

# Mill Creek River Resource Economics Study

## I. Acknowledgments

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## II. Introduction and Purpose

The primary focus of this resource economics study is to determine and quantify potential benefits from fully implementing the *Mill Creek Watershed Greenway Master Plan*, developed through a community-based planning process spearheaded by MCRP and as a collaborative effort between Hamilton County, the Mill Creek Watershed Council of Communities, the Metropolitan Sewer District of Greater Cincinnati (MSD), and MCRP. Components of the multi-objective plan include creating forested/vegetated stream buffers, restoring wetlands and stream banks, and incorporating recreational trails. The plan outlines a comprehensive greenway strategy that Mill Creek communities can employ for achieving multiple economic, social and environmental benefits.

Those anticipated short- and longer-term benefits include:

- Improved water quality that will eventually allow safe public access to and contact with the river.

- Restoration of aquatic and terrestrial habitat.
- New passive and active recreational opportunities through creation of hike and bike trails and public parks.
- Improved air quality from more people walking and biking on short trips, reducing automobile traffic.
- Improved air quality from increasing the tree canopy that filters air pollutants and sequesters carbon.
- Prevention and reduction of streambank erosion and sedimentation as a result of vegetated stream buffers that slow down and absorb stormwater.
- Open space/vegetative cover and stream buffers that will filter urban stormwater runoff.
- Eco-friendly and effective stormwater management techniques including permeable and semi-pervious pavement, bio-infiltration trenches and rain gardens, wetland filters, bio-swales, reforestation of stream buffers, green roofs and walls, and onsite storage using rain barrels and cisterns.
- Improved health of Mill Creek Greenway Trail recreational users.
- Cleanup and redevelopment of old abandoned and underutilized brownfield properties and buildings.
- Job training and jobs from development of green technologies, regeneration of the river and the natural resources within the watershed, and construction and management of the Mill Creek Greenway Trail.
- Increased property values and increased tax base for local communities and school districts.

### **III. Methodology**

Like the other benefits, the positive financial outcomes shown in the last bullet are intuitive. This report offers a formal economic analysis to determine if indeed these economic benefits will occur and how much property values and the tax base can be expected to improve. This OSU economic study provides a hedonic pricing model of residential property values in the Mill Creek corridor. It develops reasonable predictions based on benefit transfer from other sites for conservative estimates of expected benefits of greenway system implementation with emphasis on property and recreation use values. In other parts of the Mill Creek River Resource Economics Study, Mill Creek Restoration Project team members utilize CITYgreen software to examine stormwater, air quality, carbon sequestration and other benefits resulting from increased tree canopy along Mill Creek and its tributary streams.

OSU began its Mill Creek River Resource Economics study with an extensive literature review on classification of river related flows, water quality and non-market economic evaluation methods. Next, OSU developed hedonic pricing, travel cost and Contingent Valuation Method (CVM) based benefit transfer estimates for both recreation and property value impacts from implementation of the recommendations proposed in the Mill Creek Greenway Plan. In addition, OSU performed primary data collection on key physical and demographic characteristics within the Mill Creek corridor for the development and estimation of a hedonic pricing model for residential property values in this portion of the Mill Creek watershed. Finally, both the benefit transfer and onsite data collection estimates of property value impacts are linked to any property tax revenue increases. Due to budget constraints, OSU did not conduct a contingent evaluation survey to measure the Willingness to Pay (WTP) for non-use values, but this could be a valuable future effort.

## **IV. Benefit Transfer Estimation of Residential Property Impacts**

### **A. Benefit Transfer Methodology**

Urban stream restoration offers a number of benefits for nearby property owners (Streiner and Loomis, 1996). Measures to prevent and reduce streambank erosion and reduce flooding can lessen damage to both the grounds and the buildings on them. Returning a stream to a more natural state also provides both environmental and aesthetic benefits. Since these benefits accrue to nearby property owners, they should be reflected in the sale prices of property. Thus, the hedonic price method offers a means for estimating these benefits. In cases when a hedonic price study using primary data is infeasible, a benefit transfer approach offers an alternative means for estimation of project benefits in cases where the parameters or resource and policy condition changes are similar.

Benefit transfer is a method for applying data analysis from one site (the study site) to another site (the policy site) with similar resource and policy conditions. Rosenberger and Loomis (2001) note that, although primary research is the “first-best” method for estimating the valuations of resources and policies, such analysis may not always be feasible under time and budget constraints. In such cases, a benefit transfer may be a “second-best” strategy, providing a less accurate estimation method, but still proving superior to failing to account for such values at all.

The literature on benefit transfer methods can be described by three categories or approaches: fixed value transfers, value estimators, and expert judgments (Bergstrom and De Civita, 1999).

### **1. Fixed value transfers**

In the simplest version of a fixed value transfer, a single value or point estimate from the study site is applied directly to the policy site. For example, the willingness to pay for an environmental benefit in one study may be used to estimate willingness to pay for a similar benefit at another site. In a slightly more sophisticated version, the average (or other measure of central tendency) of the estimates from several study sites may be used for the policy site.

### **2. Value estimators**

With a value estimator (or function transfer), the functional form and parameter estimates used to model valuation at the study site are applied to the policy site. This allows for the policy site valuation to differ from the study site's point estimate in response to differences in the demographic characteristics or other underlying determinants of demand. If multiple study sites are used, a meta-analysis regression may be used, instead of a single demand function.

### **3. Expert judgment**

In many cases, some element of subjective judgment by the analyst is required. The analyst must determine which study sites are the best fit for a given policy site, for example. If no close match for a given policy site can be found, the analyst may choose a less than ideal match and adjust the point value or value function based on knowledge of the policy site. In more complex cases, the analyst may call on a group of experts to provide estimates without an empirical study, called "Delphi method." Of course, the benefit transfer methodology in any particular application may incorporate elements from more than one approach or category (French and Hitzhusen, 2001).

## **B. Application to Mill Creek**

### **1. Description of the study and policy sites**

Streiner and Loomis (1996) performed a hedonic price analysis for a number of stream restoration projects in California using data from property sales<sup>1</sup> over the period 1983 to 1993.<sup>2</sup> The study

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<sup>1</sup> The properties (all single-family homes) were located in Santa Cruz County, Contra Costa (near the San Francisco Bay area), and Solano County in California.

focused on projects conducted on three streams. The flow of the streams averaged 500 cubic feet per second (cfs) during storms and ranged from 2,000 cfs to 3,000 cfs during peak winter flows. The mean assessed value of the properties was \$144,085.

The peak flows at Mill Creek range from 2,000 cfs to 8,000 cfs, at various measurement sites. The stream is located in Hamilton and Butler Counties in Ohio, with mean home values of \$65,325 and \$72,244 (1982 dollars), respectively.<sup>3</sup> These values could also be denominated in 2006 values, but they are adjusted later in this analysis.

