Ecosystem Services in Urban & Developing Areas: Current Knowledge and Market Development

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Executive Summary

This report presents the findings of research estimating economic values and market development strategies for ecosystem services in urban and developing (urban-rural interface) communities. In recent years there has been a significant amount of research dedicated to the interaction of humans and ecosystem services in urban settings. The urban ecosystem represents a unique and complex combination of natural resources and human infrastructure.

The report is organized into sections discussing water, air, recreation and energy ecosystem services. In each section, various studies that estimate economic values for the benefits provided by these ecosystem services are reviewed, and markets and market-like mechanisms for provision and payment of these services are discussed. The report concludes with a descriptive list of organizations actively working to enhance, promote, and create markets and market-like mechanisms for protecting urban forests and the ecosystem services provided by these forests. Previous studies reviewed in this report estimating ecosystem service values indicate that the flow of benefits through the protection, maintenance, and enhancement of urban forests are substantial.

Key research findings include:

- In the past 50 years, human use and management of ecosystems has resulted in extensive ecosystem changes; for example, conversion of forests to developed urban uses.
- Conversion of forests and other natural areas to developed urban uses over the past 50 years has often resulted in net gains in human well-being and standards of living, but at increasing social costs.
- Social costs of forest loss include the loss of ecosystem services provided by trees and forests, many of which are in the nature of nonmarket benefits (e.g., air and water quality benefits).
- Many reliable techniques have been developed and applied to estimate the economic value of ecosystem services provided by urban forests including nonmarket benefits.
- To protect and provide ecosystem services, the United Nations Millennium Ecosystem Assessment recommends the elimination of subsidies that create incentives for overusing ecosystems, redistribution of these subsidy funds to ecosystem service payment schemes, and the use of market-based mechanisms that account for both market and nonmarket benefits and costs of ecosystem service use and management.
- Market and market-like mechanisms for urban forest ecosystem service provision and payment are a mix of public and private initiatives including conservation easements, direct payments, grants, land acquisition, loans, rebates and credit trading programs.
- Examples of cap-and-trade credit trading programs illustrate that, with limited government involvement, private transactions for ecosystem services are feasible (e.g., U.S. EPA SO_2 credit trading program).

- Various payment-for-ecosystem service programs (e.g., subsidies for tree planting) and private transactions (e.g., carbon credit trading programs) provide potential market and market-based mechanisms for sustaining urban forests and associated ecosystem services.
- The economic valuation studies reviewed in this report employ a variety of valuation techniques that vary in the specific service valued, unit of measure, timeframe of valuation, and aggregation method.
- Specific economic valuation techniques used in the studies reviewed in this report include Benefits Transfer, Conjoint Analysis, Contingent Valuation Method, Economic Impact Analysis, Energy Savings Analysis, Hedonic Price Method, Travel Cost Method, the Value of a Statistical Life, and the Water Balance Method.
- Use of each economic valuation technique depends on the specific service to be valued and the type of data available. No one technique can be judged "better" than another, as none of these techniques can find the one "true" value for the ecosystem service in question or is appropriate in every instance.
- The range of value estimated reported in previous studies varies quite widely by ecosystem service and region. Thus, it is difficult to directly compare ecosystem service values across studies (e.g., comparing "apples" to "oranges" problem).
- Water-based ecosystem services supported by forests valued in previous studies include water quantity, water quality (flow, storage, conservation), water clarity, wastewater treatment, storm water run-off control, stream bank restoration, wetlands protection, amenity values and general in-stream of off-stream benefits.
- With respect to air, previous studies primarily valued the contribution of forests to air quality. Previous studies also valued air-based ecosystem services in the form of ambient air temperature reduction, ambient air carbon sequestration and aesthetic values (e.g., visibility).
- Urban forests support a wide array of recreation activities including walking, hiking, biking, wildlife observation and photography, and fishing. Related to recreation and leisure, urban forests also provide green space that is aesthetically pleasing to people (e.g., scenic viewing values).
- In the energy arena, previous studies primarily valued the contribution of urban trees and forests to energy savings. Increases in urban forests lead to ambient temperature reduction and energy savings through increased shade and wind protection.
- An appendix accompanies this report that includes tables with detailed information on ecosystem service valuation estimates and market and market-like mechanisms for ecosystem service provision and payment.

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Section I: Introduction

This report compiles and presents available information related to the economic value and market development strategies for ecosystem services focusing on urban ecosystems. The main ecosystem service (ES) categories described in this report are: water, air, recreation, and energy. A primary purpose of this report is to review studies that estimate ES values within the urban interface or those studies concerning ecosystem services which directly impact urban well-being. Another purpose of this report is to review literature on current attempts to develop ES markets. There is a sub-section within each section outlining various payment mechanisms for each ES discussed on a continuum of options starting with purely private endeavors and moving towards purely government funded programs. The remainder of this section introduces ES concepts, the economic issues involved in ES valuation, urban ecosystem concepts and ecological issues associated with the urban interface.

Ecosystem Services

Ecosystem functions (EF), such as nutrient cycles, waste flow and recycling, produce goods and services that support life and provide social benefit to humans (Daily, 1997; Brown et al., 2007). Costanza et al. (1997) identified 17 specific functions and services provided by the natural world from complex cycles (gas and water regulation) to aesthetic, cultural and recreation services. ES distribution is dynamic and spatially variable (Chan et al., 2006). There is a high level of dependency among various ecosystem functions creating synergistic effects in both ES benefits and decisions at local levels that affect ES provision. Often these effects spill over into other areas and create larger regional or global problems (Pritchard Jr. et al. 2000). This spillover is particularly important when the various ES benefits accrue to stakeholders over space and time, creating conflicts over the intrinsic value of ecosystem services (Hein et al. 2006).

The Millennium Ecosystem Assessment (MEA) (2005) found that during the past 50 years, humans have had more impact on the world's ecosystems than at any other time in the history of human civilization. The changes brought about during this period have created a net economic gain in well-being, but at increasing environmental costs to society. In order to decrease these costs, while maintaining economic growth, changes in peoples' perceptions of ecosystem services and policies impacting ecosystems and ecosystem services are needed. The issues of most concern include: corrupt government and institutional partnerships, social and behavioral factors, underinvestment in technology, insufficient knowledge, and market failures (Reid et al. 2005).

The Urban Ecosystem

Nowak et al. (2005b) defined an urban area as a cluster of one or more census blocks with population density exceeding 1,000 individuals per square mile, the areas surrounding these clusters with a population density greater than 500 individuals per square mile, and the less populous enclaves, indentations, and connections formed by these clusters. Based on spatial modeling, land classified as urban is increasing. This increase is particularly acute in transportation corridors and coastal regions. In urbanizing areas, developed land uses such as residential, commercial and industrial uses have a higher real-estate market value than less developed land uses such as agriculture and forestry. This price differential frequently leads to one-way urban land transformations from agriculture and/or forestry uses to developed uses (Notman et al. 2006). Based on current data, land classified as urban is expected to triple in area by 2050 with 60% of the world's population living in cities by 2030 (Bolund and Hunhammar 1999; Nowak and Walton 2005a). This increase in urbanized land has serious effects on agricultural and forest lands, including increasing the probability of fire in the urban-wildland interface, exotic pest infestations, unmanaged recreation problems and increased edge effects (Nowak and Walton 2005a). This pattern of land use will have significant impacts not only on the natural world and the ecosystem services provided, but also upon human populations.

Urban areas have been a topic of considerable research during the past few years with studies improving the understanding of ecosystem functions and the links to human induced pressure on natural resources and environmental degradation (Pickett et al. 1997). Urban areas are a unique type of ecosystem melding natural and constructed components in a complex combination of human infrastructure, both physical and social, and natural components that exhibit spatial variability. For humans this is seen by the disproportional flow of capital, population and social hierarchies through neighborhoods and in nature by the flow and amount of ecosystem services in these same neighborhoods (Pickett et al. 1997; Pickett and Cadenasso 2006). It has become increasingly important to acknowledge the human component and its effects on ecosystem services. Urbanization has the combined effects of decreasing forested land while increasing population density and associated human activity. These effects increase the risk to remaining urban forests and the ecosystem services produced, making these forests vital to urban populations.

In order to adequately protect and provide vital ecosystem services from urban forests, management plans that focus on ecosystem services rather than traditional forest commodities, tree health or urban forest structure are needed (Nowak et al. 2005b). This change in planning objectives emphasizes the need for integrated ecosystem management and collaborative decision making. Keough and Blahna (2006) recommended a set of eight criterion needed to create an integrated ecosystem management policy: (1) integrated and balanced goals, (2) inclusive public involvement, (3) stakeholder influence, (4) consensus group approach, (5) collaborative stewardship, (6) monitoring and adaptive management, (7) multidisciplinary data, and (8) economic incentives.

Economics

The MEA found that approximately 60% of ecosystem services worldwide are in some state of degradation (Reid et al. 2005). A primary cause for this stems from failure to include nonmarket benefits and costs when valuing these services. The market value of ecosystem services represents only a portion of total ES value, in some cases less than a third of the total value. To combat these shortcomings and degradations, the MEA (2005) suggests several steps to improve ES valuation and allocation including elimination of subsidies creating overuse incentives and transfer of these funds to ES payments where applicable. Increasing market-based methods of ES management is also recommended.

The characteristics of ecosystem services create difficulty in market development and transactions for these services. Randall (1987) asserted that goods and services can be classified into four categories based on the degree of rivalry and exclusiveness they exhibit.

1. *Rival, Exclusive*. Rival and exclusive goods and services are bought and sold in the marketplace and are termed "private goods". These goods have well-defined property rights allowing for efficient marketplace allocations. An example of a private good is the sale of timber rights.
2. *Rival, Nonexclusive*. These are goods where consumption limits availability for others, but there is no method to actually restrict access or consumption. A congested urban park is an example of a rival, nonexclusive good.
3. *Nonrival, Exclusive*. This type of good could be provided by the public or private sector. However, the nonrival nature of the good does not allow for voluntary trades to be initiated. Assuming that congestion is not a problem, a private beach with restricted access points is a nonrival, exclusive good.
4. *Nonrival, Nonexclusive*. Goods in this category are termed "public goods". Consumers cannot be excluded and consumption does not limit availability, creating no incentive to buy or sell. Oxygen emitted into the atmosphere by trees in urban forests is an example of a public good.

Ecosystem goods and services can be classified into all of the above categories. The values of ecosystem goods (e.g. timber and fish) are easily quantifiable due to market transactions. The services provided by ecosystem functions are less tangible. Ecosystem goods can be characterized as rival, exclusive or rival, nonexclusive, while ecosystem services would be categorized as nonrival, exclusive or nonrival, nonexclusive. The nonrival and nonexclusive characteristics of ecosystem services prevents inclusion in markets, leading to systematic undervaluation due to difficulties quantifying the indirect benefits of these services (Notman et al. 2006; Brown et al. 2007). Consumption of a nonrival good or service by one individual does not reduce the amount of the good or service available for consumption by other individuals, and nonexclusive characteristics allow ownership, but do not preclude another person from using or consuming the good or service in question. To illustrate the impact that valuing nonmarket benefits of ecosystem services can have, Costanza et al. (1997) estimated the annual global value of ecosystem services to be $33 trillion. While this article created controversy about the absolute value of ecosystem services, it focused attention on the fact that these services do have economic value and attempts should be made to assess ES values when making policy decisions. A key problem to the oft exclusion of ecosystem services in federal, state and local policy decisions relates to difficulties in estimating ES values and assigning property rights.

