

# Economic Valuation of Natural Resource Amenities: A Hedonic Analysis of Hillsdale and Oakland Counties

Report #2007-09

LAND POLICY  
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*Shaping the Future from the Ground Up*





**ECONOMIC VALUATION OF NATURAL  
RESOURCE AMENITIES:  
A HEDONIC ANALYSIS OF HILLSDALE AND OAKLAND COUNTIES**

*Report #3*  
**Series on Economic Impact and Valuation Studies  
In Natural Resources and Conservation**

**Hannah Professor Research Program  
Land Policy Institute  
Michigan State University**



**LAND POLICY  
I N S T I T U T E**

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Heart of the Lakes Center for Land Conservation Policy**

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# **Economic Valuation of Natural Resource Amenities: A Hedonic Analysis of Hillsdale and Oakland Counties**

## **Executive Summary**

This study focuses on valuation of “green infrastructure” in Michigan. Green infrastructure provides numerous services to the public, including quality of life benefits, increasing the attractiveness of locations for growth, and influencing the value of properties and hence local tax collections. To understand the value of green infrastructure in Michigan, two case study counties are selected – Hillsdale and Oakland counties. In Hillsdale County, the value of water amenities are considered; and in Oakland County, the amenity values of waterways, water-bodies, recreational lands, and walkable and bikeable green infrastructure such as trails, side walks, bike lanes, and park path—are considered.

To materialize the goal of green infrastructure valuation, property sales transactions data from both counties were collected. Additional spatial data on the location of green infrastructure were also collected and analyzed. By developing a hedonic pricing model, the influence of each considered green infrastructure on property values were isolated and estimated.

Results indicate that, consistently, across the two counties and across green infrastructure types, these assets contribute positively and significantly to property values. Specifically:

- In the case of water amenities in Hillsdale County, results indicate that, on average, properties located within 15 meters, 16 to 75 meters and 76 to 150 meters from identified water amenities have 81.8 percent, 38.5 percent and 22.9 percent more value, respectively, compared to similar properties located at distances more than 150 meters from water amenities.
- In the case of water amenity in Oakland County, the results suggest that properties within 15 meters of water-bodies have a substantial capitalization of these amenities into property values, compared with properties located at more than 150 meters. The average “green-capitalization” attributable to water-bodies within 15 meters is \$55,082.
- In the case of recreational lands in Oakland County, results suggest that recreational areas have significant impact on property values, ranging in impact from 3.1 percent capitalization for properties within 15 meters, to 3.2 percent gain for properties within 15 to 75 meters, 2.2 percent gain for properties within 75 to 150 meters and a 2.6 percent capitalization for properties within 150 to 300 meters, compared to properties located at more than 450 meters.
- In the case of walkability and bikeability enabling green infrastructure in Oakland County, results indicate that the effect of these green infrastructure on



property values were significant. Existence of these composite green assets within 100 to 500 meters appreciates property values by 4.6 percent, or \$11,785; within 500 to 1000 meters results in “green-capitalization” of 2.3 percent; and within 1000 to 1500 meters results in a gain of 6.3 percent, or \$16,140, compared to properties located at more than 1500 meters away from these outdoor opportunities.

Obviously, based on the analysis of green infrastructure valuation in Hillsdale and Oakland counties, people are “voting with their feet” and “voting with their wallets.” That is people are willing to pay a higher premium for locations with high quality green infrastructure. This is vital information for local officials, as they can pursue green infrastructure strategies that are sustainable and add to the bottom-line. Local officials are somewhat supportive of green assets, but this study suggests that they should be more supportive for an economic reason, as it enhances ratables.

Green infrastructure investment also has broader implications. In the New Economy, talent and innovation are sources of new local and regional economic growth. Talent tends to migrate to places with significant green infrastructure. Jobs tend to follow people, who follow green quality infrastructure. If this is true, then the findings of this study suggest that green assets enhancement meets sustainability and enhances the economy simultaneously. As part of a long-term strategy, green infrastructure (shown to have significant economic value) can be leveraged to enhance local economic viability and sustainability at the same time.

# **Economic Valuation of Natural Resource Amenities: A Hedonic Analysis of Hillsdale and Oakland Counties**

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## 1.0 Introduction

“Green infrastructure”<sup>1</sup> is increasingly becoming important attributes, providing numerous quality of life and economic benefits to society. Green infrastructure services from public lands, water bodies, forested lands, wetlands, and other forms of open space were important drivers of recent trends in population density and wealth creation across regions of the U.S. (Mieszowski and Mills 1993, Burchell and Shad 1998, Heimlich and Anderson 2001). Increasingly, the location preference of new businesses and residents has partly been tied to location amenity endowments and natural and environmental services. The economic effects of high quality natural and environmental amenities (green infrastructure services) have encouraged many to suggest intensified green infrastructure as a potent economic growth strategy.

High quality natural and environmental amenities have also attracted increased housing density change and commercial development, which have resulted in the conversion of high natural amenities and land resources to development (Klein and Reganold 1997, Daniels 1991). As a result, a number of states have initiated some form of natural resource and land conservation initiatives to manage the increasing pressure on natural and environmental resources (Nickerson and Hellerstein 2003). These initiatives illustrate the importance of utilizing natural and environmental services and proper conservation and protection requirements.

Michigan is endowed with a multitude of natural resources, some of which are among the most distinct and abundant in the nation. These resources add to the quality of life and economic vitality of many of the counties in the state. Michigan has 3,288 miles of Great Lakes shoreline, 38,000 square miles of Great Lakes water, 11,000 inland lakes, 36,000 miles of rivers and streams, 75,000 acres of sand dunes, and 5.5 million acres of wetlands (Nelson and Stynes 2003). Michigan also has a total of 19.3 million acres in forested lands of which 38 percent are publicly owned (Hansen and Brand 2006). These resources are significant sources of amenities benefits and economic impacts. However, there is limited information about the economic value of these resources in general, and their impact on local economies through such channels as property values and appreciation.<sup>2</sup>

The proper economic valuation of green infrastructure services from public lands, wetlands, forested lands, agricultural lands, and other forms of open space can provide the information upon which timely natural resource utilization, management, and conservation can be adapted. To bridge the information gap on the economic value of natural resource amenities in Michigan, the Hannah Professor Research Program of the Land Policy Institute is publishing this particular report as part of its *Economic Impact and Valuation Studies in Natural Resources and Conservation* series. This report

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<sup>1</sup> Green infrastructure is defined as “the physical environment within and between cities, towns and villages. It is a network of multi-functional open spaces, including parks, gardens, woodlands, green corridors, waterways, street trees and open countryside.” (<http://www.greeninfrastructure.eu/?section=006.002&page=39>).

<sup>2</sup> To the extent to which high quality natural areas, such as water fronts, and trail increase property values, they also increase property tax revenues which affect local public services.

constitutes the third report in this series. The previous two reports provided a political economy analysis of state conservation spending gaps and an economic impact assessment of Rifle River Recreational Area in Ogemaw County. This particular report focuses on measuring the value of natural resource amenities in Hillsdale and Oakland counties as case studies, to inform on the value of green infrastructure in Michigan.

