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I, Jay Mittal, hereby submit this original work as part of the requirements for the degree of Doctor of Philosophy in Regional Development Planning.

It is entitled: Measuring the Externality Benefits of Voluntarily Protected Properties on Surrounding Home Values - A Case of Worcester, Massachusetts.

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Measuring the Externality Benefits of Voluntarily Protected Properties on Surrounding Home Values

A Case of Worcester, Massachusetts.

A dissertation submitted to the Graduate School of the University of Cincinnati in partial fulfillment for the degree of Doctor of Philosophy

in the School of Planning of the College of Design, Arts, Architecture and Planning (DAAP)

by

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Abstract

My dissertation examines the relationship between single-family homes (SFH) and surrounding conservation easement (CE) property parcels in the city of Worcester, Massachusetts. The research was designed to examine whether conservation easements indeed externalize benefits to the surrounding SFH values. Externalities are those factors that are outside of SFH and contribute positive or negative effective on SFH’s values.

Conservation easement is a voluntary land-conservation tool and is increasingly popular in the United States. It is used widely to protect privately owned properties offering scenic views and vistas, open spaces, rural and historic character, watersheds and natural systems, habitats and endangered species, and other preservation-worthy attributes. CE-protected parcels are restricted via an agreement for any future development. With donation of the development rights, CE advances public good-- forever-- by protecting preservation-worthy land in perpetuity, and landowners are rewarded with tax abatements. With public tax dollars involved in CE in the form of tax abatement, municipalities may need to make the case that such conservation programs have a positive public benefit and that there is a potential economic benefit on the surrounding home values, or at least the preservation of property values.

This dissertation examines the relationship between conservation-easement parcels and the values of surrounding SFH using a hedonic price modeling (HPM) framework and SFH sales data for Worcester. Using 3-D GIS, externality-capturing explanatory variables were developed that include proximity from homes to CE parcels, viewable areas of CE parcels from homes, and Conservation Easement Visibility Index (CEVI), a relative index for home samples that measures both the visibility and proximity together through a single variable.

The research findings were interesting. Contrary to expectation, distance from, and visibility of, CE property parcels from SFH samples was statistically insignificant; however, their
interaction effect was found to be significant. The interaction effect was measured via the CEVI. It was found that on average there is a marginal value creation for homes that have both features—visibility of CE parcels and proximity to them. The research findings support the notion that homeowners place higher value on quieter, everlasting, conserved landscapes, but the low effect of CE parcels on home prices could be due to lack of recognition or knowledge about the CE-protected parcels. Further, the combined effect of proximity and visibility (being able to enjoy the property from the comfort of one’s home) emerged as the key factors in driving higher home values. For few select homes with higher value of CEVI, it was found that CE parcels do create as high as a 34 percent premium to those homes. The research findings are useful for federal, state and local governments, land trusts, and land-use planners as conservation easement is the most commonly used tool in land protection. This research provides insights and tools for estimating the direct benefits of land protection, especially with scenic amenities. Since the effect of home values has implications on property tax revenues, local governments can use this as a tool to make land-protection decisions and prioritize their efforts.
To my Late Amma and Papa – I lost them during the initial years of this Odyssey.

I miss you both!

To my wife Sweta, for absolutely everything; and my daughter, Vani, for accompanying me through this journey and patiently waiting so I can listen to you, spend time with you, and play with you. Love you both!!
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Chapter 1. Introduction

This introductory chapter of my dissertation is aimed to present my dissertation topic, the background of the topic, and the context in which this research was conducted. Further, it also introduces the study area and sets the significance and relevance of this research. Key research questions, research objectives, and the methodology of my research are presented in this chapter. The chapter ends with the explanation of a few key terms frequently used in my dissertation and an overview of the rest of the chapters of the dissertation.

1.1. Introduction to the Study

This research is an offshoot of my graduate work with Prof. Carla Chifos, titled “Innovative Model of Sustainable Land Management Regimes for Heritage Protection Areas.” While working on this topic, I was introduced to various land-management regimes through various case studies in the US and Canada. I was especially intrigued with the private land protection tool called Conservation Easement (CE) because of its uniqueness as a voluntary tool and its widespread usage in the country\(^1\) as so much land has been protected\(^2\) through its use.

I came across the Blackstone River Valley National Heritage Corridor in Massachusetts and Rhode Island as part of my desk-based research on the topic. The Corridor is embellished with historic and scenic properties, conserved using various land-

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protection tools. Of these protected properties, there were several that were privately conserved using the CE as a land-protection tool.

1.1.1. Statement of the Problem
Conservation easement (CE) is the most commonly used land-protection tool in America to conserve private land, and use of easements has increased over the last two decades. Currently, nearly 37 million acres of land have been conserved through local, state, and national land trusts, equivalent to more land than the state of Ohio and approximately five times the size of Massachusetts. The 2005 Land Trust Alliance (LTA) survey result\(^4\) shows that of this, a total of 6.2 million acres are privately owned and preserved under CE. Conservation easement is a very popular land-protection tool because of its cost-effectiveness to the land protection agencies and because it is less expensive than the simple fee acquisition or purchase.\(^5\)

A large amount of public money is involved in the land conservation efforts both in the form of tax abatements and in acquisition of new land. In just the last two decades in 46 states, more than $54 billion in new conservation funding\(^6\) was created at the state and local levels. With billions of public dollars involved in protecting private land, it is important to understand if there is an economic benefit in terms of enhancement in the surrounding property values. This is important because local communities feel that they

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suffer as CEs lower property taxes, in turn diminishing local revenue.\(^7\) One method of estimation is the survey-based approach, and the other is the hedonic-modeling approach, which captures this externality effect by examining a relationship between surrounding home values and conservation-easement parcels. The review of literature reveals the absence of any systematic study that has examined the relationship between surrounding home values and conservation easements in urban settings. This is presented in chapters 2, 3, and 4.

1.1.2. Need and Significance of this Research
The review of literature as presented in chapters 2, 3, and 4 reveals that a substantial body of research has been conducted so far that has examined the relationship between surrounding home values and various types of externality-generating environmental features, such as open spaces, parks, good views,\(^8\) waterfronts,\(^9\) and beaches.\(^10\) However, there are only a very limited number of studies that have focused on the economic benefits of voluntarily-protected properties, especially in an urban context. There are two related studies by Geogheghan\(^11\), and Ready and Abdalla,\(^12\) but these were conducted in rural areas where they studied preserved farmlands. More details on these studies are presented in the later chapters.

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\(^8\)McConnell and Walls 2005; Crompton 2001; NAR 2001; Boyle and Kiel; Troy and Grove 2008; Bourassa et al. 2004.

\(^9\)Lansford and Jones 1995; Benson et al. 1998; Mahan and Adams 2000; Shultz and Schmitz 2008.


Urban areas have more dynamic land markets and experience more growth pressures. This greater growth pressure compels private property owners to convert their preservation-worthy lands into revenue-generating urban land uses. It is all the more important to understand the benefits that can be achieved by establishing conservation-easement parcels in urban centers so the policy support promoting land conservation can be made. Therefore, this research would be a useful contribution to guide urban land-use planners, local governments, and land conservation agencies in effectively utilizing CE-based conservation strategies for land protection.

1.1.3. The Research Topic
The topic of my dissertation research is how to measure the externality benefits of voluntarily protected properties on surrounding home values in the city of Worcester.

1.1.4. The Research Questions
Using information on the conservation easement-protected parcels in the city of Worcester, Massachusetts, and the sales-transactions data set of single-family homes, this research was designed to answer following questions:

1. Is there a relationship between the home prices and presence of conservation easement properties in surrounding? If so, what kinds of externality effects can be demonstrated on surrounding properties? What are the economic benefits of conservation easement programs on neighboring property prices?

2. If homes are in close proximity to the CE parcels, do conservation-easement parcels create value for the community by increasing property values and sale prices and thus the tax base for the community?

3. Do conservation-easement parcels create value for homes if they have better views of these scenic CE parcels?
1.1.5. The Research Objective

The objective of this study is to measure the economic benefits associated with privately owned property parcels protected under conservation easements (CE). For my dissertation, I am interested in investigating what happens to the price of homes that surround conservation easement-protected properties. Further, I was also interested in finding the most suited variables that could capture the externality effect of the scenic conservation easement properties. I chose the city of Worcester, Massachusetts, as my case study area because of my familiarity with the city and because of its urban characteristic. Most importantly the city was chosen as the case because of the availability of quality GIS data and because the city has several properties that were preserved under CE.

1.2. Background of the Study Area: The Blackstone River Valley Region

The city of Worcester is the largest urban center in the Blackstone River Valley region and is the second-largest city in the commonwealth of Massachusetts. (See figure 1.1 for the map of Blackstone River Valley National Heritage Corridor and the location of Worcester in the northern part of the corridor.) The city now has a population\(^\text{13}\) of 181,045. It was established as a town in 1722 and grew as America became industrialized. Inexpensive power and transportation via the Blackstone Canal (1827-1848) reinforced industrial boom, which began with industrial textile production in the 1790s.\(^\text{14}\) The Blackstone River originates from the city. A famous Boston Nature-writer Winthrop

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\(^{13}\)The city of Worcester’s population grew by 4.8% in the last decade; Census 2011.

\(^{14}\)City of Worcester, Open Space & Recreation Plan, (March 2000: 10). The Plan provides background information on the city and details of various types of open spaces in the municipal limits.
Packard said of the river: “The hardest working river, the most thoroughly harnessed to
the mill wheels of labor in the United States and probably the world, is the Blackstone.”  

The Blackstone River Valley is one of the nation’s richest and best preserved
repositories of scenic landscapes, historic structures, and sites of the American Industrial
Revolution.  The Blackstone River is one of 14 federally designated American National
Heritage Rivers, a program that aims to provide federal assistance to river communities
that face tough challenges related to natural resource and environmental protection,
economic revitalization, and preservation of historic and cultural resources.  The city of
Worcester is situated on the headwaters of the river and has several privately and publicly
protected properties in its jurisdiction.  There also several tributaries to the headwaters--
Mill Brook, Beaver Brook, Tatnuck Brook, and Middle River, and there are conservation
easement-protected properties with scenic landscapes around some of these brooks,
including Coes Reservoir, Curtis Pond, Sergeant’s Brook, Cooks Pond and Coal Mine
Brook.  The official headwater of the river is located at the Beaver and Weasel Brooks.

The city itself consists of several hills and striking topography with numerous
wetlands, lakes, ponds, and waterways. The river is subject to extensive urban run-off
and wet weather overflows.  Much of the natural run-off feeding the northern section of
the river has been cut off due to the installation of a public sewer system and other
utilities. Much of Worcester developed during the late nineteenth and early twentieth

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century’s, and its growth was linked to its abundant water resources. Although Worcester is considered urban and has a developed downtown area and traditional residential areas, many of the city's outlying areas have suburban qualities, with residential subdivisions and strip commercial developments.\textsuperscript{20}

The city of Worcester is also the largest urban center among the 13 municipalities that form the John H. Chafee Blackstone River Valley National Heritage Corridor in Massachusetts, which has over 50 privately owned, voluntarily-protected properties. Approximately 99 percent of Worcester lies within the Blackstone River Basin, which is divided into several sub-basins (see figure 1.1). The river’s headwaters flow throughout the city’s wetlands and streams, and portions of the city have been included in the congressionally designated Blackstone River Valley National Heritage Corridor.\textsuperscript{21}

In 1989, the Blackstone Heritage Corridor produced a Cultural Heritage and Land Management Plan in order to establish a guiding action plan for the Corridor using public-private partnerships in its implementation. The City of Worcester also worked with the Blackstone River Valley National Heritage Corridor Commission to promote the scenic corridor and developed a visitors’ center, park land, and bike and pedestrian paths.\textsuperscript{22}

In addition to my familiarity with this area through the land management regimes study, I also found several other attributes as listed below that were most suited for choosing this place as my case study area.

\textsuperscript{20} Ibid., 10
\textsuperscript{21} Ibid., 17.
\textsuperscript{22} Ibid., 30.
1.2.1. Rationale for Case Study Selection

Based on my review of the literature, which revealed the absence of studies on conservation easements in urban settings, Worcester represents the best available area for this case study. The city of Worcester was chosen for this research for several reasons:

- It is the only urban center in the Blackstone Corridor, as the rest of the communities are predominantly rural in nature. In low-density rural areas of the Blackstone Corridor, the economic benefits of CE properties potentially would be insignificant.
- Worcester is the largest urban center in the Corridor and the second-largest city in Massachusetts.
- More importantly, Worcester has more accurate GIS-based parcel data and has a fairly large number of SFH home sales, absent in other communities in the Blackstone Corridor.

1.2.2. Theoretical underpinning and research hypothesis

Externalities in a real estate sense are referred to as exogenous factors that are outside of a subject property and that have either a positive or a negative effect on the its value. Negative externalities emerge when undesirable effects are imposed on the subject property by the action of others—for example, blighted properties, crime, noise, and traffic, and positive externalities emerge if amenities, conveniences, or hedonic values are offered. Since each land parcel is locationally fixed, these externality effects cannot be changed endogenously in the short run. Yet when homes are located near any positive externality-generating land uses—e.g., open spaces, appealing views, parks, recreation areas, and nature preserves—high-level hedonic values are potentially capitalized into the homes, and these are reflected in their higher prices. CE parcels would potentially have the capacity to positively impact surrounding properties. In principle, we would expect

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23The key character of any real estate property is that it is physically immobile. The value in any type of real estate property is largely extracted from its surrounding land uses and activities.
that positive externalities—i.e., proximity, accessibility, and ability of the homeowners to enjoy the scenic view—would be capitalized in the surrounding homes. This is because if an open space parcel is preserved in perpetuity, that parcel will never have any construction in the future. This assurance of protection forever makes the proximity of preserved land parcels more desirable for homeowners, and therefore, in theory, the perpetual preservation of land will externalize a higher positive spillover effect to their surroundings. \(^{24}\) The presence of CE would potentially increase the value (as measured by transaction prices) of surroundings, and buyers would be willing to pay a premium price for the perpetual presence of open spaces. \(^{25}\)

1.2.3. The Research Methodology
The methodology used in this research involved three major steps: (1) a literature review was conducted to develop a theoretical and methodological understanding of the topic. A cross-disciplinary literature was reviewed because the topic cuts across multiple academic disciplines, such as land conservation and planning, real estate valuation, GIS, and environmental valuation. (2) Data for the analysis purpose was prepared, and externality capturing explanatory variables were developed using the GIS. (3) A hedonic price model was developed to estimate the marginal price contribution of the externality or benefit of the voluntary land protection on home prices.


Two types of data sets were used in my research. One included GIS-based data for conservation-easement protected parcels, home parcels, building footprints, and the city’s topographic contours. The other dataset included the sales and home attributes of SFH. Using ArcGIS 9.3 and its extensions (Spatial Analyst and 3D Analyst), I developed externality-capturing explanatory variables. These variables are two types of squared Euclidean distance from SFH to the nearest CE (proximity of environmental amenity) and two types of viewable area variables using the Viewshed analysis and weighted sum of inverse distance or conservation easement visibility index (CEVI index). The Viewsheds were generated using GIS based on Worcester’s 3-D digital elevation model (DEM) of the entire city. This DEM was a combination of topographic features (contours) and all the building footprints in the city with their actual building heights. Views were then computed from each sample home to each of the CE property parcels using automated Viewshed analysis method in GIS. A small Visual Basic code (VB code) was written, and the program was planned in such a way that using the DEM raster, it returns a visible cell area for each CE parcel for each home sample and develops a matrix for these views. This variable was then used in the hedonic equation.

Further, using the hedonic price modeling (HPM) framework, several stepwise ordinary least squared (OLS) based models were iteratively run. These iterations were run to evaluate the stability and explanatory power of the final model. The final model included five explanatory variables and thirteen variables to control for the structural and neighborhood characteristics of SFH. Another control model with all but the externality-capturing variables was developed to compare the effect with and without. Both HPM were linear in their forms and used quadratic terms for home age and logarithmic terms for the sizes of the lots and for the built area of the homes.

1.2.4. The Research Findings
The results show that homeowners paid a marginal premium for being located around the voluntarily protected property parcels. Contrary to popular belief, but more interestingly, proximity of protected parcels to the SFH by itself does not matter in creating home values. Similarly, view by itself does not matter. However, what matters most is the interaction effect of both proximity and visibility as measured via CEVI. The research findings are useful for federal, state and local governments, land trusts, and the land-use planners. The findings offer insights on the effect and provide automated-computation tools for estimating the direct benefits of land protection. My research also makes an important methodological contribution as this can be applied in several other contexts where externalities are important.

1.2.5. Overview of the Chapters
This dissertation has eight chapters. Chapters 2, 3, and 4 are based on the review of literature on three subject areas: land use and land protection, real estate valuation and

31 More details of this modeling process are presented in chapter 5.
hedonic models, and review of economic benefit studies. More specifically, chapter 2 presents the state of knowledge on conservation easement research and provides a conceptual understanding of various land protection methods, including whys and hows of land protection. The chapter presents benefits and mechanics involved in the conservation easements and the key issues and debates around this topic. Chapter 3 presents a theoretical discussion on real-estate valuation and examines methodologies that are used in capturing the externality effect of real estate properties. Further, this chapter also presents a review of environmental-valuation methods with a focus on various types of environmental amenities and findings from these studies. Chapter 4 presents a review of externality literature covering a wide range of environmental features. It provides details on the key findings from the literature on the effect of externality-generating land resources on home values. Special attention was paid to the studies that used proximity, view, accessibility, and effect of surrounding land uses as variables to capture to environmental amenity.

Chapter 5 presents a discussion on the hedonic modeling framework (HPM) data, its source, and the final variables that were used in this research. Chapter 6 presents the methodology of data preparation—how data was cleaned and how explanatory variables were developed using GIS. Chapter 7 presents two hedonic models used in this research. After specifying the model form, this chapter presents an analysis and discussion of the model, and the two models are compared and the conclusions presented. The last chapter is about the conclusions drawn from the research, and it presents some implications of the research findings for the future land-use policies. This chapter also presents the contribution of this research, its limitations, and questions for future research.
1.3. Definitions of Terms and Concepts Used

Voluntarily protected properties include privately owned properties for which owners willfully (voluntarily) sell or donate the development rights to preserve their properties, like in the case of conservation easements (CE), and the purchase of development rights (PDR). Even properties that were transacted under the transfer of development rights (TDR) are voluntarily protected properties.

Conservation Easements (CE) are privately owned protected properties with restricted future-development rights. Owners continue to enjoy all other rights except the right to develop the property. CE-protected properties are commonly known as conservation restrictions in Massachusetts. In Massachusetts conservation easements are also known as conservation restrictions.

An Externality, in planning and land-use terms, is an effect-of-use decision by one set of parties (CE parcels) on others (homeowners) who did not have a choice and whose interests were not taken into account. The externality is location-specific, is influenced by surrounding land uses and activities, and can be positive or negative.

Externality-capturing Explanatory Variables are the independent attributes that one set of parties (homeowners) observes due the presence of externality generators (CE parcels) and are designed to capture the effect quantitatively.

The Hedonic Price Model (HPM) method is based on the assumption that people value the characteristics of a good, or the services it provides, rather than the good itself. Thus, prices for homes will reflect the value of a set of characteristics--structural, neighborhood, and environmental characteristics--that people consider important when purchasing the home.
**Viewshed** is conducted in GIS and is very useful when one wants to know how visible objects and surfaces might be. Viewshed is created on a raster, like on a Digital Elevation Model (DEM), and identifies the visible cell areas that can be seen from one or more observation points.
Figure 1.1: City of Worcester in the Blackstone River Valley National Heritage Corridor
Chapter 2. Understanding Land Protection and Conservation Easement Policies

This chapter covers the review of literature on land use and land protection with an emphasis on conservation easement (CE). My goal was to understand the theoretical underpinnings of land protection (e.g., the hows and whys of land protection with a focus on CE). The review covers both traditional land protection involving regulatory land use interventions, and alternative or non-traditional land protection methods, with greater emphasis on voluntary land protection such as CE. In addition, this chapter provides details of how CE works and how it compares with other land-protection measures, including key issues and debates.

Figure 2.1 Whys and Hows of Land Protection

2.1. Land Protection - An Overview

The conceptual foundations of land protection have origins in the irreversible nature of development. Once the decision to develop land on a parcel is made, it is difficult to alter
without losing the feature that was present before, so land development is irreversible\(^\text{32}\) in nature. A timely response and effective methods are required to protect preservation-worthy lands, because if they are not protected now, they will be lost forever.\(^\text{33}\) Following figure 2.1 in this chapter, I have presented hows and whys of land protection. To answer the whys of land protection, I am presenting various benefits of land protection, and to answer the hows of land protection, I am presenting three predominant land protection methods in the next section. Land is protected using traditional and non-traditional methods and offers several public benefits as explained in the next section.

### 2.2. Whys of Land Protection - The Benefits

The key objectives of land protection are to minimize environmental impact, curb sprawl, encourage concentrated development, retain community character and prevent incompatible development. Porter,\(^\text{34}\) Sundberg,\(^\text{35}\) Rissman et al.,\(^\text{36}\) DeGroot,\(^\text{37}\) Fausold and Lilieholm,\(^\text{38}\) Freeman,\(^\text{39}\) and many others provide a rich discussion on various benefits that land protection offers. It provides several benefits, such as enhanced recreational opportunities for residents, improved habitats for wildlife, maintenance of

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groundwater recharge capacity, and protection for views and buffers between towns. From a moral perspective, protection of land ensures that future generations benefit from the initiatives taken today and continue to enjoy the same environmental quality and cultural, historic, and rural characteristics that we value today--maintaining a status quo on valuable land resources. Land protection also helps in keeping habitats undisturbed and in their natural condition, preventing uses that would impair, degrade, or interfere with conservation values.

Proximity to parks or open spaces enhances value for nearby properties and offers several public benefits. Sherer,\(^4^0\) in a Trust for Public Land (TPL) study, described an array of economic, environmental, social, and public health benefits associated with parks and open spaces. For example, access to parks promotes community health, provides greater exposure to nature and greenery and creates tourism opportunities, attracts and retains businesses and residents.

In an urban context, the value enhancement concept was first used by Frederic Law Olmstead,\(^4^1\) for the Central Park in New York as shown in table 2.1. Excerpts from the New York Central Park study are shown in table 2.1. The study showed that the assessed values of lots adjacent to Central Park increased by a factor of 10--from $26 million to $236 million--and were sold at a premium in a 15-year period. When Central Park was planned in the 1890s, these increased values represented a capitalization of a park’s value to proximate property owners, and this phenomenon was termed “the

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Proximate Principle.” The table below presents the financial implications of the creation of Central Park:

Table 2.1 Frederick Law Olmsted’s documentation of the impact of Central Park on the property tax base of the three proximate wards

<table>
<thead>
<tr>
<th>Value</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assessed value in 1873</td>
<td>$236,100,000</td>
</tr>
<tr>
<td>Assessed value in 1856</td>
<td>26,400,000</td>
</tr>
<tr>
<td>Showing an increased valuation of</td>
<td><strong>$209,700,000</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Costs of Park</th>
</tr>
</thead>
<tbody>
<tr>
<td>The total construction expenditure from 1857 to 1874 is</td>
</tr>
<tr>
<td>The cost of land of the Park to the city is</td>
</tr>
<tr>
<td>The cost of the Park to the city is</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Taxes</th>
</tr>
</thead>
<tbody>
<tr>
<td>The tax rate for the year 1873 is 2.50, yielding on the increase of valuation as above stated; Total increase of tax in three wards</td>
</tr>
<tr>
<td>The annual interest on the cost of land and improvement of the Park, up to this time, at six percent</td>
</tr>
<tr>
<td>Deduct 1%, on $399,300 of stock, issued at 5%</td>
</tr>
<tr>
<td>Excess of increase of tax, in three wards, over interest on cost of land and improvements</td>
</tr>
</tbody>
</table>

Note: For ease of readability of the numbers, I have rounded them to the nearest ($100,000) as compared to the original publication.

Source: Fox, Tom. 1990, “Urban Open Space: An Investment that Pays,” Monograph published by The Neighborhood Open Space Coalition, New York, NY; Also, quoted in Crompton 2001

Later, many studies such as Crompton42 presented value enhancement benefits of property surrounding urban parks. All these studies emphasized that proximity to parks increases property values. Similarly, access to parks promotes community health because people visit frequently for exercise, and parks provide greater economic opportunities such through tourism, attraction and retention of businesses and residents, and creates stable neighborhoods with a strong sense of community.

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2.3. Hows of Land Protection - Methods

There is extensive literature on land protection and growth management tools that include various regulatory, voluntary, and design-based urban-containment tools. Appendix A provides a comparison of various land conservation techniques such as Conservation Easements (CE), Purchase of Development Rights (PDR), Transfer of Development Rights (TDR), Special Zoning, and Fee simple purchase.

Traditionally, land protection is done using the land acquisition method; however, since it is a very expensive method, several other land-protection tools are used to achieve the land conservation objective. Pallagst, Nelson and Dawkins, and Wright have provided a good discussion on these tools. Nelson and Dawkins provide a glossary of over 60 growth-management and urban-containment tools and a discussion of how these policies were used in different contexts, all aimed to achieve the objective of land conservation. Pallagst grouped these growth-management tools into five categories: 1) Regulation oriented, such as urban-growth boundaries, development tiers, concurrent infrastructure planning, growth caps, urban service boundaries, land preservation, and mixed use; 2) Incentive oriented--tax benefits, transfer of development rights, and density incentives; 3) Design oriented, including new urbanism and transit-oriented development; 4) Collaboration, such as regional cooperation; and 5) Information oriented--land-use

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43 Used to contain / control the outward expansion of urban development.
monitoring systems. Similarly, Quigley’s study provided 12 land-use regulatory categories for residential development--building permit cap, population cap, FAR limit, downsizing to OS and agricultural use, reduced residential density, and referendum and supermajority in legislative body for density increase--and for land planning--growth management element, moratoria, UGB, tiered development, and subdivision cap. The most commonly used regulatory tools are land-use zoning, growth-management techniques, and various urban containment policies, including design-based tools (a category popular among the new urbanists) such as transit-oriented development (TOD) and mixed-use development. As discussed above, there are several tools that exist to conserve land in one way or another. I have grouped these into three categories and later provide details of each of these three tools with greater emphasis on the conservation easement--a voluntary land-protection tool--the topic of my research.

48 Bernard H. Siegan, Land Use without Zoning, (Massachusetts: Lexington Books, 1972), p. 75. Siegan argues that economic forces tend to separate uses without zoning. Siegan also argues how Houston, TX uses modest land-use controls, such as subdivision controls with restrictive covenants and terms, expiry, traffic controls, minimum housing ordinances, and a building code instead of regulatory zoning (p. 24-26), and city still creates efficient, orderly land markets. Siegan highlights the problems of strict zoning as it reduces competition, curtails development, and distorts land markets while artificially inflating land prices. Problems of non-zoning include its inability to quantify infrastructure costs and forecast future growth and public service needs (p. 128-133).
49 See Annexure – A for land conservation techniques - comparison of regulatory, voluntary, and design-oriented.
2.3.1. Land acquisition for land protection

Public land agencies use traditional methods to become the sole owner of a piece of land, acquiring full rights to the land, as is the case in creating and preserving national or state parks. In the case of such publicly owned and protected properties, these public lands provide broad societal good and are generally accessible to the public at large. Land owned by public agencies is typically acquired using fee-simple acquisition, which gives agencies full ownership rights to the property. However, this is an expensive method for preserving land for conservation purposes. Management of national parks and state parks has also been difficult and controversial because of problems associated with external threats to parks. These threats originate outside of parks’ boundaries, and the park authorities have little control over them. Thus private land owners’ participation in problem-solving is critical.

2.3.2. Regulatory Tools for Land Protection

The regulatory tools include land use zoning (i.e., agriculture zoning and development controls for environmentally sensitive areas) and large-lot zoning (also known as conservation zoning). Zoning represents public “police power.” It is used to reduce externalities from private landowner decisions, and it is a critical tool for private land conservation. Zoning serves three primary objectives: to maintain residential property values (by internalizing the externalities in the form of land value differential from one

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zone to another), to shape the form of the urban compact, and to promote the provision of efficient public services.\textsuperscript{53}

Regulatory land use control tools also include various urban containment policies such as growth caps and urban growth boundaries, urban development tiers, coordinated infrastructure planning, and greenbelts. The other frequently used variants of growth-management programs are design-oriented tools, including smart growth, sustainable development, neighborhood development, brown field development, mixed-use development, and transit oriented development (TOD).