Mill Creek varies more in size and flow than do the streams in the study site. However, within the headwaters in Butler County and within the upper reaches of some of its tributaries, Mill Creek seems to match the study site in terms of flow characteristics. In addition, the projects at the study sites are similar to the proposals for Mill Creek, including streambank stabilization, revegetation measures, improved fish habitats, and trail systems. On the other hand, the homes near Mill Creek are of lower value than the homes in the study site, although this difference can be accounted for by using a function transfer, rather than simply transferring a specific dollar amount from the study sites to Mill Creek.

## **2. Fixed value transfer**

Streiner and Loomis (1996) estimated that a river restoration project that included both erosion control measures, such as stream-bank stabilization, and a recreational trail added an average of \$19,078 (in 1982 dollars) to each property near the stream. Converted to 2006 dollars, that benefit is \$33,117.<sup>4</sup> As a percentage of assessed value, a restoration project increased the value of a property by 13.2%.

Since the home values near Mill Creek are much lower than those in the study site, the percentage of assessed value (13.2%) is a more appropriate estimate of the project benefits than is the study site's specific dollar amount. In 2000 dollars, the estimated increase in value for homes near Mill Creek would be \$14,700 to \$16,260 per home. The 13.2% increase in property values derived

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<sup>2</sup> Values were converted to 1982 dollars using the U.S. residential price index reported in the Survey of Current Business by the U.S. Dept. of Commerce.

<sup>3</sup> The values reported in 2000 were \$111,400 and \$123,200 in then-current dollars. The values were converted to 1982 dollars using the U.S. residential home price indices of 58.64 (year 1982) and 100.00 (year 2000) provided by the Bureau of Economic Analyses.

<sup>4</sup> The U.S. residential price indices are 57.608 (first quarter of 1982) and 100.00 (second quarter of 2006).

from the benefit transfer is very similar to the 10.75% increase indicated by the hedonic analysis (Section III), providing independent corroboration for that estimate.

### **3. Function Transfer or Value Estimator**

Streiner and Loomis (1996) used a non-linear functional form based on a Box-Cox transformation applied to the dependent variable only.<sup>5</sup> Thus, the regression equation was  $Y^{(\lambda)} = \alpha_0 + \beta X + u$ ,

where  $Y^{(\lambda)} = \frac{Y^\lambda - 1}{\lambda}$  and  $X$  and  $\beta$  are vectors of the independent variables and their coefficients,

respectively. The dependent variable was the assessed value of the home (1982 dollars). The independent variables and their associated parameter estimates are given in Table 1:

Table 1. Independent Variables and Parameter Estimator

<b>Variable</b>	<b>Parameter Estimate</b>	<b>Notes</b>
Improvement size	0.0104	
Lot size	0.0002	
Garage	2.0347	Dummy variable*
Creek distance	-0.0006	
Per capita income	0.0010	
Travel time to work	-0.4419	
Mean age	0.2280	
Unemployment rate	-0.2138	
Lambda	0.7169	
Education trail	7.1364	Dummy variable*
Stabilize stream banks	3.0184	Dummy variable*

\*A dummy variable is an either/or variable, taking the value of 0 when the characteristic is not present (e.g. no trail) and the value of 1 when the characteristic is present (e.g. trail has been built).

With a function transfer, this regression equation and its parameter estimates would be applied to the policy site. The analyst would need to find values for the home and region-specific variables for the homes near Mill Creek (or a representative sample of the homes). The equation

$Y = (\lambda\beta X + 1)^{\frac{1}{\lambda}}$  would be used twice for each home, once with the project dummy variables set

<sup>5</sup> Streiner and Loomis (1996) tested all four possible variations of transforming the dependent and/or the independent variables, and the best-fitting model was with only the dependent variable transformed.

to 0 and once with the dummies set to 1. The difference between the two values represents the benefit of the restoration project in terms of increasing the value of that property.

However, the regression equation and parameter estimates may not be appropriate for homes in the Mill Creek area. The mean home values differ between the study and policy site, and differences in the independent variables may not sufficiently account for those differences. However, it is the percent change in values that matters. The appropriateness of a function transfer can be tested in this case, since assessed values for the Mill Creek homes are available.

Using the regression equation with the project dummies set to 0 provides a prediction of the value of the home without the project benefits. This can be compared to the actual value of the home, either the assessed value or the price from an actual sale. Analyzing the differences over the set of homes near Mill Creek (or a sample of them) will provide an idea of how well the regression model fits the Mill Creek homes. The  $R^2$  of the study site was 0.553; if the  $R^2$  for the Mill Creek area is substantially less, then transferring the model may not be an appropriate method for estimating the benefits of the restoration project in the Mill Creek area.

The  $R^2$  statistic reflects what percentage of the variation in the dependent variable (property value) is explained by the regression model (see Glossary Appendix). The study site's  $R^2$  indicates a strong fit for a hedonic model. If applying the model to Mill Creek generates a significantly lower  $R^2$  then that result would cast doubt on the validity of transferring the function from the Streiner and Loomis study.

### **C. Tax Revenue from Increased Property Value**

The value of residential real estate near the stream would be expected to increase from environmental, aesthetic, and recreational improvements due to the implementation of the Mill Creek Watershed Greenway Program and increased use of Green Infrastructure and eco-friendly best management practices (also referred to as green BMPs) for managing stormwater. Since home values form the tax base for the Ohio real estate tax, these changes will lead to higher tax revenues for state and local government entities funded by real property taxes.

According to the Ohio Department of Taxation (ODT), net property tax (or millage) rates for Butler and Hamilton Counties in 2004 were 5.719% and 5.882%, respectively (ODT, 2004).

These figures are the averages of the total tax rates across all municipalities and school districts for two counties. The net rates account for various tax reduction factors, such as the effects of voted tax levies and minimum or maximum rates. In Ohio, real property is reappraised by independent appraisers every six years and property values updated three years after the reappraisal, so an increase in property values should be reflected in the tax base within a few years.

Table 2 below shows the total appraised value of homes within 0.5 miles of Mill Creek in Hamilton County, segregated by tax district. Each tax district corresponds to a corporation, township, and school district, each of which has a separate tax on residential property values, in addition to the county's property tax.

Table 2. Appraised Value of Study Area Homes

<b>Tax District</b>	<b>Corporation</b>	<b>Township</b>	<b>School District</b>	<b>Total Value</b>
001	Cincinnati	--	Cincinnati	\$432,739,010
011	--	Springfield	Cincinnati	\$38,255,600
032	--	Springfield	Finneytown	\$376,400
071	Lockland	--	Lockland	\$45,293,530
072	Arlington Heights	--	Lockland	\$22,347,320
175	Sharonville	--	Princeton	\$19,405,400
179	Evendale	--	Princeton	\$54,379,400
182	Reading	--	Reading	\$95,739,280
183	Evendale	--	Reading	\$69,940
201	St. Bernard	--	St. Bernard	\$42,407,760
202	Elmwood Place	--	St. Bernard	\$36,291,320

The benefit transfer indicates an estimated 13.2% increase in property value of homes near a restored Mill Creek. Using recent millage rates (Hamilton County Auditor, 2006); one can estimate the increases in tax revenues (Table 3) that these various taxing authorities will receive once the improvements of the Mill Creek restoration are fully reflected in home values. This analysis assumes that millage rates and reduction factors will not change with the implementation of the restoration project.