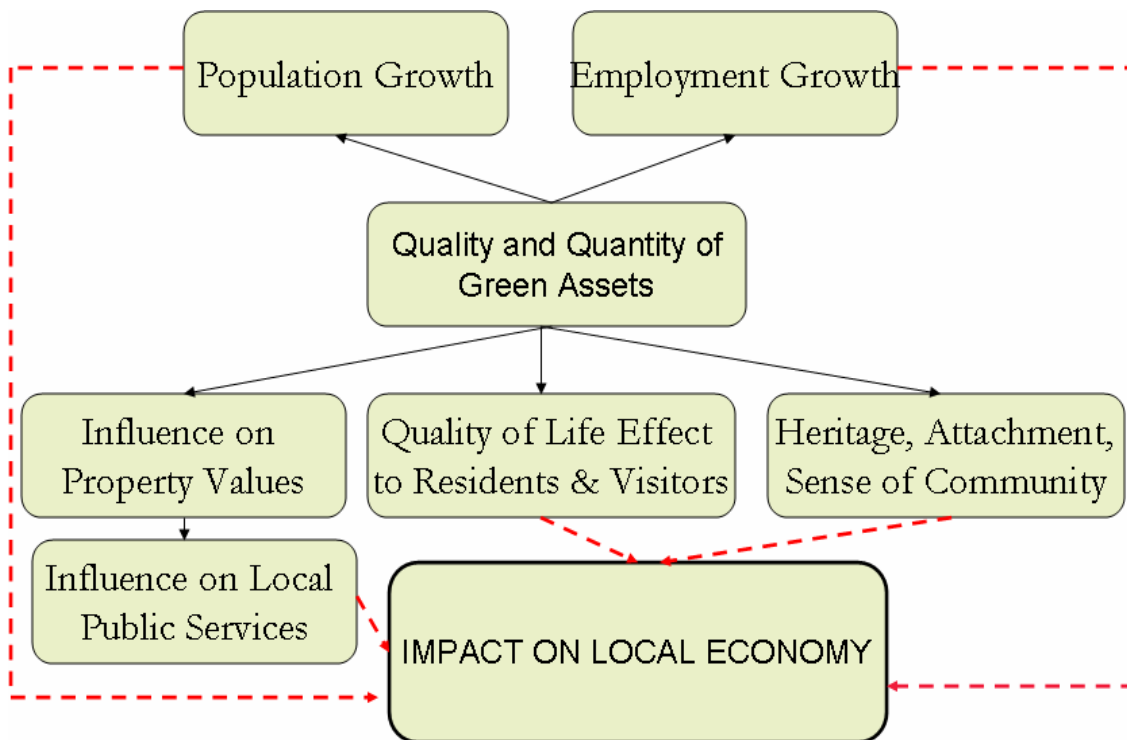
This study aims to provide:

- (1) Estimation of the value of selected natural resource amenities;
- (2) Analysis of the links between these natural resource services and such variables as property values and local economic performance;
- (3) Analysis of the benefits that households receive from being located near different natural resources through direct amenity benefits and indirect benefits—through property value appreciation; and
- (4) Policy discussion on the relevance of understanding the value of natural resource services.

## 2.0 Framework for Valuation of Natural Resource Amenities

Understanding the economic value of local green infrastructure has a multitude of benefits, including information support for: (1) local development planning based on local resources; (2) local Smart Growth based land use planning; (3) understanding the value of resources to prioritize for conservation; and (4) understanding property value, and hence, property tax impacts of local green infrastructure and its connection thereof with local economic vitality. In general, green infrastructure has broader impacts on local economies. High quality locations attract population and employment growth as these locations become desirable. High amenity areas also support the quality of life of local residents and foster community attachment and heritage. Also, high quality areas have substantial impacts on local property values that determine ability to finance local public services. All these aspects of green infrastructure services impact the vitality of local economies. Figure 2.1 summarizes these interconnections between green assets and the local economy.

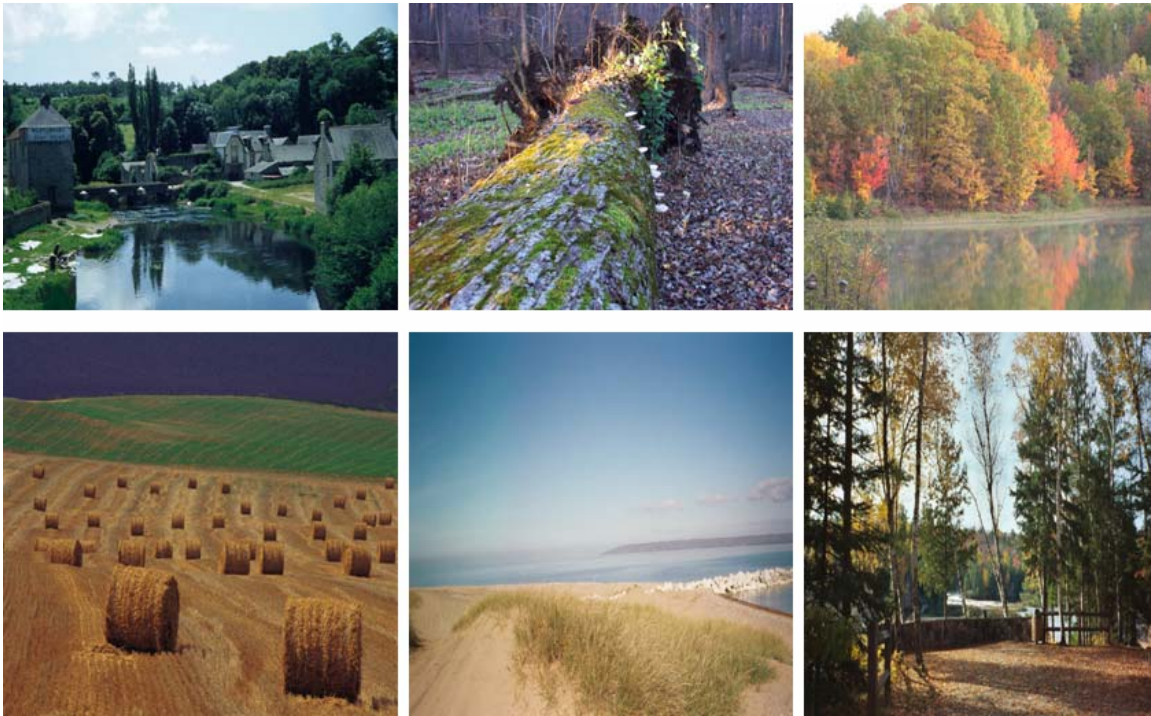
**Figure 2.1 The Links between Green Infrastructure and Local Economic Vitality**



Communities are increasingly aware of the links between local green infrastructure and economic performance. However, the value of natural resources has not been widely estimated and properly understood for local decision making purposes. Valuation of green infrastructure requires, first, clear understanding of what one means by *value*. For instance, Figure 2.2 demonstrates different types of natural resource amenities, ranging from waterfront properties to farmlands (open space). Each area depicted in these images

provides amenity benefits, but each resource has different uses. Therefore, when one *values* these resources, what particular aspect, or nature, of the resource measured is important to consider? Farmland has productive use in agriculture, but is also a source of open space; forested land provides forest products, but also provides recreational opportunities, such as hiking. Therefore, the elements of the resource characteristics being measured are an important consideration in the valuation process.