Regulatory land use control tools are mandatory and rely primarily on sanctions and fines as negative incentives with an emphasis on discouraging negative activities. On the other hand, voluntary tools rely on a mix of incentives designed to primarily reinforce current activities rather than fundamentally altering behavior. These include marginal fiscal incentives, but also rely on reputation effects and intrinsic motivation of the owner, appreciative rewards and non-fiscal values.\textsuperscript{54}

Regulatory tools are most common but have constraints. Real estate operators often influence decision of zoning boards,\textsuperscript{55} which means that regulatory tools are impermanent--subject to change through the zoning policies, variances, and subdivision regulations--and can be politically motivated.

Regulatory tools also can inflate the property prices artificially. Stricter regulations have potential to affect economic activities as only fewer people can afford

\textsuperscript{53} William Fischel, 1985.
expensive housing—a proof that Glaser\textsuperscript{56} presented in his research of how restrictive zoning affects housing prices. His research found that 34\% of home prices in Los Angeles and 19\% in Boston are owing to restrictive zoning only. Similarly, a study by Quigley\textsuperscript{57} also showed that with increased regulations, housing becomes unaffordable. Using the Malpezzi Regulation Index\textsuperscript{58} in this study, Quigley showed that the housing prices increase with the increase in Index values across several metropolitan areas of the United States.

2.3.3. \textit{Voluntary Tools of Land Protection}

The voluntary land-protection tools are incentive-driven and are more flexible. These are non-regulatory techniques that promote collaboration and participation. The voluntary programs involve ease of entry and exit and are designed in conformity with the landowners’ needs, wishes, and comfort range. In the voluntary tools, once the bundle of rights is donated or sold, the rest of the property has to adhere to the deed restriction, which delineates what is permissible and not, though these rules are decided by the landowner. Voluntary tools offer permanence to land protection.

There are several types of voluntary tools. Fee simple donation or sale is a transfer of a property by deeding it directly to a land trust or government agency for conservation or other purposes without accepting any money for the property. Bargain sale is the sale of a property to a qualified tax-exempt organization, such as a land trust or


government agency, for less than the fair-market value. In conservation-based
development, a portion of the property is protected, and another portion is converted to
development. The other three types are purchase of development rights (PDR), transfer
of development rights (TDR), and conservation easements, donation or sale.59 In TDR,
development is transferred from one location to another. Once TDR is exercised, the
development-rights-transferring property stays undeveloped, in conformity with its
conservation objective.60 However, TDRs are successful only if strong market demand
exists in the TDR-receiving market. Walls and McConnell provide a more detailed
discussion on TDR mechanisms, evaluating TDR program design, its implementation,
and outcomes through various case studies in United States.

Most of the voluntary land-protection techniques discussed above is largely based
on the trading of intangible commodities, such as development rights of the property.61

Arthur C. Nelson, and Casey J. Dawkins, Urban Containment in The United States: History, Models and Techniques for Regional and Metropolitan Growth Management, (Chicago: American Planning Association, 2004). This study was conducted to understand urban containment (UC) plans and policies in the US. One hundred thirty-one plans were analyzed; the book provides an exhaustive glossary of the growth-management and containment techniques used. The study explains four scales of urban containment: at the sub-metropolitan level (local government sets a boundary, with limited development), regional unbounded metropolitan level (with urban service boundary, such as sewage and water service), regional bounded metropolitan (UGB designed to accommodate growth for some time, say, 20 years), and natural containment (using natural barriers such as ocean and hills).


60 See Nelson et al, 1995, for details on TDR, PDR, large-lot zoning, and other techniques for preserving resource-rich land;

Of these, conservation easements have received a lot of attention in the last two decades with over 2.5 million hectares (6.2 million acres) of land being held under conservation easements by local and community land trusts. This figure does not include the large national-level land trusts.

2.4. Conservation Easement – A Voluntary Land Protection Method

The broad philosophy guiding conservation easement is that lands that hold any environmental or ecologically significant resource or any historically significant feature are ecologically and socially valuable and therefore should be saved from future development and made available to the public. In 1981, the Uniform Conservation Easement Act (UCEA) was formed to provide the legal foundation to this voluntary land-protection tool. Mayo provides a discussion on eligible holders of CE, duration of CE, and termination conditions of CE, including various purposes that are allowed under the UCEA. Dietrich provides a definition of conservation easements from the UCEA:

> A non possessory interest of a holder in real property imposing limitation or affirmative obligations, the purposes of which include retaining or protecting natural, scenic, or open space values of real property, assuring its availability for agricultural, forest, recreational, or open space use, protecting natural resources, maintaining and enhancing air or water quality, or preserving the historical, architectural, archeological, or cultural aspects of real property.

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2.4.1. Popularity of Conservation Easements in United States

Conservation easements are the fastest-growing land-protection tool throughout the United States. CE became more popular recently; however, it has existed in the United States since the 1880s. William H. Whyte\textsuperscript{65} wrote the initial major work on CE, noting that CE were first used in Massachusetts by the Trustees of Reservations to protect the parks that Frederick Law Olmsted designed around Boston. In the years since, the pace of private land conservation has tripled by local and state land trusts. That pace soared to 1,166,697 acres (~1.2 million) conserved per year, on average, between 2000 and 2005. The area under CE protected properties more than doubled between 2000 and 2005, with more than a million acres per year added during those years.\textsuperscript{66}

In America, the total land acreage conserved through private means is 37 million acres in 2005--an area roughly the size of Illinois. This was a 54 percent increase in just five years, up from 24 million acres in 2000. This includes both lands protected by local and state land trusts, and lands protected by the largest national land-conservation groups, such as the Nature Conservancy, Ducks Unlimited, the Conservation Fund, and the Trust for Public Land. For example, the Nature Conservancy controls development rights on 15 million acres in the United States (The Nature Conservancy 2005). Over 2.5 million hectares (6.2 million acres) of land--an area roughly equivalent to that of the state of Maryland--is under conservation easements, which are held by the local and community land trusts. These lands are governed by the rules of the United States’ Conservation Easement Act.


2.4.2. How Conservation Easements Work

It is important to understand how the Conservation Easements and the Land Trusts movement started from. Historically, the land trust movement was started in Boston by Charles Eliot, a Boston-based landscape architect. Eliot is also known as the founder of America’s first land trust. In 1890, in a letter published in the March 5 edition of *Garden and Forest*, Charles Eliot made an innovative proposal that a private association should be created for protecting and preserving regional scenic treasures through permanent trusteeship. He wrote, “As Boston's lovers of art united to found the Art Museum, so her lovers of nature should now rally to preserve for themselves and all the people as many as possible of the scenes of natural beauty which, by great good fortune, still exist near their doors.”

In the current time, the conservation easement CE of land operates under the Conservation Easement Act. In the early 1980s, the Uniform Conservation Easement Act (UCEA) was framed. CEAs are governed under their state Conservation Easement Acts (CEA). The state CEAs defines easements for their states, and the federal government provides tax legislation.

CEs are defined in state law and are subject to strict scrutiny. In Massachusetts, the state government approves every easement within its borders. Typically, in a CE the title to the land remains with the original owners, but their property right is limited by the terms of the easement, which specifies what alterations and uses are allowable. For

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example, the current and subsequent owners might retain the right to live in and maintain the existing residential structure, but not add additional structures or remove standing trees. This allows the landowner to retain some use of and control over the land, and also reduces the costs and responsibilities borne by the land trust. The trust is then responsible for enforcing the terms of the easement upon the current and subsequent owners of the property.  

Landowners have the right to use their land for certain purposes, depending on local zoning and building regulations. These rights are governed by deeds and the zoning codes of the local jurisdictions. Some of these rights, for example, include adding a shed, digging a well on the lot, or building a house. It is possible to restrict or prohibit some of these uses while allowing others.

A CE is a legally binding covenant between a landowner and an organization such as a land trust or state agency. The CE protects the natural and scenic features of the property by restricting selected uses, such as development. A CE can cover all or part of a property. CEs are permanent and remain in effect when the land is sold or inherited. A CE allows a property owner to retain ownership of the property, including the ability to pass the property on to heirs or to sell the property, while still providing for its protection. Successive owners take the land, subject to the same restrictions. It assures that future use of a property will be consistent with conservation purposes through specific clauses in the CE document. The CE document is a flexible tool and can be tailored to the specific goals of the landowner.

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CE owners receive tax benefits on perpetually preserving development rights. Any landowner can donate a conservation easement. For income tax purposes, this is considered a charitable deduction under most circumstances. The value of the charitable deduction is based on an appraisal of the difference between highest and best use value of land (development potential under current zoning) and the restricted value of the land. Owners whose properties have significant ecological, historic, or cultural value may be paid for their conservation restriction in the form of tax incentives.

Conservation easements are often referred to as "partial interests" in land because they do not transfer the property itself to the conservator but merely transfer the rights to enforce prohibitions against future development. In reality, it is a shared ownership. The donation of an easement could be motivated either by altruism or for tax benefits—in both cases, the opportunity costs remain the same. Owing to the partial transfer of rights, the partial interests in a property are less costly to acquire than the full property rights, making it is easier for local agencies to conserve preservation-worthy lands. If land development rights are purchased using the public tax dollars or induced by tax relief, Conservation easements spread the costs of conservation to society as a whole, while if CE owner does not sell the rights owner voluntarily undertakes the expense.

A CE involves the donation of development rights by a landowner. However, when an easement is paid for directly, and traded in the marketplace between a willing buyer and a willing seller, it is called a Purchase of Development Rights or PDR.

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70 Boyd et al., 1999.
71 Ibid.
Various actors are involved in CE, including local non-profit agencies (land trusts) and local government agencies. To understand how CEs are established, Wright’s\(^73\) article published in *JAPA* presented a 10-step process for establishing a successful CE. (This *JAPA* article was one of the first few articles in a planning journal on CE.) These are the ten steps in the process:

1) Initial meeting with the landowner and land conservation agency;
2) The landowner consults personal legal and financial advisers;
3) Title information is sought;
4) A baseline study is conducted, which means that land should have conservation purposes that must provide a significant public benefit;
5) Negotiate easement restrictions that are clear, concise, and unambiguous;
6) Easement appraisal-tax benefits for federal and state income taxes, capital gains taxes, property taxes and estate taxes are assessed;
7) The local planning board is notified;
8) The easement is finalized;
9) The easement deed is filed; and
10) Stewardship-monitoring and enforcement continue.

Conservation easements are not stand-alone, but they complement regulatory land-use controls\(^74\) and involve the trading of intangible commodities—the development rights of the property.\(^75\) Zoning and CE have a relationship. Most properties, especially the ones near urban centers, are under some type of land-use zoning. The underlying zoning defines the legally permissible use of the property, and therefore its value as the


\(^{75}\) Carruthers, “Evaluating the Effectiveness,” 391-405.
property’s value is determined on the highest and best use (HBU) basis.\textsuperscript{76} HBU is a multi-step process and involves property productivity analysis, market analysis, and financial analysis of the alternative probable uses. The HBU method accounts for option value,\textsuperscript{77} which means future potential value. This affects the value of property and thus the value of CE.

The idea behind the development right comes from the “bundle-of-rights” concept of real property ownership.\textsuperscript{78} These rights can be acquired in different ways and held for different periods; similarly, separate rights could be held by different people.

Conservation easement is a legal agreement between a landowner and a qualified non-profit or government organization that permanently limits future uses of the land, which are consistent with its conservation objectives. Several federal, state, and local parks, trails, waterways, and wildlife areas are protected and improved using conservation easements or restrictions. In conservation easement, property owners continue to retain title of their property and continue their right to enter, farm, lease, mortgage, bequeath, sell, restrict public access, and demand compensation for rights transferred. Conservation easements can be tailored to the needs of each property owner, but usually limit subdivisions, non-farm development, and other uses that hinder the conservation objective.\textsuperscript{79}

\textsuperscript{76} Appraisal Institute, \textit{The Appraisal of Real Estate}, 12th ed. (Chicago, IL: Appraisal Institute, 2001). HBU for a property is computed when the development is legally permissible, physically possible, financially feasible, and maximally productive.

\textsuperscript{77} Stephen F. Fanning, Terry V. Grissom and Thomas D Pearson, “Market Analysis for Valuation Appraisals,” (Chicago, IL: Appraisal Institute, 1994): 340-386. The total property value is a sum of its current use value, future value, and option value. If a property is in its HBU, its option value will be zero.

\textsuperscript{78} These bundles of rights include, among other rights, the right to use, sell, access and mortgage. See, Appraisal Institute, \textit{The Appraisal of Real Estate} 12th Ed. (Chicago: Appraisal Institute, 2001): 68-70.

Conservation easements involve legal documents that list what rights have been donated by the landowner. These are called deeds of easement. The deed of easement is a legally binding document that is recorded at the county courthouse and runs with the land, so if the land is sold or transferred to heirs, the restrictions in the deed of easement apply to subsequent landowners. The land subject to a conservation easement continues to be private property, usually without any right of public access.

In Worcester, property records for the conservation easement-protected properties and their deed documents are kept with the Worcester District Registry of Deeds (WDRD). A typical conservation easement deed document contains the following features: name of the grantor and grantee; purpose of restriction, including public benefits, prohibited uses, reserved rights, and allowed uses; access available or not; duration of the easement; and a description and maps of the property.

2.4.3. **Actors involved and their roles in Conservation easement**

Conservation easements involve three key actors: the private landowner, a local non-profit agency called a land trust, and a local government agency. Among all the three actors, land trusts play a very crucial role in private land conservation. Land trusts are publicly supported non-profit charitable organizations, formed with the expressed goal of protecting certain types of land resources. Financially, land trusts are dependent for their survival on the approval and generosity of the public. Typically, land trusts follow a pre-defined geographic region, such as a town’s or a county’s political boundaries, or an eco-region, such as a watershed, forest reserve, or coastline. Land trusts focus on preserving

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80 Worcester District Registry of Deeds (WDRD), Available from http://www.masslandrecords.com/malr/controller
open spaces by preventing conversion of undeveloped land or landscapes, or they may be involved in protecting specific kinds of habitat, farmland, urban green space, and specific recreational spaces like trails.⁸² There is an overwhelming focus of land trust activity on non-urban lands, and Raymond and Fairfax⁸³ argue that only 10 percent of the LTA member organizations claim to protect urban lands.

Land trusts are formed primarily to protect certain types of preservation-worthy land resources. These land trusts routinely acquire a less-than-full title of a property (i.e., partial rights) by purchasing or accepting donations of conservation easements⁸⁴. However, land trusts also conserve land by acquiring the fee title to a property--i.e., by purchasing the property outright.

Merenlander et al.⁸⁵ provide a detailed discussion on the land trusts in America and the types of properties that these land trusts protect under conservation easements. As discussed earlier, in America, over 6.2 million acres of land are protected under CE, with 2.5 million acres of land protected under CE being held by local and state land trusts. In comparison, this CE-protected land area is equivalent to the size of a few smaller states such as Maryland or Vermont. Besides these, a sizable land holding under CE is with the government agencies and national non-profit organizations.

One of the largest land trusts in the country is the Land Trust Alliance (LTA) which was founded in 1982 and is a national umbrella organization of land trusts. It acts

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⁸⁵ Ibid., 65–75.
as an exchange for other Land Trusts\textsuperscript{86} and has pioneered the use of conservation
easements to preserve private lands. LTA is now also devoted to promoting the creation
and development of land trusts and serves as a clearinghouse of information about land-
trust practices.\textsuperscript{87} The other major land trusts are The Nature Conservancy (TNC) and the
American Farmland Trust (AFLT), which led the land-conservation movement through
an extraordinary period of expansion and success.

2.4.4. Uses Allowed and Disallowed in Conservation Easements
Conservation easements may allow some uses while preventing others. For example, on
rare occasions, they may allow passive recreational access to the property, or they may
allow owners to live in and maintain the existing residential structure but not add
additional structures or remove standing trees.\textsuperscript{88}

Gustanski\textsuperscript{89} and Dietrich\textsuperscript{90} provide a list of typically permitted uses and prohibited
uses on conservation easement-protected properties. In a typical CE, the permitted uses
include agriculture, recreation, water resources, roads and trails, fences, maintenance of
structures, and transfer of the land. In addition, some of the other permitted uses may
also include farming, timber harvesting, and maintaining open space. In exceptional cases,
building a limited number of dwellings, new structures, or subdivisions is allowed. For
example, Rissman et al.\textsuperscript{91} found that some CEs allowed flexibility in terms of future

\textsuperscript{86} See Stephen Small in Gustanski and Squires, eds., 2001 p. 55
\textsuperscript{88} Ibid.;
\textsuperscript{89} Richard Brewer (2003), 155–56.
\textsuperscript{90} Gustanski in Gustanski and Squires, eds., (2001), p. 21
\textsuperscript{91} David J. Dietrich, “Conservation Easements” Chapter 30.
\textsuperscript{92} Adena R. Rissman, Lynn Lozier, Tosha Comendant, Peter Kareiva, Joseph M. Kiesecker, M. Rebecca Shaw, and
found that a spectrum of restrictions is imposed on CE-protected properties. These restrictions are more intense in
development. Rissman et al. reviewed 119 CE documents procured from TNC, which revealed that several easements allowed a wide range of private uses, such as residential or commercial uses, and some easements even allowed new structures or subdivision of the property.

There are many uses that are totally prohibited on CE-protected parcels. These prohibited uses include activities such as sub-division in general, and construction of commercial facilities, dumping, billboards, roads, utilities, and mineral exploitation in particular. In general, in CE, all residential, commercial, industrial, and institutional uses are also prohibited unless explicitly allowed in the deed of easement as discussed earlier. Due to restricted uses on conservation easement-restricted properties, theoretically, the value of conservation easement-restricted properties declines equivalent to restricted development rights.  

2.4.5. Advantages and Effectiveness of Conservation Easements over Regulatory and Land Acquisition Methods

Conservation easements are voluntary legal bindings chosen mutually by the landowner and the land trusts or government agency, but are permanent as compared to

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92 Henri LeMoyne, “Conservation Easement Highest & Best Use Analysis of a Large Recreation Residential Acreage before Easement Acquisition,” Journal of the ASFMRA (2000): 54-57. LeMoyne conducted a valuation of a 42-acre site seeking CE status in Sawtooth National Recreation Area of central Idaho—one of the most highly sought-after recreation-home areas. Since the county where the easement was located had no zoning restrictions, the owners had the flexibility of using the property for any purposes. Using the highest and best use analysis (HBU) for the site as subdivided lots, and using discounted cash flow (DCF) methods to estimate cash flows, he valued options for dividing the land into 6-lots and 3-lots. He concluded that the original single site would sell for $250,000 to $335,000. However, the 3-lot subdivision could sell for $508,464 and 6-lots for $425,564. Hence, he argued that restricting the development rights for conservation easements should claim these higher values.
environmental regulations or land-use zoning plans, which may change with time and political will. CE has dominated the land-preservation literature because it offers several advantages over other preservation methods. First, CE does not involve any direct cost to the conservation agency; hence it is a less costly way to preserve land than the traditional fee-simple land acquisition used by the state and national parks. For example, Loomis et al. presents that conservation easements are more cost-effective and less expensive than the simple fee acquisition or purchase by $6,783 per acre. Second, CE does not involve the burden of conservation on the landowner, as there is no governmental regulatory intervention or controls. The owners, even after the protection agreement has been entered into, can continue living, using, and owning the same property as before, forever. Third, CE is financially attractive to landowners due to the tax incentives attached. Fourth, it offers greater permanence to the land protection, as CEs is rarely being reversed, thereby ensuring that the lands are protected forever, in perpetuity. Fifth and the most important advantage for CE in particular and for most voluntary tools in general, is that the deed restrictions are designed in consultation with the landowner, which provides greater flexibility about what is prohibited and not prohibited. This does not require a huge government role. It is the land trust or a public

William H. Whyte in The Last Landscape (1959)  
Joe Feagin in Urban Real Estate Games (1983)

94 Land trusts do not acquire the entire bundle of landowner rights, only those specific rights that are relevant to the trusts’ conservation goals—the rights to develop the land in the future or convert the land to a more intensive use.


land conservation agency and the landowner collaboratively who decide how to conserve
and about the future use of the property.  

2.5. Conservation Easements and Academic Debates

There are several key issues that promote debate on several nuances of CE. For example,
CE as a way of land protection is increasingly becoming more popular because of their
advantages as discussed above; however, CE is more complicated than the outright
purchase.  CEs, once framed, offer very little flexibility for future adaptation and are
generally rigid. There are also issues and debates around the tax benefits and the
valuation of these CEs.

2.5.1. Duration of Conservation easements

A CE may restrict land either in perpetuity or for a certain number of years—known as a
“term easement.” Perpetual CE is generally assumed to be superior to shorter-term
lease CE because of a preference for stronger, more permanent restrictions. The federal
tax laws also provide strong financial incentives for perpetual easements but not for
limited-term easements. The easement is legally binding on present and future
landowners because the easement goes with the deed as an encumbrance. Most existing
intergenerational conservancies are designed to make it difficult for future generations to
develop conserved lands. The debate on CE about the duration is that it is impossible to
foresee with any certainty which lands will be worth conserving, and so perpetuity would
burden future generations with the costs of releasing land from conservation-easement

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98 Ibid.
99 Mayo, “A Holistic Examination,” Chapter 3. The chapter presents a discussion on eligible holders of CE, duration of CE, termination conditions of CE, and a statewide matrix of various obligations.
100 Thompson, “The Trouble with Time,” 301-620.
agreements. Similarly, Thompson also argues that although CE is supposedly permanent to serve the long-term land-protection goals, there is a need for adaptive management of CE. Over time, conditions where easement property is located and knowledge will change, and the legitimate interests of future generations will also change. Yet intergenerational conservancies provide for future generations, which will still retain ultimate control over how land will be used or conserved.

2.5.2. Tax Benefits to the Land Owners and Conservation Easements

The federal tax laws provide strong financial incentives for perpetual CE. In addition to the federal tax benefits, landowners have estate tax benefits and property tax benefits. According to the federal tax incentives, the owners can deduct up to 50 percent of their adjusted gross income (AGI) in any year (up from 30 percent); deduct up to 100 percent of their AGI, if the majority of that income came from farming, ranching, or forestry; and continue to carry over unused portions of deductions for as long as 15 years (up from 5 years) after the initial year in which the deduction was first claimed. The claim can be equivalent of the value of the encumbered development rights on the CE parcel.

Sundberg and Dye present a total tax savings formula for a typical landowner of a CE-protected property. Since the tax benefits and incentives come over a period of

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101 Jacob T. Cremer, “Fighting the Lure of the Infinite: Lease Conservation Easements at the Urban Fringe,” Environmental Law Reporter, 40 (2010): 10687-10697. This article deals with the lease and emphasizes that leases lessen the risk of burdening future generations, minimize the risks of foregone future possibilities, and are more equitable.

102 Ibid.

103 Ibid.


time, it could be estimated using the present value (PV) formula of all the incentives and tax benefits. The total tax savings for landowners would be the sum of all the PV as shown below:

\[
\text{Total tax savings} = \text{Present Value (PV) of Federal income tax}^{106} \text{ deductions} \\
+ \text{PV of State income tax deductions or credits} \\
+ \text{PV of Property tax savings} \\
+ \text{PV of Tax savings at disposition}
\]

As the total tax claim can be equivalent to the value of encumbered development rights, this gives rise to the debate on the how to value the foregone rights. Another issue of debate is that in addition to the above tax savings, in many communities, land values on properties under CE appear to go up significantly, in part because of the guaranteed amenities of open space.\(^{107}\) It is like the CE property parcels internalize externality and thus witness increase the CE parcel value. Thus, Raymond and Fairfax\(^{108}\) argue that landowners could receive double compensation for their transactions, first as reduced tax, tax credits or payments for the easement, and second as increased value on the remainder interest in their property. This remaining portion of the CE parcel may witness increased value of easement protected property in many communities. The study by Hardie et al.\(^{109}\) is of similar nature and argues that the benefits from open-space amenities remain largely

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internal to the subdivision, if property is large in size. Hardie argues that open-space amenities remain internal to the subdivision and that open space outside of the subdivision is not important to the subdivision buyers, yet those spaces internal to the subdivision are.

2.5.3. Valuation Controversies in Conservation easement

There are controversies on the valuation of CE-protected properties. Appraisers typically assess market value by using comparable sales information. However, in the case of CE, there is no conventional market for CE. The CE property market is highly illiquid, as there is a lack of resale opportunities.\(^\text{110}\) It is therefore very challenging to use any universal approach for the valuation and appraisal of CE for several reasons. First, the value of CE-protected property varies as CE characteristics and restrictions on development rights for a CE-protected property vary from one CE to another CE property.\(^\text{111}\) Second, in a given market there are only a very limited number of CE-protected properties that exist. There is a limited number of comparable transaction data that exists for CE parcels, which poses a challenge when using any comparative sales or mass-appraisal model on valuing such properties.

The CE value is appraised by a qualified appraiser. It is valued by finding the value of foregone rights. The value of conservation easement property is the difference between the estimated fair market value of the property if it were sold today, calculated using the highest and best use method and the estimated value of the property after the restrictions are imposed due to conservation easement. The difference is the value of

\(^{110}\) Boyd et al., 1999.

\(^{111}\) These restrictions are based on the agreement (voluntarily decided) between a willing landowner and a conservation organization.
development rights that landowners either donate or sell to the land trusts or municipal agencies. The other problem with conservation-easement valuation is that the potential cash flows associated with the future development are never known with certainty, unless development is imminent. The likelihood and the timing of the future land conversions have bearing on the valuation of any property. If the probability of development is higher, the easement’s value will be greater. If the property has a similar probability of development but over a longer time period, the easement value will be lower. Both the timing and future development possibilities are speculative. Boykin\textsuperscript{112} present five methods of CE valuations, all of which have HBU as the basis for valuation. These methods are

1. Comparing sale of parcels where zoning restrictions are similar to the subject CE;
2. Comparing with similar easement sales;
3. Using before-and-after easement-sales analysis, which takes into account the increase (if any, due to externality benefit) in the part value of the non-CE part of the property;
4. Estimating the value of income-producing land (agriculture or any other) using the capitalized rental income approach; and
5. Using subdivision development methodology--DCF method--before CE.

2.5.4. Public access and public benefit argument in Conservation easement
Public access may or may not be allowed in some CE parcels—for example, areas where endangered species are protected, public access is not allowed. Inviting public to such areas may adversely affect the purpose of conservation, so public access is prohibited. A research by Haight et al.\textsuperscript{113} also supports this idea where 27 rare species in the Lake

\textsuperscript{112} Boykin, “Valuing Scenic Land,” 420-426.
County near Chicago were studied. Their study concluded that with the growing public accessibility\textsuperscript{114} to these rare species sites, the rare species increasingly fall.

Korngold\textsuperscript{115} argues that neither the natural habitat nor the open space CE categories require physical access to the public in order to qualify for deductibility. With open-space easements, the public must have only a view of part of the property. It is fair to ask what the public is getting in return for its investment, especially since the choice of the property is being made by private parties outside of a public land-use plan or process. In some cases, if public good is only in the distant viewing, view becomes important.

2.5.5. Administration and management of Conservation easement

Korngold\textsuperscript{116} also argues on the administration and management of CE. He argues that the public has a limited say in how the land should be protected and how it should be developed in case of a lost conservation resource. There is a lack of willingness by the easement holders to meet the emerging needs of the community, such as for economic development or affordable housing. Further, he argues that owing to a lack of coordinated planning and public process, there is a potential for stewardship failures by nonprofits and the possibility of class conflict and elitism between those who conserve and the rest. Furthermore, Korngold argues that there is a risk to the effective policy-making and democratic principles, especially when local public land-use decisions are delegated to the non-representative, non-accountable private organizations such as land trusts.

\textsuperscript{114} Accessibility was measured as Public access per unit area of the site.
\textsuperscript{116} Ibid.
2.6. Why Conservation Easement will have Externality Effect

In market-economics terms, if the supply of ecological features is scarce, and if its protection provides greater benefits to a larger population, then that amenity-generating, ecological resource would be valued very highly both by the market and by the community. In denser urban centers, with a limited supply of environmental amenities, such as natural environments, parks, or scenic views, land conservation efforts would result in monopolistic land values in close proximity to the protected lands. These monopolistic land values would be capitalized in the surrounding properties and ultimately would be reflected in enhanced home and property values. In contrast, homeowners in rural areas with largely unregulated market conditions and a lower population to enjoy the protected property would likely experience a lower capitalized externality effect.

To fully understand the theoretical underpinnings about why people bid higher for a quality environment, it is also important to understand what is the human reaction to aesthetics and why? Also, what are the theories that drive human aesthetic reaction or people’s preference to nature? Is it a cognitive, behavioral, aesthetical, or any other underlying theory? There are efforts made to explore this question, such as those undertaken by Appleton, Bourassa, and Kaplan; however, there is a general consensus

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118 Monopolistic land values are a result of higher demand from open-space amenity seekers: more bidders drive up the land or home prices near protected properties.