Table 3. Taxing Authority and Increased Revenue

<b>Taxing Authority</b>	<b>Increase in Tax Revenue</b>
Hamilton County	\$1,326,953
Townships/Corporations (Total)	\$599,756
o Arlington Heights	18,199
o Cincinnati	363,829
o Elmwood Place	61,303
o Evendale*	0
o Lockland	23,989
o Reading	22,710
o Sharonville*	0
o Springfield	64,124
o St. Bernard	45,592
School Districts (Total)	\$3,601,144
o Cincinnati	2,321,181
o Finneytown	2,443
o Lockland	310,693
o Princeton	248,062
o Reading	413,709
o St. Bernard	305,056

\*Evendale and Sharonville do not have property taxes at the township/corporation level. However, increased tax revenues for their school districts (Princeton and Reading) are included under the school district level.

#### **D. Benefit Transfer of Residential Value Increases**

In Hamilton County, almost 9,000 homes lie within 0.5 miles of Mill Creek. These homes have a total appraised value of approximately \$787 million. Applying the average 13.2% increase in property value transferred from the Streiner & Loomis study, one can estimate that improving stormwater and floodplain management and the health of the river, and building a recreation trail along Mill Creek, will provide benefits to these homeowners of approximately \$104 million in the form of property value increases. This increase in property values translates into increased revenues through the millage rate for local governments. While homeowners will eventually have to pay higher property taxes, this added cost can be offset by the higher sales price of the homes and by the ecological, aesthetic and recreational benefits accrued from the greenway

program. This value can be compared to the actual on-site hedonic price estimates developed in the next section (Section III).

*Impacts by income class:* Mill Creek Restoration Project has raised several distributional questions, particularly with regard to increased property values. First, only homes relatively near to Mill Creek will see their values rise. Thus, the income levels and other demographics of these homeowners could be analyzed, to see what income groups are receiving the benefits. If a significant redistribution across income levels would occur, the benefits could be weighted by income levels to reflect both differing marginal utilities of income and equity concerns. The ratio of marginal tax rates is a commonly used method to weight benefits by an implied marginal value of money.

Second, some of the properties that will be affected are apartment buildings, rather than single-family residences. Estimating the distribution of benefits will depend on whether the landlord or the resident receives the benefit of increased values. It seems reasonable to assume that rents will adjust only gradually to reflect higher property values and taxes. The residents, who are likely to be lower in the income distribution, may acquire the benefits in the short term, but in the long term, rents will likely rise, shifting those benefits to the higher-income landlords.

## **V. On-Site Hedonic Estimation of Residential Property Impacts**

### **A. Background**

Hedonic pricing techniques have been used in a wide variety of applications to estimate prices of non-market amenities and “disamenities” that may be capitalized into the price of an asset such as a housing unit. The hedonic pricing method for the valuation of environmental amenities is based on the underlying assumption that different locations have different environmental attributes and such variation will result in differences in property values. This method also assumes that the value of an asset is equal to the sum of the values of individual attributes of that asset (Lesser et al., 1997). The hedonic pricing model is a widely used method for controlling for other property characteristics to estimate the impact of water quality and other river attributes such as habitat, tree cover trails and other infrastructure.

## **B. Greenways**

Greenways are linear open spaces or parks with trees and other vegetation that connect people and places together and wildlife with their habitat. Greenways are often established along natural corridors such as river or stream valleys or along historic infrastructure corridors such as railroad rights-of-way. Greenways conserve and restore streamside forests and provide ecological benefits such as improved water quality and wildlife habitat. Studies by the U.S. Forest Service and others have demonstrated that a greenway can help mitigate air pollution and pollution from stormwater runoff. In addition to the function of natural habitat preservation, greenways also provide positive amenity values for nearby residents and people who work in the area. These may include open space, enhanced views and recreational uses. Many studies have shown that the property values increase if trees are located on a property (Anderson and Cordell 1988; Dombrow et al. 2000; Morales 1980). Some hedonic studies have focused on the relationship between property values and forested areas in the surrounding neighborhood.

The preservation of greenway corridors has become an important policy issue in the United States as greenways play a critical role in floodplain management as well as in preserving biodiversity. Generally, private land markets do not fully recognize benefits of the ecological and recreational functions of greenways. Thus, private organizations and governmental entities have introduced a variety of initiatives to protect riparian corridors from the encroachment of commercial and residential land use. This is the case for Mill Creek, an urban stream that flows through Cincinnati, Ohio.

This Mill Creek analysis estimates the benefits of the proposed greenway to adjacent homeowners and links this to resulting increases in tax revenue generated from the increases in property value of nearby residential properties. To estimate the benefit of a potential greenway program to nearby residential landowners, a hedonic model is estimated that includes traditional hedonic explanatory variables as well as land use variables.

The focus is on testing the general hypothesis that proximity to a greenway will have a positive impact on nearby property values and that these greenway-related environmental amenities or disamenities are captured by the property values. To test this hypothesis, the properties within a half-mile radius of the Mill Creek main stream have been selected in Hamilton County, Ohio. The half-mile radius captures most of the residences that might be impacted by the stream. The

economic and statistical focus of the analysis is the application of multiple regression analysis to isolate the impact of greenways on property values.

### **C. The hedonic pricing function**

The assumption behind the hedonic pricing model is that the housing prices are in equilibrium and represent the market-clearing price of buying a collection of property characteristics. The purchaser of the property is actually paying for this set of property characteristics and optimizes his or her choices based on the prices of alternative locations. With these assumptions, the sales price can be decomposed into a collection of the property characteristics and the form of the hedonic price model is an equation describing the house price as a function of structural characteristics (S), neighborhood characteristics (N) and environmental characteristics or factors (Q):

$$(1) \quad \text{Salesprice / Marketprice} = f(S, N, Q)$$

Structural characteristics variables were chosen to describe the size and quality of the property itself, and neighborhood characteristics describe the neighborhood and other location-related influences on property prices. The environmental amenities or disamenities can also factor into the sales price. The first order condition representing the optimal level of each environmental amenity,  $q_i$  can be written as:

$$(2) \quad \frac{\partial u / q_i}{\partial u / \partial x} = \frac{\partial P_k}{\partial q_i}$$

The left-hand side of equation 2 represents the marginal rate of substitution between the environmental attribute and the composite good or residential property, which is the marginal willingness-to-pay for the environmental attribute. The right hand side of equation 2 is the implicit marginal price of a characteristic. The partial derivative of the hedonic price function with respect to any characteristic yields its marginal implicit price. For example, if  $q_i$  is the distance to a river, then the first partial derivative represents the additional amount that must be paid to be located an additional unit closer to the river (Mahan, et al., 2000).