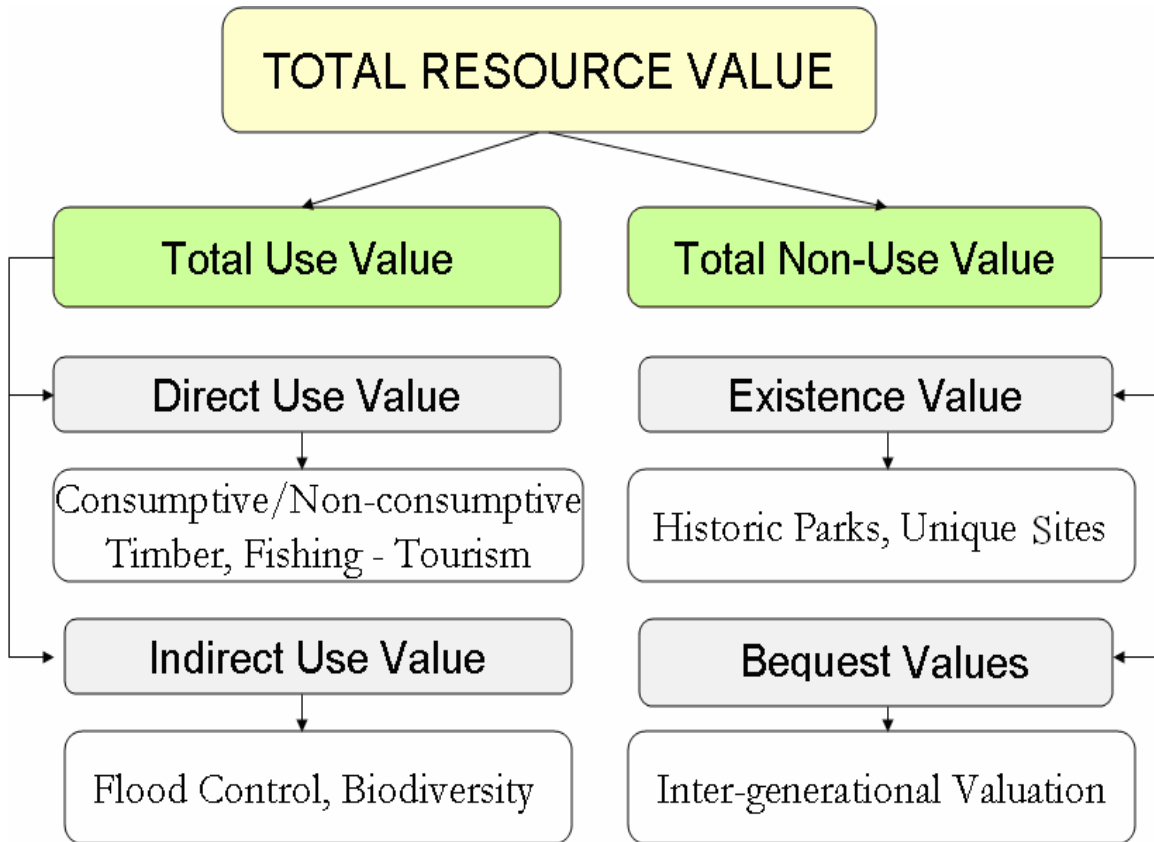
**Figure 2.2 Different Natural Resource Amenities**



In general, there are different components of green infrastructure (natural resource) values. Natural resources have *use value*, that is economic value related to direct extraction or use: farming, logging, fishing, etc. In this case, the use value is *direct* in that the resource has direct extractive or productive use values. The value of natural resources can also be *indirect*, as they are useful in supporting the consumption of secondary benefits, such as the flood control benefit of forest resources. Natural resources can also have *non-use value*, in the sense that they can be valuable even if one may not be able to directly utilize their services. This includes *existence value*, resources commanding value for the reason that they exist (such as historic parks and other unique sites) and *bequest value*, resources valued because they also have relevance for the next generation. Figure 2.3 summarizes the different aspects of green infrastructure values.



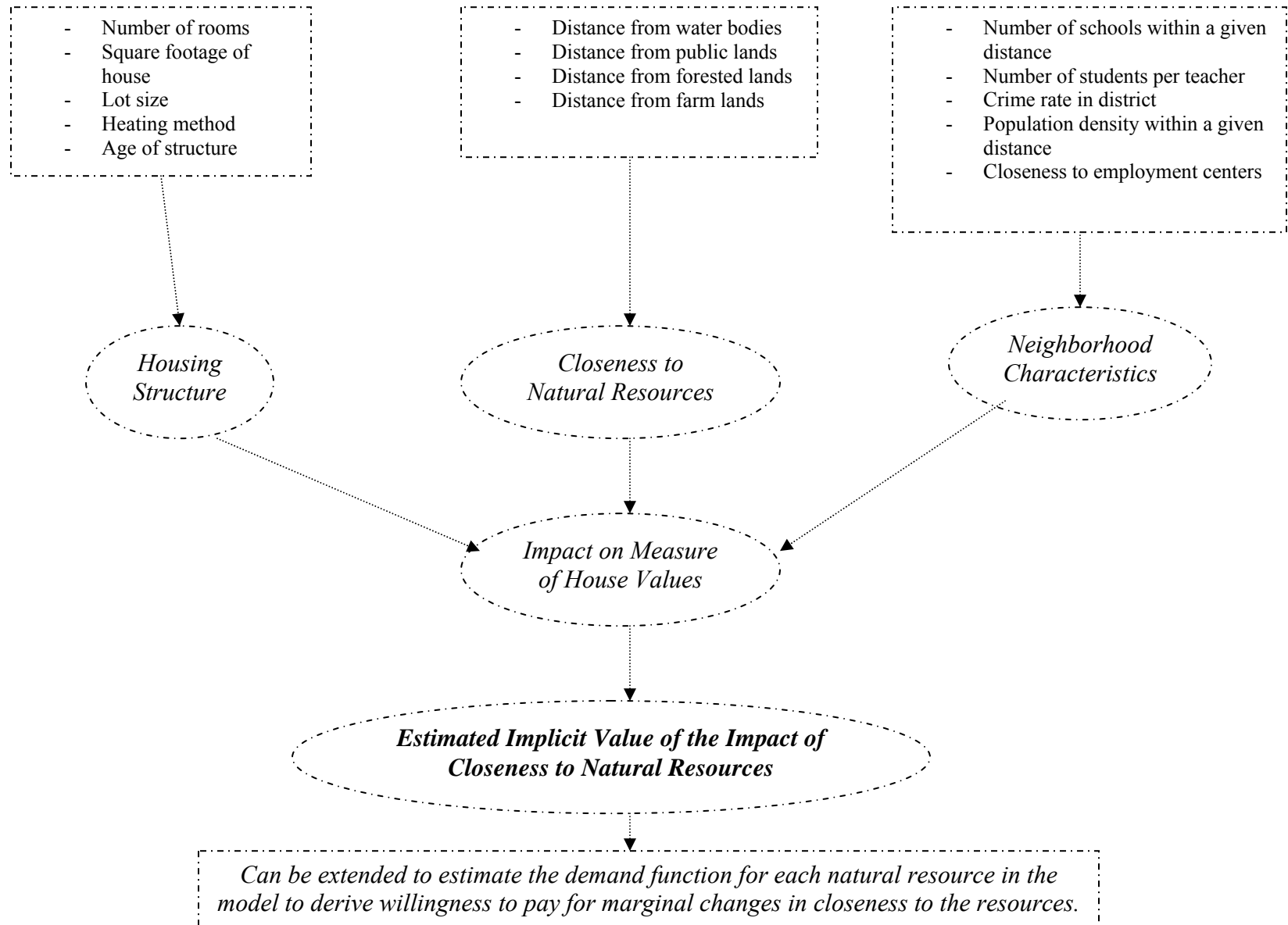
**Figure 2.3 Sources of Natural Resource Values**



This study aims to estimate the value of selected green infrastructure in Hillsdale and Oakland counties, the value estimation is focused on the *use value* of natural amenities, and will not include value estimation for potential *non-use values*. Estimation of *non-use values* often involves extensive survey on the value people attach to non-use characteristics of natural resources. *Use values* can be readily estimated from already existing secondary data, even though the data requirement is often large. Since most resource values are tied to *use values*, focus on this aspect of total valuation will provide reliable measurements of natural resource values.

There are different methods to estimate the value of green infrastructure. One sound method, based on observed market data, is the *hedonic valuation* model. Table 2.4 provides a thematic framework of a hedonic valuation methodology.

**Figure 2.4 Hedonic Valuation of Green Infrastructure Services**



A hedonic valuation method enables one to estimate the value of green infrastructure through observation of property value differences. The value of a typical house (property) is determined by different factors, but particularly by housing structure and closeness to natural amenities. Figure 2.4 summarizes the hedonic valuation framework and how natural resource values can be estimated (segmented out) from property values.

