that is probably more reliant on social capital for maintaining high levels of satisfaction. Including them in the analysis here would merely add noise variation.

The only remaining non-European or American countries were South Korea, Japan, and South Africa, which all had higher HDI values and behaved similarly to the rest of the countries in the sample. All European (including former Soviet Union countries) and North and South American countries were kept in the analysis, regardless of HDI value since they have more similar cultural backgrounds. Figure 5.2 shows observed versus predicted life satisfaction values for the 56 countries with life satisfaction data. The regression line for the 50 countries shown in diamonds is shown, along with the R^2 for that subset of countries. The six African and Asian outlier countries are also shown and labeled.

Figure 5.2: Observed versus Predicted Life Satisfaction



Revised Regression Model

In the revised regression model, the same variables were used but the six outlier countries, Bangladesh, Ghana, India, Nigeria, China and the Philippines, were excluded. The resulting R^2 was 0.724,[25] which is a substantial improvement over the basic regression model (Table 5.3). Both the natural capital variable and the human and built capital variable are highly significant in the model. Presented at the end of the chapter is a table with predicted life satisfaction values for the 172 countries that had data for the natural capital and human and built capital variables (See Table 5.6). The predicted life satisfaction values were calculated using the revised regression model equation.

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[25] Adjusted R^2 was 0.712.

Table 5.3: Revised Regression Model Coefficients for National-level Analysis[26]

	Unstandardized Coefficients		Standardized Coefficients		
	B	Std. Error	Beta	t	Significance
Constant	-2.220	.799		-2.781	.008
HDI	8.875	.884	.777	10.038	.000
Log ESP per km^2 Index	2.453	.739	.257	3.319	.002

Although causal implications cannot be concluded from this type of regression model, it is possible to identify relationships between life satisfaction and the four types of capital. First, it is very interesting to note that the natural capital variable is very important to the regression model and is not intercorrelated with the other capital variables. It appears that natural capital has a unique relationship with life satisfaction that is not encompassed by any of the other variables. The importance of natural capital was also seen in the significant bivariate correlation between natural capital and life satisfaction. This suggests that a natural capital variable should be included more often in analyses of life satisfaction, both at the individual and social level. Additional and more focused research may be able to show what role natural capital plays in contributing to people's life satisfaction.

The combined human and built capital variable, HDI, was the most important factor in this regression model, as seen in the comparison of the standardized betas and the t values from the regression equations (Tables 5.2 & 5.3). Although income or wealth is not the only factor found to influence life satisfaction, it is usually found

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[26] Sample size of the regression model was 50.

to be one of the major factors (Diener et al., 1995a; Cummins, 1998; Diener and Suh, 1999). In this instance, income or wealth is also combined with human capital, which represents health and to some extent, human rights and equality. In addition, a nation's wealth is also strongly correlated with fulfillment of basic biological needs, individualism, interpersonal trust, and political stability (Diener and Suh, 1999). The combination of all of these aspects of life reasonably makes up a large portion of the variance in life satisfaction. It is worthwhile to highlight how much better the HDI is as a predictor of life satisfaction in comparison to GDP as presented in Figure 5.1 at the beginning of the chapter. By incorporating the human capital variables, the HDI has a linear relationship with life satisfaction while the GDP does not.

The lack of a significant relationship between the social capital variable, press freedom, and life satisfaction in the regression equations is interesting. It has been shown on the personal level that social interactions with family and friends are very important to life satisfaction (Cummins, 1996), and therefore a similar importance at the national level was expected. However, as mentioned above, the social capital variable is also highly correlated with the combined human and built capital variable, HDI, and its relationship with life satisfaction is altered when one controls for HDI.

Other social capital variables including political rights rating, civil liberties rating, and corruption perceptions index, were also investigated but none had a better linear relationship with life satisfaction than press freedom, and all had significant bivariate correlations with HDI. In addition, the corruption perceptions index was not available for a large enough sample of countries to be useful in the model. The lack of a clear linear relationship of these other social capital variables with life satisfaction may have been a function of the scale on which they were measured; Freedom House only provides a 1 through 7 rating for political rights and civil liberties.

Even more importantly, the problem is that the type of social capital variables available at the national level are probably not the most appropriate. The social capital variables that are available generally do not impact individuals in their daily lives and therefore are more likely to have an impact on social-level satisfaction rather than life satisfaction. To look at life satisfaction at the national scale, variables on the importance of friends and family would be a better proxy for social capital. A survey question on the importance of family was investigated but it could not be incorporated it into the model because it was only available for a small number of countries. The lack of a good proxy for friends and family might also explain the outliers that were identified. All of the outlier countries are noted for their strong extended families and close social networks (relative to Europe and the US). Thus, a good measure of the strength of friend and family social relations might explain the outliers and improve the overall results.

As interest grows in social capital at the national level, the availability of useful indicators of national social capital may improve and allow for the investigation of the relationship with life satisfaction without interference from other variables.

Caveats to Methods

Here some common criticisms of aggregated data analyses such as this one are addressed. Two common criticisms are that 1) the analysis suffers from the ecological fallacy[27] and 2) the data are subject to the modifiable areal unit problem (Openshaw, 1983; Larson, 1986; Fotheringham and Wong, 1991; Amrhein, 1995; Seligson, 2002; Handel, 1981; Hofstede, 2002; Schwartz, 1994). To appease those concerned with the ecological fallacy, steps were taken to determine that the relationships present in our country level analysis, using mean national-level life satisfaction values, also exist at the individual level. Using the previously identified national-level variables for the combined human and built capital and natural capital, a micro-level regression model was created in which each respondent has a unique life satisfaction value and values for the two independent variables that were defined for that respondent's country of residence. The regression model was tested using all of the same diagnostics as the macro-level model and no indications of problems were found, except in the Durbin-Watson test. The regression does have serial correlation, which is a result of the grouping of respondents within countries and with country-level values. Since no other values for the capital variables are available for the individual respondents, no improvement could be made in the model. The use of hierarchical regression modeling was considered but software capable of performing this method of analysis was not available. Therefore, the results of the above-described micro-level analysis are presented as the best available. The regression analysis at this individual level was found to be significant and both of the independent variables were also found to be significant (Table 5.4). This micro-level analysis provides support for the macro-level associations and conclusions presented.

[27] The ecological fallacy is defined as "a logical fallacy inherent in making causal inferences from group data to individual behaviors" (Schwartz, 1994). This term is not related to the more common term ecology, defined as "the science of the relationships between organisms and their environment, or the study of the detrimental effects of modern civilization on the environment" (American Heritage College Dictionary, 1993).

There is additional support from the findings of the individual level analysis of satisfaction in the Baltimore, Maryland study, as presented in chapters 3 and 4 of this dissertation.

Evidence of the impact of the modifiable areal unit problem on statistical analysis, especially on regression coefficients, has certainly been shown (Fotheringham and Wong, 1991; Amrhein, 1995). This possible problem was addressed by conducting the regression analysis at the level of the individual respondents in each country surveyed, as mentioned above. The analysis could not be conducted at any other scale or with any other zonal grouping because the data on life satisfaction are only spatially associated with a country. No smaller spatial unit is identified for the respondents in the survey and therefore, no other spatial aggregation of the data is possible.

Table 5.4: Regression Coefficients for Micro-level Analysis[28]

	Unstandardized Coefficients		Standardized Coefficients		
	B	Std. Error	Beta	t	Significance
Constant	2.506	.049		50.855	.000
HDI	3.427	.046	.206	73.783	.000
Log ESP/km^2 Index	2.564	.060	.118	42.448	.000

[28] Sample size for the micro-level regression was 121,239.

Conclusions

The most important finding from this study is the significant impact that natural capital has on life satisfaction. While the positive effects of the natural environment on stress recovery and health are well-established, fewer studies have looked at the role of the natural environment in people's self-assessments of life satisfaction. This analysis suggests that people do consider their natural environmental surroundings when evaluating their life satisfaction and therefore, the natural environment should routinely be included in studies of life satisfaction.

It is also clear that the UN's HDI (as a proxy for built and human capital) is a good starting point for assessing life satisfaction. The HDI alone explains a significant percentage of the variation in life satisfaction, but the HDI could be significantly improved by adding the natural capital index, to create what might be called a National Well-Being Index (NWI). However, to complete the NWI, a suitable proxy for social capital would have to be included.

Future Work

The results indicate that work to create an adequate index of social capital that captures the importance of friends and family at the national scale would likely improve efforts to explain individual life satisfaction. Another interesting follow-up to this study would be to perform a similar regression analysis but use *national* rather than *individual* life satisfaction as the dependent variable. National-level satisfaction is also measured using survey methods but rather than asking about satisfaction in one's personal life, it asks about satisfaction with one's country. The Australian Unity Well-Being Index uses a national satisfaction question with the following wording: “Thinking now not about your own life, but about the situation in Australia generally, how satisfied are you with life in Australia?” (Cummins et al., 2001; Cummins et al., 2003). Then, one would be relating national-level capital variables with national-level satisfaction. This analysis was not possible for this study because there is not yet a widely available database of countries for which this question has been asked.