#### **D. Data collection and modeling**

The data for each single-family dwelling in the study area include structural, neighborhood, location, and water quality characteristics, as well as market value, from the year 2000 to 2002. The database was assembled from sources including the Hamilton County Assessor's Office, the Cincinnati Area Geographic Information System Organization (CAGIS), the U.S. Census Bureau, and the Ohio EPA Mill Creek TMDL. The parcels selected are within a 0.5 mile radius from the river to ensure that river attributes are reflected in the hedonic pricing function. There are 7,213 complete observations on our sample parcels along the Mill Creek within the 0.5 mile distance.

The normal choice of the dependent variable of the hedonic price function is the sales price of the property. However, the housing value chosen for this analysis is assessed value rather than sales value. The main difficulty with using actual sales prices is that some of the properties are more frequently traded than others and therefore the housing prices of those less traded are limited in number and quite old. In addition, there may be some concessionary sales. Property assessment procedures in Ohio have been standardized utilizing independent assessors for over 20 years, so they track sale prices quite closely. The dependent variable is the natural log of the assessed value, implying a nonlinear relationship between housing prices and the independent variables (i.e. structural, neighborhood and environmental characteristics).

The independent variables, their definitions and their expected signs (expected relationship to the dependent variable) are shown in Table 4. The descriptive statistics of variables are shown in Table 5. The environmental aspects of interest, those potentially affected by the proposed project, are water quality and tree coverage.

Table 4: Model Variables

Variable name	Description	Expected relationship to dependent variables
<i>DEPENDENT VARIABLES</i>		
ASSESSED MARKET PRICE	Mean market value for 2006 data and logged	
<i>STRUCTURAL VARIABLES</i>		
FULL_BATHS	Numbers of bathrooms.	Positive
FIREPLACE	Numbers of fireplaces	Positive
AIR_COND_C	Dummy variable for central air conditioning	Positive
LN_BUBAS	Total structure square footage	Positive
GARAGCAP	Garage capacity	Positive
LN_AREA	Lot square footage	Positive
Ln_AGE,	Log of year house was built subtracted from 2006	Negative
<i>NEIGHBORHOOD VARIABLES</i>		
LN_DTCINN LNDTCSQR	Natural log of distance to Cincinnati downtown and logged distance to Cincinnati downtown squared	Negative then positive
LN_DTSHO LNDTSSQR	Natural log of distance to major business district	?
CAUC%	Racial composition of the neighborhood	Positive
LN_Medi	Logged median income of each neighborhood	Positive
<i>ENVIRONMENTAL VARIABLES</i>		
ELEVATION	Elevation of property above sea level	Positive
SLOPE	Slope of property as a degree	?
LN_DTRI	Log distance from the property to Mill Creek	Negative
FLOOD	Location of the property with in 100 year floodplain area; dummy	Negative
IBI	Index of Biotic Integrity (IBI) measures fish health	Positive
ICI	Invertebrate Community Index (ICI) indicates in-stream biological community health	Positive
QHEI	Qualitative Habitat Evaluation Index (QHEI) is a qualitative visual assessment of the habitat in free flowing streams which mainly evaluates fish communities.	Positive
Urban	Land cover classified as urban	Positive
Wooded	Land cover classified as wooded area	Positive

Table 5. Household's Characteristics

	N	Minimum	Maximum	Mean	Std. Deviation
MEDIA INCOME	7213	12219	62763	32437.36	9971.146
FULL_BATHS	7213	0	4	1.30	.567
BIULDING SIZE	7210	240	11381	1415.04	623.571
AIR CONDITION	7213	0	1	.43	.496
FIREPLACES	7213	0	3	.16	.395
GARAGE_CAP	7142	0	20	3.14	6.10
LOTSIZE	6872	.01	10.50	.1750	.28022
AGE	7205	9	196	86.87	29.038
MKT_TOTAL_	7213	300	2000000	89982.47	73573.632
DISTANCE_TORIVER	7213	6.383	2639.852	1542.995	661.4297
DISTANCE_TODOWNTOWN	7213	3380.337	70399.896	30446.569	13748.2696
DISTANCE_TOSHOPPING	7213	5247.095	33799.229	23033.467	5318.6775
ELEVATION	7213	490	790	559.03	46.403
IBI	6917	15.0	27.0	20.867	3.4909
IWB	6835	3.3	6.3	4.694	1.0160
ICI	2926	6.0	44.0	21.377	9.9065
QHEI	7035	34.0	71.0	59.200	12.0059
FLOOD	7213	0	1	.03	.176
CAUC %	7213	.05	.98	.7600	.26268
SLOPE	7213	10	30	11.73	5.324
Urban	7213	0	1	.87	.337
Wooded	7213	0	1	.08	.276
SCH_1	7213	.00	1.00	.6114	.48747
SCH_2	7213	.00	1.00	.0995	.29941
SCH_3	7213	.00	1.00	.0503	.21863
SCH_4	7213	.00	1.00	.1339	.34060
SCH_5	7213	.00	1.00	.1048	.30633
Landuse_510	7213	0	1	.97	.162
Landuse_530	7213	0	1	.03	.162

## E. Water Quality

The Ohio Environmental Protection Agency (OEPA) has incorporated biological criteria into the State's Water Quality Standards and has conducted water quality and biological monitoring of Mill Creek and its tributary streams. The biological criteria that provide an indicator of water quality and the health of aquatic life includes: the Index of Biotic Integrity (IBI), the Invertebrate Community Index (ICI), the Modified Index of Well-Being (MIwb) and the Qualitative Habitat Evaluation Index (QHEI). The numeric values of IBI and MIwb are based on fish. The ICI focuses on macroinvertebrates, small, spineless aquatic insects that live at the bottom of streams, and the QHEI is used to evaluate physical riverine-riparian habitat.

The Level I land cover or wooded land classification is used as a proxy variable for greenways. Most of the properties in the study area are classified as Urban and some properties are classified as Wooded Land. A dummy or binary variable for wooded land is included to see whether property value would be significantly different in these areas than in others. If so, we can be more certain that greenways would increase property value.

## F. Regression model and results of analysis

Least squares regression analysis was used to estimate the hedonic price function. This function relates the value of real property to the structural characteristics of the property, neighborhood characteristics, and environmental characteristics such as water quality and elevation. The appropriate functional forms of the variables were chosen for the first-stage model based on previous literature reviews. See Table 4 for a description of the variables.