Structural factors that affect property values include the number of rooms, lot size, property square footage, floor space, garage square footage, etc. Closeness to high amenity areas could include parks, trails, waterways, recreational lands, open space, etc. Neighborhood characteristics could also have an impact on property values. Figure 2.4 summarizes a variety of factors that impact property values. A hedonic valuation method allows for isolation of the impact of closeness to natural resource amenities on property values. This estimated value is an indirect measure of the value of closeness to natural resource services.

A hedonic valuation method is widely used to segment the part of housing values that is attributable to the influence of natural amenities. Recent applications in decomposing the share of environmental services in property values have proven effective (Pendleton and Mendelsohn 1998, Faux and Perry 1999, Wilson and Carpenter 1999, Mohan, Polaski and Adams 2000, Taylor and Smith 2000, Leggett and Bockstael 2000). The integration of additional spatial data with housing characteristics, such as buffered measures of natural features from each property, has also proven helpful in accurately estimating natural resource values (Lake, et al. 2000).

Focusing on particular resources, hedonic valuation methodology has been applied to measure the amenity value of water (Michael, et al. 2000; Leggett and Bockstael 2000), the amenity value of wetlands (Mohan, et al. 2000), the environmental value of national parks (Kluvankova 1998), the value of scenic view (Benson, et al. 1998), and the economic value of freshwater ecosystems (Wilson and Carpenter 1999). In many of these studies, natural amenities have a significant effect on property values, and following hedonic valuation, the implicit value of each amenity is determined. For instance, Benson, et al. show that scenic quality appreciates housing values by as much as 60 percent.

### 3.0 The Study Areas: Hillsdale and Oakland Counties

Two hedonic valuation case studies were conducted in Hillsdale and Oakland counties. The Hillsdale study focused on the valuation of water-bodies (lakes, wetlands, etc.). This analysis involved the estimation of the impact of distance from water-bodies on the value of properties. The Oakland County study focused on the valuation of water-bodies, water ways, recreational lands, and a specially constructed variable designed to capture access to walkable and bikable infrastructure, such as trails, bike lanes, safety paths, and sidewalks.

Hillsdale County is a rural, agrarian county with US Census (2005) estimated population of 49,000. The county covers a land area of 599 square miles. Per capita income in the county is estimated at \$20,361, with unemployment rate of 3.8 percent. Increasingly, the county attracts residential development and second home development for residents of nearby Toledo, Ohio. There are 18 townships and 3 cities in Hillsdale County. The county's high quality lakefront and public lands provide environmental services and attract development near these resources.



Oakland County is located in southeast Michigan. The county has a total area of 908 square miles, of which 3.91 percent is water. The Census Bureau estimated (2005) population of the county was 1,214,361, which is roughly one-tenth of the population of Michigan. Oakland County is part of the Detroit metropolitan area and constitutes 62 cities, villages, and townships. General Motors, Ford, and Chrysler have significant investment in the county, though the economy of Oakland County is relatively diverse. According to Census figures, the median household income for 2000 stood at \$61,907, which compares favorably to the U.S. median household income of \$41,994 for the same period.



## 4.0 Hedonic Valuation Model

A hedonic valuation model was used in both the Hillsdale and Oakland County analyses. The only difference was in the implementation of the model: a focus on water related amenities in Hillsdale; and a focus on a broader set of green infrastructure in Oakland (waterways, water-bodies, recreational lands and infrastructure that allows walkability and bikeability, i.e., trails, sidewalks, safety paths, and park walk-paths). Of course, given the rural character of Hillsdale, it lacked data on some of the amenities accounted for in Oakland County. In other words, the two case studies differ only in the structure of the model implemented.

Figure 2.4 provides a thematic presentation of the hedonic valuation approach. In practice, a hedonic model is an econometric approach that allows one to separately estimate the values of green infrastructure. Hedonic models have different functional specifications, ranging from linear to non-linear models. A more general hedonic functional form, with flexible choices, involves the specification of a Box-Cox function that can be modeled to provide both linear and non-linear functional forms. One general specification of a hedonic model is one that transforms the dependent variable (housing unit price) using a Box-Cox transformation, while keeping independent variables (housing characteristics and closeness to natural amenities) linear. This model is specified as:

$$Y^{(\lambda)} = f(X) \tag{1}$$

$$\text{where } \left\{ \begin{array}{ll} Y^{(\lambda)} = (Y^{(\lambda)} - 1) / \lambda & \text{if } (\lambda) \neq 0 \\ Y^{(\lambda)} = \log(Y) & \text{if } (\lambda) = 0. \end{array} \right\}$$

$Y$  refers to the dependent variable (housing unit price) and  $X$  refers to all independent variables in the model that determine housing unit value, including housing characteristics and proximity to natural amenities. This model transforms the dependent variable using a Box-Cox transformation while the explanatory variables are all linear.

For the purpose of this study, a more general specification is used that transforms both the dependent and independent variables using a Box-Cox transformation. Model testing is conducted to identify particular models that fit the data well. The advantage of Box-Cox specification is that it does not impose any theoretically restrictive parameters. It allows for both linear and non-linear specification alternatives as special cases, but selects other parameter values that will generate best estimation results. The generalized Box-Cox specification can be given as:

$$y_i^{(\lambda)} = \beta_0 + \sum_i \beta_i x_i^{(\phi)} + \sum_j \kappa_j Z_j + \varepsilon_i \quad i \in (1, \dots, n) \text{ and } j \in (1, \dots, n)$$

$$\text{where } \left. \begin{array}{l} y^{(\lambda)} = (y^{(\lambda)} - 1) / \lambda \quad \text{if } (\lambda) \neq 0 \\ y^{(\lambda)} = \log(y) \quad \text{if } (\lambda) = 0 \\ x_i^{(\phi)} = (x_i^{(\phi)} - 1) / \phi \quad \text{if } (\phi) \neq 0 \\ x_i^{(\phi)} = \log(x_i) \quad \text{if } (\phi) = 0. \end{array} \right\} \quad (2)$$

The dependent variable ( $y_i$ ) is the price of houses, which is transformed using Box-Cox parameter ( $\lambda$ ); ( $x_i$ ) refers to all explanatory variables in the model, excluding dummy variables, which are transformed using a Box-Cox parameter ( $\psi$ ); and all dummy variables are given by ( $Z_i$ ). Even though it is customary to assign the Box-Cox parameters a value of either 0 or 1, a maximum-likelihood function can be specified, and the Box-Cox parameters will be determined through an optimization process. Equation (2) is estimated through different alternative models using Box-Cox transformations. The hedonic model following equation (2) allows for estimation of green infrastructure values from property sales transactions data.

## 5.0 Data Description and Characteristics

To estimate the value of selected green infrastructure in Hillsdale and Oakland Counties through the use of the hedonic model specified in equation (2), extensive data was collected from the Assessor’s Office in each county. To make sure data used in the analysis is based on market transactions of properties and based on full property structural information, extensive data editing was undertaken to exclude transactions that are not valid or are not based on free market transactions. Table 5.1 provides the description of the data used in the analysis.