119 Katherine K. Henderson and Yan Song, “Can nearby Open Spaces Substitute for the Size of a Property Owner’s Private Yard?” International Journal of Housing Markets and Analysis 1, no.2 (2008): 147-165; To correct potential externalities, open-space preservation policies, such as purchases of development rights (PDR), or restrictive zoning, such as large-lot zoning or agriculture zoning are used. See Hardie, Lichtenberg, Nickerson, “Regulation, Open Space,” 458-474.

on what people prefer—e.g., trees, foliage, bodies of water—but very little consensus on why people prefer beautiful landscapes or how to measure these preferences.

CE-protected properties usually have the following characteristics: preservation-worthy, unique landscapes with scenic views and vistas and other features such as lakes, water fountains, rivers, rivulets, unique vegetation, or other flora or fauna. In addition, to protect an environmentally significant resource, sometimes CE is for the core areas, and some other times CE properties are protected buffers around such core areas that have some important environmental resource. All of these combined have hedonic characteristics that society values highly. Such hedonic characteristics provide stimuli to human perceptions of good quality environments and a sense of being closer to nature, especially amid the hustle-bustle of dense urban areas.

2.6.1. Conservation easements and Scenic Views
Jay Appleton provided an interesting attempt to explain why scenic views are important and how humans value them. On why quality views are appealing, Appleton suggested that “humans are biologically programmed to prefer vantage points where it is possible to see a good deal without necessarily being seen.” The “ability to see without being seen” was labeled “prospect-refuge theory.” Prospect refers to having a grand view, an overview of a landscape, while the refuge refers to having a safe place to hide, a place from where one can see without being seen. The homes that command scenic views should fetch premium prices as it has been presented in several past studies, such as

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Wolverton, Benson et al., Bourassa et al., Sander and Manson, Lake et al., and Shulz and Schmitz.\textsuperscript{122}

Bourassa\textsuperscript{123} also attempted to develop a theoretical grounding of landscape aesthetics in which he started by defining landscape as “not synonymous with ‘environment,’ but it is ‘the environment perceived,’ and especially quality that is visually perceived.” Owing to this visually perceived high quality of such landscapes, those who bid to stay closer to such pleasant areas pay a premium to enjoy them. Besides the direct tangible benefits of environmental resources, such as aesthetically pleasing landscapes, vegetation, views, and long-term biodiversity and eco-services benefits, there is a theoretical vacuum that explains why people would prefer nice landscapes or environmental amenities. CE-parcels are perpetually conserved and often are scenic in nature. Large size, such scenic CE-parcels offer permanent scenic views and vistas.

Owing to quieter landscapes and permanent scenic vistas the homes surrounding the CE-parcels become desirable because. This protection of viewsheds enhances values of home sites and such homes become more expensive, providing not only additional income for the investors and preserving or enhancing home values for the homeowners.\textsuperscript{124}

\begin{thebibliography}{9}
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2.7 Chapter Summary

Land is protected primarily for three reasons: aesthetical, practical, and ethical and moral reasons. Land is protected not only to protect the core conservation targets but also to enable support to the core protection targets. CE is a superior land-protection tool, especially considering the financial constraints of the conservation agencies and the need for conserving private land to advance the public good. Scholars have also skeptically debated about the public benefits of CE because of access restrictions, protection duration, and tax benefits to the landowners. When access is not allowed, and view access to the protected property can advance partial public good, the view of CE properties is important.
Chapter 3. Property Valuation, Environmental Benefits, and Hedonic Price Modeling

This chapter presents the theoretical framework of my research from a property-valuation perspective. Focusing on how values are created and how externalities are capitalized in properties, this chapter presents a few principles of real-estate valuation. Further, these principles are then related to the environmental-benefit studies. Various methods of externality benefits-capturing have been summarized, and the hedonic method has been presented in greater detail. Specifically, my goal was to see how others have approached the challenge of quantifying an array of attributes that create a home’s market value, ultimately explaining how homes are sold in the marketplace. This review was important for guiding my work in developing variables and the model.

3.1. Theoretical Framework of Value Creation

To examine the relationship between the home values and an environmental amenity such as CE-protected property parcel, it is important to understand the body of research that has explored the linkage between real estate valuation and environmental benefits as capitalized in home values. To tease out the value contributed by conservation easements in the form of externality to homes, I wanted to see how others had calculated the value of attributes associated within\textsuperscript{125} sample homes as well as those outside\textsuperscript{126} the homes themselves, disaggregating individual attributes.

\textsuperscript{125} Endogenous factors are internal to the property, such as type of property, size, and lot area.

\textsuperscript{126} Exogenous factors are external to the property, such as uses of surrounding land use and the property’s location with respect to economic uses.
Home prices are created by the virtue of key endogenous attributes, such as type, size, and lot area of the home, and of exogenous attributes, which are located outside the home and not within the legal control of the homeowner; these include surrounding land use and the home’s location with respect to economic uses. Over time, a property’s value could increase or decrease owing to the changes in these endogenous and exogenous characteristics. In theory, in any growing market, the land-value component of a home appreciates in value due to the increasing competition for that location, while the structural characteristics depreciate with age.

The bundle of home attributes are endogenous to any home and are assumed to contribute to its market price because of the home’s physical attributes and lot size, its shape, and the local topography. Local government assessors’ offices estimate a property’s value and collect property taxes based on such attributes. The price of a newly constructed home is a theoretical sum of its construction costs or improvements, land costs, and developers’ profits. The construction costs are totally dependent on the endogenous characteristics of the house and could vary from one home type to another type depending on design or material specifications. However, it is generally constant and does not vary significantly from one market to another geographically. Further, improvements decay with age and the improvement component of the property value depreciates, while depending on the change in the exogenous characteristics, it can create or mar the value of homes over time. All this means that when a home is older, its value

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127 However, the recent real estate bust has shown that the values— even for land— may decrease or increase.
128 The value of a historic property can increase with age, but these properties are also subject to depreciation if not well-maintained.
129 Unlike land values, construction costs are generally invariable across geographies, provided that the variables such as currency, tax, and labor costs do not vary. So, the per-unit square foot cost of construction in Worcester, Boston, or in any other US city would not vary as much as the per-unit land cost.
is determined by the market’s willingness to pay according to comparative sales of similar homes in similar situations.

In addition to the endogenous attributes, there are attributes exogenous to the home that theoretically factor into a home’s value and ultimately the market price of land—theoretically. These are typically outside the control of the homeowner and are often explained with the expression “Property’s location.” It is well understood that where a property is located affects its appeal. The implicit belief that location matters is often underlined when changes in surrounding areas are being considered, such as with development projects (for example, construction of a highway, sewage treatment plant, hospital, shopping mall, or prison) or preservation efforts (such as a park, nature center, or scenic view). There is an intuitive understanding that either type of land use in surrounding properties could impact the quality of life for the homeowner and therefore the market price if the homeowner were to sell. This idea was formalized in Tobler’s\textsuperscript{130} “first law of geography” which suggests that “everything in the space is related to every other thing, and near things are more related than the far ones.”

As a background to developing models for specifically predicting the impact of conservation easements on surrounding properties, I conducted a literature review focusing on three broad subject areas: real estate valuation, assessment of the economic benefits of environmental resources, and the use of GIS-based spatial variables in hedonic models. To develop and test my own models, I wanted to build on previous research and reviewed

\begin{footnotesize}
\textsuperscript{130} Waldo Tobler (1979) as stated in Luc Anselin “The scope of spatial econometrics” \textit{Spatial Econometrics : Methods and Models} (Dordrecht, Netherlands: Kluwer Acdemics, 1988) Chapter 2, p.8
\end{footnotesize}
a) **How valuations have been conducted** for environmentally-protected properties—property surrounding parks and open spaces, land set aside for agricultural preservation, and land surrounding water bodies and scenic views;

b) **Various methods used in economic benefit studies**—calculation of economic benefits associated with various types of environmental resources including conservation easement-protected properties;

c) **Theories and mechanics of hedonic modeling** used in environmental-benefit studies—underlying assumptions, key explanatory and control variables, and role in how models; and

d) **Key findings** in past economic benefits studies (discussed in the next chapter).

### 3.2. Fundamentals of Property Valuation

There are three key features central to the discussion of land-use theories and property valuation: land productivity (how much rent a property can generate), a property’s geographic location in context with other land, and the locational monopoly (the fact that the land is immobile). The prices of properties are determined by all three features.\(^ {131}\)

The externalities can affect land values, altering which land use would dominate in which areas. Land use rules (zoning) can alter land values and uses with the intention of preserving lands for local communities, recognizing that local externalities could provide amenity or dis-amenity effects.\(^ {132}\) The positive effect on property value is called a positive externality effect, which I hypothesize is capitalized in land values and can be separated out to demonstrate the economic value on nearby environmental-protection property.

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In another study, Quigley (2007) used a simple cost formula for building SFH as \(=\text{[Structure Cost} + (\text{Land Area} \times \text{Price of Land}) + \text{Zoning Taxes}]\) and concluded that the housing cost is high due to high zoning taxes, which accounted for approximately 34 percent of the price in Los Angeles and 19 percent in Boston. See, John M. Quigley, “Regulations and Property Values in the United States: The High Cost of Monopoly”, in Gregory K Ingram and Yu-Hung Hong ed. *Land Policies and their Outcomes.* (Cambridge, MA: Lincoln Institute of Land Policy, 2007) Chapter 3.
With all these ideas interrelated, I will attempt to provide a background of key research and theories associated with these issues that create value.

3.2.1. Land Productivity and Value

David Ricardo in 1817\textsuperscript{133} discussed land productivity in the context of land rent theory. He examined spatial fertility differences of the land and its actual productivity differences in terms of generating more crops per acre, which would then affect how much, could be charged for renting the land. Further, when the land is used for agriculture or forestry purposes, the soil characteristics, means of irrigation, and slope would all contribute to determining land productivity. This productivity can then be valued assuming an appropriate rate of interest and appropriate yield (Quantity) for the present value of all future cash flows.

\[ \text{Land Value} = f(\text{Size, Location, Productivity}) \]

Where \textit{Productivity} = \( f(\text{soil, irrigation, crop type, \ldots}) \)

In reality, while land uses, land productivity, and hence values differ across geography, the land productivity differential is greater in urban contexts, since in cities, land could be put to multiple economic uses--unlike in classical valuation theories, where land was viewed from its agricultural production value only. Since all land cannot be put to agriculture uses, when land parcels are used for urban activities (e.g., commercial, residential, or any other uses), they need to be able to generate enough profit or land rent if the land is for commercial use, or equivalent utilities for homeowners, if the land is for residential use. Thus the theory of land rent holds that for a given parcel of land, its price

\textsuperscript{133} Spatial fertility differences of land and land-productivity differentials were reflected in the land rent.
is determined by the present value of all the discounted future cash flows that the land
could generate.¹³⁴

In 1826, VonThunen ¹³⁵ developed the theory of Highest and Best Use (HBU),
which refers to the monetary rent a farmer can charge for land, based on using it for the
crops that provide the highest production and price. So, if the land under subject is used
for urban usage--non-agriculture and non-forestry--, its ability to be developed for the
highest and best use in future is often determined by the underlying land use zones. The
zoning plays an important role in determining the land productivity for urban land. Thus,
the above equation could be written as

\[ \text{Land Value} = f(\text{Size, Location, Productivity}) \]

\[ \text{Productivity} = f(\text{Use ability to generate rent as determined by zoning}) \]

In these land-use theory discussions, it has been observed that buyers bid higher
for more productive land, which may be the result of environmental forces. For example,
if farmlands are in proximity to some favorable environmental features, such as
ecosystem services to improve the water quality, reduce erosion, reduce flooding, and
improve the air quality, the land’s productivity increases, and thus its value also increases.

¹³⁵ Also known as highest and best use (HBU). VonThunen’s theory referred to the monetary rent that farmers could receive from a given location. VonThunen used locational differentiation of agricultural land uses with an assumption that a city is surrounded by land of equal fertility, and he used this to develop land rent theory. See, discussion in Michael R. Romanos, “Behavioral theories of residential location: The macro approach” in Residential Spatial Structures, (Lexington, MA: Lexington Books, 1976 Chapter 3); See, also Grant Thrall, “Unifying urban land use and land use theories” in Business Geography and New Real estate Market Analysis (NY: Oxford University Press, 2002: Chapter 3, 60-63); Marvin L. Wolverton, “Highest and Best Use: The VonThunen Connection”, The Appraisal Journal (Fall 2004): 318-323.
3.2.2. Geographical Location that causes externality

Externalities can be understood from two principles of real estate valuation that explain what happens to the value of property-in-focus due to the effect of surrounding properties. Externalities are factors outside a property that can have either a positive or a negative effective on its value. The operative principles that describe the externality effects are the Principle of Progression—the value of an inferior property being enhanced by its proximity to better surrounding properties and activities, and the Principle of Regression—the value of a superior property being adversely affected by its proximity to surrounding inferior properties and activities.

The Principle of Progression - In an urban context, if some positive environmental characteristics (e.g., vegetation, landscapes, aesthetic views) or other amenities are present (e.g., convenient shopping, quiet neighborhood, high safety statistics), their positive influence might be felt in an increased value of properties nearby or within view. In residential areas, similar environmental amenities could make properties more desirable places to live and thus improve their home values. The bundle of externality effects, encompassing economic, social, and environmental opportunities, generates economic value to its surroundings. Favorable uses create positive externalities (sometimes referred to as positive amenities).

The Principle of Regression- Every parcel of land is unique in its location due to the physical immobility of real estate. If faced with negative externalities (e.g., the foul smell from a sewage treatment site, a busy and noisy highway), homeowners could experience property-value losses. Outside the direct control of the homeowner, if these

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externalities are left unabated or unmanaged, homes could decline in value. In this example, while the endogenous home characteristics remain the same (i.e., construction quality, number of rooms, amount of land on which the home sits), these externalities can become negatively capitalized in the land-value component of the property price. If the exact home were placed in a different setting where such negative external influences were not present, we would assume the market value of the property would be significantly higher.

3.2.3. **Locational Monopoly**

In bid-rent theory, the concepts of land productivity, geographic location (in the context of other economic land uses), and locational monopoly (with respect to other surrounding lands) were later applied in an urban context by Isard in 1956 and Alonso in 1965.¹³⁷ This theory emphasizes locational monopoly and the ability of a particular location to assign specific types of land uses and land rents in relation to a single city center.

Any land that is under agriculture or forestry use has a lower value than the land that is available for urban land use—that is, land which has residential or commercial zoning. A formula for seeking a variance in land use is shown below. If the land is zoned for land use (a), while demographically, economically, and locationally, land use (b) is more appropriate, the landowner could seek a variance provided the proposed use is compatible with the surroundings. The higher land use zoning (b) could enhance the value of the property that receives the zoning variance or use change. Now, with the change of zoning, the change in new land value would be:

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Value of a land parcels reflects its productivity, where productivity means ability of land parcel to generate wealth. The land parcel can then be valued assuming an appropriate discount rate and an appropriate yield with its future use. This can then be quantified as the present value of all the future cash flows.

3.3. Three key Property Valuation Methods

There are three methods that are commonly used in property valuation: comparable sales method, income capitalization method, and replacement cost method. Colwell and Trefzger\textsuperscript{138} provide a review of several property-valuation methods with emphasis on these three. This review also provides a discussion on when and for which purposes these different methods are used. Similarly, Pagourtzi et al.\textsuperscript{139} presented several other property-valuation methods, but all have their roots in the above three methods, and these real estate valuation methods are

1) *Comparable sales method* takes multiple sales of similar type of properties into account while comparing prices. Comparisons are made for similar property types and similar type of submarkets.

2) *Income capitalization method* is used to determine capital value directly by using potential revenue generation capacity (rent) of a subject property, such as a retail property or an apartment building.


3) *Replacement cost method* is used for rare sales transactions with unique construction features.

The cost to replace a similar building is estimated by using material and labor costs necessary to construct a duplicate structure.

### 3.4. Seven Methods of Valuing Externality Effects of Environmental Resources

There are a number of environmental-valuation methodologies used in the past to estimate the externality effects of environmental amenities; these include Crompton, McConnell and Walls, and Krupnick and Siikamäki. McConnell and Walls\(^ {140} \) reviewed 60 environmental-benefit studies conducted since the 1980s and examined their methodologies. Broadly, these environmental valuation methods\(^ {141} \) are of seven types and are presented in three categories as shown in figure 3.1. More detailed explanation of

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**Figure 3.1 Methods of Environmental Externality Valuation**

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\(^{140}\) Virginia McConnell, and Margaret Walls, “The value of open space: Evidence from studies of nonmarket benefits”, *Lincoln Institute of Land Policy* (2005). Reviewed over 60 studies of which over 40 were hedonic based.

\(^{141}\) For more details on these individual methods, See Annexure B at the end of the dissertation; also see, “Overview of Methods to Estimate Dollar Values”, accessed from http://www.ecosystemvaluation.org/1-03.htm on May 1, 2011.
some of these methods to value economic benefits is provided in Appendix B. These methods are:

1) *Contingent valuation method* utilizes survey techniques and seeks respondents’ willingness to pay (WTP) for environmental amenities.

2) *Choice experiment or conjoint analysis*\(^\text{142}\) does not involve a survey, but respondents react to different scenarios that involve price.

3) *Productivity method* estimates economic values for ecosystem products or services that contribute to the production of commercially marketed goods, such as agricultural products.

4) *Hedonic price method* is a revealed preference method of markets Willingness to Pay (WTP) for environmental amenities. The basic premise of the hedonic pricing method is that the price of a marketed good say, home is related to its characteristics (size, location, proximity to open space), or the services it provides. This method is the most commonly used method in environmental valuation and is presented in detail in the next section.

5) *Travel cost method* assumes that the value of a site is reflected in people’s willingness to pay to travel to visit the site. It is useful for recreational facilities and ecotourism and is more accurate when travel distances are short.

6) *Replacement cost method*, which assumes that if people incur costs to avoid damages caused by lost ecosystem services or to replace the services of ecosystems, then those

services must be worth at least what people paid to replace them. This method is further detailed and discussed in the later chapters of this dissertation.

7) Cost of community services method\(^{143}\) involves computation about how much would be saved if land that could be developed remains undeveloped or conserved.

### 3.5. Hedonic Price Models – An Analytical Framework

The hedonic price model (HPM) framework has been predominantly used in capturing urban externalities because of its superiority over other methods, such as survey-based, stated-preference methods. The hedonic price models have proved to be very useful for estimating the value of non-market environmental amenities, such as parks and open spaces, as well as dis-amenities, such as air pollution, noise, and proximity to noxious facilities like landfills.\(^{144}\) In this section, I have first presented the theory behind the hedonic modeling framework, and then I explain its linkage to the environmental-benefit studies. Later, I present the most commonly used variables in the literature that potentially can answer my research question.

#### 3.5.1. Hedonic Modeling Theory

The theoretical foundation of the hedonic pricing model (HPM) technique was laid by Lancaster.\(^{145}\) According to the theory, consumers derive their utility for any good from the bundle of characteristics of that good. For example, utility from a car is derived from its various characteristics, such as its engine size, speed, and fuel economy, number of

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\(^{143}\) John Crompton, “Programs that Work Parks and Open Spaces: The Highest and Best Use of Public Land?” *Journal of Park and Recreation Administration* 19, no. 3 (2001): 133-154. The paper presents 70 COCS case studies and the COCS methodology.

\(^{144}\) McConnell and Walls 2005.

seats, comfort, luxury, color, style, and status. If we were to assemble a car, and we knew
the price of each component, we could estimate the total price; however, if we were
disassembling it and if we knew the total price of the car, it would be difficult to estimate
the price of individual components. The hedonic modeling helps in disassociating these
individual prices from the total price by using the data of several different cars. Thus,
HPM helps in determining the implicit value of non-tradable characteristics of goods.
This can be understood using this example: If \( A \) is a tradable good, the value \((V_A)\) of this
good can be described as a function of its non-tradable characteristics, such as \( C_1, C_2, ..., C_n \) as shown below:

\[
V_A = f(C_1, C_2, ..., C_n) \quad (1)
\]

Now, let another good \( B \) have similar characteristics to \( A \) except for a particular
characteristic \( C_1 \) missing. Then, the value \((V_B)\) of good \( B \) can be written as

\[
V_B = f(C_2, C_3, ..., C_n) \quad (2)
\]

From the above, it is clear that the implicit market value of this particular
characteristic \( V(C_1) \) is the difference between the values of \( A \) and \( B \):

\[
V(C_1) = V(B) - V(A) \quad (3)
\]

We can apply this same logic to the homes, where we know the total sales price
and we want to know the price contribution for home attributes such as structural
integrity, neighborhood, and externality-generating environmental characteristics.
3.5.2. Hedonic Modeling and its Linkage to Environmental Benefit Studies

In terms of methodology, most studies that I reviewed in the chapter 4 have predominantly used hedonic modeling framework\textsuperscript{146} in estimating the environmental benefits. Some additional studies have taken into account the spatial effect of location in estimating value and measuring the environmental amenity benefit using local regression models such as geographically weighted regression (GWR).\textsuperscript{147} The review in chapter 4 shows that hedonic price modeling has been extensively used in previous studies that deal with real estate and environmental literature.

Several papers such as Malpezzi, Troy and Grove, Kang and Reichert, and Benjamin et al.\textsuperscript{148} also provide excellent discussions on the theoretical and methodical aspects of hedonic modeling. This model uses the marginal implicit price of each attribute of homes, and computes the benefits for each attribute of a home as measured via the HPM, with an assumption that the buyers and sellers interact and that homes are transacted in a perfect market condition. HPM are capable of evaluating the price of each attribute and cost for the combined bundle of these attributes. A marginal implicit price (MIP) represents the effect of a unit change in the quantity of an amenity on mean housing values, \textit{ceteris paribus}.

\textsuperscript{146} Which, is an ordinal least square(OLS) based regression model.


A hedonic equation in its simplest form is a regression of expenditures (rents or values) on various characteristics of home samples,\(^\text{149}\) where these characteristics are the independent variables in the equation, and the regression coefficients are transferred into estimates of implicit prices of home characteristics. Typically, to find the contributory value of home characteristics, a home dataset is collected and a regression is estimated using the following econometric specification:\(^\text{150}\)

\[
y_i = \beta_0 + \sum_{j=1}^{k} \beta_j H_{ji} + \varepsilon_i \quad \varepsilon_i \sim iid (0, \sigma^2) \quad \forall i = 1, 2, ..., n
\]

Where \(n\) = the total number of properties in the dataset;

- \(y_i\) = transaction price of the \(i\)th property;
- \(H_{ji}\) = the value of the \(j\)th hedonic characteristic for the \(i\)th property;
- \(\varepsilon_i\) = the residual for each observation.

The main strengths of the HPM are that the implicit values of non-tradable goods--environmental goods, in the case of my research--can be estimated based on actual transaction data. This data is a reflection of true revealed choices of the informed buyers and sellers for a particular amenity. There are some limitations with the HPM method, too. For example, it assumes perfect competition and that the actors are fully informed. This is an obvious simplification of the reality, because in reality, among many other issues, zoning restrictions create artificial market segments, hindering perfect competition.


\(^{150}\) This model specification forces a linear relationship between the Sale Price (\(Y\)) and \((X_i)\) and independent variables such as size of the lot or number of bedrooms. As for a rational economic agent, which is a home buyer, the value does not proportionately increase with the increasing size of the home. This is called diminishing marginal utility of home characteristics. Therefore it is important to identify variables that will increase the value of a home.
3.5.3. Model Preparation

a. Selection of Variables

To understand home characteristics that are used as value-creating variables, the HPM studies earlier were reviewed by Sirmans et al. Their paper is one of the seminal papers and uses meta-regression to review 125 published hedonic studies related to home values and home characteristics across the United States. This review clearly shows that among several important characteristics, 20 variables largely determine home prices. These are structural, environmental, locational, temporal, market, and financial characteristics of homes.

b. Selection of Variables and their forms

Malpezzi’s, and Troy and Grove’s papers explain how to choose independent and dependent variables and how to specify—including when to transform a quadratic term for age, or log transform for a variable with diminishing marginal utility, such as home size—in the hedonic modeling. These papers also present the advantages and disadvantages of various model forms.

Dependent Variable - Hedonic literature about the effects of environmental benefits on home values has used different dependent variables such as sale price, median home value of census tract, monthly rent per acre of land, median rent in SMSA, owner-reported value, weighted sum of land values around environmental feature, sale

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154 Extracted from different reviewed papers for this dissertation.
price per square foot of frontage, annual rent, appraised or assessed value, and per-acre land value. The literature on hedonic price functions provides no guidance in choosing between sale prices and logarithm of sale price—ln(price), price per acre (ppa), or ln(ppa). For the improved properties, the price per acre is calculated by subtracting the appraised value of the improvements from the tax records from the sale price before dividing by the number of acres.\textsuperscript{155} Of these, sales values are the most commonly used dependent variable in hedonic studies as they demonstrate negotiated market transactions of willing buyers and sellers, followed by assessed values.

c. \textit{Assumptions of the Hedonic Price Model}
There are three market-clearing conditions that should be considered when applying hedonic pricing modeling (HPM) theory:\textsuperscript{156} 1) Bundles of characteristics are equally valued by buyers and sellers, equalizing the observed price with the hedonic price; this means that attributes are identical so a kitchen in one house is identical to the other one, and the value as assigned to each of these characters is the same for all consumers; 2) Both buyers and sellers base their location and quantity decisions on maximizing behavior; and 3) Equilibrium prices are determined so that buyers and sellers are perfectly matched.

There are several assumptions in using the HPM. The economic theory requires that all the observed properties should have homogenous market characteristics with heterogeneous characteristics among the house samples. The traditional HPM assumes\textsuperscript{157}

\begin{itemize}
  \item Jeffrey A. Michael, “Conservation Easements and Property Values: Selection Effects and Differential Impacts on Vacant and Residential Properties,” Department of Economics, Towson University, Towson, MD (2007).
  \item Rosenthal (1974, p. 35)
\end{itemize}
that the residuals of the regression--i.e., the error term (ε's)--are not auto-correlated across all the $n$ observations. It assumes that error is distributed independently and identically ("i.i.d.") with a mean of zero and a finite variance for all $n$ observations.

**d. Checking for Multi-Collinearity**

Sometimes, a few home characteristics are synonymous--for example, the size of a home expressed in square feet and the number of rooms or bedrooms. Since both the variables explain home size, such synonymous variables could cause multi-collinearity\(^\text{158}\) in the HPM as both variables have a strong correlation. If multi-collinearity exists in the HPM in the presence of highly correlated independent variables, the net regression coefficients (slope) become unreliable\(^\text{159}\) and hence should be avoided.

**e. Interpretation of the Model**

Chatterjee\(^\text{160}\) and Guthery and Bingham\(^\text{161}\) provide a primer on how to interpret different regression outcomes\(^\text{162}\) based on their intercepts, coefficients, and shapes of relationships program.

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\(^\text{158}\) Gregory T. Morton, “Factor Analysis, Multi-Collinearity, and Regression Appraisal Models,” *Appraisal Journal* 45, 4 (1977): 578-588. This paper explains problems with regression modeling in appraisal, emphasizing multi-collinearity and how it could give the wrong results in terms of signs and coefficient. It also explains how collinearity could be controlled using factor analysis, and how factor analysis could be used in the regression modeling for appraisal.


\(^\text{162}\) The regression outcomes are the results from the SPSS program or any other statistical package.
3.6. Chapter Summary

This chapter covered the discussion on how externalities are created and how they are captured. Further, I discussed key real estate valuation principles and three key methods of valuation. I also presented different environmental-valuation methods that have been used in the past and then presented a more detailed discussion on hedonic price model, which is one of the most commonly used methods in externality studies. In the next chapter I will present how environmental studies have been conducted using this hedonic pricing method and what variables were used in the past.
Chapter 4. Review of Externality-Capturing Environmental Studies

The previous chapter covered the methods that were employed in the externality research. In this chapter, I have presented a review of past studies that have focused on various environmental amenities as they appeared in the externality literature. The review starts with identifying various types of environmental resources that were studied earlier, and later provides a detailed review of their actual benefits. I started my literature review with the available published reviews on the topic first to identify some key findings and key contributors, and then I used select papers and more recent papers that were more relevant to my research. The review was intended to help develop an understanding of various explanatory variables that were used in past studies and the findings of these studies. I also reviewed papers that provide guidance on specific techniques used in creating some of the key explanatory variables and their effect on home values.