The model is specified in the following equation:

$$\begin{aligned} \ln \text{Assessed price} = & \beta_0 + \beta_1 \cdot \text{FullBath} + \beta_2 \cdot \text{Aircondition} + \beta_3 \cdot \text{Fireplaces} + \beta_4 \cdot \text{Garage\_cap} + \\ & \beta_5 \cdot \ln \text{Area} + \beta_6 \cdot \ln \text{Buildingsize} + \beta_7 \cdot \ln \text{Age} + \beta_8 \cdot \ln \text{MedianIncome} + \beta_9 \cdot \% \text{Cauc.} + \beta_{10} \cdot \ln \text{Dis} \\ & \text{tcin} + \beta_{11} \cdot \ln \text{Distcin}^2 + \beta_{12} \cdot \ln \text{DtMall} + \beta_{13} \cdot \ln \text{DtMall}^2 + \beta_{14} \cdot \text{Elevation} + \beta_{15} \cdot \text{Slope} + \beta_{16} \cdot \text{Flood} + \\ & \beta_{17} \cdot \text{Urban} + \beta_{18} \cdot \text{Wooded} + \beta_{19} \cdot \ln \text{ICI} + \beta_{20} \cdot \ln \text{QHEI} + \beta_{21} \cdot \text{DTRIV} \end{aligned}$$

Marginal implicit prices are derived from the partial derivative of the predicted hedonic price function with respect to each variable of interest. Five models are tested:

- Model 1 includes all observations within 0.5 miles of Mill Creek river corridor.
- Model 2 includes parcels within the Cincinnati Mill Creek Corridor.
- Model 3 includes parcels outside the major Cincinnati city area but still along the river corridor.
- Model 4 includes observations that have property value less than \$75,000. And
- Model 5 includes property value greater or equal to \$75,000.

The regression results are reported in Table 6. Overall, the data fit all five of the regression models well because all of them pass F tests (see Glossary Appendix). The structural variables control for the effects of these characteristics and are all significant at the 1%, 5% or 10% level

and display the expected positive sign. Several of the neighborhood variables are significant at the 5% level and explained variation (adjusted  $R^2$ ) is relatively high (61 to 79%) in all but Model 4.

### **G. Environmental characteristics**

The environmental amenities variables are the elevation of individual properties, the natural log of the distance to the main stream area, the slope of the property, a dummy or binary variable for parcels located within the 100-year floodplain, the water quality indicator variables Ln\_ICI and Ln\_QHEI, one land-cover dummy variable (Urban) for urban land cover, and the other land-cover dummy variable (Wooded) for Wooded/Forestry land cover.

Table 6 Regression Result: Cincinnati/Non-Cincinnati, Lower Price Houses /Higher price Houses Models

Model	Model I		Model II		Model III		Model IV		Model V	
	All households		Cincinnati, sch_co=1,20		NONCincinnati, sch_co=7,17,18		Market price <75,000		Market price ≥75000	
	Coeff.	T	Coeff.	t	Coeff.	T	Coeff.	t	Coeff.	t
(Constant)	-51.771***	-13.637	-116.412***	-14.667	19.085***	7.723	-21.964***	-2.598	-8.834***	-2.333
FULL_BATHS	.070***	7.222	.080***	6.632	.049***	3.948	.038**	2.000	.063***	10.655
AIR CONDITION	.116***	10.881	.131***	9.093	.070***	6.237	.103***	5.191	.033***	4.817
FIREPLACES	.090***	6.576	.102***	5.566	.059***	3.998	.043	.961	.092***	12.853
GARAGE_CAP	.005***	5.405	.006***	4.934	.003***	2.808	.007***	2.632	.006***	11.914
LN_AREA	.234***	23.309	.235***	17.840	.184***	14.440	.122***	6.191	.169***	26.375
LN_BUSIZ	.378***	25.945	.376***	20.008	.418***	23.933	.253***	9.426	.292***	29.403
LN_AGE	-.275***	-18.200	-.291***	-14.421	-.276***	-16.242	-.395***	-9.947	-.138***	-16.195
LN_MEINC	.069***	2.869	.177***	6.117	.258**	2.210	-.009	-.237	.017	.825
CAUC %	.150***	6.935	.139***	4.905	1.042***	15.248	.091**	2.242	.148***	9.407
LN_DTCIN	6.798***	13.189	-1.020	-1.112	-.789***	-5.087	.689	.740	-.950	-1.531
LN_DTCQRS	-.343***	-13.431	.035	.764	--	--	-.024	-.511	.032	1.062
LN_DTSHO	5.118***	8.224	25.213***	12.331	.254***	5.728	5.456***	2.884	4.783***	11.921
LN_DTSQRS	-.273***	-8.487	-1.243***	-12.250	--	--	-.264***	-2.786	-.253***	-12.047
ELEVATION	.002***	13.658	.002***	10.687	.001***	5.857	.000	1.199	.002***	19.743
SLOPE	-.011***	-10.546	-.009***	-7.032	-.006***	-4.148	-.010***	-5.257	-.003***	-3.720
FLOOD	-.081***	-2.988	-.059*	-1.913	--	--	-.038	-1.024	.054*	1.822
URBAN	.077***	3.513	.095***	3.123	.038*	1.768	.134***	2.871	.020	1.608
WOODED	.111***	4.189	.143***	3.910	.017	.609	.140***	2.354	.051***	3.375
LN_ICI	.194***	9.474	-.042	-1.048	.229***	3.138	.012	.330	.198***	10.137
LN_QHEI	.482***	8.124	.604***	6.104	-2.051***	-7.265	.002	.019	.268***	5.033
LN_DTRI	-.002	-.248	.013	.981	.032***	3.856	.015	1.048	-.022***	-3.702
R	.802		.785		.878		.555		.890	
R-square	.643		.616		.772		.308		.792	
ADJ. R-square	.642		.614		.770		.303		.791	
STD. ERROR	.3798		.4164		.2261		.4519		.1808	
F	617.917		392.648		380.497		70.476		696.105	
DF	(21,7191)		(21,5144)		(18,2028)		(21,3328)		(21,3841)	
P-value	.000		.000		.000		.000		.0000	
N	7213		5166		2047		3350		3863	

\* = p-value<.1, \*\* = p-value<.05, \*\*\* =p-value<.01.

The coefficients on the water quality indicator variables, QHEI and ICI, are generally positive and significant across the models, with the notable exception of Model 4, which includes only homes with an assessed value less than \$75,000. The positive coefficients imply that the higher the water quality, the higher the property value, although this principle may not hold in areas of low-value housing. This result supports the notion that improvements to water quality resulting from the proposed greenway and other measures provide some benefit to nearby residents. The magnitude of this potential benefit could be estimated if the expected water quality improvement can be quantified.

The coefficients of the Urban variable are significant at 10% in Model 1, Model 2, Model 4 and Model 5. The estimated coefficients of the Wooded dummy variable are positive and significant for Models 1, 2 and 5. This positive relationship with property value shows that property located in wooded area will have a higher value. In Model 1, the marginal implicit price of a wooded location shows that such an area will increase the property value by 10.75%. Thus, an increase in property values of approximately 11% would be expected if the proposed greenway system is created along Mill Creek and its tributary streams throughout the watershed. Again, this result can be used to quantify one potential benefit of fully implementing the Mill Creek Watershed Greenway Master Plan.