**Table 5.1 Description of Data Used for Hedonic Analysis – Hillsdale County**

<b>Variable</b>	<b>Description</b>
<i>BSMTDUMY</i>	1 if there is a basement, 0 otherwise.
<i>GRNDSQFT</i>	Square footage of ground floor.
<i>NUMBATHR</i>	Number of bathrooms.
<i>QLTYRATE</i>	Quality rating of house by assessor (out of 100).
<i>GRGESQFT</i>	Garage square footage.
<i>FLRSQFT1</i>	Square footage of floor.
<i>AGE11</i>	Age of house.
<i>LOTACR12</i>	Lot size in acres.
<i>SOLD2001</i>	1 if house is sold in 2001, 0 otherwise.
<i>SOLD2002</i>	1 if house is sold in 2002, 0 otherwise.
<i>SOLD2003</i>	1 if house is sold in 2003, 0 otherwise.
<i>SOLD2004</i>	1 if house is sold in 2004, 0 otherwise.
<i>SOLD2005</i>	1 if house is sold in 2005, 0 otherwise.
<i>H2OW0-15</i>	1 if house is located within 15 meters of water, 0 otherwise.
<i>H2O15-75</i>	1 if house is located within 15 to 75 meters of water, 0 otherwise.
<i>H2075-150</i>	1 if house is located within 75 to 150 meters of water, 0 otherwise.

Now, let’s examine the data needed to conduct the hedonic analysis in Hillsdale County. Housing sales data for the years 2000 to 2005 were collected, which was obtained from the Assessor’s Office of Hillsdale County. The data was thoroughly checked for consistency, and was appropriately corrected or excluded, and was limited to “arms-length” transactions. Only “arms-length” transactions were included, due to the fact that they reflect market transactions. The housing sales transaction data includes information on sale price of properties as well as housing characteristics.

Spatial data on the distance of sold properties from identified water amenities was generated by the Hannah Professor Research Program of the Land Policy Institute and was matched with the county property sales data to determine the impact of water



amenities on property values. The sample size (number of property sales transactions) used in the final analysis was 2,504 property sales data. Table 5.1 provides both structural information of sold properties between the years 2000 to 2005 and spatial information on the distance of the sold properties from identified water features. Appropriate data transformation is also undertaken to test alternative hedonic model specifications.

In the case of Oakland County, data comprises of two categories – housing structural (and value) and spatial data on the closeness of properties to selected green infrastructure. Descriptions of these data are provided in Table 5.2.

**Table 5.2 Description of Data Used for Analysis – Oakland County**

<b>Variable</b>	<b>Description</b>
<i>GRND_FL</i>	Square footage of ground floor.
<i>TOTSQFT</i>	Square footage of lot size.
<i>BSMENT</i>	1 if there is a basement, 0 otherwise.
<i>GARAGE</i>	Garage square footage.
<i>BEDRMS</i>	Number of bedrooms.
<i>FULL-BATH</i>	Full bath.
<i>STYLBILE</i>	Structural style is Bi-Level.
<i>STYLBUNG</i>	Structural style is Bungalow.
<i>STYLCAPC</i>	Structural style is Cape Cod.
<i>STYLCOLO</i>	Structural style is Colonial.
<i>STYLCNTM</i>	Structural style is Contemporary.
<i>STYLMOBI</i>	Structural style is Mobile.
<i>STYLOTHR</i>	Structural style is Other.
<i>STYLRNCH</i>	Structural style is Ranch.
<i>STYLTRIL</i>	Structural style is Tri-Level.
<i>STYLTUDR</i>	Structural style is Tudor.
<i>STYLTWNH</i>	Structural style is Townhouse/Duplex.
<i>STYLSNGL</i>	Structural style is Single Family.
<i>YARD_IMP</i>	Yard improvement value.
<i>Sold2000</i>	Property sold in 2000.
<i>Sold2001</i>	Property sold in 2001.
<i>Sold2002</i>	Property sold in 2002.
<i>Sold2003</i>	Property sold in 2003.

**Table 5.2 Description of Data Used for Analysis (Continued)**

<i>Sold2004</i>	Property sold in 2004.
<i>Sold2005</i>	Property sold in 2005.
<i>Sold2006</i>	Property sold in 2006.
<i>H20_1DMY</i>	Property located within 15 meters of water body.
<i>H20_2DMY</i>	Property located between 16 and 75 meters of water body.
<i>H20_3DMY</i>	Property located between 76 and 150 meters of water body.
<i>H20_4DMY</i>	Property located at greater than 150 meters from water body.
<i>REC_1DMY</i>	Property located within 15 meters of recreational land.
<i>REC_2DMY</i>	Property located between 16 and 75 meters of recreational land.
<i>REC_3DMY</i>	Property located between 76 and 150 meters of recreational land.
<i>REC_4DMY</i>	Property located between 151 and 300 meters of recreational land.
<i>REC_5DMY</i>	Property located between 301 and 450 meters of recreational land.
<i>REC_6DMY</i>	Property located at greater than 450 meters from recreational land.
<i>OUTD_1DMY</i>	Property located within 100 meters of outdoor activity allowing green assets.
<i>OUTD_2DMY</i>	Property located between 101 and 500 meters of outdoor activity allowing green assets.
<i>OUTD_3DMY</i>	Property located between 501 and 1000 meters of outdoor activity allowing green assets.
<i>OUTD_4DMY</i>	Property located between 1001 and 1500 meters of outdoor activity allowing green assets.
<i>OUTD_5DMY</i>	Property located at greater than 1500 meters from outdoor activity allowing green assets.
<i>WTRW_1DM</i>	Property located within 15 meters of waterways.
<i>WTRW_2DM</i>	Property located between 16 and 75 meters of waterways.
<i>WTRW_3DM</i>	Property located between 76 and 150 meters of waterways.
<i>WTRW_4DM</i>	Property located at greater than 150 meters from waterways.
<i>AGE</i>	Age of house.
<i>SOLD2001</i>	1 if house is sold in 2001, 0 otherwise.
<i>SOLD2002</i>	1 if house is sold in 2002, 0 otherwise.
<i>SOLD2003</i>	1 if house is sold in 2003, 0 otherwise.
<i>SOLD2004</i>	1 if house is sold in 2004, 0 otherwise.
<i>SOLD2005</i>	1 if house is sold in 2005, 0 otherwise.
<i>H2OW0-15</i>	1 if house is located within 15 meters of water, 0 otherwise.
<i>H2O15-75</i>	1 if house is located within 15 to 75 meters of water, 0 otherwise.
<i>H2O75-150</i>	1 if house is located within 75 to 150 meters of water, 0 otherwise.

First, housing sales value (price) and structural attributes data for the years 2000 to 2006 were provided by the Oakland County Tax Assessor's Office. The data was thoroughly checked for consistency, type of transaction, and duplication. Out of the original 121,073 data points collected, only 45,424 were used in the final hedonic valuation analysis. This is due to data cleaning, refinements, utilization of only transactions with complete information, avoidance of duplications, and limitation of data sample to "valid-sales" transactions. The analysis benefits from having a relatively large sample size. Data transformation was undertaken as needed to refine the quality of output from the model and to test alternative models.

Second, spatial data was generated from Geographic Information System (GIS) layer files provided by the Oakland County GIS Unit. Distance of sold properties from identified natural amenities was measured from the GIS layers and reclassified into either four or six categories of distance buffers. An index closer to one indicates the natural amenity is closer to any given sold property, while an index four or six indicates the sold property is located farther from the natural amenity property. This helps measure the impact of natural amenity closeness or distance on property values, and hence natural amenity implicit values.

## 6.0 Results: Valuation of Green Infrastructure

The valuation of green infrastructure in each county is provided below. In Hillsdale County, the value of water amenities is estimated. In Oakland County, a number of different natural amenities are valued, as previously mentioned in Section 5.0.

### 6.1 Valuation of Water Amenities – Hillsdale County

In estimating the hedonic model for Hillsdale County, three sets of factors that determine property values were considered. First, physical characteristics of sold properties, such as total square footage, existence of basement, number of bedrooms, etc, are included. Second, trend variables are included to capture the tendency of property values to appreciate over time (captured by including information on when the property is sold). Third, to measure the value of water amenities in Hillsdale County, distance of sold properties are measured from identified water-bodies. The analysis conducted a comparison of property values for properties located within 15 meters, between 16 to 75 meters, and between 76 to 150 meters against those properties that are located at greater than 150 meters from water-bodies. The data used in the analysis is reported in Table 5.1.