Table 5.5: Data for the Countries Used in the Regression Models

Country	Life Satisfaction Values[a]	Human Development Index	Log (10) ESP/km^2 Index	Press Freedom Index	Predicted Life Satisfaction Values	Sample Size and Year
Colombia	8.31	.850	.67	52	6.98	6,025 – 1997
Switzerland	8.19	.930	.61	90	7.54	1,400 – 1989
Denmark	8.16	.928	.63	91	7.56	1,030 – 1990
Ghana	7.93	.473	.69	38	3.66	96 – 1995
Canada	7.89	.960	.74	82	8.12	1,730 – 1990
Ireland	7.88	.930	.65	85	7.63	1,000 – 1990 1,009 – 1996
Sweden	7.87	.936	.69	90	7.79	1,047 – 1990
Netherlands	7.77	.941	.61	82	7.62	1,017 – 1990 987 – 1996
Finland	7.73	.942	.72	85	7.90	588 – 1990 1,542 – 1995
USA	7.70	.943	.59	88	7.58	1,839 – 1990 1,127 – 1996
Norway	7.67	.943	.69	92	7.85	1,239 – 1990
Belgium	7.60	.933	.29	93	6.76	2,792 – 1990
Australia	7.58	.932	.47	93	7.19	2,048 – 1995 1,510 – 1996
Mexico	7.55	.855	.53	46	6.66	1,531 – 1990 1,093 – 1998
United Kingdom	7.48	.932	.73	78	7.85	1,484 – 1990
Italy	7.30	.922	.51	70	7.22	2,018 – 1990 1,149 – 1997
Brazil	7.26	.809	.64	70	6.53	1,782 – 1992 1,000 – 1996
Chile	7.24	.893	.57	70	7.11	1,500 – 1990 1,017 – 1997
Germany	7.22	.925	.42	82	7.03	2,101 – 1990
Dominican Rep.	7.13	.720	.81	65	6.15	417 – 1996
Uruguay	7.13	.885	.51	75	6.89	1,000 – 1996 1,079 – 1995
Argentina	7.09	.888	.46	71	6.79	1,002 – 1991
Portugal	7.07	.892	.50	84	6.93	1,185 – 1990 1,500 – 1995
China[b]	7.06	.650	.46	17	4.68	1,000 – 1990 1,211 – 1995
Spain	6.88	.935	.45	77	7.19	1,510 – 1990
Philippines	6.84	.677	.61	54	5.28	1,200 – 1996
France	6.78	.946	.41	73	7.18	1,002 – 1990
Venezuela	6.72	.860	.67	51	7.05	1,200 – 1996 2,769 – 1995
Nigeria[c]	6.71	.391	.61	31	2.73	1,001 – 1990 1,249 – 1996
Korea, Rep. of	6.69	.894	.58	72	7.13	1,251 – 1990 2,040 – 1996
India[d]	6.62	.451	.46	51	2.91	2,500 – 1990 1,054 – 1995
Japan	6.57	.940	.63	80	7.68	1,011 – 1990 1,153 – 1997
Poland	6.53	.851	.44	71	6.40	938 – 1989
Austria	6.51	.933	.50	82	7.29	1,460 – 1990
Bangladesh	6.41	.371	.74	51	2.90	1,525 – 1996 2,935 – 1996
South Africa	6.40	.717	.43	70	5.20	2,736 – 1990 1,007 – 1995
Slovenia	6.38	.887	.38	63	6.59	1,035 – 1992
Czech Rep.	6.37	.884	.35	79	6.47	930 – 1990
Peru	6.36	.729	.66	43	5.88	1,211 – 1996 1,907 – 1997
Turkey	6.30	.782	.54	27	6.04	1,030 – 1991
Croatia	6.18	.759	.52	44	5.79	1,196 – 1995
Slovakia	6.15	.875	.40	45	6.53	463 - 1990
Hungary	6.03	.857	.55	62	6.74	999 – 1990
Romania	5.88	.767	.45	50	5.68	1,103 – 1993

Macedonia, FYR	5.70	.749	.49	66	5.62	995 - 1997
						1,021 – 1996
Estonia	5.50	.758	.65	75	6.10	1,008 – 1990
						1,009 – 1996
Lithuania	5.50	.750	.47	71	5.58	1,000 – 1990
Azerbaijan	5.39	.623	.49	31	4.50	2,002 – 1996
						1,200 – 1996
Latvia	5.30	.704	.52	71	5.30	903 – 1990
						2,092 – 1996
Belarus	4.93	.783	.38	33	5.65	1,015 – 1990
						2,040 – 1995
Russian Fed.	4.91	.769	.74	45	6.43	1,961 – 1991
						1,072 – 1997
Bulgaria	4.85	.789	.38	61	5.72	1,034 – 1990
Georgia	4.65	.633	.49	30	4.60	2,593 – 1996
Armenia	4.32	.674	.61	43	5.25	2,000 – 1997
Ukraine	3.95	.665	.48	58	4.86	2,811 – 1996
Moldova, Rep.of	3.73	.610	.39	53	4.16	984 - 1996
Mean	***6.60***	*.80*	*.55*	*64.32*	***6.26***	
St. Deviation	***1.11***	*0.15*	*0.12*	*19.66*	***1.33***	

a. Most of the low-income countries under sampled the illiterate population and over sampled the urban and educated population (Inglehart et al., 2000).
b. China's sample is 90% urban and essentially excludes the illiterate population.
c. Data collection in Nigeria was stratified to be 40% urban and 60% rural. In 1990, they sampled in urban areas and within 100 kilometers of urban centers. In 1995, they sampled within 10 kilometers of Southern urban towns and within 50 kilometers of Northern urban towns.
d. India's sample was stratified to be 90% urban and 10% rural and to have 90% of the respondents be literate.

Table 5.6: Predicted Life Satisfaction Values for Additional Countries

Country	Predicted Life Satisfaction	Country	Predicted Life Satisfaction	Country	Predicted Life Satisfaction
Bahamas	8.15	Czech Rep.	6.47	Nicaragua	4.44
Canada	8.12	Russian Fed.	6.43	Namibia	4.43
Finland	7.90	Poland	6.40	Swaziland	4.30
Antigua and Barbuda	7.87	Kuwait	6.38	Moldova, Rep.of	4.16
United Kingdom	7.85	Luxembourg	6.37	Viet Nam	4.12
Norway	7.85	Dominican Rep.	6.15	Cape Verde	4.12
Sweden	7.79	United Arab Emirates	6.13	Congo	4.08
New Zealand	7.74	Ecuador	6.12	Papua New Guinea	4.06
Japan	7.68	Estonia	6.10	Tajikistan	4.01
Malta	7.68	Jamaica	6.08	Equatorial Guinea	3.93
Singapore	7.66	Lebanon	6.07	Egypt	3.77
Hong Kong	7.66	Turkey	6.04	Morocco	3.74
Ireland	7.63	Cuba	6.04	Ghana	3.66
Netherlands	7.62	Korea, Dem. People's Rep. of	5.89	Cameroon	3.62
Barbados	7.59	Peru	5.88	Iraq	3.62
USA	7.58	Croatia	5.79	Myanmar	3.60
Denmark	7.56	Bulgaria	5.72	Lao, People's Dem. Rep. of	3.48
Switzerland	7.54	Romania	5.68	Zimbabwe	3.39
St. Kitts and Nevis	7.45	Belarus	5.65	Comoros	3.32
Seychelles	7.43	Macedonia, FYR	5.62	Kenya	3.16
Greece	7.35	Lithuania	5.58	Cambodia	3.04
St. Vincent	7.30	Sri Lanka	5.55	Haiti	2.91
Trinidad and Tobago	7.30	Indonesia	5.49	India	2.91
Austria	7.29	Guyana	5.49	Bangladesh	2.90
Brunei Darussalam	7.29	Samoa (Western)	5.46	Congo, Dem. Rep. of the	2.88
Costa Rica	7.28	Iran, Islamic Rep. of	5.40	Lesotho	2.86
Italy	7.22	Paraguay	5.37	Pakistan	2.79
Australia	7.19	Syrian Arab Rep.	5.36	Nigeria	2.73
Spain	7.19	Latvia	5.30	Uganda	2.67
France	7.18	Philippines	5.28	Malawi	2.65
Korea, Rep. of	7.13	Saudi Arabia	5.27	Cote d'Ivoire	2.61
Israel	7.13	Tunisia	5.26	Tanzania, U. Rep. of	2.50
Cyprus	7.12	Armenia	5.25	Zambia	2.38
Chile	7.11	Kazakhstan	5.24	Togo	2.34
Panama	7.11	Oman	5.23	Senegal	2.34
Dominica	7.07	South Africa	5.20	Angola	2.32
Venezuela	7.05	Sao Tome and Principe	5.15	Benin	2.32
Germany	7.03	Uzbekistan	5.14	Gambia	2.28
Colombia	6.98	Jordan	5.10	Madagascar	2.24
Fiji	6.97	Albania	4.95	Guinea-Bissau	2.23
Portugal	6.93	Botswana	4.95	Central African Republic	2.06
Uruguay	6.89	Libyan Arab Jamahiriya	4.94	Sudan	2.00
Bahrain	6.88	Ukraine	4.86	Nepal	1.91
Grenada	6.82	Mongolia	4.81	Bhutan	1.82
Malaysia	6.80	Kyrgyzstan	4.78	Yemen	1.64
St. Lucia	6.80	Guatemala	4.76	Burundi	1.55
Mauritius	6.79	Vanuatu	4.69	Mauritania	1.53
Argentina	6.79	China	4.68	Mozambique	1.53
Belgium	6.76	Algeria	4.68	Guinea	1.51
Hungary	6.74	Gabon	4.66	Djibouti	1.49
Belize	6.71	Solomon Islands	4.62	Chad	1.40
Suriname	6.69	Turkmenistan	4.62	Eritrea	1.14
Mexico	6.66	Georgia	4.60	Ethiopia	1.14
Slovenia	6.59	El Salvador	4.58	Sierra Leone	1.10
Thailand	6.59	Bolivia	4.57	Mali	0.75
Qatar	6.57	Azerbaijan	4.50	Burkina Faso	0.64
Slovakia	6.53	Honduras	4.46	Niger	0.21
Brazil	6.53				

Appendix A

Model Equations and Parameter Values

Natural Space Sector

Visual image of sector is in Chapter 2, Figure 2.1.

Agriculture_Preserve(t) = Agriculture_Preserve(t - dt) + (Ag_Preserve_Flow) * dt

INIT Agriculture_Preserve = 0

Ag_Preserve_Flow = TDR_Addition * TDR_Used_Outflow * TDR_Filter

Developable_Land(t) = Developable_Land(t - dt) + (- Protect_Nat_Area_Inflow - Natural_Land_Loss - Ag_Preserve_Flow) * dt

INIT Developable_Land = 227500+10200+9900

Natural_Land_Loss = flow_to_resid_land_area + Office_and_Industry_Development + Retail_and_Parking

Developed_Land(t) = Developed_Land(t - dt) + (Natural_Land_Loss) * dt

INIT Developed_Land = NonResidential_Built_Area + resid_land_area

Protected_Natural_Space(t) = Protected_Natural_Space(t - dt) + (Protect_Nat_Area_Inflow) * dt

INIT Protected_Natural_Space = 10200+9854

Protect_Nat_Area_Inflow = (County_Park_Area + State_Increment + (Cluster_Reserve * Cluster_Filter)) * Brake

Additional_Acres_per_TDR = 0

Addition_Par = 0.000003 * Remaining_Capacity

Annual_State_Park_Area = Base_State_Park * (1 + Avg_St_Investment_Rate)^(time -1970)

Avg_St_Investment_Rate = .0136

Base_State_Park = 8250

County_Park_Area = if (time<2000) then 590 else (590 * Economic_Conditions * Addition_Par)

Delay_State_Park = delay(Annual_State_Park_Area,1)

Protected_Forest = .689 * Protected_Natural_Space

State_Increment = Annual_State_Park_Area - Delay_State_Park

TDR_Addition = if TIME>2000 then (5 + Additional_Acres_per_TDR) else 5

Residential Space Sector

Visual image of sector is in Chapter 2, Figure 2.3.