4.1. Overview of Externality Literature

Substantial literature exists that has measured or has established a relationship between environmental amenities and house prices. Past studies have been conducted for various types of lands holding environmental resources, such as open spaces—public parks, naturally preserved areas, and farmlands—and other environmental amenities. The studies reviewed here have estimated the economic benefits of such land types on home values as evident from several published reviews, such as Boyle and Kiel, McConnell and Walls, Crompton, and Bourassa et al.
Figure 4.1 Reviews of Environmental Externality Studies

Source: Based on Author’s review of journal articles and published studies.
4.2. Review of Externality Studies

4.2.1. Typology of Environmental features studied

Hedonic studies of open spaces vary in terms of how they incorporate open space variables. While some studies for example, Acharya and Bennett\textsuperscript{163} used a single open space variable to represent all the lands that were open and were ‘without any development,’ other studies such as Bolitzer and Netusil, Lutzenhiser and Netusil, Anderson and West\textsuperscript{164} differentiated these open spaces as parks, golf courses, cemeteries and other types of open spaces. Irwin\textsuperscript{165} differentiated between different types of privately owned open spaces by use such as crop land, pasture, forest, and conserved land and public open spaces by ownership such as federal, state and county owned lands. The literature has treated open spaces in multiple ways, with some studies using individual characteristics of open spaces and measuring their effect based on that characteristic while other studies have grouped and formed specific open space typologies based on similarities.

Most studies that are reviewed were conducted in urban or suburban areas on various amenities. They have generally focused on the impact on home prices associated with environmental amenities such as public parks and open spaces for example, John Crompton, Austin Troy and Morgan Grove\textsuperscript{166} and National Association of Realtors (NAR) survey\textsuperscript{167} and

\begin{footnotesize}
\textsuperscript{166} John Crompton, “The Impact of Parks on Property Values: A Review of the Empirical Evidence,” \textit{Journal of Leisure Research} 33, no.1 (2001): 1-31. This is a review of 30 impact studies of parks and opens spaces. 25 studies reported positive impacts of parks on property values. The impacts varied considerably with park attributes (e.g., area, and type of park), but generally it ranged from 10–20 percent of property values. Crompton in his review also found that there is a general agreement among most studies that the impact of parks on home values extends at least 500 feet and, in some cases, goes up to 2000 feet into surrounding neighborhoods.;
\end{footnotesize}
waterfronts studies by Lansford and Jones; Benson et al.; Mahan et al., Shultz and Schmitz.\textsuperscript{168} Other quantitative studies were conducted by Irwin\textsuperscript{169}; Ready and Abdalla;\textsuperscript{170} and Geogheghan et al.\textsuperscript{171}, which examined the impact of preserved farmlands on surrounding home values.

Externality literature is extensive, and all kinds of amenity-generating and dis-amenity-generating resources have been studied. These studies have been grouped into eight categories as shown in figure 4.1. These categories include large parks or forests, various kinds of waterfronts (riparian, lake), and distant scenic views, which includes views such as valleys, mountains, and oceans. There are also studies for undesirable features, such as pollution sources, studies in rural areas for farms, and studies in urban areas for the urban parks, playgrounds, developable open spaces in the city, and golf courses.

4.2.2. Reviewed Study

Boyle and Kiel\textsuperscript{172} reviewed 35 hedonic studies to estimate the prices consumers are willing to pay for environmental goods. This review focused on pollution sources and their effect on home values. Most studies in this review focused on distance or proximity measures,

\begin{itemize}
  \item 170 B. L Mahan, S. Polasky and R.M. Adams, “Valuing urban wetlands: A property price approach, Land Economics.76, no. 1 (2000): 100-113;
\end{itemize}

This study used hedonic model and developed land use indices within a 400-meter radius from homes.

\begin{itemize}
  \item 176 Geoghegan, “The Value of Open Spaces,” (2002): 91–98. Permanent open space increases the value of nearby residential land to more than three times the value of an equivalent amount of developable land.
\end{itemize}
while a few focused on visibility analyses (for example, visibility through the high suspended particulate matter (SPM), content in the air quality studies, and visibility of waste-filling and other sites for undesirable land uses. All studies reported that such non desirable externality generating sites had a negative effect on the home prices. The effect of this negative externality (hazardous sites) was calculated on home values. It was found that as the homes distance increases home value increases with a range of by $190 per mile to $11,450 per mile.

McConnell and Walls\textsuperscript{173} reviewed 60 published articles, 40 of which dealt primarily with the value of open space hedonic studies\textsuperscript{174} conducted in and around urbanized areas. The Appendix C provides a detailed typology of various Urban Green Spaces. Scholars have studied different types of environmental amenities, such as open spaces-- general open space, parks, natural areas, green buffers, greenbelts, wildlife habitats, wetlands, forest preserves, farmlands, and golf courses. They found that proximity to golf courses was positive, and lakes had a significant positive impact on home values. In general, large natural areas and wildlife habitats contributed a 0.07 percent to 4 percent increase in home values.

Bourassa et al.\textsuperscript{175} conducted a review of 30 studies with a focus on the economic benefit of good views on home values. Several types of aesthetically important view-generating resources were studied, such as water views, lake and ocean views, mountain or valley views, agriculture and farmlands, and forests and open spaces with landscapes. Similarly, view as an externality-capturing variable was defined in different ways: 13 studies used distance to lake; 28 studies used a binary yes/no dummy view variable or a 1-to-5- scaled dummy view quality

\textsuperscript{173} McConnell and Walls, “The Value of Open Space,” (2005)
\textsuperscript{174} Ibid.
\textsuperscript{175} Bourassa et al., “What's in a View?” (2004): 1427-1450. This study provides a chronological review of 35 studies that have used view as a variable in measuring externality impact on home values. These studies and their findings are tabulated in a six-page summary sheet in Bourassa et al. (2004): pp 1431-1436).
variable; one study used degree of panorama; 3 studies used GIS or Viewshed-based view scores; and 3 studies used land-use diversity as a proxy for view. View premium was highest for wide views of water, such as lake views, with an 89 percent premium for abutting homes, and ocean view fronts, with a 129 percent premium. Wooded areas, landscaped areas, and forest views had a premium of 3 to 8 percent. The positive impact of view was also found to diminish with distance.

Crompton\textsuperscript{176} reviewed over 25 studies of the economic benefits of parks and opens spaces in urban and non-urban areas. Crompton\textsuperscript{177} also reviewed several types of relatively small urban parks and some large-scale parks in his investigation of the proximity principle. The review of varying sizes, shapes, and types of parks concluded that proximity matters, with the influence of parks declining more rapidly with homes’ increasing distance from the park. Larger parks contributed more to increasing values of nearby homes than did the smaller parks. The externality effect varied with the park attributes (i.e., its area, use, and its type), but the premium was 10-20 percent over average. Parks with intense activities or that were heavily used had a lowered positive effect. This study also concluded that the externality effect is greater for land that is purchased for preservation as forest or open space as compared to land that is purchased and then converted to public parks.\textsuperscript{178}

\subsection*{4.2.3. Findings from the reviewed studies}
Proximity to an externality-generating resource and its views are important measurement variables. View has been defined in many ways, but mostly in qualitative terms, such as

\textsuperscript{177}Crompton, “The Impact of Parks on Property Values: Empirical Evidence,” (2005): 203-218. This study concluded that the proximate principle is relevant as home value increases with reduced distances from open spaces and parks. The study also confirms that home values increase approximately 20 percent if abutting or fronting a passive park.
\textsuperscript{178}Parks have potential to attract high numbers of users, traffic.
visibility (yes/No) or, quality of a view as good, better, or best, and as a near view or a distant view. Surrounding land uses has also been used as a proxy for View. Similarly, various measures such as diversity of land use, percentage of open space are used to define view to an environmental externality generator. Similarly, Proximity has been defined in many ways, such as direct distance, travel time distance, and discrete buffer rings to the resource, as explained in figure 4.1. The four most commonly used variables in the literature are: Proximity, View, Land-use diversity, and Accessibility. After the first set of reviews as discussed above, I started researching more on these four variables and their effects using the published literature, and my findings are presented in the next section.

4.3. Key Explanatory Variables Used in Externality Research

I further examined published literature to find the key externality-capturing variables that have been used in economic-benefits research. Figure 2.1 in chapter 2 shows the variables that have been frequently used in the literature. For my research, I was interested in discovering variables that others have found useful in successfully predicting home-value outcomes. I found five variables that were frequently used in different form. These are proximity, view, surrounding land use, accessibility, and various indices using the land-use information. I will now present these research findings, how these variables were used, and what environmental features were studied using these four different variables.

4.3.1. Proximity Variable

The most commonly used variable for externality research was proximity to or distance from an environmental resource. Proximity is grounded in the proximate principle, which suggests that the nearer a property is to an environmental amenity (positive or negative), the greater impact it will experience. Based on this theory, researchers have tested these hypotheses:
- The closer the surrounding property is to the positive amenity-generating natural resource, the greater the positive impact on home value.

- As distance from the positive amenity-generating natural resource increases, the positive impact on home value diminishes.

- The closer the surrounding property is to the negative amenity-generating natural resource, the greater the negative impact.

- As distance from the negative amenity-generating natural resource increases, the negative impact on home value diminishes.

Table 4.1 shows the extracts from various published studies that have used proximity in their externality measurements.

<table>
<thead>
<tr>
<th>Author (date)</th>
<th>Environmental Amenity</th>
<th>Proximity</th>
<th>Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asabere and Huffman (1996)</td>
<td>Golf course</td>
<td></td>
<td>premium range from 4.8% - 8%</td>
</tr>
<tr>
<td>Bolitzer and Netusil (2000)</td>
<td>Public and private parks, Cemeteries, Golf courses</td>
<td>within 1,500 feet</td>
<td>1-3% premium ($2,105) – parks 5% increase for golf courses; size</td>
</tr>
<tr>
<td>Boyle &amp; Keil (2001)</td>
<td>Pollution</td>
<td>distance declining</td>
<td>$190/mile-$11,450 /mile</td>
</tr>
<tr>
<td>Campbell and Munroe (2007)</td>
<td>Greenways</td>
<td></td>
<td>Positive amenity</td>
</tr>
<tr>
<td>Clark and Herrin (2001)</td>
<td>Parks and open spaces</td>
<td>500 feet to 3,000 feet</td>
<td></td>
</tr>
<tr>
<td>Crompton (2005)</td>
<td>Multiple</td>
<td>1/4 mile to 1 mile</td>
<td></td>
</tr>
<tr>
<td>Do and Grundmitski (1995)</td>
<td>Golf course</td>
<td>On Golf Course - frontage</td>
<td>Premium range from 4.8% - 8% 3.7% loss (Noise)</td>
</tr>
<tr>
<td>Lansford and Jones (2001)</td>
<td>Waterfront</td>
<td>Frontage</td>
<td>22% Premium, View</td>
</tr>
<tr>
<td>Litts and Miettinen (2002)</td>
<td>Forested area</td>
<td>Linear distance</td>
<td>5.9% decline per km distance 4.9 percent with View</td>
</tr>
<tr>
<td>Lindsey et al. (2004)</td>
<td>Trail</td>
<td>within a half-mile</td>
<td>14% premium ($13,056)</td>
</tr>
<tr>
<td>Loomis et al. (2004)</td>
<td>Access to bodies of water Next to park</td>
<td>Adjacent/Abutting</td>
<td>premium of $937/acre on land premium of $11,039/acre on land</td>
</tr>
<tr>
<td>Lutzeheiser and Netusil (2001)</td>
<td>Urban parks, Natural area parks, Specialty parks</td>
<td>up to 600 feet within 1,500 feet within 200 feet</td>
<td>$1,214 premium – urban parks 2% premium ($10,648) - Specialty parks</td>
</tr>
<tr>
<td>Study</td>
<td>Environmental amenity</td>
<td>Measurement</td>
<td>Impact on Property Value</td>
</tr>
<tr>
<td>----------------------</td>
<td>----------------------------------------</td>
<td>------------------------------</td>
<td>--------------------------</td>
</tr>
<tr>
<td>Mahan and Adams (2000)</td>
<td>Wetlands (open water, emergent vegetation, scrub-shrub and forested)</td>
<td>distance to and size &amp; Types of wetlands</td>
<td>$24 premium per unit acre size increase $436 premium by reducing 1,000'</td>
</tr>
<tr>
<td>NAR (2001) WTP</td>
<td>Park/protected open</td>
<td>Near park</td>
<td>10% WTP</td>
</tr>
<tr>
<td>Netusil (2005)</td>
<td>River Golf Course Trails Tree canopy</td>
<td>within 200 feet</td>
<td>54.4% premium (River) 3.34% premium (Golf course) 5.54% decreased 3.14% premium (Tree canopy)</td>
</tr>
<tr>
<td>Nicholls and Crompton (2005)</td>
<td>Urban Greenways/Trails</td>
<td>Linear distance</td>
<td>$3.97 decline per foot distance away from trail</td>
</tr>
<tr>
<td>Palmquist et al (1997)</td>
<td>Hog operations</td>
<td>Distance; Degree of hog operation.</td>
<td>Decline of upto 9%</td>
</tr>
<tr>
<td>Troy and Grove (2008)</td>
<td>Park Adjacent/Abutting</td>
<td>Premium for park, crime reduces</td>
<td></td>
</tr>
</tbody>
</table>

Source: Compiled using the above papers

4.3.2. View Variable

The second-most commonly used variable was a variable for view, the ability to see the environmental amenity from the surrounding properties. Many studies have utilized a view variable to help explain the impact of an environmental amenity on surrounding property values. They have tested these hypotheses:

- The better the view of the positive amenity-generating natural resource from the surrounding property, the greater the positive impact on home value.

- The worse the view of the positive amenity-generating natural resource from the surrounding property, the less the positive impact on home value.

- The better the view of the negative amenity-generating natural resource from the surrounding property, the greater the negative impact on home value.

- The worse the view of the negative amenity-generating natural resource from the surrounding property, the less the negative impact on home value.

Table 4.2 shows the extracts from various published studies that have used view in their externality measurements. View has been defined in several ways as presented in the figure 4.1 and in table 4.2.
<table>
<thead>
<tr>
<th>Author</th>
<th>Amenity</th>
<th>View</th>
<th>Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acharya and Bennett (2001)</td>
<td>Surrounding land use</td>
<td>land use as a proxy to View - % visible land use/cover</td>
<td>visibility is an important</td>
</tr>
<tr>
<td>Benson et al. (1998)</td>
<td>Ocean, lake, or mountain views</td>
<td>By Amenity view type &amp; by Ocean - Full, Partial (qualitative) Lake - Full, Partial (qualitative) Mountain - Full, Partial (qualitative)</td>
<td>25.6% premium – Generic view 18.1% premium - lake view 8.2%-58.9% premium for ocean view based on partial or full 126.7% premium for lake frontage view</td>
</tr>
<tr>
<td>Do and Grundnitski (1997)</td>
<td>Golf Course</td>
<td>Golf Course - frontage</td>
<td>Premium of 7.6%</td>
</tr>
<tr>
<td>Irwin (2001)</td>
<td>Private and Public land uses (Developable vs. non developable)</td>
<td>Land use indices within 400 meter radius</td>
<td>Conservation land, and publicly owned non-military land create significant positive benefits</td>
</tr>
<tr>
<td>Lake et al. (2000)</td>
<td>Visible land use &lt; 500m</td>
<td>GIS/Viewshed-visible amount of industry, rail, road unclassified land use</td>
<td>Rail view significant view to different land use insignificant</td>
</tr>
<tr>
<td>Lake et al. 1998</td>
<td>Road noise and visibility</td>
<td>GIS/Viewscores</td>
<td>negative 2.5% impact for view negative 1.07% for every Db noise</td>
</tr>
<tr>
<td>Mooney and Eisgruber (2001)</td>
<td>Treed riparian buffer (m)</td>
<td>Riparian Tree Buffer width</td>
<td>Negative 3-11% for 50’ buffer Trees obscure river view and diminish quality of the view.</td>
</tr>
<tr>
<td>Paterson and Boyle (2002)</td>
<td>Surrounding land use diversity of surrounding land use as a proxy to view</td>
<td></td>
<td>visibility is an important</td>
</tr>
<tr>
<td>Payton et al. (2008)</td>
<td>Urban forest land</td>
<td>Vegetation index using RS Normalized Difference Vegetation Index (NDVI)</td>
<td>WTP $15 and $92 annually for a permanent 1% increase in vegetation density; found that within 2-acre patch, 1.5 percent, or $1,270</td>
</tr>
<tr>
<td>Rodriguez and Sirmans (1994)</td>
<td>WTP from agents Binary dummy (Y/N)</td>
<td></td>
<td>5-15 % premium as per WTP 8 % value via HPM</td>
</tr>
<tr>
<td>Sander and Polasky (2009)</td>
<td>View of land uses</td>
<td>GIS/Viewshed-10m DEM – % viewshed under land uses - forest, grass under water</td>
<td>Increasing viewshed by 10% $5,517 premium for grassy surfaces $7,417 premium for water surface</td>
</tr>
<tr>
<td>Schultz and Schmitz (2008)</td>
<td>Lake views</td>
<td>Viewsheds</td>
<td>7.5%-8.3% premium with lake view</td>
</tr>
<tr>
<td>Seiler et al. (2001)</td>
<td>Lake Erie water views length of linear frontage</td>
<td></td>
<td>56% premium with view 93% premium with lake frontage view</td>
</tr>
<tr>
<td>Thorsnes (2002)</td>
<td>Forest preserves</td>
<td>abutting forest</td>
<td>19-35% scenery and wildlife viewing</td>
</tr>
<tr>
<td>Wolverton (1997)</td>
<td>City view panorama</td>
<td>lot’s view angle (10-160 degrees)</td>
<td>Views have diminishing marginal utility</td>
</tr>
</tbody>
</table>

Source: Compiled using the above papers
4.3.3. **Review of View Quantification Methodology**

Most view variables that were reviewed were developed using traditional qualitative processes. These qualitative view variables only can distinguish between ability and inability to view and can assess a view as a “good view.” The limitations of such qualitative view assessment are that in the case of a large home-sample study, it could be prohibitively time-consuming and expensive, particularly if these qualitative assessments involved visiting each home. GIS-based 3-D technology, therefore, is a very useful tool because it automates views as commanded from one place to an object or scene of interest. The following studies were selected in order to understand how view can be automated using the GIS viewshed. More details have been provided in chapter 6, where I have explained the methodology of creating explanatory variables used for this research.

<table>
<thead>
<tr>
<th>Authors (Year)</th>
<th>Methodological Contributions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sander and Polasky (2009)</td>
<td>How to use Viewshed in GIS</td>
</tr>
<tr>
<td>Shultz and Schmitz (2008)</td>
<td>How to develop a complex DEM</td>
</tr>
<tr>
<td>Sanders and Manson (2007)</td>
<td>How to develop quantifiable views using DEM and Viewshed/Viewscore</td>
</tr>
<tr>
<td>Lake et al. (1998)</td>
<td>View with diminishing utility</td>
</tr>
<tr>
<td>Benson et al. (1998)</td>
<td>View with diminishing utility</td>
</tr>
<tr>
<td>Wolverton (1997)</td>
<td>View with diminishing utility</td>
</tr>
</tbody>
</table>

Source: Compiled using the above papers

4.3.4. **Land Use and Surroundings Variable**

The third most commonly used variable identifies some aspect of land cover and use. As shown above, in many cases surrounding land uses have been used as a proxy for view. This variable has been used in hedonic models in different forms: as ratio-level data, such as percentage of open space; as indices, including Land Use Diversity Index and Land Use Fragmentation Index; and as binary coded measures used as dummy variables with Yes/No codes to a usage type or environmental attribute (e.g., public park, natural park or preserve, green space, lakefront...
property, ocean view property, forest, ocean, stream, chemical plant, nuclear plant, waste landfill, etc.). When using these variables, null hypotheses are often developed.

### 4.3.5. Accessibility Variable

The fourth most commonly used variable is of accessibility to the resource from the surrounding properties. This research has often focused on the accessibility from home to work, school, or to environmental amenities (e.g., parks, nature centers, lakes, scenic views, etc.) While generally testing positive environmental amenities, some researchers have also focused on the negative impact of undesirable amenities (landfills, chemical plants, nuclear plants, toxic areas, etc.). They have tested these hypotheses:

- The greater the accessibility to the positive amenity-generating natural resource from the surrounding property, the greater the positive impact on home value.
- The worse the accessibility to the positive amenity-generating natural resource from the surrounding property, the less the positive impact on home value.
- The greater the accessibility to the negative amenity-generating natural resource from the surrounding property, the greater the negative impact on home value.
- The worse the accessibility to the negative amenity-generating natural resource from the surrounding property, the less the negative impact on home value.

In this study, accessibility variables related primarily to the ease or difficulty with which environmental amenities can be reached from a home. Past studies have applied accessibility measures between homes and a variety of environmental and other properties—e.g., shops, parks,
railway stations, schools, bus routes, and the central business district. The third variable used is of weighted accessibility to the resource from homes. Specific tools that have been used to create an accessibility measure include

a) **Index of Accessibility.** This uses gravity form and accounts for the size and its inverse distance for all the open space property and creates an index.

b) **Geographical Accessibility Index.** The weighted sum of the inverse distance for the example paper by Power et al. approximated forest amenities using an index variable that measured the ratio of forest acreage to squared distance from the home and summed this data for all woodland areas for every home in the Southampton and New Forest areas of Great Britain. More details on similar indices and their uses are available through Day et al., Pooler, Geogheghan, Waters, Hidano, and Fik et al.

c) **Weighted Sum of Distances to All Protected Properties.** When considering the accessibility of homes to protected open spaces, any measure based on access to only one open space has limitations. For example, a home 200 meters from 10 protected properties is likely to be perceived as having better accessibility than another home 200 meters from a

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single protected property. As a result, measures for accessibility to protected properties were constructed using a weighted sum of distances to all protected properties.\footnote{Day et al., “Non Linearity,” 20-24.}

A few other indices have been presented at the end of this document in Appendix E.

### 4.4. Chapter Summary

The key themes that emerged from the above review are that a number of variables matter and play important and measurable role in creating additional value for the home prices. Each variable can be measured independently, although their combined effect is measured with hedonic price models which weight the impact each contributes to value. Specifically, each of these has been found to affect home value: \textit{Distance} from protected property, though only a limited distance;

- \textbf{Size} of the protected property, with larger size having greater impact, particularly in urban settings;

- \textbf{Accessibility} and ability of families to participate in the protected amenity, with passive participation likely to generate a greater positive amenity effect than active participation, which can bring negatives, such as noise and traffic;

- \textbf{View} of a scenic property, a critical component which increases value when present;

- \textbf{Surrounding land uses}, with different uses generating a range of possible impacts, from very positive to very negative;

- \textbf{Type} of protected property, whether it is permanently preserved, such as a forest or open space, or for active recreation like a park, with perpetual preservation likely to have greater positive impact;

- \textbf{Endogenous characteristics} of homes, such as lot size or yard size, with greater amenity value for homeowners with small properties; these owners value publicly protected properties since their own homes contain less natural and environmental space, compared
to homeowners with large lots and yards, who have access to environmental amenities within their own property.

These variables have been used extensively in the literature and were found relevant. Review findings show that a variety of dummy variables were used in regression models such as view, distance, type, public/private-owned property, active/passive activities permitted, land use, rural/urban. In addition, findings also show that the effect of open spaces depends on their configuration and typology, their ownership type, their development potential, their permanence, the activities associated with in them and their geographic location. The following section is about the implications of this literature review on my research.
Chapter 5. Data and Variable Selection

Most studies presented in chapter 4 have used the hedonic-modeling framework in estimating the externality effect or economic benefits of environmental amenities on home values. In this chapter, I am presenting the data that I have used in this research and the sources of that data. The review of chapters 3 and 4 provided a framework for me to choose the right data and develop the right variables that could answer my research question. The data for this research was collected from various sources and was available in a raw form. This chapter presents how this data was prepared and how variables were chosen for my final modeling purpose.

5.1. Data Used and Data Source

This section presents the description and sources of data used in this study. There are two main data sets: 1) data of the protected properties--source of amenity generation (supplier), and 2) data on homes that are recipients of this amenity (consumers). This section also presents various sources from where the data was collected and how this raw data was made usable for the study purpose using primarily GIS and other statistical programs, such as Microsoft Excel and SPSS version 15. Lessons learned from chapters 2, 3, and 4 through the literature review provided a framework for my research, enabling me to create the key explanatory variables that are used later in the model development to measure the economic benefits of conservation easements as capitalized in the surrounding home values.

This study has used two types of datasets: 1) data on conservation easement protected properties and 2) data on the sales of single-family homes. Other GIS-based data, such as the spot elevation, building footprint, and the building height data, is also used to create a 3-D building height and topographic model for the entire city. The data used was collected from various sources, and the datasets used in this research include
Datasets used for conservation easement (CE) property and home samples

1. CE property layer in GIS with location, size, and nature of protection;
2. 2000 Census block group level layer in GIS with socio-economic and housing characteristics data for Worcester;
3. Single-family homes (SFH) sales data with year, price, and house attributes, geo-coded in GIS;
4. House price index (HPI) of Worcester metropolitan statistical area (MSA) to adjust for the house sales prices;

Data used for Viewshed creation

5. Raster layers, spot elevation, and contour layers for Viewshed for the topographic map; and
6. All building footprint layers in the city of Worcester with their respective building heights to create 3-D model for the entire city.

5.1.1. Data on Conservation Easement Protected Property parcels

The data for the properties under conservation easements is collected from multiple sources. First, the GIS-based data is downloaded from the Massachusetts Office of Geographic and Environmental Information, also known as MassGIS. Second, the CE-protected properties’ data is extracted from deed documents downloaded from the Worcester District Registry of Deeds (WDRD) office, and third, data on CE-protected property was also downloaded from the Greater Worcester Land Trust (GWLT) website. In addition to the above sources, tax assessor’s parcel data was used to identify parcels under CE. The parcel data has names of the property owners. Parcels that had the name of a land trust as its owner were also added to the earlier database. After collating all the sources of information, 45 parcels were identified that were designated as CE parcels.

183 MassGIS 2008. Office of Geographic and Environmental Information
Currently, there is an absence of any standardized recording system for the CE properties in the United States. This system, although desired, exists in pieces and at different offices. There is no single source that provides reliable data, such as information the ownership of the CE properties, number and location of easements, amount of acreage, current holders of interests (that is, assignees), preservation features, public access, and the nature of the restrictions.\textsuperscript{186}

CE data assimilation is a time-intensive process. To assimilate data, one has to scan through individual legal deed documents to extract details. First, finding the CE properties by itself is a difficult process due to a lack of organized data, and then the deed documents by themselves have a non-standardized format.

Worcester has 45 parcels that are privately owned and are under CE (for details see table 1). The local land trusts, such as Greater Worcester Land Trust (GWLT) and the Massachusetts Audubon Land Trusts, manage these protected properties as the sole fee-owners or as joint-stewards (managers). The Conservation Commission of the city also has many properties under CE, but they are managed through the GWLT. The details of these CE property parcels in Worcester that are managed by the GWLT and Massachusetts Audubon are presented in table 5.1 and are also shown in figure 5.1.