In order to address this valuation problem, economists have developed techniques for estimating the economic value of nonmarket goods and services which can be applied to measure the value of ecosystem services to society (Young 2005). Nonmarket valuation techniques are divided into two major categories: revealed and stated preference techniques. Revealed preference techniques use market expenditures as a proxy for the price of a nonmarket good or service to determine its value. Stated preference techniques ask individual respondents to indicate their willingness to pay (WTP) for the nonmarket good or service in question. The Travel Cost Method (TCM) and Hedonic Price Method (HPM) are common revealed preference techniques. The Contingent Valuation Method (CVM) and Conjoint Analysis (CA) are common stated preference techniques. The following is a brief description of these nonmarket techniques, including criticisms. Also included here is an explanation of economic impact analysis and an introduction to ES markets.

Travel Cost Method (TCM)

The TCM is a method for estimating WTP for a recreation visit using the cost of travel to the recreation site as a proxy for site entry costs. Variations in individual trip costs and the relationship between travel cost and site access allows for estimation of a demand curve for recreation use. This demand curve allows for estimation of consumer surplus (CS), the difference between what an individual pays and the maximum amount that he would pay. When aggregated over the sample population, CS represents the net social benefit of the good or service in question. Drawbacks to using this method include the unresolved issues associated with joint costs on multiple purpose trips, the assumption of no utility or disutility from travel and the appropriate measure for the opportunity costs of time. Opportunity costs of time represent the value of time to an individual, typically expressed as a fraction of an individual's wage rate. These costs imply that the person could be using that time for something else of value such as earning additional income (Bowker et al. 2007; Brown et al. 2007).

Hedonic Price Method (HPM)

The hedonic price method (HPM) is a technique for estimating the implicit price of a characteristic that differentiates related products within a given class, most often used to value property attributes (Freeman III 1993). This method uses property value as a proxy to a property owner's WTP for specific attributes of a property, including various environmental quality attributes (Brown et al. 2007). An oft used example in the literature is air quality and its effect on property values. A primary problem with applying the hedonic price method is that the model only captures values related to the property itself and not environmental improvements in surrounding areas (Freeman III 1993).

Contingent Valuation Method (CVM)

CVM is a stated preference method that presents the respondent with a hypothetical payment scenario for a good or service and asks the individual to state their individual WTP for a change in the provision of the good or service (Brown et al. 2007). This technique has been used in many scenarios including estimating WTP for improved water and air quality. The validity of WTP estimations derived from CVM have been questioned because of the hypothetical nature of the valuation question. However, many studies have shown that if constructed in an appropriate manner and applied under appropriate conditions, this method generates reliable and defensible estimates of the economic value of nonmarket goods and services (Loomis et al. 2000).

Conjoint Analysis (CA)

CA was originally developed by marketing researchers as a means of estimating the incremental value of the attributes of market goods such as attributes or characteristics of automobiles and houses. In recent years, CA has been extended to estimate the value of attributes of environmental goods and services. CA presents the respondent with several choice sets containing alternative bundles of goods and services with varying levels of attributes within the choice framework (Young 2005). The individual then ranks the two bundles within each choice set by choosing the one which maximizes utility. In doing so, the individual makes a choice much like they would in a market situation (e.g., choice between two automobiles or houses with different attributes). When analyzed over a sample population, the researcher can make an inference about the value of the particular attribute based on choice behavior (Holmes and Adamowicz 2003). Like the other techniques presented, WTP is based on a proxy and not a market transaction.

Benefit-Cost Analysis (BCA)

Despite the drawbacks of non-market valuation techniques, these techniques can improve the accuracy of the Benefit-Cost Analysis procedure. BCA evaluates a proposed policy or management action by comparing benefits against costs (Brown et al. 2007). BCA is a federal requirement for most projects that will receive federal funding and has been a part of large scale water projects since the 1902 passage of the Water Reclamation Act (Young 2005). Only relatively recently have nonmarket benefits of ES been included when evaluating environmental projects. The inclusion of these nonmarket benefits allows for a more complete accounting of a policy or project proposal, improving the probability of a socially equitable outcome.

Economic Impact Analysis

Economic impact analysis is another method for evaluating the efficacy of a policy decision. Economic impact analysis estimates the changes in regional economic activity that result from some action, measured as changes in visitor spending, regional income, and/or employment (Stynes 2004). Economic impacts are the direct and indirect effects of the money a visitor spends in a local economy attributed to the resource they are there to enjoy. Using visitation rates and recreation related expenditures, the direct effects attributed to the recreation resource can be determined (Stynes 2004). In order to estimate total economic impacts on the local economy composed of the direct and indirect effects, additional information is needed. This additional information, capture rates and multipliers, is specific to each economy and requires an input-output model to estimate. One of the most popular input-output models used today is the IMPLAN (Impact Planning) model.

Markets

Since the inception of tradable SO_2 permits in the U.S. in 1990, markets have gained prominence as a method of protecting ecosystem services. Markets can play an effective role in reaching environmental protection goals if they are well designed for their particular purpose. In order to develop an efficient market for ES exchange, several requirements must be met. These requirements include: variable marginal costs for abatement, a positive correlation between the uncertainty of marginal costs and benefits of abatement, and low transaction costs (Stavins 2005). In order for market creation and proper functioning, a strong government presence is needed to define the parameters, issue the initial property rights, monitor implementation and regulate when necessary (Bayon 2004). The current and planned market and trading schemes represent a continuum with government pay schemes and private markets occupying the extremes of the spectrum. Between these two extremes is a mix of public-private partnership that varies in the degree of participation by public entities. There are four primary mechanisms of exchange for ecosystem goods and services (Notman et al. 2006; Brown et al. 2007):

1. *Individual Buyer, Government Seller*. Under this mode of exchange the government finances the management of public lands and provides access rights by redistributing tax dollars. Examples of this include park entry fees, hunting licenses, and grazing rights.

2. *Government Buyer, Individual Seller*. In this situation an individual receives a subsidy or payment for ES protection and provision. These incentive programs induce the private land owner to make decisions that are socially optimal. Examples of this type of exchange include the Conservation Reserve and Wetlands Mitigation Banking programs.

3. *Government Buyer, Government Seller*. Through these exchanges the federal government pays local or foreign governments for ES protection and provision. Examples include federal wastewater treatment payments and foreign development aid to create environmental programs in developing countries.

4. *Individual Buyer, Individual Seller*. This is the private market. In this situation, limited government involvement is needed (primarily establishment and enforcement of property rights). Traditional markets for environmental goods are prevalent for timber, mining, and private recreation experiences. However, there have been recent advances in ES market development as well.

Examples include private trusts purchasing conservation easements, and private companies paying landowners to protect biodiversity.

Section II: Water

This portion of the report focuses on those ecosystem services provided by or as a result of hydrologic cycle functions. Of primary interest are the benefits to society generated by water in the urban interface. This section contains two sub-sections. The first is a review of literature on water ES valuation focusing on water quality, flood control, erosion and sedimentation, water supply, pollution dilution, storage, and flow regulation. The second sub-section contains examples of governments, organizations, and citizens developing and implementing market initiatives to value and protect water based ecosystem services. At the end of this section and all subsequent sections, a summary of key information is outlined.

Literature Review

This literature review is divided into four parts. The first part focuses on studies using the hedonic price method. The second part introduces studies employing CVM. This is followed by a review of various studies using other valuation techniques to estimate water based ES values. The final part of this literature review presents the benefit-cost analyses (BCA) of several studies related to urban water and its provision.

Hedonic Price Method

The following is a non-exhaustive list of studies that address aspects of water quality in the urban interface and their relationship to housing prices. Steinnes (1992) found that an additional foot of water clarity on Minnesota lakes increased shoreline property value $206 per lot. This equates to a five percent property value increase per one foot improvement in visibility.

A hedonic price analysis was used to evaluate the impact of urban stream restoration programs in California communities by Streiner and Loomis (1995). A comparison was made between housing prices in areas that received funding for stream restoration and those that did not. Values were measured against three restoration "packages," environmental, engineering and a joint model of environmental and engineering packages. The environmental restoration package provided the highest increase in total property value, $52,200. The joint package providing environmental trail and stream stabilization was estimated to increase total property value by $19,080 while an engineering package of stream stabilization and flood damage reduction increased total property value by roughly $12,300 in those communities receiving stream restoration funding.

Michael et al. (1996) found Maine waterfront properties increased, on average, between $11 and $200 per foot of frontage for a one meter increase in water clarity. Mahan et al.(2000) used the hedonic price method to estimate the value placed on water resources by owner occupied single family residences in Portland, OR. Estimates indicate that proximity to a water resource increases the value of a home. Research found that decreasing the distance between a wetland and a residence by 1,000 feet increased marginal property price by $436 when based on an initial distance of 1 mile. This figure decreased to $260 when the water resource was a stream and increased to $1,644 when evaluated for proximity to a lake. Aside from the value in the general improvement of water quality, the literature also finds that homeowners are willing to pay specifically for the health aspects of improved water quality. Leggett and Bockstael (2000) found reductions in fecal coliform to state levels, 200 counts per 100 mL, led to an increase in the aggregate value of waterfront property along the Chesapeake Bay in Maryland of $12 million.

Cho et al (2006), the final hedonic study presented, estimated the value that water bodies within Knox County, Tennessee had on property values. This study employed a combination of digital parcel records and GIS, in conjunction with 2000 census information, and mapping data from the Environmental Systems Research Institute (ESRI). A total of 15,500 randomly selected parcels were used in this analysis. A weighted hedonic model was employed to account for differences in spatial variability between lakes and properties and the influences this would have on individual property value. Findings show that, measured from an initial distance of 1 mile, mean house price increases between $497 and $6,032 for a 1000 ft. decrease in distance to an individual body of water (Cho et al. 2006). In addition, this study also measured the effect of green space on housing price. These results will be presented in the recreation section of this report.

Contingent Valuation Method

The literature contains several examples of CVM applications for water quality improvement. One such study explores perceptions that Georgians have about drinking water quality, their WTP for its improvement and overall support for water quality improvement policies (Jordan and Elnagheeb 1993). In this study, the authors found an average annual WTP of $121 and $149 per household by city/municipal and private well users to avoid increased risk of groundwater contamination by nitrates. These estimates provide an aggregate annual value for decreased risk of drinking water contamination of $275 million statewide.

In North Carolina, Paterson et al. (1993) estimated the value urban households place on the benefits of public oversight and enforcement of erosion and sedimentation control. Households reported an annual WTP of $20 for this public service. The statewide value of maintaining erosion and sedimentation control in North Carolina was estimated to be $14.2 million annually.

Stevens et al.(1995) found that non-use values provided by wetlands in New England were a significant part of their total value. Results indicate that residents support wetlands preservation and the various ecosystem services that wetlands provide. Residents responded that having these areas preserved for future generations (54%) and knowing that they were protected (35%) were both valuable. Reported average annual WTP for all wetland types within 25 miles of respondent's residence was $114 per person over the proceeding five years. By wetland type, the highest per person WTP was for preserving wetlands containing rare plant species ($80-96). Annual WTP for wetlands providing flood protection, water supply and pollution control were between $74 and $80 per person. Aggregate benefit estimates for New England wetland preservation was $242-$313 million annually.

Loomis et al. (2000) estimated WTP for ES restoration along an impaired river in Colorado. The target restoration area was along a rural section of the river, but this restoration would provide tangible benefits to downstream urban inhabitants. The specific ecosystem services included for valuation were wastewater dilution, natural water purification, erosion control, habitat for fish and wildlife, and recreation. Mean household WTP was estimated at $21 per month or $252 annually for an increase in ES provision along the 45-mile study area including the purchase of 300,000 acres of conservation easements. This equates to an aggregate value between $18.5 and $71 million annually depending on the treatment of non-response error.