Housing_Units(t) = Housing_Units(t - dt) + (New_Housing) * dt

INIT Housing_Units = 156674

New_Housing = (Annual_Pop_Change/Avg_Household_Size) * Brake

resid_land_area(t) = resid_land_area(t - dt) + (flow_to_resid_land_area) * dt

INIT resid_land_area = 37500

flow_to_resid_land_area = (land_consump_by_group[Low] + land_consump_by_group[Mid] + land_consump_by_group[High] + (Total_TDR_Land_Consp * TDR_Filter) - (Cluster_Filter * Cluster_Reserve)) * Brake

Avg_Household_Size = 2.7

Cluster_Develop_Percent = .1

Cluster_Filter = if TIME <2000 then (.1) else Cluster_Develop_Percent

Cluster_Reserve = land_consump_by_group[High] * .33

HH_by_Housing_Type[Low] = Trad_New_Households * Housing_Distribution[Low]

HH_by_Housing_Type[Mid] = Trad_New_Households * Housing_Distribution[Mid]

HH_by_Housing_Type[High] = Trad_New_Households *
Housing_Distribution[High]

Housing_Distribution[Low] = .306

Housing_Distribution[Mid] = .173

Housing_Distribution[High] = .52

land_consump_by_group[Low] = Land_consump_per_HH[Low] *
HH_by_Housing_Type[Low]

land_consump_by_group[Mid] = Land_consump_per_HH[Mid] *
HH_by_Housing_Type[Mid]

land_consump_by_group[High] = Land_consump_per_HH[High] *
HH_by_Housing_Type[High]

Land_consump_per_HH[Low] = .05 + SFD_Land_Consumption * 0

Land_consump_per_HH[Mid] = .1 + SFD_Land_Consumption * 0

Land_consump_per_HH[High] = if TIME <2000 then 1, else
SFD_Land_Consumption

SFD_Land_Consumption = 1

SFD_TDR_Land_Consp = .25 * Total_SFD_TDR

TDR_Filter = if TIME <2000 then 1, else TDR_Switch

TDR_Switch = 1

TDR_TH_Distribution = 0.0605 * EXP(0.0028 * Population_Density)

TH_TDR_Consp = .1 * Total_TH_TDR

Total_SFD_TDR = TDR_Used_Outflow * (1 - TDR_TH_Distribution)

Total_TDR_Land_Consp = SFD_TDR_Land_Consp + TH_TDR_Consp

Total_TH_TDR = TDR_Used_Outflow * TDR_TH_Distribution

Trad_New_Households = if Developable_Land=0 then 0, else if
(Annual_Pop_Change=0) then 0, else

(Annual_Pop_Change/Avg_Household_Size) - (TDR_Used_Outflow * TDR_Filter)

Non-Residential Space Sector

Visual image of sector is in Chapter 2, Figure 2.4.

NonResidential_Built_Area(t) = NonResidential_Built_Area(t - dt) + (Office_and_Industry_Development + Retail_and_Parking) * dt

INIT NonResidential_Built_Area = 3137+10073

Office_and_Industry_Development = (Remaining_Capacity * Probability_of_Construction) * Brake

Retail_and_Parking = ((New_Retail/Conversion_Factor) + Parking_Area) * Brake

Aggregate_County_Income = Median_HH_Income * Households

Commercial_Parking_Par = 5

Conversion_Factor = 43560

Factor_Retail_$_per_SF = 60 * (1.03)^(TIME-1970)

Households = Population_of_Mo_Co/Avg_Household_Size

New_Retail = if New_Retail_Increment<=0 then 0, else New_Retail_Increment

New_Retail_Increment = (Supportable_SF - DELAY(Supportable_SF,1))

Non_Local_Spending = Percent_NonLocal_Employees * jobs * Median_HH_Income * Percent_Capture * Percent_Inc_on_Retail

Office_Parking_Par = 2.4

Parking_Spaces = (New_Retail/1000) * Commercial_Parking_Par + (Office_and_Industry_Development * Conversion_Factor/1000) * Office_Parking_Par

Percent_Capture = .3

Percent_Inc_on_Retail = .354

Percent_NonLocal_Employees = .421

Probability_of_Construction = if (Economic_Conditions<0.4) then 0.00005, else if (Economic_Conditions>0.8) then 0.0004, else 0.0003

Sf_per_area_Parameter = 0.000001 * Remaining_Capacity + 0.64

Supportable_SF = (Total_Retail_Spending/Factor_Retail_$_per_SF) * Sf_per_area_Parameter

Total_Retail_Spending = (Aggregate_County_Income * Percent_Inc_on_Retail) + Non_Local_Spending

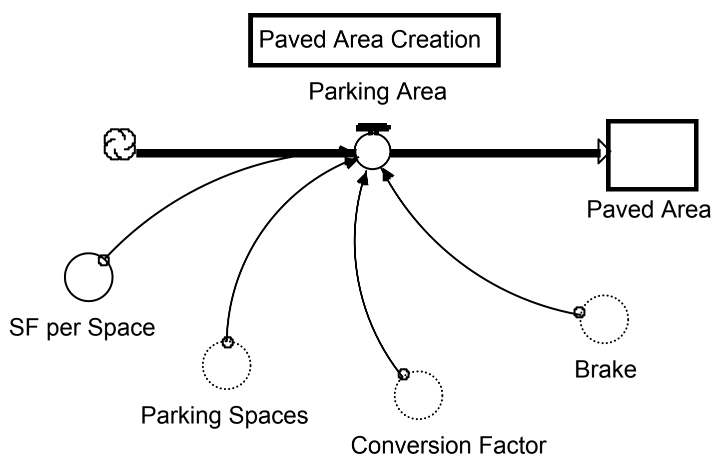
Paved_Area(t) = Paved_Area(t - dt) + (Parking_Area) * dt

nonres_land = 29500 - Paved_Area

INIT Paved_Area = 10073

Parking_Area = ((Parking_Spaces * SF_per_Space)/Conversion_Factor) * Brake

SF_per_Space = 300



Population Sector

Visual image of sector is available in Chapter 2, Figure 2.5.

Population_of_Mo_Co(t) = Population_of_Mo_Co(t - dt) + (births + In_Migration - deaths - Out_Migration) * dt

INIT Population_of_Mo_Co = 522809

births = Population_of_Mo_Co * birth_rate

In_Migration = (Population_of_Mo_Co * In_Migration_Rate) * Brake

deaths = Population_of_Mo_Co * death_rate

Out_Migration = Population_of_Mo_Co * Out_Migration_Rate

birth_rate = Birth_Rate_Dynamic * Economic_Conditions

Birth_Rate_Dynamic = (1.8 - (TIME-1970) * 0.016)/100

Constant_A = .165

Constant_A2 = 5

Constant_B = .9

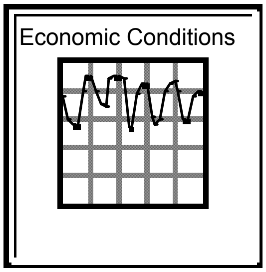
Constant_B2 = .01

death_rate = 0.0063

In_Migration_Rate = ((Constant_A * Quality_of_Life_Index)/(Constant_B + Quality_of_Life_Index)) *Economic_Conditions

Out_Migration_Rate = (Constant_A2/((Quality_of_Life_Index + 1) + Constant_B2))/100

Economic_Conditions = GRAPH(time)
(1970, 0.8), (1973, 0.75), (1975, 0.595), (1978, 0.565), (1980, 0.57), (1983, 0.795), (1985, 0.9), (1988, 0.9), (1991, 0.79), (1993, 0.705), (1996, 0.69), (1998, 0.89), (2001, 0.905), (2004, 0.905), (2006, 0.875), (2009, 0.55), (2011, 0.545), (2014, 0.785), (2016, 0.84), (2019, 0.845), (2022, 0.61), (2024, 0.57), (2027, 0.595), (2029, 0.795), (2032, 0.85), (2035, 0.865), (2037, 0.8), (2040, 0.6), (2042, 0.605), (2045, 0.755), (2047, 0.8), (2050, 0.79)



Quality of Life Sector

Ag_Per_Cap_Indicator = (Developable_Ag + Agriculture_Preserve)
/Population_of_Mo_Co

Conversion_Slider = .1

Density_Indicator = Population_Density/Max_Density

Environmental_Health_Index = (Ecosystems_Indicator * Slider_Ecosystems + Energy_Indicator * Slider_Energy + Percent_Open_Space_Indicator * Slider_Open_Space + Slider_Water_Quality * Water_Quality_Indicator)/100

Fiscal_Index = (Percent_Capacity_Indicator * Slider_Capacity + Slider_Tax * Tax_Ratio_Indicator + Conversion_Slider * Conversion_Indicator + Job_Growth_Indicator * Job_Growth_Slider)/100

Job_Growth_Slider = .3

Job_Ratio_Indicator = if (jobs/Housing_Units)/3 >1 then 1, else (jobs/Housing_Units)/3

Max_Density = 8

Max_Housing = 480000

Max_Income = Base_Median_Current_Income * ((1 + Rate)^(50))

Max_Jobs = 1200000

Max_Spending = (Max_Housing * Max_Income * Percent_Inc_on_Retail) + (Max_Jobs * Percent_Capture * Percent_Inc_on_Retail * Percent_NonLocal_Employees * Max_Income)

Max_Tax = Max_Spending * Percent_Taxable * State_Sales_Tax_Rate

Percent_Taxable = .896

Population_Density = Housing_Units/resid_land_area

Quality_of_Life_Index = (Environmental_Health_Index * Slider_Env_Health + Fiscal_Index * Slider_Fiscal + Social_Health_Index * Slider_Social_Health)/100