\textsuperscript{186} My personal experience on data collection phase of this dissertation; Also See, Korngold, “Solving the Contentious Issues,” (2007):1039-1084.
Figure 5.1. Location of CE (shown in white dots) and other Fee Owner properties (shown in black dots) held by GWLT for conservation in Worcester

Source: Greater Worcester Land Trust, 2008
### Table 5.1: Private land under conservation in Worcester

<table>
<thead>
<tr>
<th>Site Name</th>
<th>Area (Acres)</th>
<th>Type of Restriction</th>
<th>City</th>
</tr>
</thead>
<tbody>
<tr>
<td>Broad Meadow Brook Savannah</td>
<td>+/- 80.00</td>
<td>Conservation Easement</td>
<td>Worcester</td>
</tr>
<tr>
<td>Cascades East</td>
<td>30.86</td>
<td>Conservation Easement</td>
<td>Worcester</td>
</tr>
<tr>
<td>Coal Mine Brook Parcel</td>
<td>7.30</td>
<td>Conservation Easement</td>
<td>Worcester</td>
</tr>
<tr>
<td>Coal Mine Brook II Parcel</td>
<td>4.60</td>
<td>Conservation Easement</td>
<td>Worcester</td>
</tr>
<tr>
<td>Crow Hill</td>
<td>27.90</td>
<td>Conservation Easement</td>
<td>Worcester</td>
</tr>
<tr>
<td>Green Hill Park</td>
<td>487.00</td>
<td>Conservation Easement</td>
<td>Worcester</td>
</tr>
<tr>
<td>Parson’s Cider Mill</td>
<td>43.08</td>
<td>Conservation Easement</td>
<td>Worcester</td>
</tr>
<tr>
<td>Ryan Ornamental</td>
<td>1.94</td>
<td>Conservation Easement</td>
<td>Worcester</td>
</tr>
<tr>
<td><strong>Sub Total (8)</strong></td>
<td><strong>670.00</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Mass Audubon</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Granite Street Conservation Area</td>
<td>14.00</td>
<td>Conservation Easement</td>
<td>Worcester</td>
</tr>
<tr>
<td>NEPC (Nr. Granite)</td>
<td>108.00</td>
<td>CR</td>
<td>Worcester</td>
</tr>
<tr>
<td>Nr. NEPC</td>
<td>14.50</td>
<td>Owned Property</td>
<td>Worcester</td>
</tr>
<tr>
<td>Hjelm Road</td>
<td>~12.00</td>
<td>NA</td>
<td>Worcester</td>
</tr>
<tr>
<td>Massasoit Rd</td>
<td>~3.00</td>
<td></td>
<td>Worcester</td>
</tr>
<tr>
<td>Coes Reservoir</td>
<td>~12.00</td>
<td>Conservation Easement</td>
<td>Worcester</td>
</tr>
<tr>
<td>Cooks Pond</td>
<td>~32.00</td>
<td>Conservation Easement</td>
<td>Worcester</td>
</tr>
<tr>
<td>Sprague Ln</td>
<td>~1.80</td>
<td></td>
<td>Worcester</td>
</tr>
<tr>
<td><strong>GWLT Owned Land (Fee Owner)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bovenzi Conservation Area</td>
<td>120.68</td>
<td>Owned Property</td>
<td>Worcester</td>
</tr>
<tr>
<td>Brigham Road Parcels</td>
<td>2.53</td>
<td>Owned Property</td>
<td>Worcester</td>
</tr>
<tr>
<td>Cascades West</td>
<td>122.99</td>
<td>Owned Property</td>
<td>Holden/Paxton/Worcester</td>
</tr>
<tr>
<td>Cascading Waters</td>
<td>2.40</td>
<td>Owned Property</td>
<td>Worcester</td>
</tr>
<tr>
<td>Curtis Pond Parcel</td>
<td>±0.10</td>
<td>Owned Property</td>
<td>Worcester</td>
</tr>
<tr>
<td>Kettle Brook</td>
<td>14.37</td>
<td>Owned Property</td>
<td>Worcester</td>
</tr>
<tr>
<td>Marois Property</td>
<td>28.20</td>
<td>Owned Property</td>
<td>Worcester/Leicester</td>
</tr>
<tr>
<td>Nick’s Woods</td>
<td>59.76</td>
<td>Owned Property</td>
<td>Worcester</td>
</tr>
<tr>
<td>Sargent’s Brook Property</td>
<td>+/-5.00</td>
<td>Owned Property</td>
<td>Worcester/Holden</td>
</tr>
<tr>
<td>Southwick Pond</td>
<td>113.77</td>
<td>Owned Property</td>
<td>Paxton/Leicester</td>
</tr>
<tr>
<td><strong>Sub Total (10)</strong></td>
<td><strong>470.00</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Government Land Preserved with GWLT assistance</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Antell Conservation Land</td>
<td>280.00</td>
<td>Partner Massachusetts DEM</td>
<td>Spencer/East Brookfield</td>
</tr>
<tr>
<td>Turkey Hill Brook Addition to Moore State Park</td>
<td>30.00</td>
<td>Partners Massachusetts DEM; Paxton Land Trust</td>
<td>Paxton</td>
</tr>
<tr>
<td><strong>Sub Total (2)</strong></td>
<td><strong>310.00</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>


In Worcester, pockets of noteworthy and even distinctive scenic features exist, such as Broad Meadow Brook Wildlife Sanctuary\(^\text{187}\) in the south, which is the largest urban wildlife...

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\(^{187}\) City of Worcester, “Open Space and Recreation Plan,” 28. The Massachusetts Audubon Society manages these 272 acres of Broad Meadow Brook Wildlife Sanctuary, which has oak woods, fields, old pastures, streams, marshes, swamps, wildlife habitats, and nature education. The Cascade Green Belt is located in the northwestern section of Worcester. This site is comprised of approximately 300 acres of woods owned by the Worcester Parks Department and the Greater Worcester Land Trust. (Greater
sanctuary in New England with over 400 acres of woods, fields, streams, and marsh. It has over 78 different species of butterflies, habitat for owls, and a new conservation center with interpretive exhibits, a large 3-D model of the entire sanctuary, and a wall-to-ceiling map of the Blackstone River watershed. This center also serves as a visitor site for the National Park Service’s Blackstone River Valley National Heritage Corridor.\(^{188}\) In addition to this, in the North Worcester area, there is the 300-acre Cascade Green Belt Woods. Another property, Cascades East,\(^{189}\) is a 30-acre forested open space parcel that abuts the Cascades. Similarly, the Perkins Farm conservation property consists of 80 acres of young and mature woodland. The hillside of the site provides an overlook to Lake Quinsigamond.\(^{190}\) Another large conservation property is Crow Hill, a 42.1-acre parcel that is forested and contains approximately two acres of wetlands surrounding a small pond.\(^{191}\) These wetlands serve as habitat for fish and wildlife and help to recharge groundwater, enhance water quality, and aid in the control of flooding and erosion.

The protected properties in Worcester include scenic properties, historic sites of American industrialization, protected habitats, forests, outdoor recreational facilities, and perpetually and less-than-perpetually conserved land. These properties are of varying sizes. Also, the development-right agreements of these properties are held by various private land trusts and local authorities. A few of these properties are jointly managed by trusts and the

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\(^{189}\) City of Worcester, Open Space and Recreation Plan, 25. Cascades East is a 30.86 acre forested open space parcel that abuts the Cascades, which is a 36-acre preserved open space area. This parcel is a vital addition to the Cascades greenway corridor located in Holden and Worcester.

\(^{190}\) Ibid., 25.

\(^{191}\) Ibid., 28. Crow Hill is located off of Plantation Street at the terminus of Clarendon Street. The Conservation Commission has obtained ownership of 27.9 acres of the parcel through funding made available by the GWLT, which has placed a CR on the parcel.
Conservation Commission. According to Conservation Commission Official Katie Kelly Donovan, whom I interviewed in September 2008 and February 2009, the Worcester City’s Conservation Commission-owned properties are protected for largely passive recreation purposes. These properties do not have any facilities such as ball fields and tennis courts.

5.1.2. Data on Home Sales
The other dataset used in this research is the home-sales data. The property appraisal records in Massachusetts are managed by the local city jurisdictions, unlike in many states in the United States, where the county auditor’s office manages the property data. The property-sale data was procured from the Office of the City Assessor of Worcester. The city also had updated, computerized, GIS-based parcel data and appraisal data for all its nearly 46,000 parcels in the city’s jurisdiction. This GIS parcel data was downloaded from the Technical Services Division of the Department of Administration and Finance, City of Worcester, Massachusetts.

Of the total 46,000 parcels in the city, over 23,000 land parcels were zoned as single-family homes (SFH). These parcels were separated using the zoning class description code, 101 for Single Family Residential. The Assessor’s property sales were available in a tabular database form. This included sales from 1989 until year 2008, the most recent sales data. This set also had information on property attributes and had a location identifier of MAP/BLOCK/LOT for all the transacted properties, which was a unique ID for each property location. A similar MAP/BLOCK/LOT number was also present in the GIS Parcel map, which was an ID unique to each parcel. The unique IDs were joined to tie the property sales and attribute records to the parcel map. The joining of sales data to the parcels showed that a total of 14,566 SFH were bought and sold in the city from 1989 through September 2008.

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192 Various characteristics of homes, such as size, age, location, and other physical and non-physical features, including sale price and the sale date.
As a first step, all the SFH sales data from 2005 through September 2008 were separated from this sales data file to create a smaller home data file. This file had the location IDs, addresses, and descriptions of the physical attributes of the homes. As a second step, to control the potential impact of other intervening variables on the home prices, this smaller sales data file was further reduced, and only sales of homes that were within a buffer distance of one half-mile from the subject CE-protected properties were chosen. This is like creating submarkets around each of the conservation easement properties. As a third step, all the outlier sales, such as those homes with very high sale prices, and those homes with very low sale prices ($SD – 2$) were removed\textsuperscript{193} from this dataset to make the final data set of homes on which these economic benefits were computed.

Finally, datasets of SFH sales had $n=1,238$ SFH sales (Price $M = $174,253; $SD = $56,411) that were within a half-mile of at least one of 45 parcels of conservation easement-restricted properties and were transacted between 2005 and 2008. Table 2 provides descriptions of these sample homes’ characteristics, and figure 5.1 shows their locations. Using this home sales dataset of $n=1,238$ homes and 45 conservation easement property parcels as shown in figure 5.2, the three explanatory variables were created, as explained in the next section, using GIS.

5.1.3. Discussion on the half-mile buffer for home samples
The review of past studies in the earlier chapters reveals that the effect of distance from CE parcels declines with increasing distance of homes from those parcels. Research has also shown that the effect of the distance declines quickly. Since the effect of proximity matters only for a limited distance, previous research has used different buffer ranges to capture the effect. This

\textsuperscript{193} In SPSS ver 15.
buffer distance ranges from as low as 200 feet from the externality-generating feature to one mile, or even a little more in some cases. A greater number of studies have used one-quarter-mile and one-half-mile distances for the impact measurement. This is also considered a walkable distance, accessible to most homes, and offers greater visibility of the CE parcels. I therefore have used home-sale samples within one-half mile of the protected property parcels. The homes in this buffer region will be more greatly influenced by protected parcels than the homes outside of this region. This buffer also helps control for influences of factors that are outside of the half-mile buffer but that could influence values for sample homes—influences such as a view of a river or of downtown. This half-mile buffer also serves as a local submarket for homes near protected properties. The final data showing the 45 conservation easement parcels and 1,238 SFH within the half-mile buffer is shown in figure 5.2.
Figure 5.2 Map showing conservation easement (CE) parcels (N=45) and SFH home samples (N=1,238) within ½-mile buffer of CE parcels and transacted from 2005 through 2008.

Source: Greater Worcester Land Trust, Registry of Deeds, Worcester and City Assessor’s land parcel data
5.2. Selection of Variables for the Model

The above data provides with both dependent and independent variables that were needed for the hedonic model. The dependent variable is the sale price in dollars, while the independent variables are various attributes of homes that create home value.

Land-use theories explain that the externality effects on properties such as homes are capitalized in the land component of the property. Therefore, it is best to measure this externality effect on the price change of vacant lands as observed in the change in price per acre of land. It is easier to compare one land-lot with another land-lot, unlike comparing a land-lot to a property with improvements, such as homes, which have a unique set of attributes. Since vacant-land transactions are very rare in an already developed urban area, the next best option available is to use the most frequent sale data of platted single-family homes. Since home prices are for the whole property, including land and home improvements, and since the price of a home cannot be separated from these, I am using the level sales price of homes as the dependent variable, rather than price per acre.

5.2.1. Dependent Variables - Sale price adjusted to Worcester’s House Price Index

Sale price of homes are a better representation of homes’ fair market value. Sale prices are more likely to be determined by willing buyers and willing sellers, and are closer to the real market value as compared to the assessed value. In Worcester, the Assessment to Sales Value Ratio ranges from ±5 percent, which means that the City Assessor’s Office claims that if the median Assessment to Sale Value Ratio (ASR) is less than 95 percent or more than 105 percent, a

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194 With positive externality, the land has a new ability to generate higher land rent.
195 Assuming land lots have similar land use regulations and restrictions and are in the same market.
revaluation will be ordered. In the assessed values, there is always a possibility of assessment bias; however, sale price reflects the value that a homebuyer assigns to the bundle of services that is provided by a home property among the range of competing choices that are available. The home-sales data used in this research are for multiple years—from 2005 to 2008. These multi-period sale prices needed to be adjusted for inflation using CPI, local Housing Price Index; in the model, dummy variables recognizing time periods of sales should be added. Using the House Price Index for Worcester MSA, the real home prices (Sales price) were adjusted as dependent variables.

5.2.1.1. Method for Adjusting Sale Price to Worcester’s House Price Index
The Home Price Index (HPI) is a broad measure of the movement of single-family house prices and serves as a timely, accurate indicator of house-price trends at various geographic levels. The index for various geographies is available at Metropolitan Statistical Areas (MSA) level. HPI is a weighted, repeat-sales index, which means that it measures average price changes in the properties in a given market as observed by the repeat sales data or refinancing of the same properties. The information on HPI is obtained by reviewing repeat mortgage transactions on single-family properties whose mortgages have been purchased or securitized by Fannie Mae or Freddie Mac since January 1975.

To calculate change in the price—appreciation or decline—between any two quarters, I used the following formula: \[(\text{Quarter 2 Index Number} - \text{Quarter 1 Index Number}) / \text{Quarter 1 Index Number}\]
Index Number]. Also, by taking the four-quarter average for each year, annual numbers can be generated using a similar formula.201

5.2.2. Key Independent Variables to control Structural characteristics

Sirmans et al.202 reviewed 125 hedonic studies to examine explanatory variables used in the past. This review also included 24 studies that had environmental amenities close to homes. This review found 20 key house characteristics that appeared in most hedonic studies. The frequently used variables, found to affect the final home values, included structural variables of homes, neighborhood variables, community variables, location variables, inflation variables (time-related variables of homes), marketing, occupancy and selling factors, and financial variables of homes, as shown in table 5.2.

Table 5.2 Control variables used in the literature

<table>
<thead>
<tr>
<th>Construction &amp; Structural variable of homes</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Lot size, Sq ft, Age (Year as linear or Quadratic form), # of bathrooms, Bedrooms, Lot Size (Sq ft/ Log Transformed), Built Up Area (Sq ft/ Log Transformed)</td>
<td></td>
</tr>
<tr>
<td>House Internal Features - Full baths, Half baths, Fireplace, Air-conditioning, Hardwood floors, Basement (Dummy)</td>
<td></td>
</tr>
<tr>
<td>House External Amenities - Garage spaces, Deck, Pool, Porch, Carport, Garage all as dummy (Yes/No)</td>
<td></td>
</tr>
</tbody>
</table>

201 The House Prices Indexes (Quarterly Data) is available from Office of Federal Housing Enterprise (OFHE) 2009. Accessed from http://www.ofheo.gov/hpi_download.aspx. on January 3, 2009. Now available through http://www.fhfa.gov/. The HPI is not adjusted for inflation and one can use the Consumer Price Index “All Items Less Shelter” series for the adjustment. The Bureau of Labor Statistics (BLS) price index series, simply identified by ID# CUUR0000SA0L2 - has tracked non-shelter consumer prices since the 1930s. So, the dependent variable was home sale price (in dollars) adjusted to the 2008 level sales price using the HPI of Worcester MSA.


203 The square foot area used here is the Total Utilizable Area of sample homes (TULA) as provided by the City Assessor. Also see, Hamp (2007) for different ways square feet are defined and various methods of calculating these square-foot areas for different house types. D. Hamp Thomas, “Size Matters! Measuring and Calculating Residential Square Footage,” (The Measure Man, LLC, in association with Carolina Appraisers & Real Estate 2007).

204 Joachim Zietz & Emily Norman Zietz & G. Stacy Sirmans, “Determinants of House Prices: A Quantile Regression Approach”, Journal of Real Estate Finance & Economics 37 (2008): 317–333. Zeitz et al. concluded that buyers of higher-priced homes value certain housing characteristics, such as size (square footage and the number of bathrooms), differently than buyers of lower-priced homes. Beta coefficients behave differently across different-house price levels. For example, the study concluded that Beta increases as selling price increases (for square feet, acres, and full bath) and decreases as the selling price increases (for age and for view). Beta remains relatively constant as the selling price increases (for garage, air conditioning, and distance to highway and city center. No definite pattern is seen for the number of bedrooms as selling price increases. Amenities such as decks, patios, pools, basements, and landscaping were not significant as the selling price increases.
### Neighborhood variable of homes
- Median Income Group ($ Value / Log Transformed)
- Percentage Afro-Americans (Percentage)

### Neighborhood Housing Characteristics
- Median Housing Value

### Community variable of homes
- School District and Quality of Schools (Dummy), percent School district minority
- Safety and Crime (Dummy/ Crime Density)
- Amenity characteristics (Golf Course, Public sewer, water)

### Locational variable of homes
- Metro level accessibility characteristics such as Distance from Highway (Ft, / Log Transformed), Distance from CBD (Ft, / Log Transformed), Distance from nearest Shopping (Ft, / Log Transformed)
- Public sector infrastructure availability (Dummy)

### Inflation Variables (Time Related variable of homes)
- Year/Month of sales as dummy (Dummy)

### Marketing, Occupancy & Selling Factors variable of homes
- Assessors quality, Assessed condition,
- Vacant, Owner-occupied,
- Time on market, Trend

### Financial variable of homes
- FHA Finance, VA Finance, Foreclosure, Favorable financing, Property tax

Source: Adapted from Sirmans et al. 2005; Zeitz et al. 2005; Kang and Reichert 1987\(^\text{205}\), Wong et al. 2002\(^\text{206}\), Brett Day et al. 2004, and several articles reviewed that used hedonic modeling to control housing characteristics to measure the environmental benefits of open spaces, parks and other amenities.

### 5.2.3. Key Independent Variables to control Neighborhood level sub-market characteristics

Housing submarkets are defined using various dimensions of housing and its locational quality to segment the housing markets into groups of similar or near-similar-type housing units. The physical condition of nearby housing, surrounding environmental characteristics, and socio-economic status of the occupants in the neighborhood are the key measures that define quality of the housing. Bates\(^\text{207}\) and Varady et al.\(^\text{208}\) present how these characters of housing markets are

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spatially divided into submarkets that are segmented into areas of comparable quality. Galster provides a discussion of what neighborhoods are and how these neighborhoods form submarkets. The neighborhood characteristics create value in homes and hence need to be controlled for.

5.2.4. Environmental Externality capturing Explanatory Variables
The explanation and detailed methodology of these variables is given in chapter 6. These variables include two proximity measures--squared Euclidean distance from homes to conservation easement parcels and squared Euclidean distance from homes to the nearest visible conservation easement parcel--and two viewability measures--total sum of all viewable areas of all CEs combined from every home and viewable areas of the nearest CE parcels from every homes. These were combined into the interaction effect as measured via the Conservation Easement Visibility Index (CEVI), which accounts for visibility and proximity together.

5.2.5. Explanation of Variables Used in the Model
Table 5.3 below presents the final list of variables--dependent and control variables--that were chosen for the final model; these include time of sale, structural features, and neighborhood features of home samples. The last row in table 5.3 is for the environmental features that have been developed and presented in chapter 6. These environmental features include five variables that were developed to capture the externality effect.

Table 5.3: Explanation of variables used

<table>
<thead>
<tr>
<th>Variables</th>
<th>Units and explanation of variables</th>
</tr>
</thead>
<tbody>
<tr>
<td>HPI_Sales</td>
<td>Dependent Variable – Home Sale Price (in $) adjusted to Worcester MSA’s Housing Price Index for year 2008</td>
</tr>
<tr>
<td>Sl_2005</td>
<td>Homes sold in 2005 (Binary -0,1)</td>
</tr>
<tr>
<td>Sl_2006</td>
<td>Homes sold in 2006 (Binary -0,1)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Variables</th>
<th>Units and explanation of variables</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sl_2007</td>
<td>Homes sold in 2007 (Binary -0,1)</td>
</tr>
<tr>
<td>Sl_2008</td>
<td>Homes sold in 2008 (Binary -0,1)</td>
</tr>
<tr>
<td>Structural</td>
<td></td>
</tr>
<tr>
<td>Bath</td>
<td>No. of Bathrooms</td>
</tr>
<tr>
<td>Qual</td>
<td>Assessor assigned home quality index (20 to 60)</td>
</tr>
<tr>
<td>AgeSq</td>
<td>Age of Home - Squared</td>
</tr>
<tr>
<td>Log_LotSf</td>
<td>Lot area (Sq ft) - Log transformed</td>
</tr>
<tr>
<td>Log_TULA</td>
<td>Total Utilizable Area (Sq ft)-Built area (Sq ft)- Log transformed</td>
</tr>
<tr>
<td>Pool</td>
<td>Pool Available / Not Available (Binary – No=0, Yes=1)</td>
</tr>
<tr>
<td>Garage</td>
<td>Garage Available / Not Available (Binary – No=0, Yes=1)</td>
</tr>
<tr>
<td>Neighborhood</td>
<td></td>
</tr>
<tr>
<td>Hsg_Den</td>
<td>Housing Density in the neighborhood-(No. of Houses/ Acre) H001001</td>
</tr>
<tr>
<td>MdHsg_Val</td>
<td>Median Housing Value ($) of owner-occupied houses H085001</td>
</tr>
<tr>
<td>Perc_Blac</td>
<td>Percentage of Afro-Americans P006003</td>
</tr>
<tr>
<td>Environmental</td>
<td>5 Variables to be calculated in the Chapter 6</td>
</tr>
</tbody>
</table>

### 5.3. Chapter Summary

This chapter presented the data used in this research, its sources, and how it was cleaned for the modeling purpose. The chapter also presented the final variables for the modeling purpose.
Chapter 6. Methodology for Creating Explanatory Variables

This chapter presents a detailed methodology of how the externality-capturing explanatory variables were created using the ArcGIS 9.3. In the first section of this chapter, I have presented a quick recap of the lessons learned from chapter 4 and their implications for my research in finalizing the explanatory variables. Later, using GIS, explanatory variables have been developed. These variables are proximity of SFH to CE, visibility of CE from SFH, and their interaction as expressed by an index called Conservation Easement Visibility Index (CEVI).

6.1. Implications for My Research from Chapter 4

Distance from a protected property is clearly a key variable. The review of past studies revealed that the effect of distance declines with the increasing distance from the protected property, so I have used Euclidean distance to capture this effect of proximity. Research has also shown that the effect of the distance declines quickly, hence squaring the distance and entering it as a quadratic term in the HPM could capture this effect. Since the effect of proximity matters only for a limited distance, the other consideration from the literature was to choose a suitable distance buffer. Most studies have used one-quarter mile and one-half mile distance for proximity; hence, I chose only those home samples that are within one-half mile of any protected property parcels and have been bought and sold recently.

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210 Here it is important to note that distance matters but not in all cases. For example, contingent valuation studies (not presented here) indicated that some individuals have stated that they were willing to contribute in order to provide the public good of endangered species protection, even when the species is located in a distant area. While these contributions can help to save environmental assets, the relationship to donor home values would not be evident.
View of a scenic property matters. Review of past studies has shown that aesthetic views command higher values; hence a view-measuring variable is important to my research. Since in Worcester, most CE-protected properties possess scenic value or have a scenic property abutting the CE parcels, I developed view variables using the Viewshed analysis in GIS.

Size of the protected property matters. Review of past studies had mixed results on the size of the protected property, yet the general consensus is that larger is better; hence the size of the protected property is an important measurement variable. I therefore have developed a weighted summation-of-accessibility index that takes both size and accessibility into account within a single variable. The index value increases if the home sample is nearer to a large environmental amenity.

6.2. The Five Externality Capturing Explanatory Variables
There are five externality capturing variables that have been developed for this research. Two are the *proximity measures*, and two are *viewable-area measures*. The last one is an interaction variable that uses both viewability and proximity in a single variable and is expressed in an index form. These proximity variables are DistCESq, the square of Euclidean distance, which is a straight line distance from each home sample to the nearest CE parcels, and the similarly squared distance from the nearest visible CE parcel. The second set of variables is about viewable area, and these compute the viewable area of CE parcels from each home and are expressed in two ways. First is the Tot_ViewAr, which is a sum of all the viewable areas of CE parcels from each sample home, and the second is Nr_ViewAr, the viewable areas of the nearest CE parcel. These view variables were developed using digital elevation model (DEM) and the viewshed
The CEVI Index is a weighted sum of inverse distance, a variable similar to the accessibility measure, and it evaluates the interaction effect of both the viewability and the squared Euclidean distance. What these five variables really mean in a geographical sense is shown in figures 6.1 and 6.2.

Figure 6.1 Conservation Easement Visibility Index (CEVI)

Cevi_2 – CEVI Index

Viewshed analysis in ArcGIS Spatial analyst

\[ A_i = \sum_{j=1}^{I} \frac{Vis_{ij}}{d_{ij}^2} \]
Figure 6.2 Proximity and View Variables
6.3. Methodology of Squared Euclidean distance - *Home to Conservation easements*

Simple logic suggests that, spatially, wherever some resource site generates any use value, the population density of its users will be higher near that site, all other things being equal. Furthermore, as users typically place a higher value on the site than the nonusers, it could be expected that the average values would decay with the increasing distance of users from that resource site. This could also be understood from the first law of geography, that “everything is related to everything else [in geo-space], and the near things are more related than the distant things.” Literature has shown how home values increase with increasing proximity to different types of amenity-generating protected open spaces.

The review has presented that proximity has been used in many ways, such as buffer rings, Euclidean distance, and driving distance. It was unclear from the literature if the distances measured were from protected-area lot boundaries to home-lot boundaries, or if distance were from the center of the protected-property parcel to the center of the home lot. This distinction is important, especially because few CE properties are large in size, and using the distance from their centers to the home centers will lead to imprecise results. In my research, the distance used is from the home parcel boundary to the CE parcel boundary, i.e., polygon boundary to polygon boundary distance. Since view is an important feature for scenic protected properties, instead of using the network or driving distance, I used Euclidean or straight line distance.

I developed Euclidean distance (in feet) and used its square form using the Rob Chasan’s Visual Basic tool (VBtool) - “*MultipleMinimumDistance,*” which is available from

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214 Robert Chasan, “*MultipleMinimumDistance.zip*” available from ESRI’s vb script : ESRI Downloads (2003)
the ESRI’s tools section. This tool measures multiple distances and creates a matrix between the two polygon layers. Using this tool, I calculated distances from the lot boundary of each sample home parcel \((n=1,238)\) - to the parcel boundary of all CE parcels \((n=45)\).

6.4. Methodology of creating Viewability Variables using Viewshed analysis

Viewshed is a term used to indicate the entire area that an individual observer can see from a given point. It is characterized by visibility between locations. Viewshed is a computer-intensive process, and the processing time is highly dependent on the raster resolution.\(^2\)

Viewsheds were developed using the topographic digital elevation model (DEM) data and the building-height data for the entire city of Worcester. Finally, viewsheds were created to find which CE protected parcel is visible, what is the minimum distance from which the CE is visible, and how much of the area of the CE is visible from each of the home samples?

The review has presented a traditional qualitative view-capturing process that uses site surveys, which could be prohibitively time consuming, depending on the number of properties considered and how views have been qualitatively assessed. The other way this variable is used is as a dummy variable showing if a view is available or not, views as a qualitative variable on a scale of 1 to 5, views as abutting property, and a view proxy using land use diversity as a primary variable for a 400-foot radius from each home sample. A few studies have also used 3-D GIS and DEM.

In this research, I found that the 3-D GIS technology is very useful in automating and quantifying views. This means that views can be measured objectively, automatically, without physically visiting the home sites. Sander and Manson \(^{216}\) created viewsheds based on natural topography (DEM of land-elevation data) and view-impeding 1,850 built structures. The study used different methods for determining building heights--actual versus uniform heights, based on familiarity--and average heights and locations--actual footprints versus generalized locations using a buffer around the centroid of property parcel.

Lake et al. and Shulz and Schmitz \(^{217}\) presented a methodology of developing viewshed using GIS in their environmental-benefit study. Their study focused on views and their economic benefits to the view-commanding surrounding properties. The viewshed analysis has been carried out using the 3-D and Spatial Analyst software in the ArcGIS 9.3. \(^{218}\) Using the building footprints (polygon data) and building-heights data, a vantage point was set at six feet above the ground, and viewshed was developed that accounted for both the topographical undulation and the view-obstructing buildings (as visual barriers) that obstruct the view of CE properties from the surrounding homes. Weights are assigned to those homes that commanded views of the CE sites.\(^ {219}\)

\(^{218}\)Another study which used Viewshed is Yin and Hastings’s study for Niagara Falls, where GIS Viewshed was used to assess the visibility. Li Yin, and Jonathan Hastings, “Capitalizing on views: Assessing visibility by using 3d visualization and GIS technologies for hotel development in the city of Niagara Falls, New York”, Journal of Urban Technology 14, no. 3(2007): 59–82. This study examined whether it would be possible for a hotel on the US side to have views of the Niagara Falls, especially the Horseshoe Falls, if the city allowed taller buildings.  
\(^{219}\)Ideally, Light Detection and Ranging (LIDAR) data should be used to create extremely detailed terrain models. Automated delineation of roof planes from LIDAR data would give more precise viewsheds, as it would have data on all the vertical obstructions that obstruct the view, such as building heights and tree heights. LIDAR is a remote- sensing system used to collect topographic data (Source: http://www.csc.noaa.gov/products/sccoasts/html/tutlid.htm accessed in December 2008).
There are several prerequisite steps before conducting viewshed analysis. DEM is required for viewshed calculation. I therefore created a DEM using the topographic and building-heights data. As discussed earlier, viewshed is a computer-intensive process, and the processing time is highly dependent on the raster resolution. I first chose an appropriate cell size for my raster resolution.220

6.4.1. Creation of DEM Raster
Before developing the DEM, it was critical to select a raster cell size and the viewshed parameters which would enable processing to be completed in a reasonable amount of time without losing the finesse of details.221 In this research, I used the raster resolution of 10-foot by ten-foot cells, which means that each pixel on the raster is a ten-foot-by-ten-foot cell or a grid in size. All of the viewsheds were calculated at human eye level taken at 1.5 meters above the ground and assuming that the observer is located at the center of the home samples.222

The final DEM raster involved three steps: the creation of a topographic raster, the

![Figure 6.3 Merged Raster – DEM of building heights and topographic features of the City](image)


222 One may argue that the center of the house is not the best place to find a viewshed, as windows are placed on the edges, but in my research, for casting viewsheds and for simplicity, I have considered homes as just a point instead of a polygon.
creation of a building-height raster, and the summation of the two rasters prepared in the first two steps to get 3-D DEM raster for the entire city as shown in the figure 6.3 below.