Three separate models were also analyzed to provide the best estimates for the value of water amenities in Hillsdale County. A double-log model (Model 3) performs better in explaining patterns in the data, and is used in the final analysis. Table 6.1.1 summarizes the estimated results by category, i.e., physical characteristics of property, market trends, and environmental factors.

First, the impact of physical characteristics of property on property values in Hillsdale County is considered. The results indicate that the existence of a basement, a one percent increase in ground square footage, a one percent increase in quality rating, a one percent increase in garage square footage, and a one percent increase in floor square footage are expected to increase average property values by 0.23 percent, 0.03 percent, 1.2 percent, 0.03 percent, and 0.45 percent, respectively. As expected, the results suggest that structural factors of properties do have influence on the property value.

Second, consider the impact of market trends on property values in Hillsdale County. The results indicate that, on average, properties sold in 2001, 2002, 2003, 2004, and 2005 had higher market values by a 4.9 percent, 10.4 percent, 15.5 percent, 17 percent, and 20.9 percent, respectively, compared to average values in 2000. This shows a significant appreciation in average property values due to market conditions.

**Table 6.1.1 Estimated Values of Water Amenities – Hillsdale County**

Variables	Linear Model (Model 1)			Semi-log Model (Model 2)			Double-log Model (Model 3)		
	Coef.	Prob. Value	Elasticity	Coef.	Prob. Value	Elasticity	Coef.	Prob. Value	Elasticity
<i>Physical Characteristics of Property</i>									
<i>BSMTDUMY</i>	20,854	0.000	0.150	18,545	0.000	0.110	0.231	0.001	0.165
<i>GRNDSQFT</i>	2.757	0.567	0.032	-17,077	0.323	-0.142	0.162	0.033	0.162
<i>NUMBATHR</i>	16,281.4	0.000	0.241	50,253	0.000	0.418	0.056	0.238	0.056
<i>QLTYRATE</i>	581.522	0.054	0.428	8,675.55	0.165	0.072	1.209	0.000	1.209
<i>GRGESQFT</i>	25.290	0.162	0.091	3,241.89	0.001	0.027	0.026	0.000	0.027
<i>FLRSQFT1</i>	22.115	0.232	0.312	13,898.1	0.336	0.116	0.447	0.000	0.447
<i>AGE11</i>	25.494	0.624	0.013	633.08	0.683	0.005	0.305	0.000	0.305
<i>LOTACR12</i>	100.897	0.116	0.026	5,969.72	0.012	0.049	0.003	0.801	0.003
<i>Market Trends</i>									
<i>SOLD2001</i>	1,808.8	0.632	0.003	539.468	0.889	0.001	0.049	0.335	0.008
<i>SOLD2002</i>	5,176.77	0.169	0.010	4,230.66	0.251	0.007	0.104	0.046	0.020
<i>SOLD2003</i>	9,448.65	0.024	0.020	8,157.52	0.024	0.014	0.155	0.006	0.033
<i>SOLD2004</i>	12,226.6	0.007	0.027	9,941.35	0.006	0.018	0.170	0.004	0.038
<i>SOLD2005</i>	20,156.4	0.004	0.012	19,367.4	0.000	0.009	0.209	0.009	0.012
<i>Environmental Factors</i>									
<i>H2OW0-15</i>	20,854.4	0.000	0.177	93,055.8	0.000	0.149	0.819	0.000	0.158
<i>H2O15-75</i>	91,273.5	0.000	0.032	34,464.9	0.000	0.028	0.385	0.000	0.034
<i>H2075-150</i>	35,418.5	0.000	0.016	18,281.9	0.000	0.014	0.229	0.001	0.021
Sigma-sq.	2711936	0.041	-	2880531	0.000	-	0.463	0.009	-
$\Theta$		-			1			0	
$A$		-			0			0	
-Log-lik.		30,735			30,810.826			31,540	

Third, the impact of water amenities on property values is considered. The results indicate that on average, properties located within 15 meters, 16 to 75 meters, and 76 to 150 meters from identified water amenities have 81.8 percent, 38.5 percent, and 22.9 percent more value, respectively, compared to similar properties located at distances more than 150 meters from water amenities. Table 6.1.2 summarizes the estimated property value appreciation as a result of closeness to water amenities.

In dollars, this would mean that, on average, properties located within 75 to 150 meters from water sources have \$22,760.05 more value compared to similar houses located at more than 150 meters from water amenities. Similarly, houses located at 15 to 75 meters from water amenities have \$38,264.72 more value than similar houses located at more than a 150 meter distance. Finally, houses located adjacent to water amenities within a 15 meter distance have \$81,399.50 more premium value compared to similar houses located at the 150 meter distance from these water amenities. Since these estimated values are independent of the structural and market trend effects on property values, they are indirect measures of the value of water amenities in Hillsdale County.

**Table 6.1.2 The Effect of Water Amenities on Property Values – Hillsdale County**

Location of house from Water Amenities	Percentage gain in property value	Amount gained in property value
<i>Within 15 meters</i>	+ 81.9%	+ \$81,399.50
<i>15 to 75 meters</i>	+ 38.5%	+ \$38,264.72
<i>75 to 150 meters</i>	+ 22.9%	+ 22,760.05
<i>Base comparison: &gt; 150 meters</i>	<i>Base</i>	<i>Base</i>

The predictable decline in value as one moves away from water amenities indicates that these amenities clearly have a significant impact on property values, and hence local tax income. The estimated values of housing premiums due to amenities are for an average house. Adding these benefits (property value gain from closeness to water amenities) across many houses in Hillsdale can give a clear image of the magnitude of social benefits derived from water amenities.

The results have further implications: the appreciation of housing values due to closeness to natural amenities indicates the value that people attach to the environmental benefits of natural resources. To the extent that the environmental services of water amenities influence property values, they will have indirect effects on local tax revenues through the effect on property values.

## 6.2 Valuation of Natural Amenities – Oakland County

In estimating the hedonic model for Oakland County, similarly, three sets of factors that determine property values were considered. First, physical characteristics of sold properties, capturing such factors as total square footage, existence of basement, number of bedrooms, style of property, etc, are included. Second, trend variables are included to capture property values appreciation (or depreciation) over time by including property “year sold” data. Third, selected green infrastructure, such as waterways, water-bodies, recreational lands, and neighborhood walkability and bikeability access attributes (captured by trails, park walk path, safety path, and sidewalks) are included. The analysis conducted comparison of property value differences on the basis of distance (closeness) from the identified green infrastructure. The data used in the analysis and the distance categories from each selected green infrastructure is reported in Table 5.2 and the estimated results are provided in Table 6.2.1.