Sales_Tax_Collected = State_Sales_Tax_Rate * (Total_Retail_Spending * Percent_Taxable)

Slider_Ag_land = .15

Slider_Capacity = .5

Slider_Density = .25

Slider_Ecosystems = .1

Slider_Energy = .15

Slider_Env_Health = .34

Slider_Fiscal = .33

Slider_Jobs = .6

Slider_Open_Space = .4

Slider_Social_Health = .33

Slider_Tax = .1

Slider_Water_Quality = .35

Social_Health_Index = ((Density_Indicator * Slider_Density) + (Job_Ratio_Indicator * Slider_Jobs) + (Ag_Per_Cap_Indicator * Slider_Ag_land))/100

State_Sales_Tax_Rate = .05

Tax_Ratio_Indicator = Sales_Tax_Collected/Max_Tax

Acres_of_trees_for_mitigation = ((Mill_lbs_CO2_equiv * 1000000)/3309309) * 466

Conversion_Indicator = 1 - (Natural_Land_Loss / (2251.23 * 2))

Ecological_Services = 189

Ecosystems_Indicator = Total_Ecosystems_Value/Upper_Eco_Index

Energy_Indicator = 1-(Total_E_Use_kWh/Total_E_use_possible)

Job_Growth_Indicator = ((jobs - (DELAY(jobs,1))) / DELAY(jobs,1)) / .1

kWh_to_lbs_CO2_conv = 0.00021815 * 3.67 * 1.102 * 2000

max_res_HH_by_type[Low] = residential_land[Low]/Land_consump_per_HH[Low]

max_res_HH_by_type[Mid] = residential_land[Mid]/Land_consump_per_HH[Mid]

max_res_HH_by_type[High] = residential_land[High] /
Land_consump_per_HH[High]

Mill_lbs_CO2_equiv = (Total_E_Use_kWh * kWh_to_lbs_CO2_conv)/1000000

NonResidential_E_Use = (NonResidential_Built_Area * Conversion_Factor) *
NonRes_E_use_conv

NonRes_E_use_conv = 15.4

Percent_Capacity_Indicator = Remaining_Capacity/Total_County_Area

Percent_Open_Space_Indicator = ((Protected_Natural_Space + Developable_Land +
Agriculture_Preserve) / Total_County_Area)

Residential_E_Use = (HH_by_Housing_Type[Low] * res_E_use_conv[Low]) +
(HH_by_Housing_Type[Mid] * res_E_use_conv[Mid]) +
(HH_by_Housing_Type[High] * res_E_use_conv[High])

residential_land[Low] = Housing_Distribution[Low] * 295000

residential_land[Mid] = Housing_Distribution[Mid] * 295000

residential_land[High] = Housing_Distribution[High] * 295000

res_E_use_conv[Low] = 4713

res_E_use_conv[Mid] = 4988

res_E_use_conv[High] = 9942

Services_Value = 8498

Societal_Services = 88

Total_Ecosystems_Value = Total_Forest_Value + Total_Water_Value

Total_E_Use_kWh = NonResidential_E_Use + Residential_E_Use

Total_E_use_possible = ((nonres_land * Conversion_Factor) * NonRes_E_use_conv) + (max_res_HH_by_type[Low] * res_E_use_conv[Low]) + (max_res_HH_by_type[Mid] * res_E_use_conv[Mid]) + (max_res_HH_by_type[High] * res_E_use_conv[High])

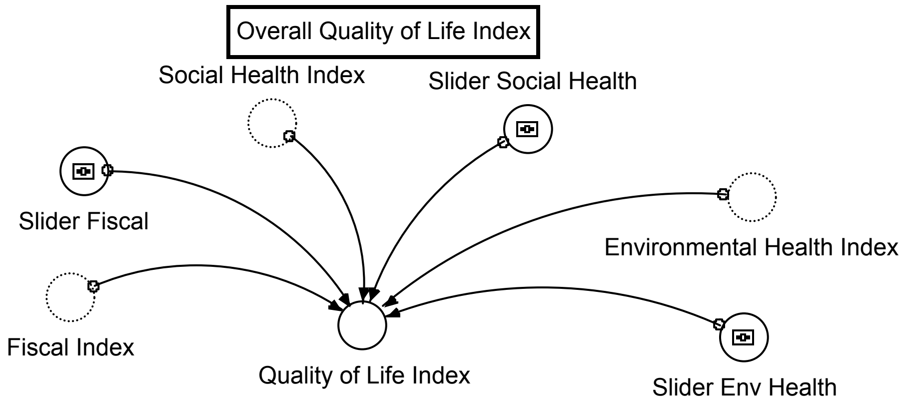
Total_Forest_Value = ((Protected_Forest + Developable_Forest) / Hectare_Conversion) * (Ecological_Services + Societal_Services)

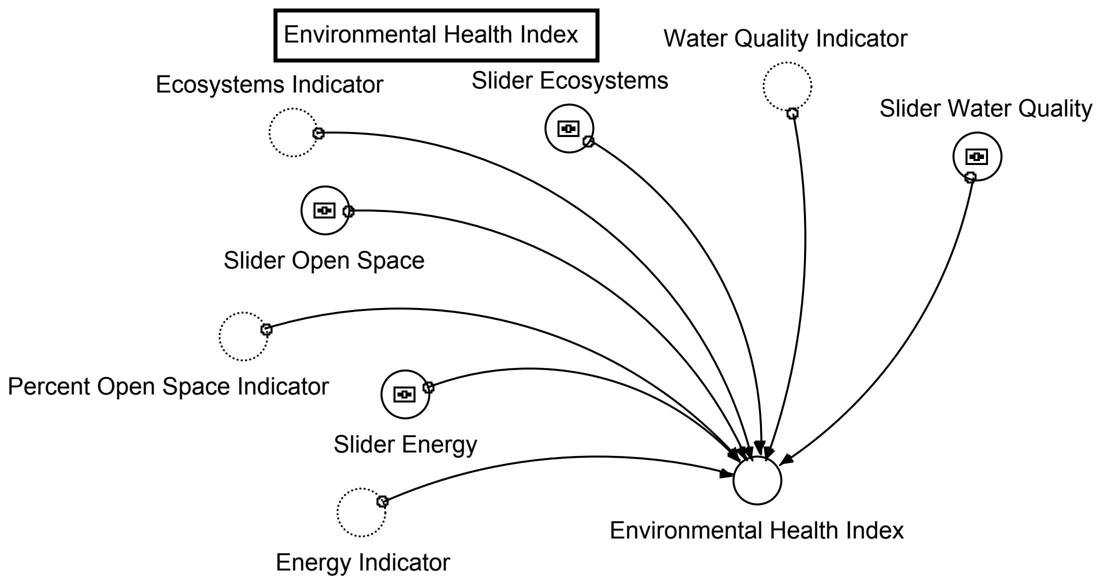
Total_Water_Value = (Water_Area/Hectare_Conversion) * Services_Value

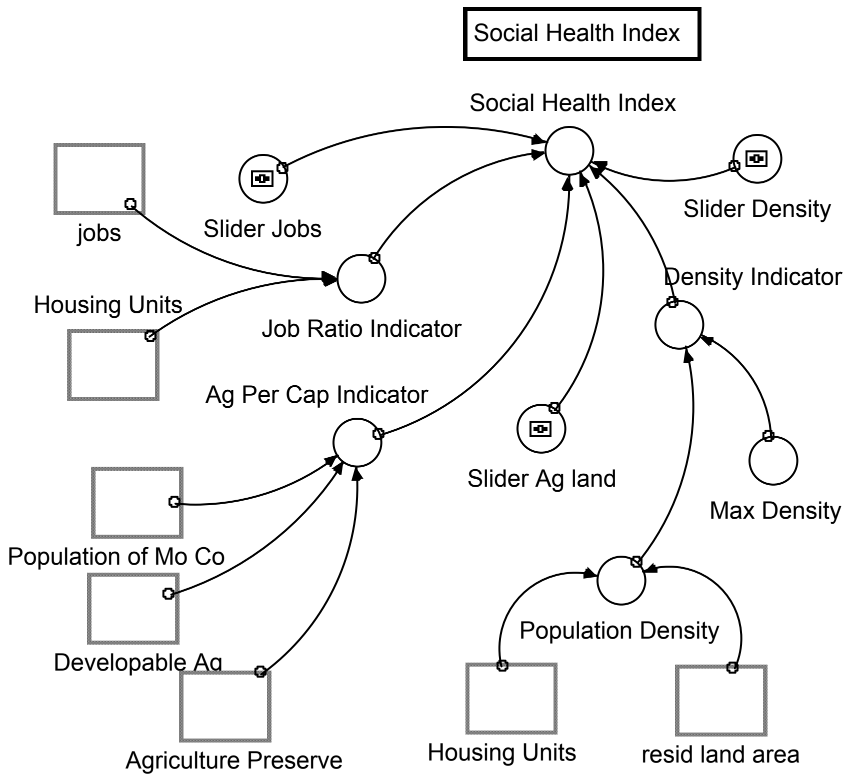
Upper_Eco_Index = ((Forest_Context/Hectare_Conversion) * (Societal_Services + Ecological_Services)) + Total_Water_Value