## **H. Links to property tax revenues**

For estimating potential greenway property tax revenue impacts, the increase in values of the water quality indicator and the existence of tree cover were assumed to be associated with positive impacts on residential property values. It follows that we could calculate the increase in tax revenue associated with these increases in property values. In order to get lower bound or more conservative estimates, we excluded the population outside of the City of Cincinnati's portion of the watershed. Using the average values of independent variables, the value of the average residential property was calculated as \$75,422. The increase in the property values from the proposed greenway was then calculated from the econometric model assuming the coefficient of wooded land cover variable. The construction of a greenway would be expected to increase the property value by almost 11%.

The increase in property value was also calculated for expected improvements in water quality by assuming that the greenway induced improvement in the ICI level from 18.6 to 25 and in the QHEI level from 57.8 to 65. We then derived the percentage increase in real property values with respect to the expected improvement in the two water quality indicator measures, increases of 5.00% and 5.66%, respectively. The increase in the parcel value was multiplied by the millage rate of \$89.48 per \$1,000 to determine how much tax revenue would be generated each year by the simulated increase from proposed construction of a greenway.

Using a property tax rate of \$89.48 per \$1,000 of assessed value, water quality-related improvements would generate an increase in property tax revenue of \$8,198,247 annually. Even if we reduce the expected change in water quality from the proposed greenway to one-half of our “best guess” assumption, it would still result in over \$4 million annually of additional property tax revenues, or benefit capture, for local government jurisdictions and the citizens they serve. The increased property taxes must be paid by the owners, but they are based on an increase in value of residential property not an increase in the millage rate. Thus, for each \$89 of additional tax a property owner must pay, the property value has increased by \$1000 and local government services to them have improved.

## **I. Comparisons of benefit transfer and onsite hedonic models**

It is now possible to compare the foregoing on-site results with the earlier benefit transfer analysis of hedonic pricing results from three stream restoration projects in California. These results from research by Steiner and Loomis (1996) were adjusted to reflect differences in the number and value of properties and stream flow characteristics. However, the California projects involved both construction of greenways and stream bank stabilization. On average, the California project increased residential property values by 13.2 percent. This percentage increase was multiplied by the average home values in Mill Creek and the resulting property value increases were translated into increases in property tax revenues based on millage rates in the two counties partially located in the Mill Creek watershed.

The total estimated annual increase in property tax revenues for the proposed Mill Creek greenway is \$5,528,853 based on this benefit transfer analysis. This estimate is less than on-site hedonic model estimation (except the low bound estimate from more conservative water quality

impact assumptions) but of a similar order of magnitude, providing some corroboration for the estimated benefits of the project.

## **VI. Benefit Transfer Estimation of Recreation Values**

### **A. Background**

Benefit transfer will be utilized as a tool to measure the potential recreation use benefits resulting from ongoing development of the Mill Creek Greenway/stream buffer system and more widespread use of other eco-friendly stormwater management strategies. Benefit transfer is especially useful when primary research is simply not possible or cannot be justified due to time and budget constraints, or when the potential impacts of the policy change are expected to be low. Benefit transfer should not be used however, as a replacement for primary data collection and thorough analysis. Using the above methods and several studies, we can now explore the potential recreational use values of implementing the Mill Creek Greenway Plan. All values discussed below are adjusted for inflation and reported in 2004 U.S. dollars unless otherwise noted.

In 2003, the Ohio Department of Natural Resources (ODNR) prepared its Statewide Comprehensive Outdoor Recreation Plan (SCORP). As part of this study, the ODNR conducted a survey of Ohio citizens' actual choices and stated preferences for outdoor activities. The survey does not provide estimates in dollar-terms of the benefits to citizens of such activities, but it does provide qualitative evidence to be considered along with such dollar-benefit estimates.

One part of the survey measured Ohio households' current participation rates in various trail activities. Approximately 73% of households engaged in walking for pleasure, 44% in bicycling (hard surface), 19% in in-line skating, and 25% in jogging/running. The ODNR concluded that "recreation providers should develop trail opportunities that serve the traditional trail activities" and "(multi-use trails) should be given strong consideration in development decisions." (ODNR, 2003, p. 4.20) All of these activities could be enjoyed on the recreation trails and greenways proposed in the Mill Creek Watershed Greenway Master Plan.

When asked about which types of trails should be developed in the future, Ohio households indicated the strongest preferences for community trail systems, walking trails, and hard-surface

bicycle trails. (ODNR, 2003, p. 4.25) These categories include the trail system proposed in the Mill Creek Greenway Plan, indicating that households support the development of such a system. These findings and the endorsement of trail-development by the ODNR lend further support to recognizing the potential for the Mill Creek Greenway Plan to provide recreational-use benefits for communities within the Mill Creek watershed.

## **B. Estimates of recreation use values**

In 1995, Siderelis and Moore studied the economic benefit of converting abandoned railways into scenic recreational trails. Individuals often use these renovated rail-trails for the types of activities that could be expected at Mill Creek including biking, jogging and walking. In addition, there are rails-to-trails opportunities within the Mill Creek watershed, since the Mill Creek Valley has historically served as a major north/south transportation route for trains. The authors studied three rail-trails in different communities in different parts of the U.S. with different characteristics. As a result, rough estimates of the economic recreational use value of a specific activity could be developed to estimate policy site-specific benefits.

The authors' first study site is the 26-mile Heritage Trail (a rail-trail along the Mississippi River) in rural Dubuque County Iowa. Second, the authors' studied the economic benefits of the 16-mile St. Marks Trail in northern Florida. The St. Marks trail is mostly rural but passes by several small towns. The third trail in their study is the 7.6-mile Lafayette/Moraga Trail near Oakland, California, which passes through several urban and suburban communities. None of these trails runs alongside a stream for any substantial length, although the Heritage Trail features numerous river crossings.

Using the Individual Travel Cost Method (ITCM), Siderelis and Moore found the economic value of individual trips to rail-trails. Based on revealed preference theory, the authors assumed that "individuals do not buy trips to a rail-trail unless they find it worth the price, as measured by their travel costs to that trail." (Siderelis and Moore, 1995) The travel costs in the study were the combination of vehicle-related costs and opportunity costs in the form of a foregone fixed portion (1/3) of an hourly wage per trip. The results of the study, average individual consumer surplus, per activity day are reported in Table 7.

Table 7. Benefits of rail-trail projects (*Siderelis and Moore, 1995*)

Study Site	Individual Consumer Surplus
Heritage (Iowa)	\$36.56
St.Marks (Florida)	\$60.31
Lafayette/Moraga (California)	\$5.83

The above values represent the benefits of recreational “rail-trail” use in three different settings. Although the authors studied rail-trails exclusively, they note that rail-trails have very specific characteristics. “They generally extend long distances, have very low grades, hard surfaces, straight alignments, and do not allow motorized vehicles. Only multi-purpose greenway trails might share similar characteristics and could be considered substitutes.” (Siderelis and Moore, 1995) Further, because of the unique characteristics of a rail-trail, the authors specifically studied the benefits of using the rail-trail for recreation or alternative transportation use only.