The final study addressed in this section is a valuation study of Canadian WTP for water quality improvement. Brox et al.(2003) asked respondents within the Grand River Watershed, an urbanized watershed in Southern Ontario, to state their WTP for a return to provincially acceptable water quality standards. Mean monthly WTP per household, as an additional charge to their water bill, was estimated to be $8.29 Canadian ($7.63 U.S.), equating to an aggregate WTP of $21.5 million Canadian ($19.8 million U.S.). These estimates suggest an ES value greater than the current budget, $12-18 million annually ($11-16.5 million U.S.) for water projects in the Grand River Basin.

Other Methodologies

This section presents the findings of pertinent valuation studies of water based ecosystem services that used methods other than HPM and CVM. The first of these studies values wetland quality using CA. Morrison et al.(1999) used this stated preference technique to value non-use values of environmental and non-environmental attributes of a major wetland in New South Wales, Australia. Respondents were presented with four scenarios where wetlands characteristics changed in conjunction with increases of water to the wetlands area and a subsequent increase in water rates. Estimates show that the highest average WTP was seen for the fourth scenario in which marsh area increased from 1000 km^2 to 1800 km^2, water bird breeding frequency increased from every four years to every two years, the number of endangered and protected species increased from 12 to 20, while maintaining the current level of irrigation related job opportunities. Depending on model specifics, a one-time WTP between $95 ($86 U.S.) and $103 ($93 U.S.) per household was estimated.

In a series of studies, Guo et al.(2000; 2001) estimated the total ES value for the Chinese county of Xingshan using a combination of market values, direct, and indirect values with land use patterns to estimate a total annual ES value of approximately $75 million U.S. in Xingshan county. Using the water balance method, water conservation and storage benefits were valued at $43,253 U.S. annually (Guo et al. 2001). The water balance method approximates the total value by multiplying the cost of water by the amount of water left after evapotranspiration. In this case the cost of water used was $0.15 U.S. per ton or roughly $19 U.S. per 1,000 cubic feet. Guo et al.(2000) measured the value of in-stream flow and regulation for the purposes of hydropower generation and found an annual economic value of $646,000 U.S. due to the increased output in hydropower resulting from improved natural flow regulation in a forest ecosystem.

Brown (2004) gives a detailed look at the theory, application and values of stream flow from rivers with headwaters originating in national forests within the contiguous 48 states using benefits transfer methodology. Benefits transfer is the use of economic information from a specific study site in the evaluation of a policy site with similar resources and policy conditions. This methodology is often used when primary research in not feasible due to budgetary or time constraints (Rosenberger and Loomis 2001). Using available data and previous studies Brown estimates the large-scale average marginal value of in-stream and off-stream water uses. Estimates of annual marginal value ranged from $5-$84 per acre foot across the country. The aggregate value of total stream flow value for rivers with headwaters in national forests was approximately $7 billion annually. This study also gives a detailed treatment of western U.S. water markets that will be presented in greater detail in a later section.

Olewiler (2004) used benefits transfer to estimate the value of natural capital in several Canadian ecosystems. This study estimates the ES value in an urban watershed and within several agricultural watersheds. The urban watershed investigated was the Lower Fraser Valley in Vancouver, BC. The study estimated benefits on a per hectare basis and found that wetlands provided ES values ranging from $5,792-$24,330 per hectare ($5,300-$22,300 U.S.). Lakes and rivers in the Lower Fraser Valley provided a single estimate of $8,500 ($7,800 U.S.) per hectare in ES value (Olewiler 2004).

In another study using benefits transfer, Batker et al. (2006) report ES Values in The King County Conservation District (KCD). The study found a total annual ES value within the KCD between approximately $9 billion and $32 billion (Batker et al. 2006). Urban areas produced an annual value from approximately $187 million to $989 million. Lakes, rivers, ponds and reservoirs had an estimated total annual value between $4 million and $22 million, and wetlands between approximately $46 million and $161 million (Batker et al. 2006). The primary source used in this benefit transfer valuation was the Ecosystem Services Database (ESD), an open source research platform containing bibliographic information, datasets, statistical, and dynamic models, algorithms and results from valuation studies conducted world wide (Villa et al. 2002). The ESD is maintained by the Ecoinformatics Collaboratory within the Gund Institute for Ecological Economics at the University of Vermont http://esd.uvm.edu/cgi-bin/esd.c?reset=1(8/10/07).

Benefit Cost Analysis

A great example of using water based ecosystem services as a cost effective alternative to traditional engineered options can be found in Breaux et al (1995). This study examines the cost saving measures from using wetlands in three different applications (municipal, industrial, and commercial) as a wastewater treatment option. The first situation is an analysis of using wetlands as a cost-effective method for tertiary treatment of municipal wastewater in Thibodaux, Louisiana. Analysis found that using the wetlands option, as opposed to sand filtration, would save the municipality and subsequently the taxpayers between $448,000 and $1.31 million, depending on treatment assumptions and wetlands filtration. These savings estimate a use value per acre of wetland of $775-$2300.

A great example of ecosystem services paying for themselves can be found in Loomis et al.(2000). This analysis estimated the benefits of ES restoration policy measures along the Platte River, near Colorado Springs, CO. As we saw earlier, residents in the area reported an annual WTP of $252 for improvements along the river. These improvements, conservation easements and water rental, had an estimated implementation cost of $13.3 million. The conservative estimate of total annual benefit from resident WTP was $18.54 million, a net surplus of at least $5 million.

Holmes et al (2004) provide evidence of the cost effectiveness of stream restoration by comparing the benefits and costs of riparian restoration along the Little Tennessee River in North Carolina. This study used CVM to estimate the value of five ecosystem services provided by the river; game fish, water clarity, habitat, water use, and ecosystem naturalness. Researchers used a computerized survey to estimate WTP for four restoration packages, a "base case" of continued best management practices (BMPs) along the river and BMPs plus 2, 4, and 6 miles of riparian restoration. Aside from improved use of interactive maps and land use photography, the computerized survey allowed researchers to customize the bidding structure of each respondent based on their initial bids for current BMP implementation and the 2 mile restoration package. This allowed for more accurate WTP estimates for the four and six mile restoration projects. Total benefit estimates for BMPs plus riparian restoration ranged from approximately $243,000 for 2 miles of stream restoration to $2.8 million for 6 miles of restoration, an estimated WTP of $19-$90/ft.

Costs were estimated based on previous restoration projects and included riparian restoration projects with and without animal fencing and projects developing revetments along the river. Revetments are large tree trunks or branches that are secured to the river bank by cables (Holmes et al. 2004). Total cost of previous restoration projects was estimated to be $5.72/ft. When benefits and costs were compared, a benefit-cost ratio ranging from 15.65 to 3.33 was found. Research indicates that riparian restoration is a cost effective strategy to improve ES provision along the Little Tennessee River.

Markets

This section identifies efforts around the world to value and protect water based ecosystem services in a socially optimal manner. These initiatives are presented based on the classifications outlined earlier and used by Notman et al. (2006). Based on these classifications, the primary types of exchanges in this section are Government Buyer, Individual Seller and Individual Buyer, Individual Seller exchanges.

Government Buyer, Individual Seller

Coatepec, Mexico. This city, located in the state of Puebla, added a surcharge to municipal water bills in 2001 to fund an ecosystem services payment program protecting the local drinking water source (Brown 2007). Under the program, these surcharges provide annual per acre payments to upstream land owners to practice sustainable agriculture and dissuade conversion of forested areas into agriculture land. The program is administered similarly to ecosystem payment programs in Costa Rica and Ecuador. This program has been so successful that the Mexican government used it as a model for a nationwide ES payment program encouraging landowners to protect vital water based ecosystem services supported by their land (Brown 2007).

Costa Rica. The country of Costa Rica has been at the forefront of ES marketing with public and public-private mechanisms. In 1997 the country developed a countrywide ES payment system (PSA) to ensure ES protection within its borders. PSA created a regulatory framework providing contracts to landowners for ES provision from their lands. There are four ecosystem services governed by this program: greenhouse gas emissions (GHG) mitigation, hydrological services, biodiversity, and recreation and ecotourism (Pagiola 2002). Once a proper land management plan has been submitted and approved, the landowner signs a contract and receives payments over a five year period for ES protection and provision. Proper implementation and oversight is handled by a national conservation system and local NGO's (Pagiola 2002). Funding for water payments are partially financed by beneficiaries of the protected services. Several hydroelectric producers and a brewery have signed contracts to pay for downstream watershed management services. However, these payments only make up a part of the payment scheme, to date additional funding has been provided through the Global Environmental Facility (GEF) (Pagiola 2002).

Ecuador. In Quito, a water fund was developed to ensure the city's water sources remained of high quality. In order to protect the upstream sources for downstream consumption, a water fund (FONAG) was created in 2000 using seed money from GEF. Pressures affecting the watersheds include municipal water provision, hydropower production, rural populations, timber companies, and agricultural concerns. FONAG is a non-declining endowment fund with investment from public and private sectors. All returns are used for conservation practices within the watershed. Monies for these investments can come from any user within the watershed. In practice most of these monies have originated from the municipal water supplier of Quito and a hydroelectric producer. The water supplier provides $.01 per water sale and the hydroelectric producer pays a flat annual fee. By August, 2001 FONAG has received $301,700 (Echavarria 2002).

Massachusetts PILOT Program. In Massachusetts, policy makers and communities have developed a Payment in Lieu of Taxes (PILOT) program to protect city water sources. The program, funded by Massachusetts Water Resources Authority water users, makes direct payments to communities within the watershed to fund protection and land acquisitions projects (Zimmerman 2006). To date, funds dispersed total $62 million. The program, began in 1985, has increased public ownership in each of the three primary watersheds it operates by 6-14% (Salzman et al. 2004).

Mexican Forest Fund (MFF). Mexican authorities enacted the MFF to protect watersheds in the state of Querertaro. This program, administered by the National Forest Commission and funded by water use fees paid to the Central Water Authority, pays farmers on priority identified lands and lands that directly impact downstream users to protect forest cover. The maximum annual payment is $40 per hectare of protected land (Bayon 2003). Contracts are signed for a term of five years and satellite imagery is used to verify that land characteristics remain unchanged. Fiscal Year 2002 produced $19 million in payments to land owners protecting 126,000 hectares (Bayon 2003). In addition to government payments, a local NGO (Grupo de Ecologico Sierra Gordo) uses GEF funding to promote environmental awareness and create private ES markets in the watershed by identifying potential downstream customers for upstream water based ecosystem services.

New York City/Catskills. One of the most cited case studies to date in valuing the economic benefit of water based ecosystem services is the New York City/Catskills watershed management project. The 1974 Safe Drinking Water Act (SDWA) sets allowable limits on contaminant levels for potable water, and the regulations that must be met for surface waters to forgo filtration (National Research Council 2000). In 1997, authorities found that New York City's drinking water supply exceeded parameters set forth in the SDWA and required extra filtration. Faced with the choice of building a multi-billion dollar water treatment plant or managing the upper watershed, the New York City Water Authority embarked on an innovative watershed management plan unprecedented in scope and cost (National Research Council 2000). Instead of building a water treatment plant at an estimated cost of $6 to $8 billion, the watershed authority decided to invest between $1 and $1.5 billion in upper watershed management to improve drinking water quality (Chichilnisky and Heal 1998). The 1997 Memorandum of Agreement (MOA) was an important moment in ES valuation, becoming the legal basis for a long term watershed management plan (National Research Council 2000). The essential elements of the watershed plan are: Land Acquisition and Comprehensive Planning, The Watershed Agricultural Program, The Watershed Forestry Program and regulations on setbacks and buffer zones (National Research Council 2000). Aside from these programs, the MOA stipulates a comprehensive monitoring program throughout the watershed. To date 70,000 acres of sensitive land within the watershed have been purchased or protected, 2000 septic systems have been upgraded or replaced, several sewage treatment plants have been upgraded or built, and several million dollars have been set aside for flood and erosion control. Aside from these direct management actions, there has been increased income and employment generated in the watershed through increased community project development and ecotourism (Kenny 2006).