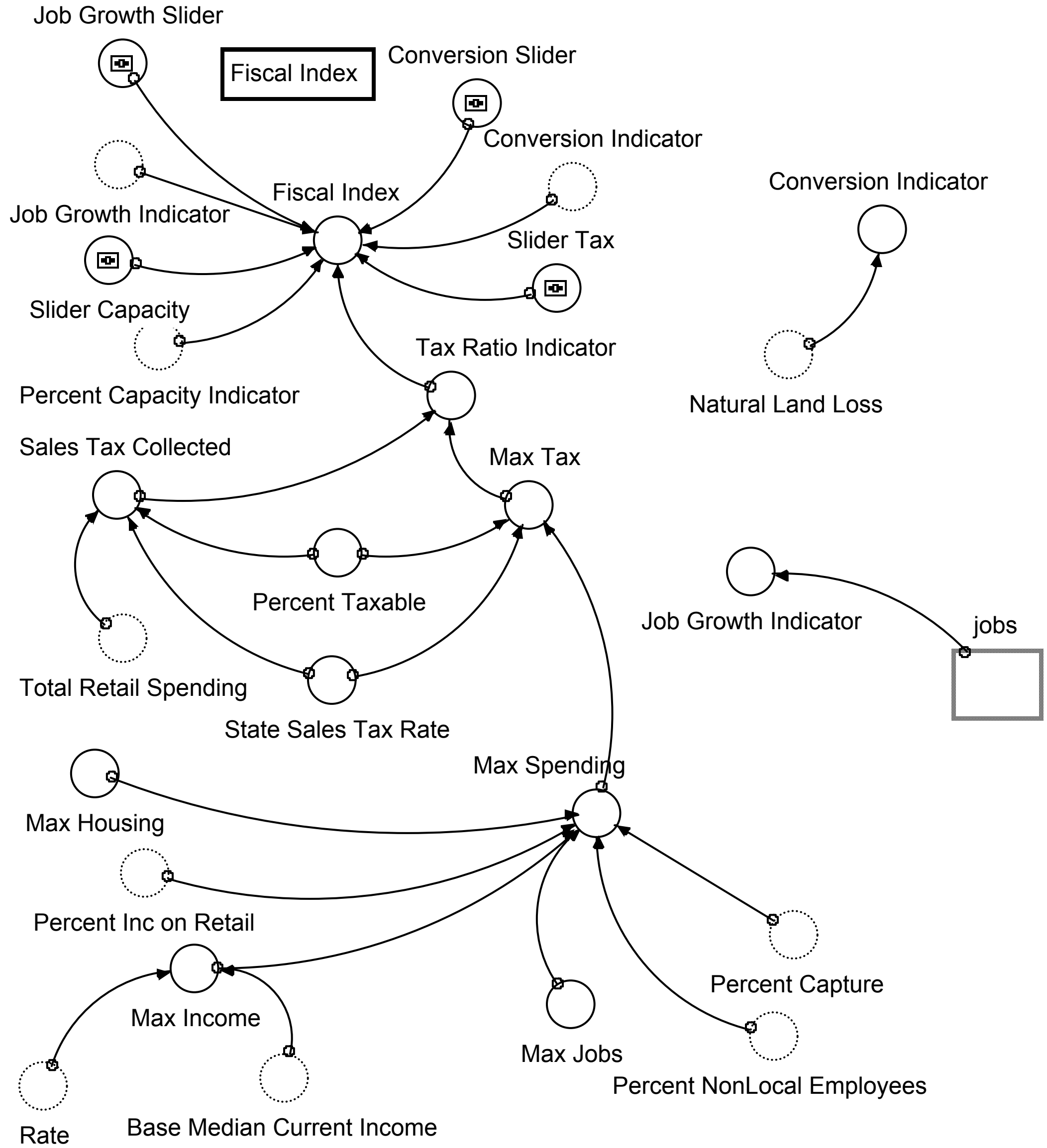
Water_Quality_Indicator = 1 - ((Agriculture_Preserve + Developable_Ag + NonResidential_Built_Area + resid_land_area) / Total_County_Area)

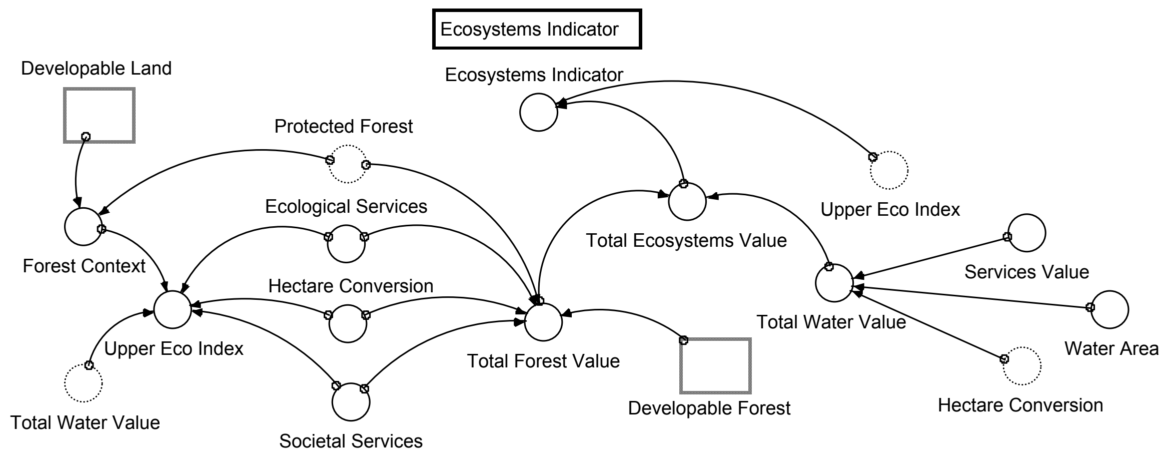
Model visuals for QOL sector are below.

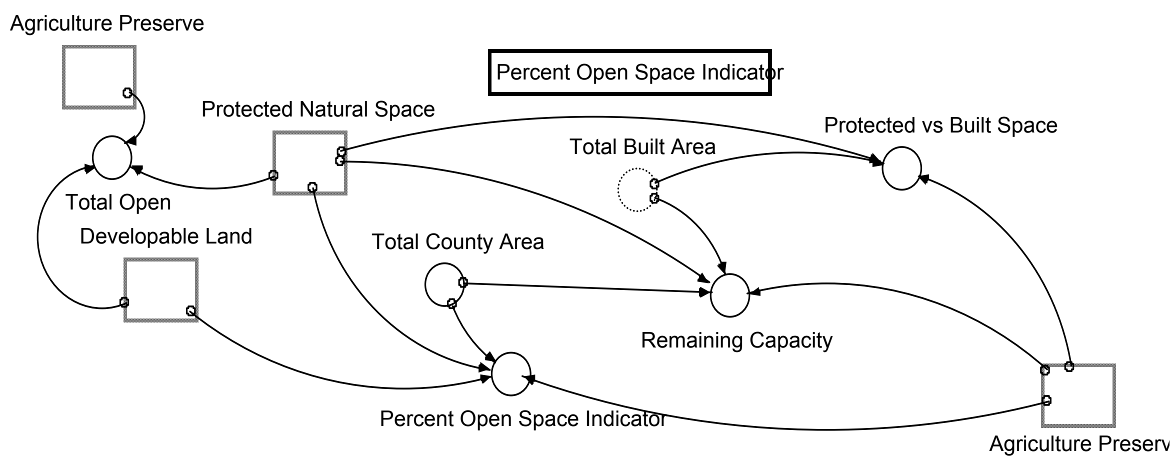

Overall Quality of Life Index
Social Health Index
Slider Social Health
Slider Fiscal
Environmental Health Index
Fiscal Index
Quality of Life Index
Slider Env Health

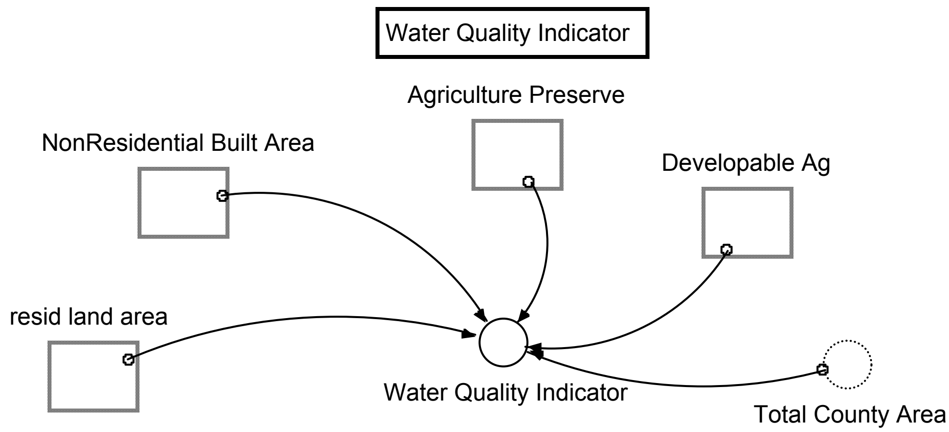

Environmental Health Index
Water Quality Indicator
Ecosystems Indicator
Slider Ecosystems
Slider Water Quality
Slider Open Space
Percent Open Space Indicator
Slider Energy
Environmental Health Index
Energy Indicator

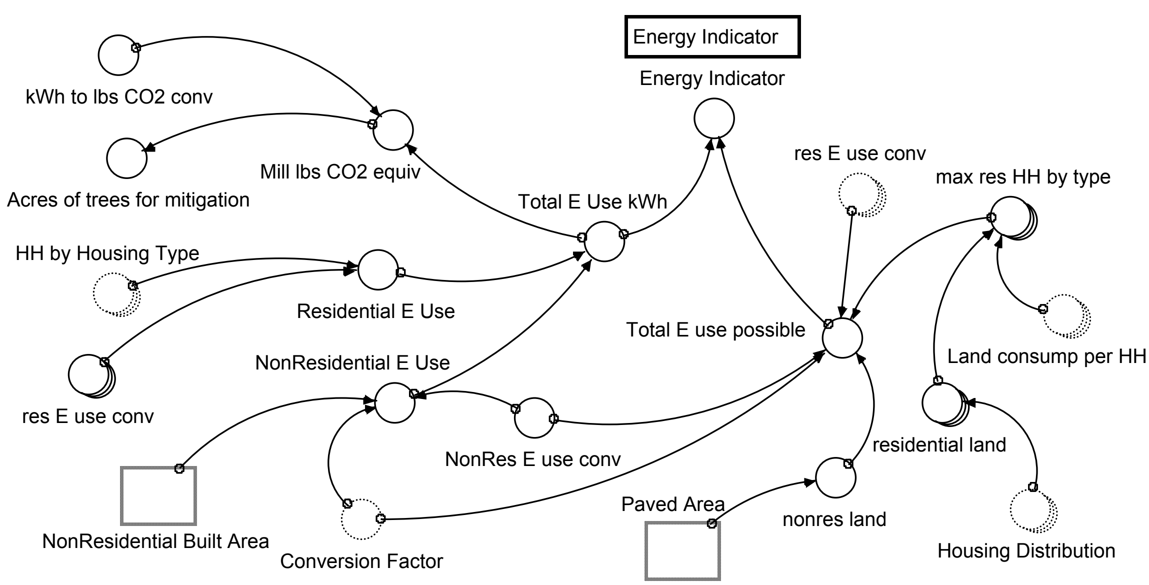

Social Health Index
Social Health Index
jobs
Slider Jobs
Slider Density
Housing Units
Job Ratio Indicator
Density Indicator
Ag Per Cap Indicator
Slider Ag land
Max Density
Population of Mo Co
Developable Ag
Population Density
Agriculture Preserve
Housing Units
resid land area