### C. Application to Mill Creek

The study described above presents several estimates of the value, in dollars per activity-day, of several activities which could be enjoyed on the proposed Mill Creek greenway trail system: walking, jogging, and cycling. The estimates range from \$5.83 to \$60.31 per activity day. While some parts of the urban Mill Creek watershed are relatively healthy and beautiful, other parts – particularly within the Mill Creek corridor in Hamilton County – suffer from blighted conditions. With this in mind, OSU assumed that few people would be likely to spend an entire day in recreation along the trail, unless they are in more scenic areas of the watershed similar to some of the study sites. In addition, the proposed Mill Creek trail, running through urban areas, seems most similar to the Lafayette/Moraga trail. Therefore, OSU decided that the lower end of the range of values is most appropriate for valuing activity-days on the proposed Mill Creek trails.

The Statewide Comprehensive Outdoor Recreation Plan (SCORP) survey provides estimates of the annual household participation rates for trail-based activities, which are summarized in Table 8 below (ODNR, 2003). In 2004, Hamilton County included 380,585 households. Assuming that participation rates in Hamilton County are similar to those statewide, the aggregate number of activity-days per year, across all trail-based activities, for Hamilton County residents is 32,743,440 activity days. Given the estimated value of \$5.83 per activity day, the aggregate recreational value from trail-based activities would be \$190,894,256 per year.

Table 8. Household Participation Rates

Activity	Households Participating	Activity-Days per Participating Household	Activity-Days for Hamilton County
Walking	73.4%	68.4	19,107,498
Jogging/Running	24.8%	81.7	7,711,261
Cycling	44.1%	35.3	5,924,681
<b>Total</b>			<b>32,743,440</b>

Note that this figure represents an estimate of the total value of trail-based recreation to Hamilton County residents, not just that portion that would be undertaken on the proposed Mill Creek trails. Additionally, some of the recreation that would take place at Mill Creek would be a substitution for that which would otherwise have taken place at existing trail resources. Although rigorously estimating the value that represents new benefits arising from the proposed Mill Creek greenways is beyond the scope of this analysis, we can undertake some rough approximations.

Conservatively, we might assume that one-quarter of the households in Hamilton County could recreate in areas that would be served by the Mill Creek trails. This represents approximately 95,000 households.

It is important to avoid double-counting in the form of recreational benefits accruing to residents whose home values increase as a result of the Mill Creek restoration. Such an increase in home values may reflect at least some of the additional recreational amenities offered by the proposed trails. Thus, a calculation of the recreational use benefits of the restoration project will exclude the 9,000 homes near Mill Creek which formed the population for estimating an increase in property values. This exclusion leaves 86,000 households whose recreational use benefits should be estimated.

A recent study (Hitzhusen, F.J. 2007, Ch. 10) of the Lower Great Miami River in Ohio offers some rough guidance as to how much new usage the Mill Creek trails might spur. The authors estimated the impact that constructing additional access points to the river for boating and other recreation would have on the usage level of the river. Using focus groups and research by Silva, et al (2000), the authors concluded that the proposed additional access points would increase the number of recreational uses of the river by three visits per person annually. From their initial estimate of 18 trips per year, this represents a 16.7% increase in the usage level.

The Lower Great Miami River study focuses on recreational boating, which is not a current river use for Mill Creek and its tributaries. Moreover, despite their geographic proximity, the two rivers have different physical characteristics and settings. For example, the Lower Great Miami meets the basic aquatic-life-use criteria set forth by the Ohio EPA (Hitzhusen, et. al., 2007), indicating that it is not as degraded as Mill Creek. Also, the Lower Great Miami runs through primarily rural areas, while the section of Mill Creek under consideration has a decidedly urban setting. Thus, transferring the estimates from the Miami study site offers only a crude approximation of the benefits at the Mill Creek policy site. Using the SCORP estimates previously discussed, we calculate the estimates for the increase in recreational activity presented in Table 9.

Table 9. Increase in Recreational Activity

<b>Activity</b>	<b>Participation Rate</b>	<b>Households</b>	<b>Activity per Household</b>	<b>Initial Activity</b>	<b>16.7% Increase in Activity</b>
Walking	73.4%	61,656	68.4	4,217,270	704,384
Jogging/ Running	24.8%	20,832	81.7	1,701,974	284,230
Cycling	44.1%	37,344	35.3	1,307,653	218,378
<b>Total</b>					<b>1,206,892</b>

Thus, a rough approximation of the increase in recreational activity in Hamilton County that the proposed Mill Creek trails would generate is 1,206,892 additional activity-days per year of walking, jogging, and cycling. Using the previous estimated benefit of \$5.83 per activity-day, this increase would provide an annual benefit worth \$7,036,180 to recreational users of the trail system. It is very important to note that the estimation method is preliminary and the estimates should accordingly be only the most general indication of the potential recreational benefits of the Mill Creek Restoration/Greenway Program. For example, if we had assumed that only one eighth (rather than one fourth) of the households in Hamilton County could recreate in areas to be served by Mill Creek trails, the benefit estimate is reduced by 50% to \$3,518,090. In reality, this might be a more realistic estimate.

## VII. Summary and Conclusions

Since implementation of the Mill Creek Watershed Greenway Master Plan is still in its early stages this resource economics study attempts to provide some estimates of possible economic benefits from development of the entire Mill Creek Greenway system. Benefit transfer methods are used to adjust the benefit estimates for both river corridor residential property owners and recreational users from other greenway studies. In addition, on-site data are collected to estimate a hedonic pricing model for residential property values in the Mill Creek corridor. Finally, both the benefit transfer and on-site estimation of residential property value impacts are linked through millage rates to estimate impacts on property tax revenues to local governments and school districts in the Mill Creek corridor.

In all cases OSU attempted to generate conservative and defensible estimates of potential economic benefits from the proposed greenway. This included explicit methods to net out any double counting of benefits to property owners and recreational users of the greenway trails. It also included a discussion of the historic context of Mill Creek, resource economic methods and available literature on applications of these methods in other river corridors. A book published in 2007, edited by Hitzhusen on Economic Valuation of River Systems from Edward Elgar Publishers, spells out these methods and application to a wide range of cases in further detail.

In general, our conservative estimates provide some promising evidence of economic benefits from the proposed Mill Creek Greenway system. For example, full implementation of a greenway that provides stormwater and floodplain management, prevents and reduces streambank erosion and provides a multi-purpose recreation trail along the Mill Creek could provide \$104 million increase in property values in the corridor based on OSU's benefits transfer analysis. This translates into an annual rent equivalent (see Glossary Appendix) of \$7.28 million or an annual increase in property tax revenues of \$5.5 million. The on-site data collection and estimation of the hedonic pricing model showed an eleven to sixteen percent increase in residential property value from corridor tree cover and water quality improvement. This translates into a \$5.5 to \$8 million annual increase in property tax revenue. The benefit transfer results for annual recreation value of the greenway ranged from \$3.5 million to \$7 million depending on use rate assumptions.