6.4.1.1. Creation of Topographic Raster
The raster was created in the ArcGIS Spatial Analyst. This first raster was based on the topographic data, and it is a DEM of the natural topography of the city. Contour and spot elevation data of the city of Worcester was used in creating this raster. Alternatively, a similar topographic DEM for the Worcester area could have been downloaded from the USGS website; however, to maintain accuracy and consistency, I created mine from the city’s dataset.

6.4.1.2. Creation of Building Height Raster
In Worcester, building-height data was available for only the transacted properties. Using the average height criteria of a specific land-use type (for example, if the average SFH were 14 feet tall, all the homes in Worcester for which building heights were not available were assigned this average height), building heights were then assigned to the actual building footprint, wherever it was missing.\textsuperscript{223} The same process was repeated for all different land-use types, such as retail, commercial and industrial land uses.

Figure 6.4 Building Height Raster after assigning heights to the building footprints

The second raster created for this research had only the building heights. Actual heights were assigned as a $z$-value to the building footprints, and a value of zero was assigned to rest of the area that included unbuilt areas, streets, roads, railways, and empty lots. On the building footprint raster, the actual building heights were assigned to the building footprint polygons obtained from the city’s GIS cell wherever height data was available; average building heights were based on their use codes. Wherever there were no buildings, a zero value was assigned to the raster.

6.4.1.3 Creation of merged DEM raster - Building Height and Topographic Raster

The two rasters, the building heights raster and the topographic raster, were then merged into one combined DEM. This merged raster created a real-time 3-D model of Worcester, which displayed the city’s topography and the views impeding buildings,\footnote{Sander and Polasky, “Value of Views,” (2009): 837–845. This study assigned the heights to the buildings based on its land use type. Data for building heights included only information for buildings with more than 7.5 square meter footprint area. The data was obtained from the County Surveyor’s Office. This paper was published recently and is closer to my study in its methodology. Also, this study used a maximum view distance of 1 kilometer.} both very important for the accuracy\footnote{I have used data on buildings but data on view-impeding trees.} of viewshed calculation.

6.4.2 Conservation Easement Visibility Index (CEVI)

My advisor, Prof. Lin Liu, conceptualized this variable of the Conservation Easement Visibility Index (CEVI). CEVI is a single measure that accounts for both the accessibility and the visibility together--or, in other words, visual accessibility. It is a single measure that captures the effect of how accessible a CE-protected site is from SFH samples and how much closer that site is to the same SFH. Similar to this measure, CEVI is a single measure that captures the effect of how visible a protected site is in terms of visible area and how much closer that visible portion of the site is from a given home sample.
CEVI is like a typical measure of accessibility, which consists of two parts: 1) a transportation element, which is usually measured by travel distance, travel time, or travel costs; and 2) the activity elements, which represent the opportunities available, usually measured as the size or importance of an activity or its attractiveness. An accessibility index is commonly specified as a gravity-type index. So, in my data sample, if I define Visual Accessibility (A) of an SFH (i) to the CE-protected property parcels (j), it is a weighted summation of squared-inverse-distance based on the size of protected properties and their inverse distances from SFH.\footnote{Pooler, “Measuring Geographical Accessibility,” (1987): 269-289. Waters, “Most Beautiful Formulae,” (1995:175-192.); Noboru Hidano, The Economic Valuation of the Environment and Public Policy: A Hedonic Approach (Edward Elgar Publishing, 2002) 66-67. Fik, Ling, and Mulligan, “Modeling Spatial Variation,” (2003): 623-647. This paper uses location-value signatures using x-y coordinates in a spatial model.} Details on similar types of indices and their use are available in Pooler,\footnote{Pooler, “Measuring Geographical Accessibility,” (1987): 269-289.} Waters, Hidano, and Fik et al. In this type of index, if a home is located closer to a larger sized CE parcel, it will have a greater influence of externality generated by the CE parcels. This variable could be written as shown below:

\[ A_i = \sum_{j=1}^{J} \frac{CE_{ij}}{d_{ij}^\lambda} \]

where A is the visual accessibility index, \( CE_{ij} \) is the attraction factor of the conservation easement-protected property defined by its area of the visible portion of the CE from the home, (or it could be any other characteristics such as size or any feature in CE that could cause attraction); \( d_{ij} \) represents the distance between SFH homes (i) and conservation easement protected parcel (j), and \( \lambda \) is an appropriate distance-decay exponent, typically used as \( \lambda = 2 \). The literature does not provide enough information on what should be the value of this exponent or
how this value should be justified. For example, this exponent for commercial retail studies is taken \( \lambda \) as 2. In this dissertation, I am using the exponent as \( \lambda = 2 \).^228

6.4.3. Methodology of Creating Conservation Easement Visibility Index

My advisor, Prof. Lin Liu also guided Shuyan Huo, his graduate student in the Department of Geography, to develop the algorithm for preparing the matrices that are required to compute the Conservation Easement Visibility Index (CEVI) variable in the GIS environment. Later, Shuyan Huo^229 wrote Visual Basic code to calculate the three matrices for this variable, which uses the DEM (as developed before), home samples, and CE parcel data. More detail of the methodology is presented in the next section.

The CEVI calculation involves three steps, and each step provides a matrix. The three steps are 1) calculate the visible area of each CE\(_i\) parcel from each HOME\(_i\); 2) calculate the shortest distance to the visible portion of each CE\(_i\) parcel from each HOME\(_i\), and then 3) calculate the CEVI\(_i\) as a weighted index for each HOME\(_i\). The three matrices include the area matrix, the distance matrix, and the CEVI matrix. The distance matrix accounts for distances of each home from each CE parcel. Similarly, the area matrix accounts for the visible area of each CE parcel from each home. To fill data in these matrices, first I created two empty database tables (*.dbf), one for the area matrix and one for the distance matrix. In each table, each row is a HOME\(_i\), with MAP-ID as the identifier for homes, and each column is a CE\(_j\) property parcel, with MAP-ID as the identifier for CE. Thus, an area matrix, A\(_{ij}\), and a distance matrix, d\(_{ij}\), are created.

6.4.3.1. Creating Visible Area Matrix (Viewability)

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228 I tested my model for the three different \( \lambda \) values of 1, 1.6 and 2 and found that all are significant; however, the model improves more if \( \lambda = 2 \).

229 Shuyan Huo, MA Geography, “VB script for the CEVI Index,” Department of Geography, University of Cincinnati 2009.
This matrix provides raster-cell areas that are visible from HOME(i) to CE(j) parcels. The first step uses the Viewshed analysis function of Arc Map 9.3 to identify the visible areas on the DEM. This function calculates the visibility for each ten-foot-by-ten-foot pixel on the DEM from one or more observer locations, based on a virtual surface. In this case, individual HOME(i) is the observer location, and the virtual surface is represented by a DEM raster whose pixel values are the sum of terrain elevations and building heights as explained earlier. It is a merged raster developed with topography and building-heights data.

For each HOME(i), first I used the Viewshed analysis to generate an output Viewshed(i) raster. This output has only two possible pixel values—a value of one indicates visible and a value of zero indicates invisible. This output is then clipped. For this clipping of the Viewshed(i) raster by each CE(j) property, I extracted a smaller Viewshed(i,j) raster, which keeps only the visibility values (1 or 0) for the pixels inside CE(j). The number of visible pixels in the Viewshed(i,j) raster represents the visible area of CE(j) from HOME(i). This output of area calculation was saved as A(i,j) in the Area matrix.

Figure 6.5 Visible Area Matrix (Homes to all Visible CE Parcels)
6.4.3.2. Creating Shortest Distance Matrix

This is the second step. To calculate the shortest distance, the Euclidean distance function of Arc
Map was employed. This function calculates a distance($i$) raster for each HOME($i$), whose pixel
values are the Euclidean distances from each pixel to HOME($i$). As mentioned above, the
Viewshed($i,j$) raster had three possible values: no value outside the CE($j$) boundary, and a value
of one for visible and a value of zero for invisible cells inside the CE($j$). Thus, the result of
Viewshed($i,j$) raster-timing distance($i$) raster will also have three possible types of values: 1) no
value for outside pixels; 2) positive values for inside visible pixels, which are equal to the
distance values; and 3) a value of 0 for inside invisible pixels. Thus, the smallest positive pixel
value in this result raster represents the shortest distance of the visible portion of CE($j$) to each
HOME($i$). This was saved as $d(i,j)$ in the Distance matrix.

6.4.3.3. Creating CEVI using the Area and Distance Matrix

This matrix is a combination of the shortest distance and the area matrix and was defined by an
index value as follows:
\[
CEVI_i = \sum_{j=1}^{n} A_{ij} / d_{ij}^\beta
\]

in which \((i)\) is the index of HOME; \((j)\) is the index of CE; \((n)\) is the number of CEs; and \((\beta)\) is a user-input variable. Fig 6.6 shows how the two tables (Area and distance matrix) as shown in the figure 6.4 and figure 6.5 were used to develop the third table for CEVI. The tables were developed for different \(\beta\) values and CEVI was calculated. Later, a corresponding new field was added to the attribute table of HOMEs data, and calculated CEVI for different \(\beta\) values were saved to this field. First, I set \(\beta\) values at \(\beta = 1, \beta = 1.6, \text{ and then } \beta = 2.\)

To understand what these different \(\beta\) values mean, greater \(\beta\) value means giving higher weighting to those homes that are nearer to CE. If we use \(\beta = 2\) in computing CEVI, it means that a protected parcel say, 100 feet from a home sample means (CEVI value of \(1/100^2 = 1/10,000\)) and receives a weight over 6 times that of a protected property at 1000 feet distance (CEVI value of \(1/1000^2 = 1/1000,000\)), and a protected property at over 2000 meters distance receives almost no weight at all as the denominator is so large. So \(\beta\) values = 1 means that all protected property are considered equally attractive to the homeowners.²³⁰

All of the above-created externality-capturing variables have been summarized in table 6.1.

6.4.4. Explanation of Final Externality Capturing Variables and other Variables used in the Model

The table 6.1 below presents variables used in the final model. The five externality-capturing variables as developed above are listed under the *Environmental* heading (see the last five rows of the table 6.1 below). The dependent variable is sale price adjusted to the house price index of Worcester at the year 2008 level. The other variables are the control variables to control for the time of the sale, structural features of homes, and neighborhood characteristics of home where they are located and are the same as those explained in chapter 5.

\[
CEVI_i = \sum_{j=1}^{n} \frac{A_{ij}}{d_{ij}^\beta}
\]
Table 6.1 Explanation of final variables used for modeling including the five externality capturing variables

<table>
<thead>
<tr>
<th>Variables</th>
<th>Units and explanation of variables</th>
</tr>
</thead>
<tbody>
<tr>
<td>HPI_Sales</td>
<td>Dependent Variable – Home Sale Price (in $) adjusted to Worcester MSA’s Housing Price Index for year 2008</td>
</tr>
<tr>
<td>Time of Sale</td>
<td></td>
</tr>
<tr>
<td>Sl_2005</td>
<td>Homes sold in 2005 (Binary -0,1)</td>
</tr>
<tr>
<td>Sl_2006</td>
<td>Homes sold in 2006 (Binary -0,1)</td>
</tr>
<tr>
<td>Sl_2007</td>
<td>Homes sold in 2007 (Binary -0,1)</td>
</tr>
<tr>
<td>Sl_2008</td>
<td>Homes sold in 2008 (Binary -0,1)</td>
</tr>
<tr>
<td>Structural</td>
<td></td>
</tr>
<tr>
<td>Bath</td>
<td>No. of Bathrooms</td>
</tr>
<tr>
<td>Qual</td>
<td>Assessor assigned home quality index (20 to 60)</td>
</tr>
<tr>
<td>AgeSq</td>
<td>Age of Home - Squared</td>
</tr>
<tr>
<td>Log_LotSf</td>
<td>Lot area (Sq ft) - Log transformed</td>
</tr>
<tr>
<td>Log_TULA</td>
<td>Total Utilizable Area (Sq ft)-Built area (Sq ft)- Log transformed</td>
</tr>
<tr>
<td>Pool</td>
<td>Pool Available / Not Available (Binary – No=0, Yes=1)</td>
</tr>
<tr>
<td>Garage</td>
<td>Garage Available / Not Available (Binary – No=0, Yes=1)</td>
</tr>
<tr>
<td>Neighborhood</td>
<td></td>
</tr>
<tr>
<td>Hsg_Den</td>
<td>Housing Density in the neighborhood-(No. of Houses/ Acre) H001001</td>
</tr>
<tr>
<td>MdHsg_Val</td>
<td>Median Housing Value ($) of owner occupied houses H085001</td>
</tr>
<tr>
<td>Perc_Blac</td>
<td>Percentage of Afro-Americans P006003</td>
</tr>
<tr>
<td>Environmental</td>
<td>5 Nos. of Externality Capturing Variables</td>
</tr>
<tr>
<td>Tot_ViewAr</td>
<td>Total View area of (All CEs combined) expressed in number of visible cells -10’x10’ from home</td>
</tr>
<tr>
<td>DistCESq</td>
<td>squared Euclidean distance from the nearest CE/CR property (in ft ) = 1/sq ft from home</td>
</tr>
<tr>
<td>Nr_ViewArea</td>
<td>View area of the nearest CE property expressed in number of visible cells -10’x10’ from home</td>
</tr>
<tr>
<td>MinDistSq</td>
<td>Squared Euclidean distance of the nearest visible CE property (in ft)</td>
</tr>
<tr>
<td>Cevi_2</td>
<td>CEVI Index - (ViewArea / Sq m)</td>
</tr>
<tr>
<td>Tot_ViewAr</td>
<td>Total View area of (All CEs combined) expressed in number of visible cells -10’x10’ from home</td>
</tr>
<tr>
<td>DistCESq</td>
<td>squared Euclidean distance from the nearest CE/CR property (in ft ) = 1/sq ft from home</td>
</tr>
<tr>
<td>Nr_ViewArea</td>
<td>View area of the nearest CE property expressed in number of visible cells -10’x10’ from home</td>
</tr>
</tbody>
</table>
Chapter 7.  Model Development

This chapter presents the models that were developed to quantify the economic benefits that conservation easement-protected properties externalize on surrounding homes. In this chapter, first a descriptive summary of the data and variables is presented, and later the functional form of the conceptual model is presented. Finally, two hedonic price models (HPM) were prepared using the Statistical Package for Social Scientists (SPSS version15.0). The first model is called the Conservation Easement Model and includes the five environmental externality-capturing explanatory variables as developed in the previous chapter. This first model has the explanatory variables that include spatial variables to find the relationship between CE parcels and homes. The second model is called Control Model and includes all but the five externality variables. Both the models are ordinary-least-square (OLS) regression models.

7.1. Model Preparation and Descriptive Summary

Table 7.1 presents a descriptive summary of the data used in the HPM. All homes were SFH and were bought and sold from 2005 through 2008. All the homes were located within the 0.5 mile buffer distance from the CE-protected property parcels. The table shows that the sample size was $n=1,238$ homes, and the average price of homes was $174,253$, with a standard deviation of $56,411$ (Price $M = 174,253$, $SD = 56,411$).
As part of the model preparation, first all of the outlier home sale records were checked. These outliers included those homes with either a very high sale price or a very low sale price. These outliers also included homes with extreme characteristic features, such as very large lots, very large built-up areas, or size. These outliers in the data set could also be results of mistakes in the data recording and thus were eliminated. Finally, the home samples that were within two standard deviations (SD–2) of the mean value were included in the final data set of \( n = 1\,238 \).\(^{231}\)

After adjusting the sale prices for year 2008, using the house price index (HPI) of Worcester MSA as explained in chapter 6, the sale prices were then plotted to see the normality in the data as shown in the figure 7.1 above. The above histogram shows that the sample home prices were normally distributed. The next step was selection of variables.

A scatter plot matrix was prepared to visually detect relationships between the variables as shown in the figure on the next page. After plotting various structural, neighborhood, and externality-capturing variables, and after plotting the home attributes as independent variables, \(^{231}\)In the SPSS version 15, a feature exists that allows the researcher to refine the data samples based on the defined range of standard deviations and to remove the outlier records.
the final variables were chosen. Some variables were transformed\textsuperscript{232} and were used with the quadratic or log transformation. For example, the lot size was log transformed due to the diminishing utility effect associated with the size of a lot. Similarly, for variables such as home age and distance from CE, the variables were quadratically transformed and were used as a squared term. This transformation accommodates the potential premium price for old historic homes and similarly, it accommodates for the distance where home values rapidly fall with the increasing distance from the amenity. Some homes in my sample were as old as 166 years (see Descriptive Table). The three variables--Age, Total Utilizable Area (TULA), and the LogSqft, along with their transformed forms and overall distribution--are shown in the scatter plot matrix plot in figure 7.2.

Further, based on the literature, to control for the structural features of homes in my data sample, to maintain parsimony, and to avoid multi-collinearity, certain home features were selected. These included the number of baths, quality of the house, transformed age of the house represented as Age Squared, Log transformed home lot, Square foot area represented as Log\textunderscore LotSf, Log transformed TULA (Total utilizable area of the home represented as Log\textunderscore TULA), and binary variables for the availability of swimming pools and garages. In addition to this, to control for the neighborhood effect on home prices, I used three census block group variables. These were housing density represented by number of houses per acre, median housing value of owner-occupied houses, and percentage of Afro-Americans. Table 7.1 presents the summary descriptions of these variables.

\textsuperscript{232} This transformation was performed based on a theoretical empirical relationship of the independent variables and the dependent variable of home prices.
Figure 7.2 Scatter plot Matrix showing relationship between variables and Home Values

Scatterplot Matrix for the variables used
Table 7.1 Descriptive statistics of home samples ($n=1,238$) within 0.5 mile from CE-protected parcels ($n=45$).

<table>
<thead>
<tr>
<th>Variables</th>
<th>Units and explanation of variables</th>
<th>N</th>
<th>Min</th>
<th>Max</th>
<th>Mean</th>
<th>Std. Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>HPI_Sales</strong></td>
<td>Home Sale Price in $ - Adjusted to HPI</td>
<td>1238</td>
<td>13,939</td>
<td>675,000</td>
<td>174,253</td>
<td>56,411</td>
</tr>
<tr>
<td><strong>Time of Sale</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SL_2005</td>
<td>Homes sold in 2005 (Binary -0,1)</td>
<td>1238</td>
<td>0</td>
<td>1</td>
<td>.31</td>
<td>.464</td>
</tr>
<tr>
<td>SL_2006</td>
<td>Homes sold in 2006 (Binary -0,1)</td>
<td>1238</td>
<td>0</td>
<td>1</td>
<td>.26</td>
<td>.440</td>
</tr>
<tr>
<td>SL_2007</td>
<td>Homes sold in 2007 (Binary -0,1)</td>
<td>1238</td>
<td>0</td>
<td>1</td>
<td>.26</td>
<td>.439</td>
</tr>
<tr>
<td>SL_2008</td>
<td>Homes sold in 2008 (Binary -0,1)</td>
<td>1238</td>
<td>0</td>
<td>1</td>
<td>.16</td>
<td>.371</td>
</tr>
<tr>
<td><strong>Structural</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bath</td>
<td>No. of Bathrooms</td>
<td>1238</td>
<td>1</td>
<td>6</td>
<td>1.30</td>
<td>.54</td>
</tr>
<tr>
<td>Qual</td>
<td>Assessor assigned home quality index (20 to 60)</td>
<td>1238</td>
<td>20</td>
<td>60</td>
<td>40.34</td>
<td>3.08</td>
</tr>
<tr>
<td>Time</td>
<td>Age</td>
<td>1238</td>
<td>0</td>
<td>166</td>
<td>.31</td>
<td>32.79</td>
</tr>
<tr>
<td></td>
<td>Age of Home Squared (Year²)</td>
<td>1238</td>
<td>0.00</td>
<td>27,556.00</td>
<td>4,436.13</td>
<td>4,026.91</td>
</tr>
<tr>
<td>Log_LotSf</td>
<td>Lot area (Sqft) - Log transformed</td>
<td>1238</td>
<td>7.11</td>
<td>12.35</td>
<td>9.06</td>
<td>.52</td>
</tr>
<tr>
<td>LotSft</td>
<td>Lot area (Sqft)</td>
<td>1238</td>
<td>1227</td>
<td>23,1198</td>
<td>10,172.05</td>
<td>9,357.58</td>
</tr>
<tr>
<td>Log_TULA</td>
<td>Total Utilizable Area Built Area (Sqft)- - Log transformed</td>
<td>1238</td>
<td>6.10</td>
<td>8.93</td>
<td>7.19</td>
<td>.33178</td>
</tr>
<tr>
<td>TULA</td>
<td>Total Utilizable Built Area (Sqft)</td>
<td>1238</td>
<td>448</td>
<td>7548</td>
<td>1407.73</td>
<td>574.635</td>
</tr>
<tr>
<td>Pool</td>
<td>Pool Available / Not (Binary – No=0, Yes=1)</td>
<td>1238</td>
<td>0</td>
<td>1</td>
<td>.02</td>
<td>.14</td>
</tr>
<tr>
<td>Garage</td>
<td>Garage Available / Not (Binary – No=0, Yes=1)</td>
<td>1238</td>
<td>0</td>
<td>1</td>
<td>.16</td>
<td>.36</td>
</tr>
<tr>
<td><strong>Neighborhood</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hsg_Den</td>
<td>Housing Density in the neighborhood-(No. of Houses/ Acre in census block group)</td>
<td>1238</td>
<td>0.11</td>
<td>13.24</td>
<td>3.07</td>
<td>2.48</td>
</tr>
<tr>
<td>MdHsg_Val</td>
<td>Median Housing Value ($) of owner occupied houses in census block group</td>
<td>1238</td>
<td>71,700</td>
<td>261,500</td>
<td>121,894.35</td>
<td>25,053.14</td>
</tr>
<tr>
<td>Perc_Blac</td>
<td>Percentage of Afro-Americans in census block group</td>
<td>1238</td>
<td>0.00</td>
<td>34.84</td>
<td>4.59</td>
<td>5.04</td>
</tr>
<tr>
<td><strong>Environmental</strong></td>
<td>Sum of total Viewable area of (All CE parcels)</td>
<td>1238</td>
<td>0.00</td>
<td>853,700.00</td>
<td>86,712.76</td>
<td>129,262.33</td>
</tr>
<tr>
<td>Metric</td>
<td>Description</td>
<td>N</td>
<td>Mean</td>
<td>SE</td>
<td>CI</td>
<td>Source: City of Worcester and calculations made using the GIS tool.</td>
</tr>
<tr>
<td>--------------</td>
<td>------------------------------------------------------------------------------</td>
<td>----</td>
<td>----------</td>
<td>--------</td>
<td>----------</td>
<td>----------------------------------------------------------------------</td>
</tr>
<tr>
<td>DistCESq</td>
<td>Squared distance from the nearest CE property (in sq ft) from home</td>
<td>1238</td>
<td>561,456.48</td>
<td>180,391.17</td>
<td>170,662.28</td>
<td></td>
</tr>
<tr>
<td>Nr_ViewArea</td>
<td>Viewable area of the nearest CE parcel expressed in number of visible cells -10’x10’ from home</td>
<td>1238</td>
<td>438,100.00</td>
<td>30,028.76</td>
<td>59,983.75</td>
<td></td>
</tr>
<tr>
<td>MinDistSq</td>
<td>Squared distance of the nearest Visible CE parcel (in sq ft)</td>
<td>1238</td>
<td>144,000,000.00</td>
<td>38,923,887.93</td>
<td>60,067,510.55</td>
<td></td>
</tr>
<tr>
<td>Cevi_2</td>
<td>CEVI Index - (weighted summation of Viewable area / distance in Sq ft) for CE parcels from homes</td>
<td>1238</td>
<td>926.00</td>
<td>3.98</td>
<td>35.63</td>
<td></td>
</tr>
<tr>
<td>Valid N (list wise)</td>
<td></td>
<td>1238</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The Model Specification

Any model is a mathematical abstraction of reality, and it is selected on the basis of simplicity and credibility. In this HPM, I have used a linear form of regression in my model specification. All parameters were entered in the equation linearly after transforming required variables as discussed in the earlier section. The general form of the model is linear and is also presented in a visual form conceptually:

$$Y_i = \beta_0 + \beta_i(\text{Structural})_i + \beta_i(\text{Neighborhood})_i + \beta_i(\text{Externality})_i + \epsilon_i$$

Figure 7.3 Conceptual Explanations of Home Values

The final model was specified as

$$\text{HPI Sales} = \text{sl}_2005 + \text{sl}_2006 + \text{sl}_2007 + \text{sl}_2008$$

$$+ \text{bath} + \text{qual} + \text{agesq} + \log_{10}(\text{lots})^2 + \log_{10}(\text{TULA}) + \text{pool} + \text{garage}$$

$$+ \text{hsg\_den} + \text{md\_hsg\_val} + \text{prc\_black}$$

$$+ \text{Tot\_ViewAr} + \text{DistCESq} + \text{Nr\_ViewArea} + \text{MinDistSq} + \text{Cevi\_2} + \epsilon_i$$

Where dependent variable $Y_i =$HPI Sales (Sale price adjusted to house price index)

and independent variables $X_i =$sl$_{2005}$, sl$_{2006}$, sl$_{2007}$, sl$_{2008}$, bath, qual, agesq,

---

234 The lot area, and TULA were log-transformed, and age and distance variables were in quadratic squared form.
The Model Results

This section presents the analysis of the two models that were developed. The first model is called the Conservation Easement Model and includes the five environmental externality-capturing explanatory variables, which includes spatial variables as developed in chapter 6. The second model is called the Control-Model and did not include the externality variables. Both the models were OLS-based regression models.

7.3.1. Analysis and Discussion of the Conservation Easement Model

This model is named the Conservation Easement Model. The summary of this model is presented in table 7.2, and the beta coefficients of various independent variables are presented in table 7.3. This model includes $n=1,238$ home samples with the sale price $M = $174,253, $SD = $56,411. These were all single-family platted homes, and spatially these homes were located within a 0.5 mile distance from the 45 conservation easement-protected property parcels. This buffer distance is important for both viewing and proximity reasons. For homeowners to be able to receive a hedonic pleasure of proximity and view, conservation easement parcels within a one-half mile distance of homes are reasonable. With the distance growing farther than this distance, the view quality will deteriorate, and the hedonism will be negatively affected. This is even

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235Henderson and Song, “Nearby Open Spaces” (2008): 147-165. Using spatial lag and spatial error models, and using interaction variables of private yard areas with open space variables, this study concluded that proximity to open spaces creates home values, but the size of home lot yards matters more. Homes with smaller yards have more value than homes with larger lots. See,

236 Platted SFH were used to control for the price variation across land-use typology within the residential use category.

237 Home samples were chosen from a large pool of sales using the 0.5 mile buffer distance criteria from the CE parcels. This decision was made for the walking distance, to control for view quality, and to control for many other value-influencing factors elsewhere in the city. In addition, the buffer also acts as conservation easement home submarkets.

more important, if view is toward a polygon object such as a patch of open space or a
conservation easement-property parcel. This distance is not so significant for expansive scenic
panoramas such as distant mountains or oceanfront views. The distance is not so critical as such
views are expansive views.

The aim of this model was to capture the externality effects of CE or economic benefits
of CE as capitalized in surrounding home values. The control variables were the same as
mentioned earlier and included physical home characteristics, neighborhood characteristics, and
year of the sale. The model was linear in nature, and the variables were in their pure form and in
their squared or log-transformed form.