Job Growth Slider
Fiscal Index
Conversion Slider
Conversion Indicator
Fiscal Index
Job Growth Indicator
Slider Tax
Slider Capacity
Tax Ratio Indicator
Percent Capacity Indicator
Sales Tax Collected
Max Tax
Percent Taxable
Total Retail Spending
State Sales Tax Rate
Max Spending
Max Housing
Percent Inc on Retail
Max Income
Percent Capture
Max Jobs
Percent NonLocal Employees
Rate
Base Median Current Income
Conversion Indicator
Natural Land Loss
Job Growth Indicator
jobs


Ecosystems Indicator
Developable Land
Ecosystems Indicator
Protected Forest
Ecological Services
Upper Eco Index
Forest Context
Total Ecosystems Value
Hectare Conversion
Services Value
Upper Eco Index
Total Water Value
Total Forest Value
Water Area
Total Water Value
Developable Forest
Hectare Conversion
Societal Services


Agriculture Preserve
Percent Open Space Indicator
Protected Natural Space
Protected vs Built Space
Total Built Area
Total Open
Developable Land
Total County Area
Remaining Capacity
Percent Open Space Indicator
Agriculture Preserv


Water Quality Indicator
Agriculture Preserve
NonResidential Built Area
Developable Ag
resid land area
Water Quality Indicator
Total County Area


Energy Indicator
Energy Indicator
kWh to lbs CO2 conv
Mill lbs CO2 equiv
Acres of trees for mitigation
Total E Use kWh
res E use conv
max res HH by type
HH by Housing Type
Residential E Use
Total E use possible
Land consump per HH
res E use conv
NonResidential E Use
NonRes E use conv
residential land
Paved Area
nonres land
NonResidential Built Area
Conversion Factor
Housing Distribution

Forest Development Rate Calculations

Developable_Ag(t) = Developable_Ag(t - dt) + (- Ag_Lost) * dt

INIT Developable_Ag = 131516

Ag_Lost = if Natural_Land_Loss>Developable_Ag then 0, else if Natural_Land_Loss>Developable_Forest then (Natural_Land_Loss + Ag_Preserve_Flow + Protect_Nat_Area_Inflow), else ((Natural_Land_Loss + Protect_Nat_Area_Inflow) * (1 - Forest_Dev_Rate)) + Ag_Preserve_Flow

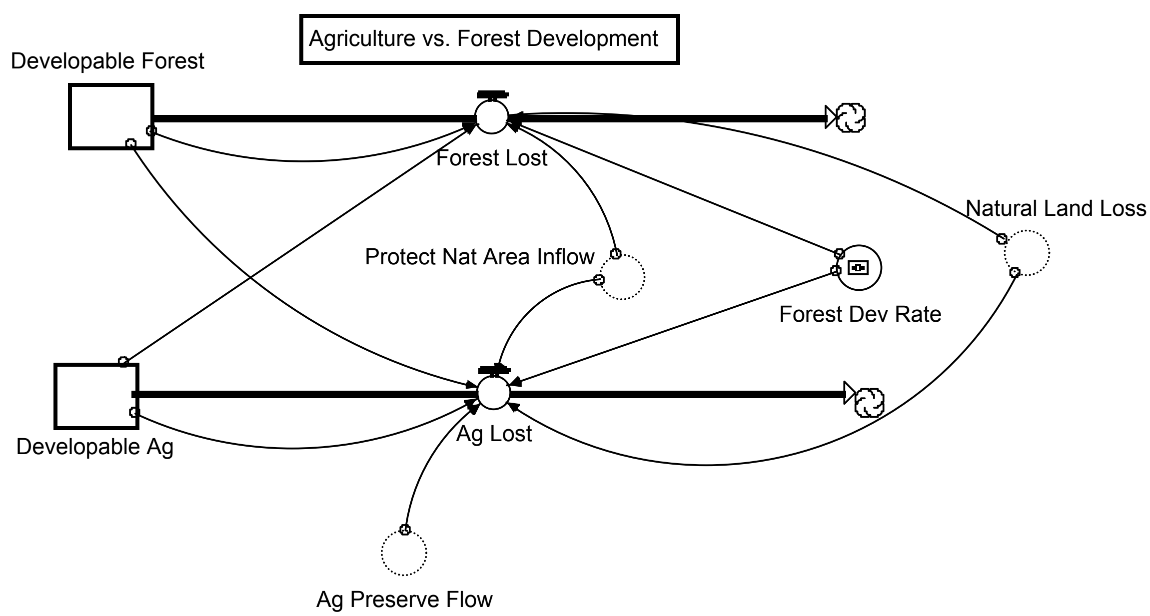
Developable_Forest(t) = Developable_Forest(t - dt) + (- Forest_Lost) * dt

INIT Developable_Forest = 97316

Forest_Lost = if Natural_Land_Loss>Developable_Forest then 0, else if (Natural_Land_Loss>Developable_Ag) then (Natural_Land_Loss + Protect_Nat_Area_Inflow), else ((Natural_Land_Loss + Protect_Nat_Area_Inflow) * Forest_Dev_Rate)

Forest_Context = INIT(Developable_Land) + INIT(Protected_Forest)

Forest_Dev_Rate = .5



Job Creation Calculations

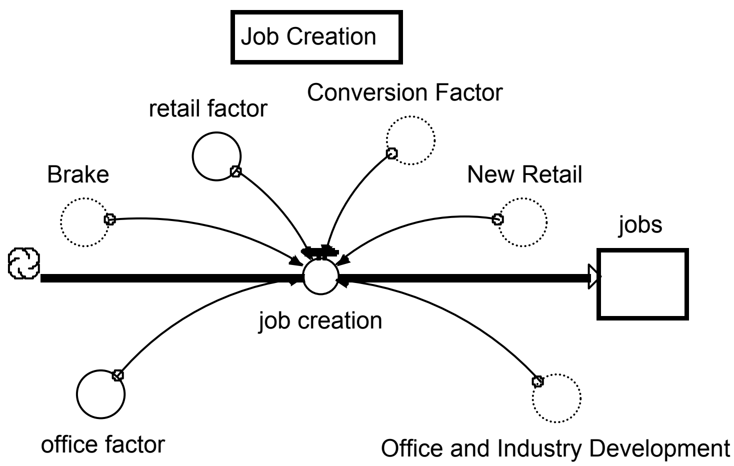
jobs(t) = jobs(t - dt) + (job_creation) * dt

INIT jobs = 183330

job_creation = ((New_Retail/retail_factor) + (Office_and_Industry_Development * Conversion_Factor/office_factor)) *Brake

retail_factor = 400

office_factor = 350



TDR Calculations

Receiving_TDRs(t) = Receiving_TDRs(t - dt) + (TDR_receiving_Flow - Used_TDRs) * dt

INIT Receiving_TDRs = 14427

TDR_receiving_Flow = PULSE(Pulse_Size,2000,Pulse_Frequency)

Used_TDRs = if (time > 1980) then TDR_Used_Outflow, else 0

Sending_TDRs(t) = Sending_TDRs(t - dt) + (- TDR_Used_Outflow) * dt

INIT Sending_TDRs = 19297 – 2481 – 6889

TDR_Used_Outflow = ((if TIME >1980 then if Perceived_Ratio <0.48 then ((ROUND(RANDOM(0,1)) * Annual_TDR_Potential)), else (Annual_TDR_Potential), else 0) * Brake) * TDR_Brake

Annual_TDR_Potential = RANDOM(0,(0.1 * Sending_TDRs),100)

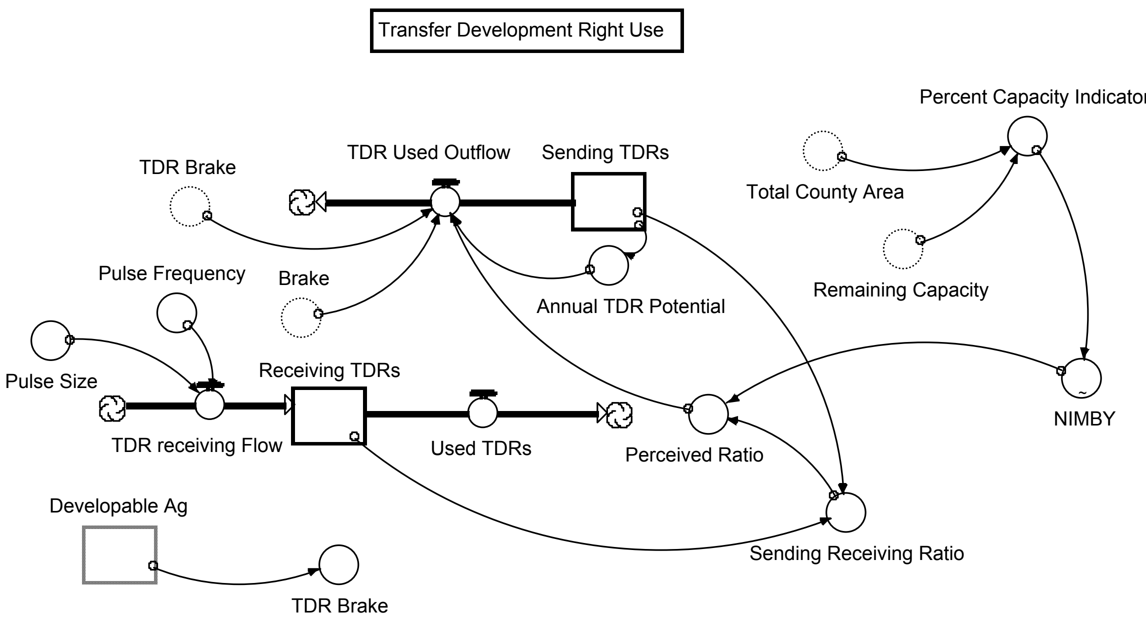
Perceived_Ratio = Sending_Receiving_Ratio * (1 - NIMBY)