Individual Buyer, Individual Seller

Ecosystem Marketplace. The Ecosystem Marketplace is a website dedicated to ES market development and payment schemes and lists current tradable ES markets. Broad markets classifications include Water, Carbon, and Biodiversity (www.katoombagroup.org/ 2007). Water markets include: The U.S. Wetland Mitigation Bank, The Hunter River Salinity Trading Scheme, North Carolina Ecosystem Enhancement Program, Mexico Payment for Hydrological Services, U.S. Water Pollutant

Trading and Offset, and the Costa Rica Water Based Ecosystem Service Market. In total, these markets have traded $373,655,115 in wetlands and ecosystem services over the past ten years with The U.S. Wetland Mitigation Bank being the most active market (www.katoombagroup.org/ 2007), 8/10/07.

Great Miami River Watershed Water Quality Credit Trading Program. A water quality trading scheme was set up for the Great Miami River Watershed in southwest Ohio by The Water Conservation Subdistrict of Miami, Ohio, U.S. EPA, Ohio Department of Natural Resources, Ohio Farm Bureau Federation, and various agricultural producers and conservation districts. The primary concern of this trading program is non-point source pollution associated with nitrogen and phosphorous. As such, a credit represents one pound of phosphorus (TP) or nitrogen (TN) prevented from entering the Great Miami Watershed. The market for these credits consists of agricultural operations, storm water management programs and those upgrading home sewage treatment systems. To receive a credit for an activity, the activity must be undertaken voluntarily and not originate from the requirements of a local, state or federal law. Only those public or private entities that hold a state-issued NPDES permit modified for participation in the trading program and contribute to administrative and analytical costs of the trading program may purchase water quality credits (Miami Conservation District 2005). Credit prices are determined by market transactions and generally cover capital, operating, administrative and maintenance costs for project implementation. A cost analysis of the credit trading scheme was performed before its implementation and findings suggest that annual cost savings between $305 and $376 million can be expected from this trading program (Miami Conservation District 2005).

Perrier Vittel. An excellent example of a private transaction for water based ecosystem services is the Perrier Vittel case. The French bottling company initiated a program to protect the water quality of their source springs from agricultural activities in the catchment area. These strategies included the purchase of farm lands at above market values surrounding the water source, granting farm rights to farmers agreeing to follow BMPs and long term payment contracts to dairy farmers to use less intensive techniques (Salzman 2005). To date the strategies have been successful in reducing water pollution and changing farming habits around the springs.

Western U.S. Water Markets. The western U.S. water markets represent a successful implementation of water trading schemes. Historically, this market has sold water primarily for consumptive uses, irrigation and municipal use. However, there has been a general increase in purchases and leases for environmental purposes by public and private trusts. These purchases were primarily for ecosystem services associated with increased stream flow and biodiversity (Brown 2004). Over a 14 year period, the majority of sales in these markets have been by farmers to municipalities for a mean price of $77 per 1,000 acre foot (Brown 2004).

Summary

- The economic valuation methods used in this section include Benefits Transfer, Conjoint Analysis, Contingent Valuation Method, Hedonic Price Method, Water Balance Method and Benefit Cost Analysis.
- Specific ecosystem services valued by these techniques include: water quality, flood control, erosion and sedimentation, water supply, pollution dilution, storage, and flow regulation benefits.
- Value estimates for the benefits of these services ranged from $14 to $257 per 1 meter increase in water clarity for on Maine lakes to between $1,025 and $3,042 per acre for wetlands used to treat waste water in Louisiana.
- Water based ecosystem service market development represents a mix of public and private initiatives.
- Strategies for these initiatives include conservation easements, land acquisition, credit trading and water commodity markets.
- For more information about a specific study in this section, please refer to the Appendix.

Section III: Air

This section addresses ES protection and provision in urban air-sheds. Primary interests include urban air quality, the benefits to society that accrue from clean air, development of effective management strategies in the urban interface, and attempts to develop markets for air based ecosystem services. Urban air pollution from stationary and mobile sources is a major problem in both the developed and developing world (He et al. 2002; Rawski 2006). Today, a primary concern is the effect of air pollution on public health. In 1990, it was estimated that approximately 300 million people in Bangkok, Thailand would be exposed to dangerous levels of air pollution from auto emissions (Faiz 1993). Several studies have identified air pollution as a primary source of health related illness (Streets et al. 1999; Peng et al. 2002; Mukhopadhyay and Forssell 2005). In many cases the impact that these exposures have on the economy is great. Resosudarmo (2003) found that the health related impacts to the Indonesian economy resulting from poor air quality represented 0.2% of GDP.

Beattie et al. (2002) noted that the challenges of urban air quality were complex and required increased assessment and protection measures to mitigate. In response to these complexities, researchers have developed new techniques to combat urban air quality issues, suggesting new and innovative pollution control measures such as integrated response and management methods. In the Chinese city of Xiamen, city planners are working to combat degradation of air quality while meeting transportation needs by developing an integrated transportation plan (ITP) (Yang 1998). This is an analytical approach applying computerized decision support tools to guide planners, policy-makers, and citizen groups to meet transport needs while maintaining healthy air.

Another tool being incorporated into urban air management plans is Geographic Information Systems (GIS). GIS within an integrated monitoring and support system for air quality management was investigated by (Jensen et al. 2001). In this study, GIS was incorporated into the current management plan to decrease air pollution impacts on human health and exposure in the Danish city of Middlefart. This system has the advantage of utilizing GIS in the analysis of problems and exposures, thereby improving the discussion and ultimately implementation of effective strategies based on spatially specific problems or goals.

In addition to new technologies and concepts, managers and activists are refocusing on the natural aspects of cities. The healthy urban forest provides many benefits including the capacity to improve ambient air quality. The urban forest provides both public and private benefits through temperature reduction, pollutant removal, trapping greenhouse gas emissions, energy reduction and amenity values (Nowak 2000a). When incorporating urban forests into a management plan several factors need to be considered. The specific environmental factors, such as location and size, play an important role in the impact that an urban forest will have. Current literature investigating the impacts and benefits of urban forests on air quality suggest a mix of vegetation types (Bolund and Hunhammar 1999). In the next sub-section, current literature on economic values of urban forests is presented. The second sub-section presents programs designed to encourage air quality markets.

Literature Review

This sub-section presents literature valuing ES protection and provision in urban air-sheds. Current published research addresses economic, health, and environmental aspects of polluted urban air-sheds throughout the world. The review of this research is divided into four parts. The first part focuses on studies using HPM and the second presents CVM studies. This is followed by a review of studies using other valuation techniques. The final part of this literature review presents several benefit-cost analyses (BCA) that address urban air quality.

Hedonic Price Method

An early study of urban air quality and its effects on property prices is presented by Nelson (1978). This study used housing prices in the District of Columbia to estimate the marginal price for a reduction in suspended particulate matter (PM). Findings estimated average WTP for a 1 μ/m^3 reduction in PM to be \$60 to \$70 per day. Smith and Ju-Chin (1995) applied meta-analysis using hedonic studies between 1968 and 1988 to estimate WTP for a 1 μ/m^3 reduction in suspended PM. Average WTP over the analysis was \$110. This estimate was applied, using benefits transfer, to measure a 1 μ/m^3 reduction in PM reduction in the air-sheds of Chicago, Los Angeles, Anaheim, and St. Louis. Estimates produced significant variability in WTP among the cities. Total WTP was estimated at \$2.2 million in Anaheim, \$40.6 million in Chicago, \$87.2 million in St. Louis and \$254.4 million in Los Angeles.

The developing world also provides examples of HPM being used to value reductions in urban air pollution. Kim et al.(2003) used HPM to estimate the marginal value of an air quality improvement through reduction of SO_x and NO_x concentrations in Seoul, South Korea. City-wide, self-reported, homeowner prices were used to estimate the WTP for a permanent, 1ppb, improvement in SO_2 emissions. WTP estimates were $2,333 per household or 1.43% of mean house value.

Murty et al. (2003) provide another example of the impacts of urban air quality on the housing market in a developing country. This study estimated the benefits to local households of air pollution reductions in Delhi and Kolkata, India. Using household surveys for each city, annual household WTP for a reduction in PM concentration to the 200 μ/m^3 level was estimated. Results found an average annual household WTP of INR 19,870.70 ($451 U.S.) for Delhi and INR 84,355.71 ($1,915 U.S.) for Kolkata. Using average households per city, total annual benefits for this reduction in suspended PM was estimated to be INR 26.635 million ($605,000 U.S.) and 46.655 million ($1 million U.S.) respectively.

The final study in this section uses the structure of the Clean Air Act Amendments (CAAA's) to evaluate air quality effects on property values. Chay and Greenstone (2005) use non-attainment status for PM as a variable to measure changes in county level housing prices from 1970–80. Results found a mean increase, over 10 years, of $2,400 for housing values in counties initially identified as non-attainment areas. This corresponds to a 10μ/m^3 reduction in PM. Total WTP for the non-attainment areas was approximately $45 billion. Per household WTP for a permanent 1 μ/m^3 decline in PM concentration was $243.

Contingent Valuation Method

Portney and Mullahy (1990) used data from a National Health Survey and benefits transfer methodology to quantify the link between long term exposure to air pollution and chronic respiratory disease in urban areas. Results found a statistically significant link between ozone (O_3) concentrations and incidences of sinusitis and hay fever. A 10% reduction in the average hourly ambient O_3 concentration reduced adult sinusitis by 1%. Using previous CVM studies, estimated annual per person WTP for this 10% reduction was $1000. The urban population was assumed to be 135 million persons. A 1 % reduction in ozone concentration would reduce cases of adult sinusitis by 1.35 million, producing an aggregate value of $1.35 billion.

Alberini et al. (1997) estimated WTP to avoid future acute respiratory illness caused by air pollution in three Taiwanese cities. Reported median WTP to avoid a 1 day acute illness with 2 symptoms was $20 per person per day. These per person benefits produced a total morbidity value for avoiding a pollution related illness of $262 million. Using CVM methodology, Carlsson and Johansson-Stenman (2000) estimated individual WTP for a 50% reduction in air pollution in Sweden. Results found that individuals would be willing to pay 160SEK/month ($24 U.S.) or 2000 SEK/year ($295 U.S.) on average for this reduction.

The final CVM study presented estimated WTP for improved urban air quality in Beijing, China. Wang et al. (2006) found that two-thirds of respondents in Beijing would be willing to pay for a 50% reduction in air pollutants over a five year reduction period. Estimates found an annual household WTP of 143CNY ($19 U.S.), approximately 0.7% of annual household income. The total annual WTP for this 50% reduction was 3.36 billion CNY ($434 million U.S.).

Other Methodologies

Hall et al (1992) estimated the health impacts of ozone and PM in California's South Coast Air Basin (Hall et al. 1992). Measurements were made for both indoor and outdoor pollutant exposure using a set of 1,000 time-activity combinations. In order to estimate the value these pollutants had on health related costs, three valuation techniques were used, cost of illness (COI), WTP, and willingness to accept (WTA). The WTP estimates were derived using benefits transfer from relevant CVM studies. The COI measurements utilized wage level data to estimate health related costs. Results show that citizens in the basin are exposed to high levels of both O_3 and PM concentrations. Reduction of PM levels to current NAAQ standards could prevent around 1,600 deaths annually. These deaths were valued using statistical life measurements of $1.8 million, $4 million, and $9.2 million. The value of PM reduction ranged from $2.9 to $14.9 billion, basin-wide, with an average value of $6.4 billion. The health benefits of O_3 reduction ranged from $1.2 to $5.8 billion with an average value of $2.7 billion.