The appropriate interpretation of a regression outcome can reveal the findings from these
models. In a regression model output, the R-square somewhat overestimates the success of the
model when applied to the real world, so an adjusted R-square\textsuperscript{239} value is used, which takes into
account the number of variables in the model and the number of observations (participants) our
model is based on. This adjusted R-square value gives the most useful measure of the success of
our model.

The model summary is presented in table 7.2 on the next page. As evident from this table,
the variables used in the Conservation Easement Model had 60.7 percent explanatory power to
predict home prices in Worcester as observed from their market sale prices. The model summary
is $R^2 = 60.7$, $F(1, 219) = 106.49$, $p < .001$. The Durbin-Watson statistic\textsuperscript{240} is 1.9, which means
that there is no autocorrelation in the data samples used in the modeling.

\textsuperscript{239} Adjusted R-squared is a standard, arbitrary downward adjustment to penalize for the possibility that with many independents, some of the variance may be due to chance. In the case of more independent variables, the adjustment penalty will be greater.

\textsuperscript{240} The Durbin-Watson statistic tests for serial correlation of error terms for adjacent cases.
Table 7.2: Summary of Model Conservation Easement

<table>
<thead>
<tr>
<th>Model</th>
<th>R</th>
<th>R Square</th>
<th>Adjusted R Square</th>
<th>Std. Error of the Estimate</th>
<th>Change Statistics</th>
<th>Durbin-Watson</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>.782(a)</td>
<td>.611</td>
<td><strong>.607</strong></td>
<td>35430.889</td>
<td>.611</td>
<td>106.49</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

a Predictors: (Constant), Cevi_2, MdHsg_Val, Pool, Sl_2006, AgeSq, MinDistSq, Log_LotSf, Sl_2008, DistCESq, Nr_ViewArea, Bath, Garage, Perc_Blac, Qual, Hsg_Den, Sl_2007, Tot_ViewAr, Log_TULA

b Dependent Variable: HPI_Sales

Table 7.3 provides the beta weights, $t$ values, and the significance levels of variables in the model, including the VIF. In table 7.3, the variation inflation factor (VIF) for all the variables used in the model is $<1.6$, which means that the model is stable, and there is a total absence of multi-collinearity among the variables. This also means that all the variables are independently contributing to the model prediction. VIF is simply the reciprocal of tolerance. Therefore, when VIF is high, there is high multi-collinearity and instability of the $b$ and beta coefficients. When tolerance is close to zero, there is high multi-collinearity of that variable; other independents and the $b$ and beta coefficients will be unstable. In the model, given the VIF values, there is no multi-collinerality.

Table 7.3 provides the $t$ statistics, which test the significance of each beta coefficient for each variable. It is possible to have a regression model that is determined to be significant overall by the $F$ test, but where a particular coefficient is not significant. Closer examination of this table shows that barring the pool variable, all other variables that signify physical features of homes were highly significant—statistically within $p <0.01$—and have the right sign as expected. Similarly, the three neighborhood variables were also found highly significant within $p <0.04$ and have the right signs as expected.

There were five conservation easement externality-capturing variables that were used in this model and were of the greatest interest for this research. These were Tot_ViewAr, the sum
of viewable areas of all CE parcels combined, expressed in number of ten-foot-by-ten-foot cells visible from homes; DistCESq, squared Euclidean distance of homes from the nearest CE property (in square feet); Nr_ViewArea, viewable area of the nearest CE parcel expressed in number of cells visible from homes; MinDistSq, squared Euclidean distance of the nearest visible CE parcel (in square feet); and the Cevi_2, the CEVI Index, a weighted summation of inverse distance: Viewable Area / Square Feet.

Of the five explanatory variables, four were found to be statistically insignificant within \( p < 0.05 \), which means that those variables do not contribute any value to the model. In other words, this means that these four variables have no role in creating home price. The fifth variable, CEVI, which is the interaction term of visibility and distance (CEVI_2) was found to be statistically significant within alpha = 0.03 (97 percent) \( p < 0.03 \) and has a positive sign, which means that this variable has a role in creating value for homes. The positive sign of the beta means that with the increase in the value of this variable, the value of the home prices will increase. This interaction effect variable--CEVI_2 variable--has the beta coefficient of Beta = 64.18, \( t(2.23) \) and \( p < .03 \). It signifies the importance of both the distance to CE parcels from homes and the visibility of CE parcels from homes together. Similarly, this also means that among the home samples chosen for the study, even though a home is abutting the CE parcel (highest level of proximity) or is just a short distance (for example, ten feet) away, if a home has zero visibility of CE parcels, the price effect on homes will be zero.

The Conservation Easement Visibility Index value for CEVI_2 for average home samples is \( CEVI_2 M = 3.98, SD = 35.63 \). For the samples, the CEVI index value ranges from 0 to 926. The beta coefficient of CEVI_2 of 64.18 means that by increasing the index value by one unit, the average home value will increase by $64.18, holding all other variables constant. This also
means that for at least one home that has the highest CEVI index value of 926, in my sample of
\( n = 1,238 \) homes, the home price will increase by \$64.18 \times 926 = \$59,430. The other four externality variables were found insignificant, signifying that independently proximity (distance) does not matter, and independently viewability also does not matter. The output for the rest of the four variables were Tot_ViewAr Beta=0.001, \( t(1.14) \), and \( p < .89 \). Tot_ViewAr is insignificant. Similarly, another view variable called Nr_ViewArea is also found insignificant with \( Beta = -.019, t(-.98) \) and \( p < .33 \). This variable was intended to measure the viewable area of the nearest conservation easement parcel from homes. The insignificance of these two view variables could be explained by the fact that just viewing scenic properties is not a sufficient condition for a premium price for homes, as the scenic properties could be far away from home samples.

The proximity variable of DistCESq is insignificant, with \( Beta = 0.008, t(1.31) \) and \( p < .19 \). One other proximity variable was MinDistSq, which measures the minimum distance from which a conservation easement parcel is visible. The MinDistSq was also found insignificant, with \( Beta = -4.68E-022, t(-.22) \), and \( p < .83 \). This can be explained in two ways: first, consider a case where home samples are abutting conservation easement parcels, but the homes have a total visual disconnect with the scenic conservation easement parcels. Alternatively, if homes have low accessibility to the abutting scenic parcels, the proximity of conservation easement parcels has a very low value for homeowners. The second explanation, which is more relevant for the MinDistSq variable because the view to conservation easement parcels exists, is the potential lack of knowledge and lack of recognition of the presence of conservation easements among the homeowners.
The high significance p<.03 of the interaction CEVI variable suggests that combining the two independent variables of viewability and proximity is more relevant. The findings of this model are important, as they partially answer one research question: As revealed in the capitalized home prices, how many externality benefits do the conservation easement protected-properties externalize on their surroundings, due to homes’ proximity to and visibility of conservation easement parcels?
Table 7.3 OLS Output Showing Significance and Coefficients of Variable used in Model Conservation Easement with 5 Externality Variables (DistCESq; Tot_ViewAr; Nr_ViewArea; MinDistSq; and CEVI with Lambda=2) - with n=1,238 Homes within 0.5 mile from CE Parcels transacted from 2005 through 2008

<table>
<thead>
<tr>
<th>Model</th>
<th>Unstandardized Coefficients</th>
<th>Standardized Coefficients</th>
<th>t</th>
<th>Sig.</th>
<th>95% Confidence Interval for B</th>
<th>Correlations</th>
<th>Collinearity Statistics</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>B</td>
<td>Std. Error</td>
<td>Beta</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>(Constant) *</td>
<td>-623833.145</td>
<td>30824.098</td>
<td></td>
<td>20.238</td>
<td>-684307.311</td>
<td>-563358.978</td>
</tr>
<tr>
<td></td>
<td>SI_2006*</td>
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<td>2681.107</td>
<td>-.060</td>
<td>-2.879</td>
<td>-12980.105</td>
<td>-2459.914</td>
</tr>
<tr>
<td></td>
<td>SI_2007*</td>
<td>-11923.263</td>
<td>2696.756</td>
<td>-.093</td>
<td>-4.421</td>
<td>-17214.061</td>
<td>-6632.465</td>
</tr>
<tr>
<td></td>
<td>SI_2008*</td>
<td>24723.812</td>
<td>3089.346</td>
<td>.163</td>
<td>8.003</td>
<td>18662.786</td>
<td>30784.837</td>
</tr>
<tr>
<td></td>
<td>Bath*</td>
<td>18042.607</td>
<td>2336.454</td>
<td>.172</td>
<td>7.722</td>
<td>13458.690</td>
<td>22626.525</td>
</tr>
<tr>
<td></td>
<td>AgeSq*</td>
<td>-1.699</td>
<td>.295</td>
<td>-.121</td>
<td>-5.753</td>
<td>-2.278</td>
<td>-1.120</td>
</tr>
<tr>
<td></td>
<td>Log_LotSf*</td>
<td>5026.370</td>
<td>407.154</td>
<td>.275</td>
<td>12.345</td>
<td>4227.570</td>
<td>5825.170</td>
</tr>
<tr>
<td></td>
<td>Pool</td>
<td>18687.121</td>
<td>2125.414</td>
<td>.173</td>
<td>8.792</td>
<td>14517.245</td>
<td>22856.996</td>
</tr>
<tr>
<td></td>
<td>Garage*</td>
<td>54800.677</td>
<td>4224.143</td>
<td>.322</td>
<td>12.973</td>
<td>46513.280</td>
<td>63088.074</td>
</tr>
<tr>
<td></td>
<td>Hsg_Den*</td>
<td>8807.526</td>
<td>3015.139</td>
<td>.057</td>
<td>2.921</td>
<td>2892.089</td>
<td>14722.962</td>
</tr>
<tr>
<td></td>
<td>MdHsg_Val*</td>
<td>-982.989</td>
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<td>19957.266</td>
</tr>
<tr>
<td></td>
<td>Perc_Blac*</td>
<td>5202.460</td>
<td>7520.626</td>
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<td>-2.045</td>
<td>-1926.173</td>
<td>-39.805</td>
</tr>
<tr>
<td></td>
<td>Tot_ViewAr</td>
<td>54800.677</td>
<td>4224.143</td>
<td>.322</td>
<td>12.973</td>
<td>46513.280</td>
<td>63088.074</td>
</tr>
<tr>
<td></td>
<td>DistCESq</td>
<td>-1.699</td>
<td>.295</td>
<td>-.121</td>
<td>-5.753</td>
<td>-2.278</td>
<td>-1.120</td>
</tr>
<tr>
<td></td>
<td>Nr_ViewArea</td>
<td>-11923.263</td>
<td>2696.756</td>
<td>-.093</td>
<td>-4.421</td>
<td>-17214.061</td>
<td>-6632.465</td>
</tr>
<tr>
<td></td>
<td>MinDistSq</td>
<td>24723.812</td>
<td>3089.346</td>
<td>.163</td>
<td>8.003</td>
<td>18662.786</td>
<td>30784.837</td>
</tr>
<tr>
<td></td>
<td>Cevi_2*</td>
<td>18042.607</td>
<td>2336.454</td>
<td>.172</td>
<td>7.722</td>
<td>13458.690</td>
<td>22626.525</td>
</tr>
</tbody>
</table>

a Dependent Variable: HPI_Sale, n= 1238, df=18;

*significant at $p < .05$
### 7.3.2. Analysis and Discussion of Model 2: Control MODEL

The Control Model used the same 1,244 home sample dataset as used in the earlier model (Price $M = $174,253, SD = $56,411). The model summary is presented in table 7.4 on the next page.

As evident from this table, the variables used in the Conservation Easement Model had 60.3 percent explanatory power to predict home prices in Worcester as observed from their market sales price. The model summary is $R^2 = 60.3$, $F(1, 224) = 146.75, p < .001$. The Dublin-Watson statistic\(^{241}\) is 1.9, which means that there is no autocorrelation in the data samples used in the modeling.

#### Table 7.4 Summary of Control Model

<table>
<thead>
<tr>
<th>Model</th>
<th>R</th>
<th>R Square</th>
<th>Adjusted R Square</th>
<th>Std. Error of the Estimate</th>
<th>Change Statistics</th>
<th>Durbin-Watson</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>.780(a)</td>
<td>.609</td>
<td><strong>.603</strong></td>
<td>35453.602</td>
<td>R Square Change: .609</td>
<td>F Change: 146.75</td>
</tr>
</tbody>
</table>

a Predictors: (Constant), Perc_Blac, Sl_2006, Bath, Pool, Garage, Log_LotSf, Sl_2008, AgeSq, MdHsg_Val, Hsg_Den, Qual, Sl_2007, Log_TULA

b Dependent Variable: HPI_Sales

Table 7.5 provides beta weights, $t$ values, and the significance levels of variables in the model, including the VIF. Barring the pool variable, all variables that signify physical features of homes are statistically significant within $p < 0.01$ and have the right sign as expected. Similarly, the three neighborhood variables are significant within $p < 0.04$ and have the right signs as expected. In table 7.5, the variation inflation factor (VIF) for all the variables used in the model is <1.6, which means that the model is stable, and there is a total absence of multi-collinearity among the variables.

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\(^{241}\) The Durbin-Watson statistic tests for serial correlation of error terms for adjacent cases.
7.4. Conclusion for this research from the two Models

The comparison of the above two models suggests that by introducing five externality-capturing variables, the predictability of the Conservation Easement Model, although improved as compared to the control model, shows an almost insignificant improvement. The model improvement is a mere 0.4 percent, from 60.3 percent to 60.7 percent. This fractional improvement in the model provides the following insights on what we can infer from this research.

On average, homeowners within the half-mile mile radius of the conservation easement parcels in Worcester are indifferent about their location preference in relationship with the conservation easement parcels. The only value contributes to the home prices are due to the fifth variable, which is CEVI index, while the other four variables do not contribute to the home price. The average homes in Worcester have a low CEVI index of 3.98 as shown in the Descriptive summary table. With such low average value of the CEVI index, the home value creation is only a fraction of the average value.

We can also infer that on average, homeowners are either unaware or ignorant of the presence of conservation easement parcels that may be present near their homes, or they do not seek any hedonic value in living in close proximity to these conservation easement parcels. This is, however, not true for all of the home samples.

A closer examination of the descriptive summary of home samples and of the beta coefficients of the conservation-easement model also reveals some interesting facts. It can be inferred that a few homeowners are aware of the perpetual nature of land preservation and of the passive form of scenic and recreation amenity that conservation easement parcels offer. The
knowledge about the existence of externality generating amenity such as Conservation Easement

the amenity-seeking groups of homeowners’ and the new home buyers are attracted to such
locations and bid premium to buy this amenity. Such homeowners seek high value in
conservation easement parcels and pay premium price for homes that are not only in proximity
but also have a view of these scenic parcels to enjoy the hedonic pleasure of such amenity.

These amenity-seekers own the homes in the sample dataset that had a high CEVI index
value. The maximum CEVI value was 926 among the sample of $n=1,238$ home owners. These
homeowners do pay a premium to have greater visibility and closer proximity. This premium

can be computed as Beta coefficient x maximum value of CEVI index, which is equivalent to

$59,430 \ ($64.18 \times 926\)$. Considering the average sample with price $M = \$174,253$, $SD =

$56,411$, the highest premium for the highest CEVI index value home sample is equivalent to 34
percent of the mean home price, which is significant.
Table 7.5 OLS Output Showing Significance and Coefficients of Variable used in Control model without the environmental variables: with \(n=1,238\) homes within 0.5 mile distance from CE parcels bought and sold from 2005 through 2008.

<table>
<thead>
<tr>
<th>Model</th>
<th>Unstandardized Coefficients</th>
<th>Standardized Coefficients</th>
<th>t</th>
<th>Sig.</th>
<th>95% Confidence Interval for B</th>
<th>Correlations</th>
<th>Collinearity Statistics</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>(Constant) *</td>
<td>-624578.163</td>
<td>30656.189</td>
<td>-20.374</td>
<td>.000</td>
<td>-684722.663</td>
<td>-564433.662</td>
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<tr>
<td>Sl_2006*</td>
<td>-7718.179</td>
<td>2677.516</td>
<td>-.060</td>
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<td>.004</td>
<td>-12971.208</td>
<td>-2465.150</td>
</tr>
<tr>
<td>Sl_2007*</td>
<td>-11787.255</td>
<td>2695.060</td>
<td>-.092</td>
<td>-4.374</td>
<td>.000</td>
<td>-17074.704</td>
<td>-6499.807</td>
</tr>
<tr>
<td>Sl_2008*</td>
<td>24486.339</td>
<td>3083.527</td>
<td>.161</td>
<td>7.941</td>
<td>.000</td>
<td>18436.755</td>
<td>30535.924</td>
</tr>
<tr>
<td>Bath*</td>
<td>17922.754</td>
<td>2334.393</td>
<td>.171</td>
<td>7.678</td>
<td>.000</td>
<td>13342.899</td>
<td>22502.609</td>
</tr>
<tr>
<td>Qual*</td>
<td>5029.480</td>
<td>405.851</td>
<td>.275</td>
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<td>.000</td>
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<td>5825.721</td>
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<td>AgeSq*</td>
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<td>.293</td>
<td>-.123</td>
<td>-5.850</td>
<td>.000</td>
<td>-2.292</td>
<td>-1.141</td>
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<tr>
<td>Log_Lot<em>Sf</em></td>
<td>18853.525</td>
<td>2114.087</td>
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<td>8.790</td>
<td>.000</td>
<td>14435.890</td>
<td>22731.159</td>
</tr>
<tr>
<td>Log_TULA*</td>
<td>55196.080</td>
<td>4205.434</td>
<td>.325</td>
<td>13.125</td>
<td>.000</td>
<td>46945.422</td>
<td>63446.737</td>
</tr>
<tr>
<td>Pool*</td>
<td>4707.840</td>
<td>7505.089</td>
<td>.011</td>
<td>.627</td>
<td>.531</td>
<td>-10016.423</td>
<td>19432.104</td>
</tr>
<tr>
<td>Garage*</td>
<td>9175.647</td>
<td>3006.035</td>
<td>.059</td>
<td>3.052</td>
<td>.002</td>
<td>3278.096</td>
<td>15073.199</td>
</tr>
<tr>
<td>Hsg_Den*</td>
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<td>-.041</td>
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<td>.049</td>
<td>-1845.701</td>
<td>-2.595</td>
</tr>
<tr>
<td>MdHsg_Val*</td>
<td>.162</td>
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<td>.072</td>
<td>3.470</td>
<td>.001</td>
<td>.070</td>
<td>.254</td>
</tr>
<tr>
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<td>-.048</td>
<td>-2.431</td>
<td>.015</td>
<td>-964.919</td>
<td>-103.027</td>
</tr>
</tbody>
</table>

* Dependent Variable: HPI_Sales, \(n=1238\), \(df=13\)

*a significant at \(p < .05\)
Chapter 8. Conclusions

This is the concluding chapter of my dissertation and once again restates my original research question and how it was addressed. The chapter presents the final research findings and the contribution of this research. Additionally, there are several lessons that have been learned in the process of this research, which have been presented at the end of the chapter. These could be taken up as future research issues.

8.1. The Research Findings

This research was designed to find out if there is a relationship between the home prices and nearby conservation-easement properties. Further, it was intended to measure the economic benefits of conservation easement programs on neighboring property prices. The answer to the above question is yes, there is a relationship, although marginal, and there is an effect on home values if the visibility and proximity both are addressed at the same time. The model shows that for a unit increase in the CEVI index, the sample home value increases by $64.18. On average, there is an increase in home values of $255 for the sample homes located within one-half mile of the 45 CE parcels.

The other question that this research was aimed to answer was, “Do conservation-easement parcels create value for the community by increasing property values and sale prices--and thus the tax base for the community--if homes are in close proximity to the CE parcels?” As the research findings reveal, conservation easement parcels definitely do not mar the home values near them; rather, on average, they create a marginal value increase. Now, do conservation easement parcels create value for homes if they have greater visibility of these scenic CE parcels? The answer to this is yes and no. Just the visibility is not an adequate
condition for home-value creation. Similarly, just the proximity is not an adequate condition for home-value creation. This is because CE parcels may be visible but may be too far from homes, and so homeowners do not receive enough enjoyment to pay premium prices. Similarly, CE parcels may be too close but not be visible from nearby homes. This visibility component is important, as several CE parcels do have limited or no public access. The two visibility and proximity measures alone were not statistically significant. This means that independently these measures do not create value for homes.

However, when both the measures were combined into the CEVI, the effect of externality was statistically significant, which means that for homeowners, it is their ability of being closer and being able to view from the comfort of their homes that creates the amenity’s value. This value creation for homes is as low as null for some homes that have zero visibility but as high as $59,430 because of the CE parcel. This is a 34 percent appreciation of average home values.

For homeowners, a home that is just distance $d$ away from a greater number of protected properties, $N$, is likely to be perceived as having higher visual accessibility than another identical home, which is at a similar distance of $d$ but from a smaller number of protected properties, $n$. This is because although average distance is the same, the numerator term on the index $N$ is greater than $n$ ($N > n$). This value increase is due to the “amenity magnet” effect that greater ($N$) protected properties externalize on homes, holding all other variables constant.

8.2. The Research Contributions
This research offers two direct contributions--first, it has land-use policy implications, and second, the CEVI and visibility methodology has applications in the real-estate industry. The

\[ \text{CEVI} = \frac{\text{visible area}}{N} \]

If the numerator is zero, CEVI is zero.
third contribution is an indirect one and is largely theory-based: it provides guidance to the regional-planning professionals.

8.2.1. Implications on Land Policy
The ability to place an economic value on ecosystems is central to formulating sound environmental policies.\(^ {243} \) When considering environmentally sensitive properties, sound land-use policies need to be able to quantify the value of preserving green space, including assessing appropriate tax credits to keep the protected property undeveloped, measuring the impact of conservation easements on surrounding property and home values, and quantifying public dollars needed to preserve and manage the land.

The Conservation Easement Model presented in the previous chapter demonstrates a potential 34 percent increase in the mean home values for homes with the highest CEVI index value of 926. The average increase in home values will be approximately $64.18 \times \text{Mean CEVI Index value (3.98)} = $255.44, which is a minuscule 0.15 percent of the mean home price. This finding is interesting to both the conservation agencies, such as land trusts, and to the public policy-makers, such as local land-use authorities, because appreciation in surrounding home values increases the tax base, which in turn encourages land-use agencies to promote land conservation.

From the two models, it was clear that the perpetual nature of conservation and its passive form of recreation activities and visual quality of CE parcels result in an amenity effect, which homeowners experience by living near CE-protected properties of which they have a view. Based on higher home prices for homes with a higher CEVI index, it was clear that residents place a greater economic value on those homes that are closest to quieter, everlasting

\(^{243}\) Krupnick and Siikamaki, “How People Value,”, 2007 PAGE.
landscapes and from where they can enjoy the scenic view of these conservation-easement parcels.

8.2.2. **Application in the Real Estate Industry**
The methodology used in this research is a useful contribution for application in the real estate industry. The externality-capturing variables—especially visibility—with automated quantification of visibility using the Viewshed GIS are a useful contribution to appraisers.

This tool is also very useful for mass rapid appraisal of properties. In the past, to add hedonic value associated with a view amenity would require traditional qualitative assessments made by visiting each home in order to determine “*ability-to-view*” or to assess the quality of the view. This process is prohibitively time-consuming and expensive. The GIS-based 3-D technology, therefore, is a very useful tool because it automates quantification of views. Once automated views are computed, the output just requires validation on site. Therefore, a smaller-sized sample of homes can be used to validate the View output as generated by the GIS. This automation saves time and resources for view estimation, which is otherwise a very labor and capital intensive activity if measured using the traditional physical on-site inspection of homes.

This research also offers visibility measurement as a useful tool, especially in the early stage of any property-development or property-investment decision-making. This can be understood through a case where a scenic resource exists and a developer wants to plan a new real estate project—for example, building hotels and resorts near Niagara Falls. Using the viewability tool and CEVI index, the developer or the real estate investor can estimate potential views from their site. Based on this, the developer could also provide input to the design and planning team so that the design team can plan rooms with full views to the falls—rooms
available for a premium price. All of this can be done long before the actual design and construction stages of the project.

Using this research, a view-attribute value can be captured and assigned for any properties that are near any environmental resource. Similar to contribution from the quantification-of-view variable, the CEVI index is a new measure in the environmental-externality research literature. No research has used this index that captures both the view and distance together in a single variable. CEVI provides both a new theoretical contribution—being able to see while being closer—and methodological contribution—combining the effect of two important environmental-capturing variables, view and distance together—to the environmental-externality research.

8.2.3. Guiding Regional Planning
This research provides some insights a) for the need for regional cooperation as the externality effects or land-protection benefits reach beyond the city limits, while the tax burdens are more local to the city, and b) on how to spatially target CEs so that the public benefit could be increased and even the tax base could be increased, based on the understanding from CEVI.

From the ex post analysis of this dissertation and also from the earlier research reviews, it is clear that the externality benefits of environmental resource such as CE-protected properties are spread to its surroundings—specifically, to its immediate surroundings, where the CE sites offer greater visibility and are closer in proximity. Also the externality effects are in all the directions. If a CE parcel is on the periphery of a local

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244 Ex-post analysis is a check of what actually happened, and ex-ante analysis is a prediction of what will happen.
jurisdiction—for example, the Cascade East conservation-easement land parcel, Worcester is located along the northern boundary of Worcester. The ex ante analysis in Worcester for this CE parcel would show that the environmental benefits as accrued from this Cascade East would benefit not only the Worcester residents, but also the city that is abutting it, the one north of Worcester. The land-protection benefits reach beyond the city limits, while the tax burdens are more local to the city. Since local residents typically support part of the CE public costs, it is only the city residents who have foregone the benefits of future development and the property taxes from the CE parcel. In a situation like this there is a need for regional cooperation in order to share not only the benefits but also the costs.

Regarding spatial targeting of CE parcels, this research provides some direction based on the CEVI index in relation to present homes and CE parcels. The CEVI index for each home is in a gravity formula form, which has a viewable area of CE in its numerator and distance squared to CE in its denominator. A higher value of the CEVI index means either the numerator is very large or the denominator is very small. A large numerator means greater viewability of a CE, and a smaller distance means closer proximity to the resource. Since a higher CEVI value from homes creates value for those homes, in terms of spatial targeting, when conservation planners prioritize the land preservation of a scenic site with limited public access, they should ensure that the scenic resources should have greater visibility to the public. Although spatial targeting is practically difficult in the case of voluntary land protection, whenever there is a chance, targeting should be done to those properties that provide a view to a large number of private homes or properties.
8.3. Research Limitations

There are a few limitations to this research. From the methodological standpoint, this research has employed the hedonic method. The method is based on several assumptions, such as that in the sales of homes, the market is in perfect competition, and the actors are fully informed. It also assumes that the home buyers have similar choice preferences and that the characteristics of each home sample are similar to one another, which is an obvious simplification of reality.

The research has identified only the visible size of the conservation easement parcels as the varying characteristics. It has assumed that all the parcels have similar scenic values and that the quality of the view will only vary by viewable area. It has ignored the individual features of the conservation-easement parcels, which may have different scenic values.

The research has considered home samples around the 45 conservation-easement parcels and assumed that these conservation-easement parcels and their half-mile buffer areas will serve as local submarkets for homes. It was assumed that there would be no other home-value-influencing variable that is present in any of these submarkets.

While creating the viewsheds to measure the viewable areas of the conservation-easement parcels from homes, viewsheds were created from the centroid of homes, which means that homes were assumed as points. Further, it was assumed that a viewer would be looking from an average human height from the ground. Another limitation is a house is a polygon, with windows on its sides, and a home sample may have multiple floors. This research precludes viewable areas from any other point of the house in all the three x, y and z directions.

Last, the estimated marginal values investigated with the Conservation Easement Model do not capture all of the potential values associated with land protection. For example, the model does not include the value that non-property owners may ascribe to private land protection,
including the values held by visitors to some of those protected properties. In addition, the economic benefits estimated do not include any nonuse values associated with land protection, for example, the role that land protection plays in protecting groundwater, wildlife habitat, and natural places.

8.4. Future Research (Planning implications of Conservation Easement)

There are several questions that emerge from this research and require deeper investigation. This research introduces several topics that could be of interest to a planner but that require further investigation:

The measurement of the viewable area and the development of the CEVI index as an amenity-capturing variable are important. More importantly, the variable-development methodology is highly beneficial in the real estate industry. The view variable can be easily measured for any real estate property using methodology employed in this research. In the future, the tool itself can be developed as a plug-in for ArcGIS. Further, augmented reality systems where one plugs in just the location (latitude and longitude) of homes and the z-value of the viewer should be able to quickly generate viewsheds.