**Table 6.2.1 Estimated Values of Green Infrastructure – Oakland County**

Variables	Linear Model (Model 1)		Double-Log Model (Model 2)	
	Coef.	t-statistic	Coef.	t-statistic
<i>Physical Characteristics of Property</i>				
GRND_FL	19.352	5.417	0.093	6.839
TOTSQFT	154.665	55.855	0.665	46.715
BSMENT	22335.5	10.565	0.021	26.962
GARAGE	12791.6	5.777	0.032	33.125
BEDRMS	-5808.84	-6.071	0.009	3.449
FULL-BATH	30507.59	21.101	0.086	23.929
YARD_IMP	3.265	27.286	10 <sup>-5</sup> x4	13.614
STYLBILE	-25996.43	-3.696	-0.065	-3.561
STYLBUNG	31477.20	12.291	0.058	8.364
STYLCAPC	20101.80	2.564	0.083	4.105
STYLCOLO	-28529.67	-11.167	-0.006	-0.913
STYLCNTM	3551.13	0.742	0.101	8.189
STYLMOBI	-62368.42	-2.646	-0.523	-8.585
STYLOTHR	-12033.04	-3.047	0.003	0.301
STYLRNCH	26327.84	9.935	0.061	8.480
STYLTRIL	-22119.78	-4.675	-0.052	-4.275
STYLTUDR	79642.97	7.639	0.184	6.853
STYLTWNH	-38613.92	-2.001	-0.194	-3.885
<i>Market Trends</i>				
Sold2001	35999.46	5.769	0.061	3.796
Sold2002	20276.21	4.240	0.057	4.650
Sold2003	29839.62	6.272	0.098	7.990
Sold2004	4697.95	8.500	0.129	10.700
Sold2005	50059.58	10.638	0.152	12.507
Sold2006	43752.14	9.199	0.111	9.032
<i>Environmental Factors</i>				
<i>Water Amenities</i>				
H2O_1DMY	67690.33	23.872	0.215	29.356
H2O_2DMY	-6733.81	-2.533	-0.007	0.298
H2O_3DMY	-13518.17	-6.199	-0.023	-4.143
<i>Recreational Land Amenities</i>				
REC_1DMY	11014.84	2.887	0.031	3.126
REC_2DMY	21091.97	8.181	0.031	4.706
REC_3DMY	16283.03	6.723	0.022	3.558
REC_4DMY	17720.45	8.632	0.026	4.993
REC_5DMY	11020.15	4.933	0.006	1.023
<i>Trail Amenities</i>				
TRL_1DMY	5494.85	1.709	-0.006	-0.745
TRL_2DMY	20523.39	6.545	0.046	5.680
TRL_3DMY	21780.71	6.285	0.023	2.548
TRL_4DMY	29102.75	7.181	0.063	6.055
<i>Waterways Amenities</i>				
WTRW_1DM	1000.14	0.800	0.019	1.883
WTRW_2DM	-1407.72	0.672	0.013	1.481
WTRW_3DM	-3515.77	0.185	0.022	3.198
Intercept	-150458.3	-24.070	6.051	111.28
Θ	-	-	0	0
Λ	-	-	0	0
-Log-lik.	-624,693.17		-21,317.04	
R <sup>2</sup>	0.56		0.57	



In the case of Oakland County, several specifications were estimated, and the appropriate model specification was selected based on results from the log-likelihood test, Akaike Criterion, and significance levels. The double-log specification (Model 2) was chosen over the linear specification. Table 6.2.1 summarizes the estimated results by category, i.e., physical characteristics of property, market trends, and environmental factors.

First, consider the impact of property physical attributes on property values in Oakland County. As expected, the results suggest that a one percent increase in ground floor square footage (*GRND\_FL*), total square footage (*TOTSQFT*), basement square footage (*BSMENT*), and garage square footage (*GARAGE*) increase property values by 0.09 percent, 0.66 percent, 0.02 percent, and 0.03 percent, respectively. Similarly, additional bedrooms (*BEDRMS*) fetch a 0.9 percent gain in property values, full bath (*FULL\_BATH*) brings 8.6 percent gain, and yard improvement (*YARD\_IMP*) adds a slight increase in property value. The style of building also matters. Holding single family home style as a base comparison, *BiLevel*, *BUNG*, *CAPC*, *COLO*, *CNTM*, *MOBI*, *OTHR*, *RNCH*, *TRIL*, *TUDR*, and *TWNH* styles differ in comparative value by -6.5 percent, 5.8 percent, 8.3 percent, -0.06 percent, 10.1 percent, -52.3 percent, 0.03 percent, 6.1 percent, -5.2 percent, 18.4 percent, and -19.4 percent, respectively.

Second, consider the effect of market trends on property values in Oakland County. The results suggest that holding average property values in the year 2000 as a base comparison, average property values appreciated by 6.1 percent in 2001, 5.7 percent in 2002, 9.8 percent in 2003, 12.9 percent in 2004, 15.2 percent in 2005, and 11.1 percent in 2006. These indicate the market trend effect on property values.

Third, consider the property value impacts of the four identified natural resource amenities in Oakland County – water-bodies, recreational lands, neighborhood walkability and bikeability green infrastructure, and waterways. Let’s consider each green infrastructure separately.

*Water-Bodies:* Table 6.2.2 summarizes the effect of the presence of or proximity to water-bodies on property values by distance and by degree of effect in Oakland County. Properties were classified by their distance from water-bodies within 15 meters, 16 to 75 meters, 76 to 150 meters, and beyond 150 meters. The results suggest that properties that lie within 15 meters of water-bodies have a substantial capitalization of these amenities into property values, compared to properties located at more than 150 meters. The average “green-capitalization” attributable to water-bodies within 15 meters is \$55,082. This substantial gain in property value signals the implicit value of water amenities to Oakland County residents. Beyond the 15 meter buffer, however, water-body amenities have a rapidly diminishing impact on property values. This could be perhaps due to the scenic value associated with these amenities, which diminishes as the scenic quality declines. The results suggest that water amenities have substantial value that can be capitalized into property values, but they have a high sensitivity to distance and scenic quality.

**Table 6.2.2 The Effect of Water Amenities on Property Values – Oakland County**

Location of house from Water Amenities	Percentage gain in property value	Amount gained in property value
<i>Within 15 meters</i>	+ 21.5%	+\$55,081.71
<i>15 to 75 meters</i>	Insignificant	-
<i>75 to 150 meters</i>	-2.3%	-\$5,892.46
<i>Base comparison: &gt; 150 meters</i>	<i>Base</i>	<i>Base</i>

*Recreational Lands:* Table 6.2.3 summarizes the effect of proximity to recreational lands on property values by distance and by degree of effect in Oakland County. Properties were classified based on distance from identified recreational lands following the distance categories of 15 meters, 16 to 75 meters, 76 to 150 meters, 151 to 300 meters, 301 to 450 meters, and beyond 450 meters. The results suggest that recreational areas have significant impact on property values, ranging in impact from 3.1 percent capitalization for properties within 15 meters, to 3.2 percent gain for properties within 15 to 75 meters, 2.2 percent gain for properties within 75 to 150 meters, and a 2.6 percent capitalization for properties within 150 to 300 meters, compared to properties located at more than 450 meters. The results soundly conclude that recreational lands have significant value, more so the closer one gets to these resources. Recreational areas are part of quality of life, and their significant positive value per house measures their implicit market value to Oakland County residents.

**Table 6.2.3 The Effect of Recreational Amenities on Property Values – Oakland County**

Location of house from Recreational Land	Percentage gain in property value	Amount gained in property value
<i>Within 15 meters</i>	+3.1%	+\$7,942.01
<i>15 to 75 meters</i>	+3.2%	+\$8,198.21
<i>75 to 150 meters</i>	+2.2%	+\$5,636.27
<i>150 to 300 meters</i>	+2.6%	+\$6,661.04
<i>300 to 450 meters</i>	Insignificant	-
<i>Base comparison: &gt; 450 meters</i>	<i>Base</i>	<i>Base</i>

*Walkability and Bikeability Allowing Green Infrastructure:* Table 6.2.4 summarizes the effect of walkability and bikeability allowing green infrastructure on property values in Oakland County. Green assets in this category are sidewalks, bike lanes, trails, park paths, and safety paths. Properties were classified by their distance from the green infrastructure at within 100 meters, 101 to 500 meters, 501 to 1000 meters, 1001 to 1500

meters, and beyond 1500 meters. Results indicate that the effect of these green infrastructure on property values were significant, but not within 100 meters. Existence of these composite green assets within 100 to 500 meters appreciates property values by 4.6 percent, or \$11,785, within 500 to 1000 meters results in “green-capitalization” of 2.3 percent, and within 1000 to 1500 meters results in a gain of 6.3 percent or \$16,140, compared to properties located at more than 1500 meters away from these outdoor opportunities. The insignificant result for much closer proximity could be perhaps due to the congestion and disutility of having people walk and exercise at closer proximity to one’s property. However, once these green assets are close enough to bring amenity, yet far enough to reduce the impact of congestion, they command substantial value.