Pulse_Frequency = 0

Pulse_Size = 2000

Sending_Receiving_Ratio = Sending_TDRs/Receiving_TDRs

NIMBY = GRAPH(Percent_Capacity_Indicator)
(0.00, 0.98), (0.1, 0.94), (0.2, 0.795), (0.3, 0.39), (0.4, 0.25), (0.5, 0.175), (0.6, 0.14), (0.7, 0.11), (0.8, 0.09), (0.9, 0.09), (1, 0.09)



Other Parameters and Calculations

Base_Median_Current_Income = 71614

Brake = if Developable_Land <1000 then 0, else 1

Future_Median_HH_Income = Base_Median_Current_Income * ((1 + Rate)^Time_Parameter)

Hectare_Conversion = 2.47

Last_Pop = DELAY(Population_of_Mo_Co,1)

Median_HH_Income = if (time <=2000) then Past_Median_HH_Income, else Future_Median_HH_Income

Protected_vs_Built_Space = (Protected_Natural_Space + Agriculture_Preserve) / Total_Built_Area

Rate = if (Economic_Conditions <.4) then .02, else if (Economic_Conditions >.8) then .05 else .04

Remaining_Capacity = Total_County_Area -(Protected_Natural_Space + Total_Built_Area + Agriculture_Preserve)

TDR_Brake = if Developable_Ag=0 then 0, else 1

Time_Parameter = Time - 2000

Total_Accounted_Land = Agriculture_Preserve + Developable_Land + NonResidential_Built_Area + Protected_Natural_Space + resid_land_area

Total_Built_Area = resid_land_area + NonResidential_Built_Area

Total_County_Area = 324500

Total_Open = Agriculture_Preserve + Developable_Land + Protected_Natural_Space

Water_Area = 12013

Past_Median_HH_Income = GRAPH(time)
(1970, 14968), (1975, 19919), (1980, 32156), (1985, 44148), (1990, 56720), (1995, 62738), (2000, 71614)

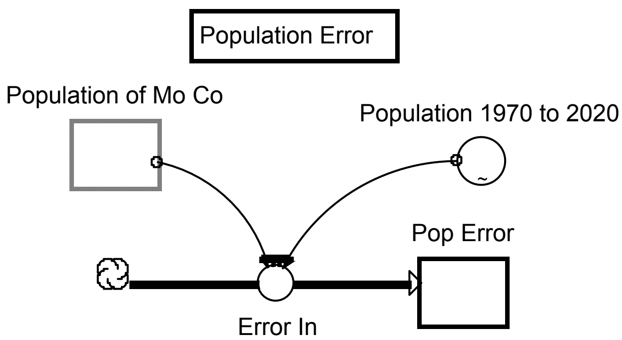
Population_1970_to_2020 = GRAPH(time)
(1970, 522809), (1975, 589400), (1980, 579053), (1985, 628000), (1990, 757027), (1995, 810000), (2000, 855000), (2005, 910000), (2010, 945000), (2015, 975000), (2020, 1e+006)

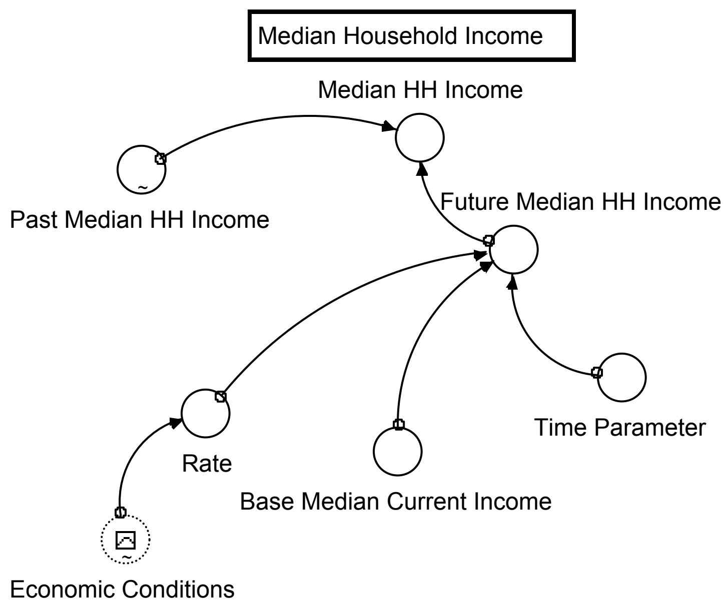
Pop_Error(t) = Pop_Error(t - dt) + (Error_In) * dt

INIT Pop_Error = 0

Error_In = ((Population_of_Mo_Co - Population_1970_to_2020)) / (Population_of_Mo_Co)

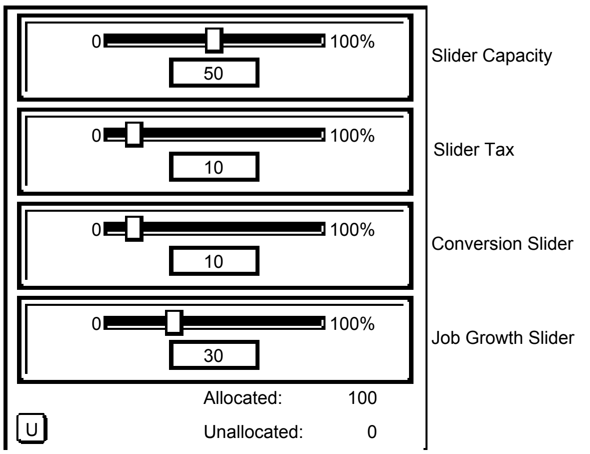
Annual_Pop_Change = If (Population_of_Mo_Co-Last_Pop <0) then 0, else
Population_of_Mo_Co-Last_Pop



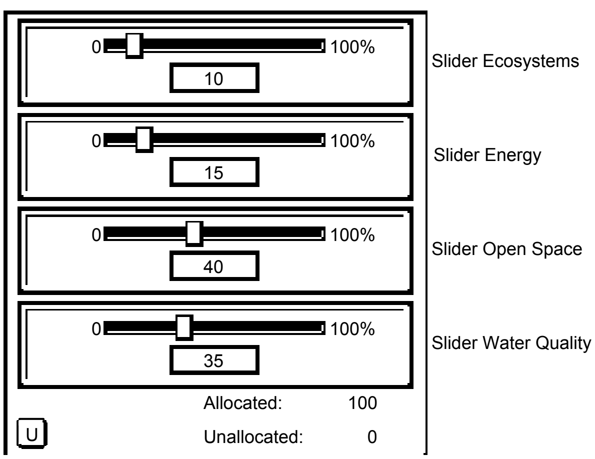


Quality of Life Indicator Weighting Controls

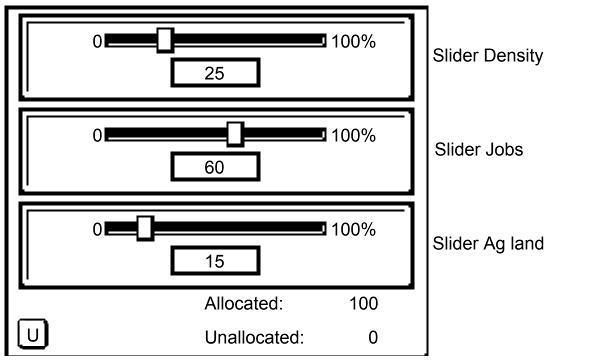
Weighting Control for Economic Health Index



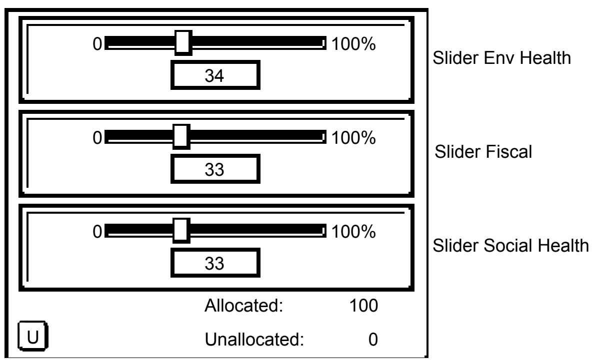
Weighting Control for Environmental Health Index



Weighting Control for Social Health Index



Weighting Control for Overall QOL Index



Appendix B

Baltimore Ecosystem Study

August, 2003

Dear Resident,

We are conducting a survey on outdoor recreation and neighborhood characteristics in central Maryland and your telephone number was randomly chosen to take part. In the next few weeks, your household may be called by Hollander, Cohen, and McBride, a professional survey research firm, who will be doing the interviews for the Baltimore Ecosystem Study. Please tell others in your home that we will be calling, so that we can be sure to include your household's input in the survey. Thank you in advance for your help.

Sincerely,

Matthew A. Wilson
Co-Principal Investigator
Baltimore Ecosystem Study, Baltimore Office
University of Maryland, Baltimore County

Baltimore Ecosystem Study
c/o 22 West Road, Suite 301
Baltimore, Maryland 21204

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Appendix C

The Greater Baltimore Recreation and Neighborhood Questionnaire

Good evening. I'm ... of Hollander, Cohen, and McBride, a professional survey research firm. You may recall having received a postcard in the past few weeks, letting you know that I would be calling to conduct a survey for the Baltimore Ecosystem Study on outdoor activities and neighborhood characteristics. [IF RESPONDENT VOLUNTEERS NO RECOLLECTION OF POSTCARD, VERIFY STREET NAME; CONTINUE ONLY IF SAME] For the survey, we'd like to speak with a household member that is over the age of 18. Would that be you? IF N/A: Ask for availability and call back time.

TIME BEGUN:_________________

1. Thinking about everyone in your household, which of the following outdoor recreational activities has anyone done in the past year? [READ EACH; EMPHASIZE THEY ARE RESPONDING FOR THE ENTIRE HOUSEHOLD AND ONLY FOR THE PAST 1 YEAR.]