Rabl and Spardaro (2000) provide a summary of methodologies and results valuing the external costs of energy technologies and environmental damage in Europe. The researchers used data from year 1998 of the External Costs of Energy (ExternE) Project. Economic valuation was based on the value of a statistical life (VSL) and years of life lost (YOLL). The VSL used in this study was €3.1 million ($4.2 million U.S.). Using this method, the value of YOLL was estimated to be €83,000 ($111,000 U.S.) for chronic mortality, €155,000 ($209,000 U.S.) for acute mortality, €450,000 ($608,000 U.S.) for non-fatal cancers, and €1.5-2.5 million ($2-3.4 million U.S.) for fatal cancers. Links were established between PM, NO_x and SO_x emissions during electrical production and the associated health costs. Results found that most of the health-related costs were associated with chronic mortality. The estimated costs to mortality and morbidity in Europe were estimated to be 15 €/kg ($9/lb U.S.) for PM and 0.3 €/kg ($0.18/lb U.S.) O_x and SO_x emissions.

Benefit Cost Analysis

McPherson et al.(1994) used BCA to quantify the effects of urban vegetation and improved management on the environment in Chicago, IL. The benefits evaluated in this study included air quality and atmospheric carbon dioxide, effect on wind and air temperature, local-scale energy and water exchange and potential energy savings. Estimates from 1991 data found that urban trees in the greater Chicago area contributed to direct improvements in ambient air quality by removing 15 metric tons of CO, 84 tons of CO_2, 89 tons of NO_2, 191 tons of O_3, and 212 tons of PM. These removals provided an annual value of $1 million within the City of Chicago and $9.2 million to the greater Chicago area. Using a 7% discount rate and 30 year timeframe, the net present value of costs associated with tree planting and maintenance was $38 million or $402 per tree.

McPherson et al. (2005b) performed a BCA analyzing the benefits and costs of maintaining an urban forest in five cities . This study used the Street Tree Resource Analysis Tool for Urban Forest Managers (STRATUM) program to compile the relevant information. STRATUM is computer based management and analysis tool using data from street tree inventories to provide dollar estimates of annual environmental and aesthetic benefits from urban forests (www.fs.fed.us/psw/programs/cufr/stratum.shtml 2005). The benefits valued were storm water runoff reduction, energy savings, air quality improvements, CO_2 reduction, and aesthetics. Associated costs consisted of expenditures by municipal forestry divisions, expenditures by departments responsible for sidewalk and curb repair and leaf cleanup. Trip and fall claims were also included in cost estimates. Five cities were included in this study: Ft. Collins, Cheyenne, Bismarck, Berkeley, and Glendale. Net annual benefits from urban forest programs ranged from $358,000 in Cheyenne to $1.2 million for the community of Ft. Collins. On average, aesthetic benefits (i.e. property values) were greatest. However, there was significant variability in the type and quantity of the benefits for each city. Annual costs for urban forests ranged from $276,000 for Glendale to $2.4 million in Berkeley. Pruning costs, administration and inspection were the highest costs in all cities. Annual per tree costs were estimated to range from $13 to $65 while benefits per dollar invested ranged from $1.37 to $3.09 per tree. BCA ratios for each of city varied from 1.37 (Berkeley), 2.09 (Cheyenne), 2.18 (Ft. Collins), 2.41 (Glendale) to 3.09 (Bismarck).

The next two studies do not implement a complete BCA; instead they provide benefit estimates of urban forests. The first study was performed by Nowak et al. (2000b) using the Urban Forest Effects (UFORE) program to quantify benefits and suggest management techniques for Brooklyn's urban forest. UFORE allows the urban forest manager or researcher to collect data on urban forests and the ecosystem services provided to the community (www.ufore.org/about/01-00.html 2007). Given this information, researchers can quantify these effects as economic benefits. The air pollutants analyzed were CO, NO_2, O_3, PM and SO_2. The value of reducing these pollutants in the ambient air was estimated to be $1.3 million annually. The Brooklyn urban forest, approximately 610,000 trees, produced a total annual value of $679 million based on compensatory value estimates.

The final study of this section estimates the removal of pollution and greenhouse gases by urban forests in American cities (Nowak et al. 2006). Computer modeling was used to estimate the first-order effects of urban forests in 55 U.S. cities. The economic values were based on a per ton national median externality value estimated by benefits transfer methodology. There was significant variability among the cities with annual values ranging from a high of $60.7 million to a low of $116,000. Total value for reductions in PM, O_3, SO_2, CO, and NO_2 was estimated at $3.8 billion annually.

Markets

The initiatives presented in this sub-section are attempts by governments and firms to value and protect air sheds and consist of two types, cap and trade and command and control programs. Both approaches require more government involvement and oversight as compared to traditional market exchanges, especially the command and control (e.g., government tax and monitor) approach.

Individual Buyer, Individual Seller

Cap and Trade Programs. Cap and trade programs are prevalent around the world, once established these trading schemes allow for private firms to exchange to an efficient level of emission. However, these programs require a strong government presence to establish the limit on emissions, establish the tradable permit system, and monitor implementation and compliance (Notman et al. 2006). This system was first enacted with the establishment of the U.S. Acid Rain program.

US. SO_2 Trading Program. The 1990 U.S. Acid Rain Program established a market for SO_2 emission rights and began the process of using the government to set pollution allowances, assert property rights, and allow entities to achieve pollution reductions through market transactions. This system has come to be known as "cap and trade." This market development bodes well for the wide scale inclusion of pollution externalities in private business decisions (Bayon 2004). The original program was a two phased program concentrating first on coal fired electric utilities in the eastern U.S.. A starting year, 1995, was set by the federal government for the utilities to have the allowances needed to cover emissions. These allowances were calculated on an annual basis, based on emission levels between 1985 and 1987. The utilities covered were encouraged to trade or bank allowance permits. After 2000, the second phase applied these measures nationwide. The program has been very effective at reducing emissions, increasing trade volume, and generating savings through market transactions. Total estimated savings from the inception of the U.S. Acid Rain Program is $1 billion, a 30-50% savings over conventional command and control measures (Stavins 2005).

Chinese SO2 Trading Program. To improve environmental quality China developed a SO_x trading program similar to the U.S. Acid Rain program. The program sets an annual emission allowance that can be used to meet emissions. Emission rights can be traded to firms needing additional rights or banked for future emission needs. The success of this project has led to pilot projects to determine the feasibility of developing trading programs for other pollutants (National Center for Environmental Economics 2004).

Dutch NO_x Trading Program. The Dutch have developed a rate-based trading program for NO_x based on performance standard rates and fossil fuel consumption. Rates can be met through reduction or credit purchase. This program is mandatory for all emissions sources with electricity production capacity of 20MW or more. The goal is a 50% reduction by 2010 from the base year of 1995, with assessment at the mid-year of 2005. For an added measure of flexibility, a pollution bank mechanism was created for future use in emission control (National Center for Environmental Economics 2004).

Santiago PM Trading Program. Chilean officials enacted a PM trading scheme in the early 1990's in the capital city of Santiago. The system capped total emissions at current levels and granted emitters capacity rights in perpetuity. New entries and expanding emitters were required to buy capacity rights from current sources (National Center for Environmental Economics 2004). The Chilean program has been successful in decreasing PM emission in Santiago. In 1993, capacity to emit was 7,442 kg/day compared to 1,637 kg/day in 1999. In 1998, capacity rights for one kg/day of emissions ranged from $1,100 to $11,500 (National Center for Environmental Economics 2004).

Slovakia. This eastern European country established a national cap and trade program with specific emission quotas developed for administrative districts for individual polluters producing over 50MW of electricity. These quotas can be traded as a whole unit or in partials (National Center for Environmental Economics 2004).

Command and Control

Aside from these market initiatives several governments worldwide have set up traditional command and control methods to combat degradation of air quality and provide compensation for citizens suffering adverse health effects from air pollution. These government programs do not allow for the efficiency that a market solution allows but, ensure that some level of environmental protection is asserted.

Pollution Levy System. The Chinese operate a polluter pays or fee-based Pollution Levy System. This system is comprehensive, containing legislation that covers air, water, and waste. Aside from providing a revenue source for provincial and local protection boards, the program contains a component that provides an 80% rebate for future investment in pollution control. This program only applies to industrial sources. Analysis of the fees found that they were, in some cases, lower than control costs. However, it has been recognized that even a fee less than the efficient rate can create emission reductions. For air, all SO_2 emissions are levied, for other pollutants only those emissions beyond the current standard are charged. Fees vary throughout the country with the highest fee levied in Beijing, $150/metric ton (National Center for Environmental Economics 2004).

France. France imposes a charge on emissions of hydrochloric acid, sulfur-containing compounds, nitrogen oxide-containing compounds, non-methane hydrocarbons, solvents, and other volatile organic compounds at a rate of $30 per metric ton. This fee applies to all power facilities producing over 20 MW, incinerators with an hourly capacity over 3 metric tons and all emitters with an annual production over 150 metric tons (National Center for Environmental Economics 2004).

Japan. Japan created a sulfur emission charge to provide revenue to compensate victims of pollution-related diseases. The charge is based on a 4:1 ratio between stationary and mobile sources. The current tax rate for stationary emitters varies from $0.625 to $56.25/m^3 with a retroactive rate of $0.82/m^3 for emissions between 1982 and 1986 (National Center for Environmental Economics 2004).

Sweden. The Swedish government enacted a tax and rebate system on all emitters producing 50GwH or with capacity to exceed 10MW of electric production. The tax is levied on NO_x emissions at a rate of $5.9/kg or $5400/short ton. The rebate portion creates an income transfer from high to low emitters. This system has lead to innovative strategies to lower costs from plant to plant, creating incentives to install measurement equipment, keep the equipment in good repair, and limit emissions. In several instances larger facilities have linked emission reduction to employee compensation (National Center for Environmental Economics 2004).

Summary

- Values for the ecosystem services presented in this section were estimated using Contingent Valuation, Hedonic Price Method, Value of Statistical Life and Benefit Cost Analysis,
- Research shows there is significant economic value in improved air quality from reductions in the health impacts associated with air pollution.
- The national average annual household willingness to pay for a 1% reduction in sinusitis was estimated to be $2,800.
- Urban forests can help reduce air pollution in urban areas. For example, Brooklyn's urban forest was estimated to remove $1.6 million annually in urban air pollutants
- Cap and trade and command and control programs are the primary mechanisms currently used in large scale air quality initiatives.
- Cap and trade programs for PM, NO_x and SO_x emissions have been enacted around the world with sound results.
- For more information about a specific study in this section, please refer to the Appendix.

Section IV: Recreation

Another important service provided by natural ecosystems is an outlet for recreational activities. This section addresses the provision of recreation within urban ecosystems. However, included in this section is research focusing on recreation in rural areas since urbanites often recreate along the urban/wildland interface. Discussion begins with the concept of recreation, historical use patterns and the complexities of recreation resource management in the urban context. This is followed by a review of current research valuing outdoor recreation. The final sub-section presents attempts to manage and provide urban recreation resources.

Chubb and Chubb (1981) divided recreation resources into six categories:

1. *Undeveloped recreation resources.* These are recreation resources where the physical attributes of the land, water and vegetation are untouched.

2. *Private recreation.* Recreation resources comprising a diverse array of resources such as second homes, land rented or leased for hunting and resources owned by quasi-public organizations.
3. *Commercialized private recreation.* These are private resources that include shopping malls, theme parks, museums, gardens, and resorts.
4. *Publicly owned recreation resources.* Publicly owned resources include parks, sports and leisure facilities, national parks and forests, and tourist sites.
5. *Cultural resources.* This category contains both the public and private sectors, such as libraries.
6. *Professional resources.* These are the management and administrative elements responsible for recreation provision and management.