In summary, adding the low estimate of annual recreation benefits and property value increases results in an annual total of \$9.5 to \$10.8 million in economic benefits for Mill Creek and surrounding communities. In addition, annual increases in property tax revenues of \$5.5 to \$8 million will accrue to local governments and school districts and may provide improved services to property owners and taxpayers.

Alternatively, one could take the range of \$70 to 104 million increases in property value and add discounted (at 7 percent) annual recreation benefits of \$3.5 million over 20 years and come up with a range of \$107.1 to \$141.1 million in discounted present value. Finally, the CITYgreen analysis conducted for the Mill Creek River Resource Economics Study also documents other quantifiable economic benefits from increasing the tree canopy within the river corridor, thereby achieving improved air quality, increased carbon sequestration, and greater stormwater volume storage benefits. Over a twenty-year period all of these benefits provide substantial rationale for implementation of the Mill Creek Watershed Greenway Master Plan.

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## IX. Glossary of Terms

**Assimilative Capacity:** The capacity of a natural environment to receive waste without deleterious effects on aquatic, human, plant or animal life (See carrying capacity).

**Biodiversity:** The size and composition of plants and animals in a certain environment. Since environmental degradation is concomitant with a decrease in the number of species able to survive, biodiversity is considered to be a barometer of the health and complexity of any environment.

**Carrying Capacity:** (1) In recreation, the amount of use a recreation area can sustain without deterioration of its quality. (2) In wildlife, the maximum number of animals that an area can support during a given time of the year. (3) Some authors apply the concept to the human population planet earth can sustain (See assimilative capacity).

**Classical Economics:** An era of economic thought, circa (1750-1870), in which a group of predominantly British economists used Adam Smith's works to analyze production, distribution and exchange. The pillars of this school include the labor theory of value, comparative advantage theory, the Malthusian population theory, and the quantity theory of money (See Neo-classical Economics).

**Consumer Price Index (CPI):** A monthly measure of changes in the prices of goods and services consumed by families and individuals. The cost of a *market basket* in a base year is assigned the number 100 and indexes for subsequent years are relative to the base year.

**Consumer Surplus:** An approximation of willingness-to-pay as defined by the area under the demand curve and above the ruling price.

**Contingent Valuation (CY):** The direct questioning of individuals about the valuation placed on environmental or other resources or amenities. The CY method can be used for

direct estimation of willingness-to-pay, existence values or option value (See Travel Cost Method).

**Cost/Benefit Analysis (CBA):** A quantitative evaluation of the *true* costs versus benefits to society of a proposed plan of action.

**Demand Curve or Schedule:** The relation between the price of a good or service and the quantity demanded, *ceteris paribus*.

**Diminishing Marginal Utility:** The generalization, sometimes called a law, that the more you have of anything (e.g., goods, services, money), the less important one additional unit of it is.

**Discounting:** Reducing an uncertain future economic value to an equivalence with a certain current economic value, through the use of a discount rate.

**Dummy Variable:** Also called a binary or zero: one variable meaning each observation does or does not have a particular characteristic.

**Economic Surplus:** Composed of consumer surplus to buyers and producer surplus to sellers. The first is the difference between the maximum amount of money a consumer is willing to pay and what is actually paid. The second refers to the difference between what resource owners earn in current use and the minimum sum they would be willing to accept.

**Ecology:** The study of the interrelationships between living organisms and their environment, both in the physical and biological senses.

**Elasticity:** (own price) The relationship between the percent change in quantity of a good or service demanded or supplied and the percent change in price of the good or service.

**Elasticity:** (income) The relationship between the percent change in quantity of a good or service demanded (e.g., food) and the percent change in income.

**Existence Value:** The value placed on a resource or amenity by an individual because of its existence irrespective of use, such as placing a positive value on the existence of a population of fish even if one never fishes.

**Externality:** An incidental, third-party or external effect from economic production or consumption activity which is not accounted for by the market price.

**F-Test:** Also called F-ratio is the ratio of two independent variance estimates.

$F = MS_B / MS_W$  so when the null hypothesis ( $H_0$ ) is true and both  $MS_B$  and  $MS_W$  are estimating the same parameter,  $\sigma^2$  (the variance among observations) the expected value of their ratio (F) is approximately 1.0.

**Gross Willingness-to-Pay:** The total amount one is willing to pay for a resource or amenity rather than go without it. It is approximated by the area under the demand or average revenue curve up to the level of consumption (See Net Willingness-to-Pay).

**Infrastructure:** The transportation network, communications systems, legal and financial institutions, and other public and private services necessary for economic activity.

**Neo-Classical Economics:** It is a re-statement of classical economics in terms of differential calculus (marginalist approach), while discounting the heavy emphasis on natural law that the classical school embraced (See Classical Economics).

**Net Willingness-to-Pay:** Gross Willingness to pay minus the cost of purchasing the output.

**Non-point source pollution:** Pollutants that cannot be traced to a specific source, e.g., storm water runoff or soil erosion (See Point Source Pollution).

**Opportunity Cost:** The value of the foregone or sacrificed opportunity, i.e., the economic value of resources in their highest value use.

**Option Value:** The value placed on a resource or amenity by an individual to maintain the possibility of using the resource or amenity at some future time, such as placing a positive value on a population of fish because one might want to fish for them at a future time.

**Point Source Pollution:** Pollutants that can be traced to a specific source such a factory smokestack or chemical spill (See non-point source).

**Property Rights:** Description of the relationship of one person to another with respect to a re- source or line of action. Property is the right, and not the object over which the right extends.

**Renewable Natural Resources:** Resources such as forests, rangeland, soil and water that can be restored and improved.

**Rent Equivalent:** The annual change in potential rent from a property from a change in the value of the property.

**Resource Allocation:** The distribution of resources among competing uses. Optimum resource allocation is achieved through the price system in which resources move from less to more profitable uses. In fact, economics itself has been defined as the study of how resources are allocated.

**R-Squared:** In multiple regression (statistical) analysis  $R^2$  is a metric that shows the percent of variation in the dependent variable e.g., property value explained by the independent variables, e.g., size of house, proximity to natural amenities, etc.

**Social Time Preference:** Incorporating a concern for future generations in the determination of an optimal discount rate.

**Travel Cost (Recreation) Demand (TO:** An approximated demand for recreation activities using proxy variables such as number of trips for quantity demanded and the cost of travel and other recreation expenses for price. The estimated TC demand function allows estimation of consumer surplus (See Contingent Valuation).

**Watershed:** The total land area, regardless of size, above a given point on a waterway that contributes runoff water to the flow at that point. It is a major subdivision of a drainage basin.