It would be interesting to apply VonThuunen’s bid-rent theory to measure the economic benefits of land conservation and open spaces. If protected properties are the highest amenity marketplace, would the amenity buyer bid higher to be closer in proximity and be able to view and participate in the amenity at the convenience of the buyer’s home?

CE has been advocated as a tool that curbs sprawl, so it would be interesting to research the effect of land conservation on the size of the city. Is there any relationship between protecting land and how much sprawl it generates? Another important research area is how to
automate the valuation of conservation-easement properties. In addition to these, based on my understanding of the topic and review of land protection literature, several questions emerge that need to be investigated in greater detail—I discuss these in the following subsections.

8.4.1. Potential Need for cooperation to promote Conservation Easements in the regional context

Policies to conserve land may have little impact overall on the nation’s balance of available open lands, but they can make a profound difference in the quality of life at the margin—that is, to the people who are living in the urban areas or on its fringe areas, like the interface between urban and rural lands.

Ex-ante analysis is a prediction of what will happen, and ex-post is a check of what actually happened. These help to give an idea of future movements in price or the future impact of a newly implemented policy.245 From the Ex post analysis of this dissertation and also from earlier research reviews, it is clear that the economic benefits of conservation-easement protected properties are spread to its surrounding properties and specifically to its immediate surroundings with visibility. Now, if any CE land parcel is on the periphery of a local jurisdiction—for example, the Cascade East conservation-easement land parcel is located along the northern boundary of Worcester--, the environmental benefits as accrued from this land protection would help not only the city of Worcester but also the city that is abutting it to the north. So, the ex-ante analysis would show that land protection benefits reach beyond the city limits, while the tax burdens are more local to the city of Worcester. This is because it is the City of Worcester and its residents who have funded part of the CE and have foregone the benefits of future development.

245 Freeman, Measurement, 14.
and the property taxes from the protected land. In a situation like this, there is a need for regional cooperation in order to share not only the benefits but also the costs.

8.4.2. Potential Need for advancing knowledge of Conservation Easement as tool for land protection to Urban & Regional Planners

The conservation biologists, property-rights professionals, and natural resource and appraiser’s-science scholars have made scholarly contributions to the land-conservation literature. As usage of conservation easements as a land-protection tool becomes more frequent, planning schools should introduce training on conservation easement in their land-use class curricula. A survey by Anthony and Forkenbrock of the US planning schools in 2006 regarding their land use and land policies course curricula revealed that schools paid greater attention to traditional land use zoning and controls. Similarly, Merill and Lapping’s survey found a major scope for improving the quality and quantity of teaching on conservation easement. This is especially important, considering the growing popularity of this land-protection tool that the local authorities are using more frequently than before.

8.4.3. Potentially, Land Owners’ Income has Implications on the success of Conservation Easements

If financial benefit is the sole purpose of owning conservation-worthy property, then the landowners with the largest potential tax benefits will be much more likely to donate easements, while those with low incomes and small estates will see very little financial benefit from making an equivalent donation, especially in states with no assured property tax relief.

249 Sundberg and Dye, “Tax and Property.”
8.4.4. Landowner’s choice seems to have Spatial Implications on Conservation Easements

Owing to the tax benefits associated with CE—especially in the form of tax credits and not a stream of income—from the landowners’ perspective, two things are important here which could also affect the geography and the size of property under CE land protection. Sundberg and Dye\textsuperscript{250} argue that if land size is small and landowners do not have high income, there are fewer incentives for the landowners to participate in land protection. Brewer also argued that the “landowners appear to be much more willing to donate easements on larger parcels, rather than donating the parcels themselves.”\textsuperscript{251} This potentially is because landowners’ financial obligations in terms of property taxes are higher for a large parcel. In addition to this, there is also a component of diminishing marginal utility from excessive land and diseconomies associated in the management of large pieces of land.

8.4.5. Will there be an economic incentive for a land rich, but cash poor land owner to protect land under conservation easements?

If the donated value of the development rights on a land parcel is disproportionately greater than the landowners’ annual income, such owners will have limited economic incentive in land conservation. Sundberg and Dye\textsuperscript{252} present a discussion on the available tax incentives for CE land owners and present a Present Value (PV) based methodology to estimate the total tax benefits. Going by the land owner’s expected annual income and the compensation of value loss in conservation easement via tax benefit, it can also be concluded that there is a relationship between how much a person earns and how much that person would be willing to participate in the conservation-easement program.

\textsuperscript{250} Ibid. Assesses all available tax incentives and requirements needed to meet federal standards for CE, provides a model of relevant tax incentives, and examines the dollar benefits created by CE under different sets of assumptions.

\textsuperscript{251} Brewer, Conservancy, 153-154.

\textsuperscript{252} Sundberg and Dye, “Tax and Property,”
For example: Assume that a land owner’s adjusted gross income (AGI) for tax

calculation = $I=$100,000

And % of AGI or, rate at which deduction is allowed = r = 35%

So his tax liability (straight line) = $V=$200,000

If owners donate development rights on CE parcel = $V=rIx

And if $V > (rxI), then the tax benefits will flow in a multi-year period. According to

the revised laws, it can be for a maximum of 15 years.

So, in the first year equivalent of $(rxI), the tax benefit will be used, and the remaining

($V – $rxI) will be left for the next year’s calculation. This cycle will continue until the full

value of $V is received in terms of tax benefits to the land owner.

Now, the key issue here is that this tax credit process assumes that the land owner will

have a taxable income and hence taxes. But what if there is a land-rich but cash-poor landowner?

Will there be an incentive for such land owners to protect all the land?

Now assume that if the value of the donated development rights V is divided over 15

years as an annuity, then each year’s approximate tax benefits = V/15 (Annuity)

= 200,000/15

= $13,333 (This will be taken out from the taxes)

Assuming income is constant, the tax deduction schedule for each year will be as follows:

1\textsuperscript{st} year, federal tax benefit = V/15

2\textsuperscript{nd} year, federal tax benefit = V/15

3\textsuperscript{rd}………………….. =…..

15\textsuperscript{th} year, federal tax benefit = V/15
The maximum tax benefit that a landowner could expect will be the present value of a 15-year annuity assuming that the discount rate for a 10-year treasury rate\textsuperscript{253} = 3.46% 

\[
\text{PV (Tax Benefit)} = \frac{V}{15} \times \left[ 1 - \frac{1}{(1.0346)^{15}} \right] / .0346 \\
= $153,999.4 \\
+ \text{PV of state income tax deductions or credits} \\
+ \text{PV of property tax savings}
\]

So, in a situation like the above, economically rational landowners either will use their tax credits in the early years to receive the full value of $V$, or will donate only part of the land instead of the entire property, especially if the donated value is disproportionate to the income, following the annuity methodology.

\textbf{8.4.6. Potentially Conservation easement can prevent undesirable growth, but does it contribute to the sprawl?}

Malpezzi\textsuperscript{254} and Knaap and Nelson\textsuperscript{255} presented that how the stricter land-use restrictions and limited availability of developable land creates artificial scarcity of buildable land and drives up the price of homes. Quigley and Rosenthal\textsuperscript{256} reiterate the same: when local regulators effectively withdraw land from its buildable supplies—whether through zoning, growth management, or any other regulation—the land factor and the finished real estate products can become pricier. In the case of CE parcels, since protected parcels are put out of developable use through the development restrictions, either the land values will go up (since land supply is restricted), or the future development will jump beyond the restricted area and increase the


\textsuperscript{254} Malpezzi, “Urban Regulation,” 323-349.

\textsuperscript{255} Knaap and Nelson, \textit{Regulated Landscape},”

horizontal spread of the city. This was also presented in Platinga’s theoretical model, where a city expands by exactly the same size as the conservation easement-protected land to replace the loss of developable land; the public utilities and service networks also expand. The property taxes will also fall if the area under conservation easement is too large. Further, spatially, people will live farther away from the city centers as the presence of conservation- easement parcels means lost development opportunities in that area. The presence of conservation easements in a city increases land rents within the city.

William Whyte’s seminal work, *The Last Landscape*, suggests that like urban growth boundaries, conservation easements could be used to prevent undesirable urban development pressure and contain growth. Whyte also suggests a plethora of options to curb sprawl, which includes conservation easements, along with the traditional use of police powers, outright purchases, taxing policies, greenbelts, physiographic studies and cluster development, design of play areas and small spaces, and scenic roadway design.

It would be interesting to see what will prevail. Will the CE parcels contribute to the sprawl by jumping the new growth beyond its location? Or, will the CE parcels contain the sprawl by offering high amenity value, which the amenity-seekers will potentially result into higher density development as most homeowners would be interested in living near the CE parcels.

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Consider a hypothetical case of a city with a closed system—that is, with fixed, rigid city boundaries, but that is experiencing population growth, and has conservation-easement parcels in the city area. There could be several scenarios that may result:

- The conservation-easement parcels will be under pressure for development. If growth succeeds the preservation, conservation-easement parcels will be destroyed, and growth will replace the protected properties.
- If conservation-easement parcels are protected, the land values will increase in the city area as more people bid for the fixed amount of developable land.
- If the available lots in the city are fixed in size—indivisible—more people will share the same land lot (land sharing).
- Crowding will occur, resulting in high population density.
- If the available lots are divisible, it may result in a greater number of smaller lots, and a greater number of individually occupied end-user plots.

Now, consider this same city, but with an open system— flexible city boundaries and experiencing population growth, but with conservation-easement parcels. The implications will be the following:

- The land values will not be affected as people can go beyond the boundary.
- There will be no crowding.
- Divisibility and indivisibility of lots will have no effect on the lot density or on the population density.

On the contrary, if the city is an open system, which means it has boundaries that could be stretched, the urban growth that is competing to locate in; the protected area lots would eventually relocate somewhere else. This means the same development potential equivalent of growth would jump outside the city to the next best location. So, at the city level, the sprawl or undesirable growth near the protected properties is checked, but at a regional level, conservation easement does not curb sprawl. In fact, it actually gives rise to the sprawl.
8.4.7. Several factors seem to be responsible for the spatial pattern (Geography) of Conservation easement

Limited budgets and dynamic land markets impose constraints on conservation agencies. Acquisition of conservation-worthy land occurs in a sequence of events, depending on the availability of funds and of sites.

Do conservation easement-protected land parcels follow any geographical pattern in a city or in a region? The original legislation placed a geographical restriction on parcels qualifying for the 2031(c) benefit by requiring that they be near urban areas or specific categories of natural areas, such as national parks. The 2001 legislation removed that requirement, so that location is no longer a criterion in determining eligibility for the benefit.²⁶⁰ Typically, the geographical patterns CEs follow are the pattern of environmental features. McDonald et al.²⁶¹ highlighted that the conserved land follows a spatially clustered pattern over space. The geography of contemporary conservation actions is influenced by the past decisions.

To understand this, first we need to know how land is chosen for the conservation purpose, as its geography is determined by whether or not those land selection features are available. Brewer²⁶² provided nine rules for the land trusts in choosing land for protection. These rules are preserve landscapes or representative natural ecosystems, plan and protect high-quality sites,²⁶³ preserve intact functioning ecosystems, preserve the largest areas possible, add land around preserves, save some small preserves, construct corridors or linear connections (if

²⁶⁰ Sundberg and Dye, “Tax and Property,” (2006) PAGE. Assesses all available tax incentives and requirements needed to meet federal standards for CE, provides a model of relevant tax incentives, and examines the dollar benefits created by CE under sets of assumptions.
²⁶³ This does not mean that the low-quality, degraded sites should be rejected, as such types of sites do require restoration and could be conserved and returned back with a greater public use.
easy), save land with rare, threatened and endangered species, and prioritize land based on constraints.

Leigh and Fairfax argue that usually easement deals are constructed to meet the specific financial and real-estate needs of the donor or seller. Conserved land thus comes under protection only because it is available to a land trust, not necessarily because it is an appropriate parcel to conserve. The landowner, rather than the trust, drives the process. This could thus affect the geographical pattern of land conservation. And in urban areas especially, the prevailing price of land for conservation, underlying zoning and alternative land-use conversion possibilities, landowners’ incomes, and their ability to receive the highest and best tax benefit from the land determine the successfullness of conservation.

Further, as the possibility that CEs will materialize is purely dependent on the mutual agreement between the property owners (their willingness to protect) and the land trusts (their ability to maintain, manage, conserve, and provide the required support to the working land and to conserve the protected feature), not all the properties that are worth preserving could be conserved through CE. This results in a mosaic of land lots--some conserved, some not--and this mosaic may include some conserved through conservation easement, while the other lots could be conserved using a different technique, such as acquisition, TDR, or bargain sale.

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References


Aspen Valley Land Trust. ND. Conservation Easement Appraisal Considerations


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Appendix A

Comparison of land conservation techniques - Conservation Easements (CE), Purchase of Development Rights (PDR), Transfer of Development Rights (TDR), Special Zoning, and Fee simple purchase from John Wright (1994)

**TABLE 1. Comparison of major techniques**

<table>
<thead>
<tr>
<th>Conservation Easements</th>
<th>PDRs</th>
<th>TDRs</th>
<th>Special Zoning Districts</th>
<th>Fee Simple Purchases</th>
</tr>
</thead>
<tbody>
<tr>
<td>Permanent: partial legal interest; only rights necessary to protect conservation values are acquired.</td>
<td>Same as easements</td>
<td>Permanent: only rights necessary to protect conservation values are transferred.</td>
<td>Temporary: laws, regulations, land use planning goals, politics change.</td>
<td>Permanent: full interest, all rights acquired.</td>
</tr>
<tr>
<td>Compensation: potential tax benefits; many landowners do not gain substantially.</td>
<td>Compensation: direct cash payment</td>
<td>Compensation: direct cash payment for each development right transferred</td>
<td>No direct economic compensation; landowners may resist regulation.</td>
<td>Compensation: direct buyout; landowners may not willingly sell.</td>
</tr>
<tr>
<td>Land stays on tax rolls.</td>
<td>Land stays on tax rolls.</td>
<td>Land stays on tax rolls.</td>
<td>Land is removed from tax rolls.</td>
<td>Expensive local acquisition costs: 100% of fee simple value</td>
</tr>
<tr>
<td>Inexpensive local acquisition costs; federal tax incentives</td>
<td>Moderate local acquisition costs can be 30–70% of free simple value.</td>
<td>High administrative costs; cumbersome, yet marketplace funds system</td>
<td>Administrative costs only; fees and taxes fund system, routine planning function.</td>
<td></td>
</tr>
<tr>
<td>Low management costs</td>
<td>Low management costs</td>
<td>Moderate management costs</td>
<td>Low management costs</td>
<td>High management costs</td>
</tr>
<tr>
<td>Potentially high enforcement costs</td>
<td>Potentially high enforcement costs</td>
<td>Potentially high enforcement costs</td>
<td>Low to moderate enforcement costs</td>
<td>Low enforcement costs</td>
</tr>
<tr>
<td>No liability exposure</td>
<td>No liability exposure</td>
<td>No liability exposure</td>
<td>No liability exposure</td>
<td>Significant liability exposure; public use insurance is needed</td>
</tr>
<tr>
<td>Encouraged by stewardship; financial incentives are important but not the driving rationale.</td>
<td>Economic compensation is very important; stewardship secondary.</td>
<td>Economic compensation is very important; stewardship secondary.</td>
<td>General public interest is served; may be compatible with stewardship.</td>
<td>Private stewardship is eliminated.</td>
</tr>
<tr>
<td>Record: 1,000,000 acres; unknown amount of tax incentives used.</td>
<td>Record: 205,000 acres in 9 state programs; costing $400 million; approximately 1.5 million acres under federal and other programs; cost unknown.</td>
<td>Record: 36,000 acres; cost unknown.</td>
<td>Record: acreage and cost unknown.</td>
<td>Record: millions of acres bought by all levels of government and by private conservation groups; cost unknown.</td>
</tr>
</tbody>
</table>
Appendix B

Methods to Value Economic Benefits

1. Contingent Valuation Method – A Stated Preference Method

The Contingent Valuation Method (CVM)\textsuperscript{265} is a survey-based approach or stated-preference method, where surveys are conducted to learn how much respondents are willing to pay (WTP) for protected environmental amenities. For example, a paper by Krupnick and Siikamäki\textsuperscript{266} describes contingent valuation methods that involve developing and administering surveys in which respondents are presented with specific environmental outcomes and are asked how much they are willing to pay for each. The role of surveyors is critical in stated-preference approaches, as the survey design can influence responses. For example, how participants respond can become more valid if important information relevant to the issues at hand is shared during the survey. (Boyd and Krupnick\textsuperscript{267})

Christy Mathews\textsuperscript{268} highlights the limitations of these contingent-valuation methods, including the unreliability of survey responses as well as the fact that survey respondents do not need to bear the consequences of their answers. Their responses do not represent a commitment to spend actual dollars for the real purchase of an environmental amenity. Also, participants may have little incentive to reveal their true value for the natural resource; they might not be able to gauge how they feel, and there is no way to check the validity of their responses.

Choice Experiment or Conjoint Studies

Choice experiments or conjoint studies provide a tool to estimate how respondents trade off environmental benefits, costs, and other relevant variables. By varying the levels of key attributes across different scenarios and examining respondents’ choices, conjoint analysis provides a tool to estimate how much people are willing to pay for different environmental outcomes. Survey respondents identify their preferences among one or more programs or alternative management strategies, specifically altering different attributes of the program, such as different environmental outcomes and varying monetary costs.

Humans are rational economic agents, When it comes to paying for a good or a service, the price they are willing to pay for environmental amenities is calculated in this analysis by utility scores which can be translated into valuations.

Hedonic Price Method – A Revealed Preference Method

A house is a bundle of structural features (e.g., number of bedrooms and bathrooms, square footage), lot size, neighborhood amenities, and environmental and other community attributes. Unlike the two preference methods above, hedonic price models express the price of a

\textsuperscript{265} Khristy E. Mathews, “Under the Microscope: Dissection of a Contingent Valuation Survey,” The Appraisal Journal 76, no. 3 (Summer 2008): 259-269. This study highlights limitations of contingent-valuation method as being survey based. The respondents, in reality, have no commitment of real dollars on their WTP input. Further, respondents’ responses are not comparable, as they might have different, unspoken assumptions that might affect their responses.
\textsuperscript{266} Krupnick and Siikamäki, “How People Value,” 14-16.
\textsuperscript{267} Boyd and Krupnick, “Definition and Choice,” 1-64.
\textsuperscript{268} Ibid., 159-160.
product as a function of its characteristics or attributes. This takes a market-based approach and assumes there are willing sellers and buyers who interact and engage in market transactions. Real property comes with a bundle of rights, which includes the right to own, occupy, lease, mortgage, access, develop, transfer, and to bequeath\textsuperscript{269}. Single-family homes (SFHs) are metaphorically equivalent to a basket of goods with different home attributes, each having potentially different utility-generating capabilities.

In hedonic pricing models, revealed preference is derived using actual sales prices as the predictor variable and running regression models to quantify how home and environmental attributes contribute to market sales price. The resulting coefficients allow us to attach dollar values to each attribute that contributes to a home’s sale price, including the role of open spaces and other amenities. Hedonic price models have proved particularly useful for estimating the value of non-market environmental amenities, such as parks and open space, as well as dis-amenities, such as air pollution, noise, and proximity to noxious facilities such as landfills\textsuperscript{270}.

Most studies examining the value of environmental amenities have used such hedonic-estimation techniques to measure direct benefits or environmental externalities’ impact on, for example, surrounding house prices. Some reviews of the study findings are available through Boyle and Kiel, McConell and Walls, and Sirmans et al.\textsuperscript{271} These market-based studies rely on information obtained from real-world market transactions. As such, they are preferred over survey-based methods, as they often reflect the outcome of the negotiation process, where willing buyers and sellers interact in the marketplace.

**Travel Cost Method**

To infer the value of the site, the travel-cost method\textsuperscript{272} uses observations of individuals’ out-of-pocket travel expenditures and time costs to get to a recreation site. The value of the amenity is assumed to be higher than the time and travel cost that the amenity-seeker spent to experience it. Travel cost methodology is not very frequently used, except when estimating the value of a destination amenity that attracts visitors from a distance.

**Cost of Community Services Method**

In this valuation strategy, the focus is mostly to measure a property’s non-use value. The Cost of Community Services methods (COCs) first estimate the public service costs imposed by new developments (e.g., roads, sewers, schools, etc.) and assume that the avoidance of these costs is a benefit provided by open space.\textsuperscript{273} Crompton\textsuperscript{274} presented a meta-analysis of 70 COCs and discussed the five-stage methodology:

\textsuperscript{269} Appraisal Institute, *Appraisal of Real Estate*, 69.
\textsuperscript{270} McConnell and Walls, “Value of Open Space,”
\textsuperscript{271} Ibid. Reviewed over 60 studies, of which over 40 were hedonic-based.
\textsuperscript{273} Sirman\textsuperscript{s et al.}, “Composition of Hedonic Pricing Models,” 3–43. This study summarized, reviewed, and synthesized over 125 hedonic-modeling studies, looking into different variables that the studies have commonly used.
\textsuperscript{274} Sirman\textsuperscript{s et al.}, “The Value of Housing Characteristics,” 215–240. In this 2006 study, they conducted meta-regression analysis. In meta-regression, the regression coefficient of various published studies becomes the dependent variable, and the coefficient from each study becomes observation from the 125 studies, using the B weights (coefficients) and R-squared data from the findings of the past studies in Sirmans et al. (2005)
\textsuperscript{272} Ibid.
1) **Identify all service categories** (e.g., provision and maintenance of roads, sewers, water, sanitation, schools, etc.), and allocate municipal budgets for each category, e.g., water or sanitation in residential, commercial, and other land-use categories.

2) **Allocate total municipal expenditures** to the selected land uses in the city, giving specific definitions to land uses and grouping different types of open spaces into one single category of open space.

3) **Categorize municipal revenue** by sources such as inflows from property taxes, income tax, sales tax, and state or federal funds.

4) **Allocate municipal revenues** to the land-use categories.

5) **Compare revenue to expenditures** for each land-use category.

---

Crompton, “Programs That Work,” 133-154. John Crompton conducted 70 COCS case studies—fiscal-impact studies of land uses, focusing on parks and open space, and studies of residential land uses. Explaining the five-stage process involved in the cost of community services (COCS), Crompton concluded that the public cost of servicing residential land uses (education, public safety, public works, water, sanitation, roads) is higher than the expected revenue from the property taxes. The study concluded that the expenditure-to-revenue ratio of open-space land use is 0.3, while for the residential land use, it is 1.15.
Appendix C

Urban Green Spaces – A Typology

Amenity Green Space

1.1 Recreation Green Space
   1.1.1 Parks and gardens
   1.1.2 Informal recreation areas
   1.1.3 Outdoor sports areas Play areas

1.2 Incidental Green Space
   1.2.1 Housing green space
   1.2.2 Other Incidental Space

1.3 Private Green Space
   1.3.1 Domestic gardens

Functional Green Space

2.1 Productive Green Space
   2.1.1 Remnant farmland
   2.1.2 City farms
   2.1.3 Allotments

2.2 Burial Grounds
   2.2.1 Cemeteries
   2.2.2 Churchyards

2.3 Institutional Grounds
   2.3.1 School grounds (including school
   2.3.2 Farms and growing areas)
   2.3.3 Other institutional grounds

Semi-natural habitats

3.1 Wetland
   3.1.1 Open/running water
   3.1.2 Marsh, fen

3.2 Woodland
   3.2.1 Coniferous woodland
   3.2.2 Deciduous woodland
   3.2.3 Mixed woodland

3.3 Other Habitats
   3.3.1 Moor/heath
   3.3.2 Grassland
   3.3.3 Disturbed ground

Linear Green Space

4.0.1 River and canal banks
4.0.2 Transport corridors (road, rail, bikeways and walking routes)
4.0.4 Other linear features (e.g. cliffs)

Federal Income Tax Deduction Limitations for Individuals


The tax code allows individuals a tax deduction for contributions to charitable organizations that are tax-exempt under section 501(c)(3). In general, the donor is entitled to deduct the fair-market value of property donated to a 501(c)(3) organization. However, the amount the donor can deduct is limited to a set percentage of the donor’s adjusted gross income (AGI), that is, the donor’s taxable income before claiming itemized deductions like mortgage interest or charitable contributions. If the donor gives property rather than cash, the applicable limitation is generally 30 percent of his AGI for that year. If the value of the charitable contribution is greater than 30 percent of AGI, then the donor can carry the deduction forward and claim the excess amount as a deduction against future income for five years.

The low percentage limits and short carry-forward period have frustrated conservation-minded landowners. Frequently, the conservation interest a private landowner wants to give is worth many times what he could ever deduct under the 30 percent AGI limit, even over five years. To help remedy this problem, Congress enacted more generous limits for conservation easements. For easements donated by December 31, 2009, landowners can deduct the value of the easement—up to 50 percent of their AGI, instead of only 30 percent of AGI. Moreover, the new rules are even more favorable for farmers and ranchers, who often own very valuable land but have relatively little income. Now, qualified farmers and ranchers who donate a conservation easement before the end of 2009 can deduct up to 100 percent of their taxable income.

Lawmakers also increased the length of time landowners have to use excess deductions that exceed even these more generous percentage limitations. For easements made in 2007, easement donations that exceed the allowable annual limits can be applied against future taxable income for the next fifteen years, rather than the five years allowed under the rules that apply to other kinds of charitable contributions.

Summary of benefits available to landowners who donate conservation easements:

- Landowners can deduct up to 50 percent of their adjusted gross income in any year (up from 30 percent);
- Landowners can deduct up to 100 percent of their adjusted gross income if the majority of that income came from farming, ranching, or forestry; and
- Landowners can continue to carry over unused portions of deductions for as long as 15 years (up from 5 years) after the initial year in which the deduction was claimed.

### Appendix E

Landscape Pattern Indices from Geogheghan et al. (1997)

<table>
<thead>
<tr>
<th>Index</th>
<th>Equation</th>
<th>Description</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diversity&lt;sup&gt;a&lt;/sup&gt;</td>
<td>[ H = - \sum_k (P_k \ln(P_k)) ] where ( P_k ) = proportion of landscape in cover type ( k )</td>
<td>Complexity of landscape measured as the average uncertainty of a given state</td>
<td>Measures extent to which landscape is dominated by a few or many landuses</td>
</tr>
<tr>
<td>Edge to interior ratio (fragmentation)</td>
<td>[ R = \sum_i \frac{P_i}{A_i} ] where ( P = ) perimeter length, ( A = ) area of interior, ( i = ) land cover type</td>
<td>A reflection of patch size and shape</td>
<td>Measures potential loss of function of landuse due to decreased size or loss of interior</td>
</tr>
<tr>
<td>Fractal dimension&lt;sup&gt;b&lt;/sup&gt;</td>
<td>[ L = k x (1 - D) ] where ( L = ) boundary length, ( s = ) cell length or resolution of measurement, ( D = ) fractal dimension, ( k = ) estimated parameter</td>
<td>Degree that edges are convoluted vs. straight and uniform between landuse types</td>
<td>Measures extent of human change on the landscape</td>
</tr>
<tr>
<td>Edge length between landuses&lt;sup&gt;c&lt;/sup&gt;</td>
<td>[ E_{i,j} = \sum_i e_{i,j} ] where ( e_{i,j} = ) no. of interfaces between cells of types ( i ) and ( j ), ( L = ) length of edge of cell</td>
<td>Similar to contagion but more specific to interactions between particular landuses</td>
<td>Can be used to assess flowpaths for overland movement of materials</td>
</tr>
<tr>
<td>Contagion&lt;sup&gt;d&lt;/sup&gt;</td>
<td>[ C = 2s \log 2 + \sum_m \sum_{i,j} q_{i,j} \log(q_{i,j}) ] where ( q_{i,j} = ) probability of landuse ( i ) being adjacent to landuse ( j ), ( s = ) no. of observed landuses</td>
<td>Degree to which landscape is divided into many small patches vs. a few large patches</td>
<td>Measures increased risk that organisms will not be able to access needed resources</td>
</tr>
<tr>
<td>Lacunarity&lt;sup&gt;e&lt;/sup&gt;</td>
<td>[ \lambda(r) = \frac{\sum S^2(Q(S, r))}{\sum</td>
<td>S^2(Q(S, r))</td>
<td>^2} ] where ( Q(S, r) = ) probability distribution of occupied sites from generated map, ( S = ) no. of occupied sites in window, ( r = ) length of window</td>
</tr>
</tbody>
</table>

<sup>a</sup> Turner (1990).
<sup>b</sup> O'Neil et al. (1988).
<sup>c</sup> Hunsaker and Levine (1995).
<sup>d</sup> Turner (1989).
<sup>e</sup> Plotnick et al. (1993).