Recreation in its many forms is an indelible part of American life. The 2001 National Survey of Fishing, Hunting, and Wildlife-associated recreation found that during 2000, 82 million U.S. residents actively engaged in some form of wildlife recreation (U.S. Department of the Interior and U.S. Department of Commerce 2002). Recreation decisions are important personal and household consumption decisions and integral parts of state and local economies. The same survey found that participation in outdoor recreation during 2000 produced $108 billion in expenditures, accounting for 1.1% of GDP. As the urban population continues to grow and becomes increasingly willing to trade work hours for leisure time, there is significant need to address issues related to urban recreation activities and infrastructure (Loomis and Walsh 1997).

Recreation plays a significant role in the health and well-being of urban citizens, often providing a respite from the banality of urban life. With more than 80 percent of U.S. citizens living in urban areas, providing and managing urban outdoor recreation activities becomes increasingly important (Dwyer 1999). Urban recreation is complex, encompassing a spectrum of activities pursued along a wide array of land types. In an update of the National Survey on Recreation and the Environment (NSRE), Cordell et al (2005) found that the most popular recreation activities for the citizens of eight major eastern cities were picnicking, viewing/photographing wildlife, swimming, and day hiking.

Recreation, as with other ecosystem services, is often undervalued and therefore not allocated in optimal amounts. The urban interface makes this problem particularly acute with space and land value at a premium. Traditionally, recreation has been publicly financed. To offset the costs of providing recreation, the generally accepted method has been user fees for access to local, state and federally provided recreation. However, problems arise when determining an appropriate level for access fees. Currently, fees do not cover the operating costs of the parks, but raising fees is not seen as equitable due to the societal benefit that recreation provides and the potential exclusion of marginalized groups that result from rate increases (Loomis and Walsh 1997).

New opportunities for recreation regularly open in urban settings. A focal point of these new recreation resources are greenways and parks. As citizens and governments become aware of the importance of environmental health in urban ecosystems, city planners are incorporating once degraded rivers, lots, and open space that provide recreational opportunities and other ecosystem services into development plans. The supply of these resources are balanced by a complex set of demand factors including amenity, site and other influences that satisfy individual needs and desires (Marcouiller and Prey 2005).

Recreation planning provides another example of the need for integrated management when assessing ecosystem services. When planning a recreation site, a broad set of activities including site planning, environmental resource management, and budgetary analysis must be addressed. One important role of this integrated planning concept is balancing the regional supply of recreation resources with public demand, while ensuring the protection and maintenance of the physical resource creating the recreational opportunity (Marcouiller and Prey 2005). This becomes increasingly important when the recreational resource is part of an economic development strategy, stressing the need to increase tourism dollars. All of this is further complicated when the environmental demands of growing urban environments and the dynamic nature in which they grow are incorporated. In order to create an effective strategy for recreation planning, policy integration between government, non-profits, and commercial interests is fundamental.

Dwyer (1994) recognized several trends that define the complexities of recreation management into the foreseeable future. These include: the decreasing rates at which outdoor recreation is increasing, increased diversification of recreational enthusiasts, the special problems in recreation resource management this diversification creates, difficulty in predicting future use patterns, greater inclusion of resources in or near urban centers and reevaluation of pay methods and funding schemes. In this vein, the following sub-section provides an account of current literature valuing outdoor recreation and its demand.

Literature Review

In this sub-section, studies that estimate the value that consumers, homeowners, and recreation enthusiasts place on various recreation resources are presented. The valuation techniques used in these studies include HPM, CVM, and TCM. There are also results from studies using other valuation methodologies and economic impact analysis.

Hedonic Price Method

Correll et al. (1978) present an early hedonic model estimating the value that adjacent homeowners attribute to green space in Boulder, CO. The sample included three greenbelt areas within the city and properties within 3,200 feet of these greenbelts. Findings suggest that as distance from the greenbelt increases property values decrease. In this study the property value reduction was $4.20/ft. The presence of a greenbelt led to amenity values that increased total property value by $5.4 million.

In a series of studies, Lansford Jr. and Jones (1995a; 1995b) produced two studies estimating the recreational and aesthetic value of water in central Texas. The first study sought to estimate the marginal value of lake proximity, report factors inducing price variation in lake-front homes, and estimate the total implicit price of recreational and aesthetic benefits of lake front properties along Lake Austin, TX. On average, the point estimate for recreation value decreased at the rate of $4.21 for every 1 ft increase in distance from the waterfront. This study found that recreation value was no longer a factor in housing cost beyond 2,000 feet. Inside this area, the recreational value represented 22% of total home value, an average of $42,191 per home. The aggregate recreational value of Lake Austin associated with property value was valued at almost $66 million (Lansford Jr. and Jones 1995a).

The second study estimated similar values, along with in-stream water value at Lake Travis, Texas. The data consisted of sale prices for homes along Lake Travis water front and up to 1.5 miles away. Results found that property value decreased by $6.19 for every foot of increased distance from the lakefront. The aggregate value of recreational benefits associated with Lake Travis was estimated to be $49 million, an average of $13,300 per home, approximately 15% of the total property value (Lansford Jr. and Jones 1995b).

HPM was used to value improved access to woodland in Southhampton, UK by Powe et al (1997). The researchers employed GIS to measure the distance from homes to access points to New Forest. This information was used to construct a forest index for each property measuring access potential and other environmental factors. A total of 872 mortgages from 1990-1992 made up the data source for this study. Estimates found that for a one unit change in the forest index average property value changed by £543 ($1,080 U.S.). This average change was created by planting an additional hectare of woodland within 100m of a property (Powe et al. 1997).

Tyravainen (1997) used property values to estimate the value of urban forests. This study presents results estimating the value of the urban forest in Joensuu, Finland. The dataset was a sample of 1,000 sales of row house apartments in various neighborhoods throughout the city over a three year span between 1984 and 1986. Results suggest that the amount of forested area near the apartment and proximity to a watercourse and recreation area had a positive effect on housing price. In monetary terms, a 100 meter increase in distance from the watercourse and recreation area decreased housing prices by 154 FIM/m^2 ($34.50 U.S.) and 42 FIM/$m^2$ ($9.40 U.S.) respectively. If these numbers are applied to examples of land use patterns and their effects, changes in the local recreation district would cause a 7 percent reduction in property value.

A similar study was performed in 2000 using Salo, Finland as the study site and produced similar results (Tyravainen and Miettinen 2000). Results indicate recreational opportunities provided by the urban forest have a positive effect on property value. A forest view increased housing price by 4.9 percent while a 1 km increase in distance from the forest induced a 5.9 percent decrease in housing price. Price changes were most responsive within the first 300 meters, suggesting that the effect on property values of recreational opportunities is strongest for properties within walking distance of the forest. Total value of the forest area incorporating both amenity views and recreation opportunities was estimated to be 22.82 million FIM ($5.2 million U.S.) annually (Tyravainen and Miettinen 2000).

Lutzenhiser and Netusil (2001) used the hedonic method in Portland, OR to estimate the effect of open-space type and size on housing prices. For this study the generic term "open-space" was deconstructed into four types of parks in the urban setting: traditional urban parks, natural area parks, golf courses, and specialty parks. Researchers were interested in the type of park that influenced sale price the most and the size of each of these parks that maximized this sale price. Results show that all park types had a significant effect on sale price for homes within 1,500 ft. Natural area parks provided the greatest effect, $10,648. This was followed by golf courses ($4,849), specialty parks ($5,657), and urban parks ($1,214). Sale price was maximized for natural resource parks at 258 acres, golf courses at 169 acres, urban parks at 148 acres and specialty parks at 112 acres.

The next hedonic study is an article investigating the impact on residential property price of Boston's "Big Dig" project (Tajima 2003). The "Big Dig," otherwise known at the Central Artery/Tunnel Project, was a massive transportation project undertaken in the early 1990's by the City of Boston to ease congestion through the city center using a 3.5 mile tunnel to divert the current interstate underground and subsequently freeing the above ground area for other uses. City officials, at the behest of citizens and environmental groups, agreed to convert the majority of land into the Rose Kennedy Greenway. The data was comprised of housing attributes and the property's spatial relationship to highways and green space. Approximately 16,000 properties from nine metropolitan zip codes were used in this investigation with condominiums making up the primary housing type. Variables for distance from highways and parks were significant and had a negative and positive relationship to property price respectively. Results found that doubling the distance from a large park decreased property value by 6%. Estimates indicate that destruction of the current highway will increase total property value in the surrounding area by $732 million and the greenway addition would increase the total property value by $252 million.

The final hedonic study presents the second half of findings reported by Cho et al. (2006). In addition to estimating the value bodies of water had on housing price, this article also estimated how green space proximity within Knox County, Tennessee affected mean housing price. Findings show that, when measured from an initial distance of 1 mile, mean house price increased between $662 and $840 for a 1000 ft. decrease in distance to individual parks (Cho et al. 2006).

Contingent Valuation Method

Berrens et al. (1993) use CVM to test for congestion effects on recreational fishing sites in urban settings and determine WTP for increased fish stocking along the Williamette and Clackamas Rivers in Portland, OR. Anglers were asked how much they would be willing to pay for an increase in the number of fish released and how the corresponding increase in anglers may affect their experience. Average per person WTP for an extra fish was $8 and anglers did not feel that congestion was an issue at this particular recreation site.

Lindsey and Knaap (1999) estimated the value of a greenway system in Indianapolis, IN using CVM. The study area consisted of primarily private property along an impaired stream on the Crooked Creek Greenway. Researchers investigated differences between stated and actual WTP for management funds earmarked for greenway improvements. The survey was distributed to property owners, renters, and county residents. Each resident type was asked to state their WTP, or provide a donation representing their actual WTP, to support the management of a greenway foundation. Fifty percent of residents asked to state their WTP responded favorably, while those asked to donate had a response rate of less than 40%. Mean stated per person WTP among property owners was $11 (Lindsey and Knaap 1999).

CVM was used by Tyrvainen (2001) to estimate the benefits of urban forests in the Finnish cities of Joensuu and Salo; specifically, WTP for wooded recreation areas and protection from future housing development. City residents indicated a strong preference for access to and protection of these forested recreation areas. Responses indicated the primary benefits generated from these areas were natural, social, and climatic benefits. CVM responses in Joensuu, the more heavily wooded town, indicated a monthly per household WTP of 42-53 FIM ($9.50-$12 U.S.) for an access fee to the forested area depending on recreational opportunities provided. This is compared to a range of 31-76 FIM ($7-$17 U.S.) per household per month as reported by inhabitants of Salo. On an annual basis, benefits accrued from recreational use of urban forests in the two cities were estimated to be 4.35-8.58 million FIM ($974,000-$1.9 million U.S.) and 0.58-6.14 million RIM ($129,000-$1.3 million U.S.) for Joensuu and Salo respectively (Tyrvainen 2001).

Travel Cost Models

Rockel and Kealy (1991) investigated several factors that influenced the demand for non-consumptive outdoor recreation and estimated total benefits accrued from these recreation trips using TCM. Recreation activities included time spent observing, feeding and/or photographing wildlife. Data used was part of a national survey performed by the U.S. Fish and Wildlife Service in 1980. A policy variable describing total forested area in each state was positively correlated to participation in non-consumptive recreation activities, illustrating the effects that the loss of forest area can have on outdoor recreation participation. Results found that a 10% increase in forested area led to an increase of 277,000 individuals participating in non-consumptive recreation activities. Total value for non-consumptive outdoor recreation participation in the U.S. varied from $8.7 billion to $164.5 billion, with an annual individual WTP from $198 to $3,731 depending on model specifics.