**Table 6.2.4 The Effect of Composite Outdoor Activity Allowing Green Assets on Property Values – Oakland County**

Location of house from Composite Green Assets	Percentage gain in property value	Amount gained in property value
<i>Within 100 meters</i>	Insignificant	-
<i>100 to 500 meters</i>	+4.6%	+\$11,784.92
<i>500 to 1000 meters</i>	+2.3%	+\$5,892.46
<i>1000 to 1500 meters</i>	+6.3%	+\$16,140.22
<i>Base comparison: &gt; 1500 meters</i>	<i>Base</i>	<i>Base</i>

*Waterways:* Table 6.2.5 summarizes the effect of proximity to waterways on property values in Oakland County. Properties were classified based on their distance from waterways at 15 meters, 16 to 75 meters, 76 to 150 meters, and beyond 150 meters. Results suggest that waterways tend to have a marginal positive impact on property value, estimated at a “green-capitalization” of 1.9 percent for properties within 15 meters and 2.2 percent for houses within 75 to 150 meters, compared to properties located at more than 150 meters. The estimated implicit value for waterways is smaller, yet positive. Waterways do have non-market value, and residents put a premium on such locations.

**Table 6.2.5 The Effect of Waterways on Property Values – Oakland County**

Location of house from Waterway Amenities	Percentage gain in property value	Amount gained in property value
<i>Within 15 meters</i>	+1.9%	+\$4,867.69
<i>15 to 75 meters</i>	Insignificant	-
<i>75 to 150 meters</i>	+2.2%	+\$5,636.27
<i>Base comparison: &gt; 150 meters</i>	<i>Base</i>	<i>Base</i>

In summary, the results clearly indicate that green infrastructure commands significant value, as estimated in the case of Hillsdale and Oakland Counties. Natural resources also have significant impacts on local economies through property values and quality of life. The appreciation of housing value due to closeness to natural amenities indicates the value people attach to the environmental benefits of natural resources, and their willingness to “vote through their foot” and to “vote through their wallet.” The results also suggest that, to the extent that the environmental services of natural resources influence property values, they will have indirect effects on local tax revenues through their effects on property values.

## 7.0 Conclusion and Implications

This report presents the findings of a study designed to document the impacts of natural resources (green infrastructure) on property values and therefore on local tax revenues. Applications of the hedonic valuation technique to Oakland and Hillsdale Counties suggest that green infrastructure, or natural resources, have significant amenity values that translate into higher property values. Our approach isolates the value of green infrastructure attributes such that the impact of green infrastructure in enhancing property value is estimated. With every single attribute measured, the results support the positive economic value and impact of green infrastructure.

In the case of water amenities in Hillsdale County, it was found that properties located within 15 meters reflected an 81.9 percent gain property value (or \$81,399.50), properties located within 15 to 75 meters gained 38.5 percent in property values (or \$38,264.72), and properties located within 75 to 150 meters gained 22.9 percent in value (or \$22,760.05). The enhancements in property values are quite significant, given average property values from property sales transaction data is around \$100,000. The difference in property value at different distance from water amenities shows people are “voting with their foot” and with their “wallet” in support of green infrastructure.

This study also conducted valuation analysis of waterways, water-bodies, recreational lands, and walkability and bikeability allowing green infrastructure in Oakland County. In the case of water amenities, it was found that properties located within 15 meters gained 21.5 percent in value (or \$55,081.71) compared to properties located beyond 150 meters from water amenities. In the case of recreational lands, properties within 15 meters gained 3.1 percent in property value (or \$7,942.01), properties within 15 to 75 meters gained 3.2 percent in value (or \$8,198.21), properties within 75 to 150 meters gained 2.2 percent in value (or \$5,636.27), and properties within 150 to 300 meters gained 2.6 percent in value (or \$6,661.04). In the case of walkability and bikeability allowing green infrastructure (such as trails, bike lanes, side walks, and park path), properties located within 100 to 500 meters gained 4.6 percent in property value (or \$11,784.92), properties located within 500 to 1000 meters gained 2.3 percent in value (or \$5,892.46), and properties located 1000 to 1500 meters gained 6.3 percent (or \$16,140.22) compared to properties located beyond 1500 meters. Finally, in the case of waterways, it was found that properties located within 15 meters of waterways gained 1.9 percent in property values (or \$4,867.69) and properties located within 75 to 150 meters gained 2.2 percent in value (or \$5,636.27), compared to properties located beyond 150 meters of waterways. Given the average property value from property sales transaction data of \$275,000, the gains in property values as a result of proximity to green infrastructure are significant in economic value and impact.

The results from both Hillsdale and Oakland Counties consistently show that, when it comes to green infrastructure, people are “voting with their feet” and “voting with their wallets.” The positive findings for green infrastructure should be good news for local officials, since their rates increase with amenities. Local officials are somewhat

supportive of green assets; however, this study suggests that they should be more supportive for an economic reason, as it enhances ratables.

The study results have numerous implications:

- (1) Natural amenities do matter, have significant value, and have a bearing on local property values. Therefore, efforts to protect such resources are sensible responses to protecting value.
- (2) Natural amenities have substantial effect on local property values, from which some local public services are provided. To the extent that property taxes are relevant to local government units, understanding the important links provided in this study between local economies and natural resources is crucial.
- (3) Natural amenities are different in value as implicitly measured in the market place; as such, estimated green infrastructure values can provide the guide as to which resources are highly valued by local residents for conservation purposes, especially in the face of limited conservation funding.
- (4) Given the fact that green infrastructure affects property ratables, local decision makers can enhance long-term financial viability of their communities through green infrastructure based strategies.

Green infrastructure investment also has broader implications. In the New Economy, talent and innovation are sources of new local and regional economic growth. Talent tends to migrate to places with significant green infrastructure; jobs tend to follow people, who follow green infrastructure quality. If this is the case, then the findings of this study suggest that green assets enhancement meets the goals of environmental and economic sustainability. As part of a long-term strategy, green infrastructure (shown to have significant economic value) can be leveraged to enhance local economic viability and sustainability at the same time.

## References

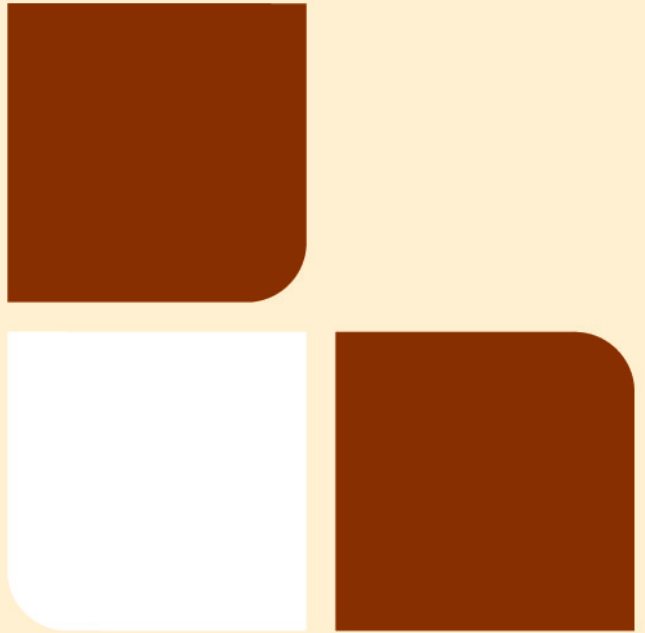
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