- - - - - - - - - - - - - - - - -

FOR EACH "YES" ACTIVITY ASK:

2a. Now, thinking **only about yourself**, in the past year, about how often per week, month, or year do you typically [NAME ACTIVITY]? [IF 2A = 0 (NONE), SKIP TO NEXT Q. 1 YES ACTIVITY]

2b. Do you most often do this activity alone, or with family members, or with friends? [UP TO 2 RESPSONSES]

2c. **[Q. a-d ONLY**] Do you usually do this activity in a public park or recreation area, or do you do it elsewhere? [PUBLIC INCL SCHOOL GROUNDS] [UP TO 3 RESPONSES]
[IF PUBLIC PK/SCHOOL GROUNDS/REC AREA , 2c1: Is that a City, County, State, or Federal Pk? [ADD DK]?
[IF ELSEWHERE, 2c2: Is that at home, in your neighborhood, in your own county, in other area counties, (BALTIMORE CITY, BALTIMORE, CARROLL, ANNE ARUNDEL, HOWARD, HARFORD, FREDERICK, QUEEN ANNE, PRIVATE CLUB - CODED,) elsewhere in Md, or out-of-state?]

[**Q. e-g ONLY**] Do you usually go [NAME ACTIVITY] in any park's water area, in rivers, in lakes, in the Chesapeake Bay, the ocean, ("e" ONLY: in pools,) or elsewhere? FOLLOW UPS FOR PARKS, POOLS & ELSEWHERE.

PARKS: City, County, State, or Federal?

POOLS: private club, residence pool, public pool?
IF ELSEWHERE, SPECIFY OTHER

Q. 1	YES	NO	Q. 2a HOW OFTEN	Q. 2b WITH	Q. 2c WHERE
a. Take a walk for exercise or jog?	1	2	______ X _________	__________	______________
b. Go biking or play outdoor sports, such as softball, basketball, tennis, soccer, golf, or others?	1	2	______ X _________	__________	______________
c. Picnic or Barbeque outdoors or go camping with a tent?	1	2	______ X _________	__________	______________
d. Take a drive for pleasure?	1	2	______ X _________	__________	______________
And any of the following water activities:					
e. Go swimming?	1	2	______ X _________	__________	______________
f. Go canoeing, kayaking, or sailing?	1	2	______ X _________	__________	______________
g. Go motor boating or fishing?	1	2	______ X _________	__________	______________

IF ALL NO IN Q.1, SKIP TO Q. 3

3. On about how many days out of the past year were you on or in the water of Maryland rivers, streams or lakes, the Bay, the ocean, or used their shores or the areas surrounding them?

_________DAYS

Now, I would like to ask you about areas called watersheds. A watershed is the drainage area to either a body of water itself or to its tributaries, such as the rivers & streams that eventually flow into it.

4a. Do you live in a watershed?

YES   NO   DON'T KNOW

→ IF NO OR DON'T KNOW, SKIP TO Q. 5

4b. What watershed is that? [DO NOT READ] [UP TO 5 VOLUNTEERED RESPONSES]

-1 CHESAPEAKE BAY
-2 BALTIMORE HARBOR/ PATAPSCO RIVERHARBOR
-3 LOCH RAVEN RESERVOIR
-4 LIBERTY RESERVOIR
-5 PRETTYBOY RESERVOIR
-6 GUNPOWDER FALLS/RIVER
-7 GWYNNS FALLS
-8 JONES FALLS
-9 PATUXENT RIVER
-10 SEVERN RIVER
-11 MAGOTHY RIVER
-12 SUSQUEHANNA RIVER/ CONOWINGO DAM
-13 BACK RIVER
-14 HERRING RUN
❑ OTHER________________
-99 DON'T KNOW [SKIP TO Q. 5]

5. How likely would you be to take part in the following efforts to improve and maintain the quality of the watersheds near where you live? Would you be very likely, somewhat likely, somewhat unlikely, or very unlikely to…?

VERY LIKELY	SOMEWHAT LIKELY	SOMEWHAT UNLIKELY	VERY UNLIKELY	D.K.
4	3	2	1	❑

a. Pay increased recreation or other usage fees

b. To support a modest (small) tax increase to be used for water quality issues?

c. To support legislation to require all developments be set back from streams and flood plains?

d. To volunteer to work on cleanup and/or pollution patrols?

Now I have some questions about your neighborhood. For these questions, "neighborhood" includes both the block or street you live on and several blocks or streets in each direction. Please keep this in mind when answering these questions.

6. How long have you lived in your present neighborhood? ______ YEAR(S)

→ IF LESS THAN 1 YEAR: #___ MONTHS

7 & 8. In regard to the following environmental and quality of life issues, I'd first like you to tell me (7) if you consider it to be a major problem, somewhat of a problem, or not a problem in your neighborhood, and (8) then tell me if you feel it has experienced improvement, declined, or remained the same in the past few years? The first one is…

Not a Problem	Somewhat	Major Problem
Declined	Remained Same	Improvement
1	2	3

a) Cleanliness of streets and sidewalks

b) Availability of parks and open spaces

c) Quality of parks and open spaces

d) Safety and security

e) Air quality

f) Water quality

9. On a five-point scale, how strongly would you agree or disagree with the following statements about your neighborhood with a score of one being strongly disagree, up through five being strongly agree.

STRONGLY AGREE				*STRONGLY DISAGREE*	*DK NA*
5	4	3	2	1	❑

a. People in the neighborhood are willing to help one another.

b. This is a close knit neighborhood.

c. People in this neighborhood can be trusted.

d. There are many opportunities to meet neighbors and work on solving community problems

e. There is an active neighborhood association.

f. Municipal (local) government services (such as sanitation, police, fire, health & housing dept) are adequately provided and support the neighborhood's quality.

g. Churches or temples and other volunteer groups are actively supportive of the neighborhood.

For the next few questions, I am going to ask you how satisfied you are with your life and with life in your neighborhood, on a scale ranging from zero to 10. Zero means you feel very dis-satisfied. 10 means you feel very satisfied. And the middle of the scale is 5, which means you feel neutral.
[USE A PROBE OF "*Would you like me to go over this again for you?*" WHEN NEEDED]

10. Thinking about your own life and personal circumstances, how satisfied are you with your life as a whole (using a scale of zero through 10)?

0	1	2	3	4	5	6	7	8	9	10	99
VERY DIS-SATISFIED					NEUTRAL					VERY SATISFIED	DK

11. Thinking about the situation in your neighborhood generally, how satisfied are you with life in your neighborhood (using a scale of zero through 10)?

0	1	2	3	4	5	6	7	8	9	10	99
VERY DIS-SATISFIED					NEUTRAL					VERY SATISFIED	DK

12. How satisfied are you with the quality of the natural environment in your neighborhood (using a scale of zero through 10)? (IF NEEDED, DEFINE THE NATURAL ENVIRONMENT AS "TREES, ANIMALS, GRASSY AREAS, STREAMS, AND OPEN SPACES")

0	1	2	3	4	5	6	7	8	9	10	99
VERY DIS-SATISFIED					NEUTRAL					VERY SATISFIED	DK

13. On a scale of 0 through 10, with 0 being the worst and ten being the best, how would you rate your neighborhood as a place to live?

0	1	2	3	4	5	6	7	8	9	10	99
WORST										BEST	DK

14. If you could, would you move away from your neighborhood?
    YES NO DON'T KNOW

15. Do you own or rent where you live?
    OWN RENT OTHER

16. Is your current residence an attached single family home such as a townhouse or rowhouse, or is it a duplex, an apartment building, or an individual detached family home?

TOWNHOUSE/ ROWHOUSE	DUPLEX	APARTMENT BLDG	INDIVIDUAL/ DETACHED

17. Approximately how many trees, total, would you estimate are visible from the windows in your residence…. [READ CATEGORIES]

    none, less than 10, 10-50, 51-100, or over 100?

18. Does your residence have a yard with grass or trees?
    YES NO
    IF NO→ SKIP TO DEMOGRAPHICS INTRO

19. Do you or someone in your household make the decisions for what gets planted and what is maintained in this yard, or does someone else outside of the household make these decisions? [UP TO 5 RESPONSES]

    HOUSEHOLD MEMBER

    OTHER -- Is this done by:

    a landlord, a co-op, or a landscape service? DK

    Specify Other Volunteered Responses

[IF NEEDED, DEFINE CO-OP AS "A COOPERATIVE OR ORGANIZATION JOINTLY MANAGED BY ALL RESIDENTS"]

20. Does your residence have a lawn to which any fertilizer is applied?
YES NO DK

21. Do you maintain any type of garden in your yard?
YES NO

Finally, I have a few questions about you and your household to help us in analyzing the results of this study. Please remember that all of your responses are completely confidential.

22. a. Including yourself, how many people live in your household? _____
[IF 1 SKIP TO Q 24, INSERT #3 FOR Q 23]
b. How many are under the age of 18? ________

23. Are you married, [PAUSE] or living with someone as a couple, or are you single, divorced, separated, or widowed?

MARRIED COUPLE SINGLE/DIVORCED/SEPARATED/WIDOWED

24. Please stop me when I reach the category that includes your age. Are you:

under 35,
35 to 44,
45 to 54,
55 to 64, or
65 or over?

25. What is the highest grade of school you have had the opportunity to complete?

LESS THAN HIGH SCHOOL
HIGH SCHOOL GRADUATE
SOME COLLEGE
COLLEGE GRADUATE
POSTGRADUATE WORK

26. Are you yourself currently employed full-time, a full-time student, employed part-time, or not employed?

EMPLOYED FULL TIME
EMPLOYED PART TIME
FULL TIME STUDENT
NOT EMPLOYED/RETIRED/DISABILITY

27. Do you consider yourself to be….[READ CATEGORIES] [UP TO 2 RESPONSES]

White Caucasian
African-American or other Black
Hispanic
Asian
Or some other ethnic group? [SPECIFY]
[IF MIXED IS SPECIFIED IN OTHER CATEGORY, PROBE FOR COMBINATION OF GROUPS.]

28a. And lastly, is the total annual income of all members of your household over $50,000 or under $50,000?

❑ Over $50,000 ❑ Under $50,000 ❑ REF/DK

b. If over $50K, is it:
$50,000 - $75,000
$75,000 - $100,000,
$100,000 - $150,000
OVER $150,000?

c: If under $50K, is it:
$35,000 - $50,000,
between $25,000 - $35,000,
$15,000 to $25,000, or
under $15,000?

29. GENDER: Male Female

And I dialed ______________________________________ . Is that correct?
PHONE NUMBER

This survey is being conducted by the research firm of Hollander Cohen & McBride. May I have just your first name and last initial in case my supervisor wishes to verify this interview?

NAME: ____

That's all the questions I have. Thank you for taking the time to speak with me.

TIME ENDED________________
DATE: ________________ INTVR: ________________

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