Siderelis and Moore (1995) estimated the economic benefits of three types of rail-trails using TCM. The study trails included a rural rail-trail (The Heritage in Iowa), a rail-trail along the urban/wildland interface (The St. Marks in North Florida), and an urban rail-trail (The Lafayette/Moraga in North Central California). Survey data produced mean travel cost estimates of $21, $16, and $2 per person per trip for each trail. Per person WTP (consumer surplus) estimates for each trail were $30, $50, and $5 respectively. Using these WTP estimates and annual trip totals, total economic benefits were estimated to be $4 million, $8.5 million, and $1.9 million per trail.

Gren et al. (1995) use benefits transfer to estimate the recreational benefit of the Danube floodplain as part of a larger study estimating the total value of natural resources and ecosystem services along the length of the river. Recreation estimates included hunting permit expenditures and were valued to be €360/ha ($196/acre U.S.) annually. After adjusting for cost of living differences along the floodplain, annual recreation value along the Danube was estimated to be €109/ha ($60/acre U.S.). Using population statistics, the total recreational value of the Danube floodplain was estimated to be €175 million ($235 million U.S.) annually.

Siderelis and Gustke (2000) estimated the site benefits associated with a trip to the North Carolina Zoological Park (NCZP). Data was elicited through an on-site screener survey followed by detailed mailed survey. Results produced a mean round-trip travel cost of $84 per travel party. Mean per trip per party WTP (consumer surplus) was $44. Based on the estimated 800,000 visitors in 1994, the aggregate benefits for viewing wildlife at NCZP were estimated to be $35 million (Siderelis and Gustke 2000).

Betz et al. (2003) used a variant of the TCM to determine the market for a proposed rail-trail near Athens, GA. In order to estimate the potential value in developing the Antebellum Rail Trail (ART), a Contingent Trip Model for expected trips was developed. The model yielded WTP (consumer surplus) estimates of $18 per person per trip. Expected annual visitation was approximately 416,000, Using per trip WTP, estimated visitation and response rates, total economic benefit of the ART was estimated to be $7.5 million (Betz et al. 2003).

Bowker et al. (2007) estimated the total benefit and economic impact of the Virginia Creeper Trail (VCT) with TCM. The VCT is a tourist destination located in Southwest, Virginia, drawing visitors from the region's urban centers.   Trail visitors were surveyed and counted at various exit sites along the trail based on a random sampling plan during the winter and summer seasons of 2002-2003. The estimated WTP (consumer surplus) per trip per group was between $29 and $39 depending on the treatment of time. Annual primary trips to the VCT during the sample period were estimated to be approximately 101,000. Using this estimate and group WTP estimates, total annual recreational access values are between $2.3 and $3.9 million. The results of the economic impact analysis of this trail are presented later in this report.

Other Methodologies

Lockwood and Tracy (1995) use joint TC/CVM to estimate the economic benefits of recreation at Centennial Park near Sydney, Australia. The study site, a 220 acre park on the outskirts of Sydney, provides many diverse recreation activities including horseback riding, cycling, jogging, bird-watching, picnicking and walking. Estimates of visitation are around 3 million annually. The results of an on-site visitor survey were used in a TCM to estimate a consumer surplus $7.50 per visit. Annual visitation was estimated to be 3.1 million, producing a total annual economic benefit to visitors of $23 million. To capture local WTP to keep Centennial Park in its current state, an off-site survey was used in a CVM. Results suggest an annual household WTP of $26. Using the total population of Sydney, approximately 1.2 million people, the total value of Centennial Park in its current state is estimated at $31 million annually.

Fadali and Shaw (1998) use CA to investigate the demand for a water bank for in-stream uses at Lake Walker, Nevada. Per person annual WTP to ensure that Lake Walker remains a viable recreation resource was estimated to be $83. Based on estimates, around 50,000 acre feet annually will need to be diverted from agricultural uses to ensure protection of the recreation resource. The total value of in-stream water use at Lake Walker was estimated to be approximately $4 million. This is compared to the annual value of water for agricultural purposes, ranging from $12-$45 per acre foot. This produces a total value for agricultural water between $600,000 and $2.25 million. Differences suggest a net value of in-stream water use ranging from $1.75 to 3.4 million, showing that enough demand for recreation on Lake Walker to make a water banking system feasible.

Another example of combined TCM/CVM methodology is reported by Shrestha and Loomis (2001). This study examines the use of benefits transfer with meta-analysis to international recreation sites. The dataset for this study incorporated recreation studies from U.S. sites over a thirty year period, 1968 to 1998. This study included both CVM and TCM models and utilized methodology variables to account for intrinsic differences in TCM and CVM. To account for monetary differences, results were presented using a conversion factor or as a ratio of the conversion factor and per capita income of the countries included. Results suggested that benefits transfer was useful when original studies are not feasible, but introduce approximately 24-30% error in benefits estimates (Shrestha and Loomis 2001). Depending on the model used and income differences, predicted WTP (consumer surplus) estimates were $35-$40 per trip.

Kaval and Loomis (2003) used benefits transfer to estimate outdoor recreation values at major recreation areas in the U.S. and Canada. The study included various types of recreation areas. National Forest and Park, State and City Land, and various other land entities were all included. Recreation demand studies conducted between 1967 and 2003 covering thirty types of outdoor recreation activities were used. WTP values ranged from $.30/per person/per day for hiking to $464/per person/ per day for fishing. The average estimate of WTP over all recreation types was $40/per person/ per day.

The New Jersey Department of Environmental Protection produced a study to estimate the Total Economic Value of parks, forests and recreational facilities managed by the Division of Parks and Forestry in New Jersey. Total Economic Value represents both use and non-use values, including value from recreation, economic activity, ES, property enhancements, consumptive goods, bequest and existence values (Mates and Reyes 2006). In this study, both non-use values and increases in property value were acknowledged benefits of these parklands, but were not included due to difficulties in translating value estimates into dollar equivalents. Recreational value was estimated using TCM estimates transferred from previous studies. An average WTP of $21 per person/day was estimated. Based on annual use estimates of 14.2 million visitors, average total value for recreation in New Jersey was $304 million (Mates and Reyes 2006).

The last study presented used TCM/ CVM joint methodology to estimate the value of the urban forest in Chandigarh, India (Chaudhry 2006). TCM revealed that total recreational value for annual visits to Chandigarh was 92.4 million Rs ($2.2 million U.S.), a per person/visit WTP of 308 Rs ($7.50 U.S.). CVM responses found a WTP of 153 Rs ($ 4 U.S.) per household for creation of new greenspace. Total recreational value of the forest by residents of Chandigarh was estimated to be 27.5 million Rs ($675,000 U.S.). Total value of the urban forest to residents and visitors of Chandigarh was estimated to be 120 million Rs ($2.9 million U.S.).

Economic Impact Analysis

Moore et al. (1994) performed an economic impact analysis of three diverse rail trails across the U.S.. The most urban of these trails was the Lafayette/Moraga and the most rural was the Heritage Trail. The St. Marks Trail could be described as an urban/wildland trail. Annual visitation was heaviest for the Lafayette/Moraga (400,000) and lightest for the Heritage (135,000). Visitation to the St. Marks received an annual visitation of 170,000. Average per person/day expenditure was smallest for the Lafayette/Moraga ($4) and highest for the St. Marks ($11). The Heritage Trail produced an estimated mean per person/day expenditures of $9. Direct impact by non-local residents on the respective economies for each of these trails ranged from $294,000 (Lafayette/Moraga), $400,000 (St. Marks), and $630,000 (Heritage Trail).

Studies of linear trails in Canada show positive economic impacts to local economies as well. Using a detailed survey that included user registries and on-site interviews, Schutt (1998) estimated the economic impact of the Bruce Trail on local economies and the use of trail development as a logical development strategy. The Bruce Trail is a single purpose footpath that traverses southern Ontario. Annual visitation was estimated to be 410,000 between July 1994 and June 1995. Users were asked to complete a detailed list of expenditures related to their trail visit. Average per person expenditures on non-durable goods per visit was $20. Using IMPLAN input-output modeling, the total estimated economic impact of the Bruce Trail on economies adjacent to the trail was $60 million with 1,100 job equivalents produced. In addition to these impacts, spending in these economies contributed an additional $1.8 million and $1.6 million to the provincial and federal tax rolls.

Aside from estimating the economic benefits of the VCT, Bowker et al. (2007) also estimated the total economic impact of visitation on local economies in Southwestern, VA. Similar to Schutt (1998), respondents were asked to fill out a detailed expenditure profile indicating total and local spending. These profiles were analyzed using IMPLAN input-output analysis to determine the total impact of non-local expenditures on the economies of Abingdon and Damascus, VA. The total estimated economic impact attributed to non-local expenditures for VCT trips was estimated to be $1.61 million dollars for the survey period, 2002-2003 (Bowker et al. 2007).

The VCT, along with two other trails, the Washington and Old Dominion (W&OD) and the New River Water Trail, were a part of a larger study to estimate linear trail use, describe user demographics, and estimate benefits associated with trail use and the economic impact of linear trail use in Virginia. More information on the W&OD

portion of the study can be found at www.americantrails.org/resources/adjacent/WODstudy04.html (8/10/07) and New River study can be found at http://www.americantrails.org/resources/adjacent/WNRstudy04.html (8/10/07).

Markets

This section consists primarily of initiatives enacted in communities and primarily funded by public resources to provide public recreation access. However, within these examples are initiatives that can be characterized as public-private partnerships and in some cases include significant contributions from private interests.

Individual Buyer, Government Seller

Abruzzo Tourism Project. Through the "Global Leaflet" periodical distributed by U.S.DA Forest Service International Programs, Schneider (2007) writes about a unique Italian program promoting community tourism initiatives. The Italian program, funded by The Ministry of Cultural Property and Activities, stresses heritage and recreational tourism. With seed funding from the government, 30 communities in the Abruzzo region of Italy are working together to create parks, build infrastructure and market to visitors the recreation and heritage opportunities available. Known as the "Green Province," Abruzzo is home to the National Park of Abruzzo, the centerpiece of community recreation and tourism plans. The program has been successful enough be a part of a technology sharing agreement between the U.S.DA Forest Service and regional authorities in Abruzzo.

Cleveland Metro Parks. Bixler (1999) presents a case study of the Cleveland Metro Parks, a recreation district providing 19,650 acres of woodland composed of 14 reservations within the greater Cleveland area. The park district attracts around 40 million visitors annually. The reservations support a myriad of outdoor recreational opportunities from hiking and swimming to golfing and cycling. Property tax revenues produce primary funding with supplements from user fees and federal, state and local grants. The park district is active in acquiring new lands in order to maintain and improve on the inter-connectedness between the reservations. The district is also active in developing recreation easements with industrial and private landowners. To further provide recreation access, the park district has recently embarked on the Ohio and Erie Canal Reservation, a green-space initiative that includes several corporate sponsors.

Thomas Hanraddy Fields. This is a "brownfield" remediation example with funding provided through the Green Acres matching funds program (Knee et al. 2001). Green Acres is a state run program that will match community funding to improve and develop urban green spaces in New Jersey. The City of Elizabeth, NJ foreclosed on an abandoned plastics plant then used Community Development Block grants to demolish and remediate the site. A bond referendum provided the necessary funding to construct the fields and Green Acres provided the grant and loan structure to offset the bond. At the project's conclusion, a two acre lot was converted into a park of baseball fields and playgrounds.

The Pocket Park Program. This program, in Lakewood, NJ, is managed by the county and targets foreclosed, abandoned or recently deemed environmentally sound land parcels for conversion to playgrounds or pocket parks. This initiative, introduced in 1995, converted fifteen urban spaces into pocket parks by the end of the century (Knee et al. 2001). To ensure safety, the parks are inspected weekly and promptly repaired or painted when problems arise. Funding for this program is entirely public with land acquisition and construction costs financed through the city's capital funds and maintenance by the Public Works Department.

Central Richmond Greenway. This project will create 32 acres of linear trail and nature learning center on a former "brownfield" in Richmond, California. Funding will come from diverse sources including federal, state and local governments and community partners. Non-profit organizations will play a role in organizing in-kind community and volunteer labor (Knee et al. 2001).

Southside Community Park. Plans for this park, also in Richmond, California, include increasing and improving an existing linear trail. Improvements, covering four acres, include walking trail additions, playing fields, and picnic tables. This project has backing from multiple partners including the State of California, non-profit grants, local public investment and community in-kind donations of labor.

Vincent Park. This is a three acre park providing biking and walking paths along the San Francisco Bay. The park, built on a former "brownfield," is currently part of a larger mixed-use development. Funding for this park was a joint public-private venture with remediation costs funded by federal dollars and park development costs incurred by a private developer as part of a community revitalization effort.

Individual Buyer, Individual Seller

At Kw'o:kw'e:hala Eco Retreat. This is an example of a private recreation opportunity, tailored to urbanites, outside of Vancouver, BC. The At Kw'o:kw'e:hala Eco Retreat offers patrons opportunities to participate in various recreation activities from hiking and cycling to relaxation and activities aimed at environmental consciousness (At Kw'o:kw'e:hala Eco Retreat 2007). The resort offers various packages starting at $145/day that can be customized to fit individual interests and seasonal highlights. These package deals include lodging in a rustic setting and environmentally conscious cuisine.

Summary

- The valuation methods used in this section include: Benefits Transfer, Conjoint Analysis, Contingent Valuation, Economic Impact Analysis, Hedonic Price Method, Travel Cost Method and Benefit Cost Analysis.
- People in urban settings value and are willing to pay to live near and protect urban forests.

- The estimated value of recreation benefits varied across studies. For example, residents of Joensuu, Finland reported a monthly willingness to pay between $9.50 and $12 for access to recreation site within the city and potential users of a proposed rail trail in Athens, GA received an estimated consumer surplus of $22 per person/trip.
- To date, the majority of recreation programs are publicly funded by federal, state and local governments.
- For more information about a specific study in this section, please refer to the Appendix.

Section V: Energy

In this section, research, initiatives and information about the energy saving potential of urban forests are presented. First is a review sub-section. This review presents studies valuing the urban tree canopy as a function of energy savings through shading effects, and temperature and wind reduction. A second sub-section presents initiatives promoting tree planting programs and individual energy savings using tree shade.

Energy is a fundamental element in both economic development and ecosystem functions and often creates conflicts between these two interests. Over the last 20 years increased energy consumption has created great advances in wealth and prosperity but, not without consequences (Hinrichs 1996). The tradeoff for increased wealth and prosperity has been the degradation of air, land and water. Today many citizens, managers, and politicians are seeing the need for a more sustainable growth pattern, better efficiency in the use and consumption of energy, and the development of alternative energy sources.

These problems are particularly acute in urban areas. Urban areas, characterized by impervious surfaces and low levels of vegetation, trap heat and create what is known as an "urban heat island" (UHI). A “heat island” is a city that has historically seen annual air-conditioning demand rise more than 10% over the last 40 years (Akbari et al. 2001). This increased demand for cooling has a measurable cost effect. In 2002, “heat island” cities combined to spend over $20 billion on cooling city buildings (Akbari 2002). This includes the cities of Atlanta, Chicago, Houston, Los Angeles, New York City, and Phoenix, all of which experience an average temperature 2.5^{o} C higher than that of surrounding rural areas (Akbari 2002). Increased cooling demand has a direct link to increased energy consumption, increasing electricity production that leads to increased air pollution as utilities and power plants meet demand. Air quality is further degraded by this scenario since peak demand often occurs during periods when air pollution already exceeds NAAQS, producing health related impacts.

Researchers have identified two methods to decrease demand for cooling in urban areas, increasing tree canopy and using high-albedo construction materials. High-albedo materials reflect more light from building surface area, meaning less heat is trapped (Akbari et al. 2001). Urban forests improve climate conditions and promote energy conservation through shading, evapotranspiration and air-flow effects. If properly placed, a single mature tree can save between 10% and 15% annually (McPherson 1994). Recent estimates indicate that urban trees cover about 28% of urban land, leaving potential for increases in tree cover. Residential settings, most often, provide the available area for urban forest expansion and provide the highest level of benefits.

Literature Review

This literature review is slightly different from the review in previous sections. Since the focus of the research presented in this sub-section all investigate energy savings associated with trees the sub-section will not be divided into parts.

In order to maximize the benefit of trees for energy savings they must be placed in the proper location. Heisler (1986) calculated that in 1982, U.S. single-family detached homeowners spent a total of $63 billion on energy for space heating and cooling units. A summary of previous research suggest that placing trees in a strategic pattern on the western side of a dwelling maximized energy saving potential in the summer while compensating for winter energy losses through wind reduction. When compared to a similar detached dwelling in open space, this western arrangement saved the homeowner between 20-25% on energy expenditures.

Akbari and Taha (1992) estimated the heating and cooling savings associated with vegetation and white surfaces in the Canadian cities of Toronto, Vancouver, Edmonton, and Montreal. The study estimated the energy savings effects of shading, wind shielding, and evapotranspiration on gas-heated, electric-heated, and R-2000 one and two story detached and row homes. Results show the variability of savings by city. Annual savings in Toronto ranged from 6-15% for heating and 19-55% for cooling by housing type and heating method. The annual mean savings was $79 per home and ranged from $30-$180 per home associated with the increased cover of three trees per house. In Edmonton, Montreal, and Vancouver average annual savings for heating were 8%, 11% and 10% respectively. The cooling expenditures in both Edmonton and Vancouver are fully offset (100%) by shade and evaporative cooling effects, while average annual savings were 35% in Montreal.

McPherson et al. (1994) estimated the energy savings of trees for one, two and three story residential buildings using different tree planting scenarios in Chicago, IL. These scenarios accounted for trees at various stages of growth and distance from dwellings. To simulate the effects of shading, computer models were used along with meteorological data of the Chicago area. Findings supported previous research suggesting that trees can contribute to energy savings through summer shading and winter wind blockage if planted in appropriate locations. Results report that a 10% increase in tree canopy, roughly three trees per location, could reduce total energy costs 5-10%, an annual savings of $50-90.

Similar findings were found by Simpson and McPherson (1996) in California. Several factors were incorporated into this study including climate information, tree configuration, building energy efficiency and peak and annual energy usage. These factors were simulated in a model to predict changes in energy use and shade effect. Three housing types, an energy efficient standard, an insulated attic, and an un-insulated house, were modeled with tree planting patterns and zonal weather data for computer simulations. Results found that planting a tree along the western side of the house produced the greatest savings. However, results found a 20% diminished return on savings for each additional tree planted. On a percentage basis, savings were larger in cooler climates than hotter climates but, the actual amount of energy saved was larger in hotter climates. Insulated homes produced nearly 3 times the savings of un-insulated homes with the same tree pattern. Average savings ranged from a 10-50% reduction in annual energy use, saving homeowners $30-$110 depending on climate zone.

Rosenfeld et al (1998) used computer modeling to estimate the energy savings for commercial and residential buildings in the Los Angeles Air Basin (LAAB). Results found that commercial buildings realized 25% less energy savings than residential structures. Estimates of direct monetary savings associated with tree shading were $58 million annually. Meteorological simulations found the indirect benefits of each cool community strategy, trees and lighter materials, contributes equally to energy savings. Estimates suggest that using tree shade and high albedo materials could reduce the ambient temperature $3^{o}C$ in Los Angeles by 2015. The indirect benefits associated with trees were estimated to create a monetary savings of $35 million. Projected smog reductions were measured using the aforementioned meteorological model and suggest the "cool communities" approach can reduce smog in the LAAB by 12%. Based on an annual smog cost of $3 billion, this reduction is worth approximately $360 million, of which trees were associated with 50%, worth an estimated $180 million annually. The total value of the urban forest in direct, indirect and smog reduction benefits in the LAAB was estimated to be $273 million.

Simpson and McPherson (1998) revisit the energy savings associated with increased shade on residential air conditioning use in Sacramento, California. Shade effects were estimated using computer simulations based on a random sample of 254 residential properties. Results show that the shading effects of three trees per property could reduce average summer energy consumption by 22%, and peak energy demand 2.3% per additional mature tree. Total per tree savings, including wind reductions, were estimated to be $14 annually.

The previous research was extrapolated to capture regional effects by Simpson (1998) using sub-regional data for Sacramento County. The impacts of trees were determined by summing energy use for representative residential and commercial buildings by building types and age. Changes were estimated based on simulated effects in climate patterns, planting shade trees, and building characteristics. Results found an estimated 1.1 million trees with shade potential in Sacramento County. These trees produced an annual cooling savings of $10.7 million. Trees also attributed to reductions in average maximum air-temperature and wind speed, between $1.9^{o}C$ and $2.3^{o}C$ in temperature reductions and a $1.3 million annual savings from wind speed reductions. When aggregated across land use type, county wide benefits attributed to the urban forest from shade, air temperature and wind speed reductions were estimated to be $20 million annually, $17 million to residential dwellings. This amounts to approximately $39 per dwelling and between $8 and $16 per tree.

When assessing the benefits of the urban forest in Stevens Point, WI, Dwyer and Miller (1999) incorporated GIS to assess the urban forest and lands along the urban fringe. GIS and aerial photography was used to assess land use cover in the study area. With this data and information on various aspects of the urban forest, provided by CITYgreen, the impact on energy savings was estimated. CITYgreen, is a GIS based land use application that analyzes ecosystem services in an area and computes a dollar based estimate of these services. This program can provide estimates for storm water runoff, air quality, energy savings, carbon sequestration, and tree growth (www.americanforests.org/ 2007) The results suggest that energy savings increase as the tree canopy increases. In the case of Steven Point WI, energy savings attributed to the urban forest were approximately $127,000 annually.

In Australia, Brack (2002) estimated the value of the public urban forest in Canberra. This study used the Decision Information System for Managing Urban Trees (DISMUT) model to estimate these values. DISMUT is primarily used as a way to inventory and project growth models for proper maintenance of Canberra's urban forest. In this analysis, DISMUT was used to predict crown cover and volume of trees planted before 1990 to estimate their potential value between years 2008 and 2012. Total value estimates included energy savings, air pollution reduction, hydrologic benefits and carbon sequestration. The estimated total value of Canberra's urban forest between 2008 and 2012 was $20 million annually. Individual annual value estimates were $1.5 million, $1 million, $1.3 million, and $300,000 for energy savings, pollution reduction, hydrologic benefits, and carbon sequestration respectively.

Konopacki and Akbari (2002) present an analysis of "cool communities" strategies for "heat island" mitigation in five regional cities: Baton Rouge, Chicago, Houston, Sacramento, and Salt Lake City. The value of energy savings, peak power avoidance, and CO_2 reduction at residential, office and retail space were estimated. For each city a "base case" was measured against three individual heat island reduction strategies and a combination scenario incorporating all strategies. The three single scenario strategies were: strategic use of shade trees, high-albedo roofing materials, and urban reforestation with reflective pavements and surfaces. In each city the combined scenario realized the highest benefit with total value variable among cities.

Baton Rouge. The combined effect of reduction strategies led to an annual rate payer savings of $15 million, reduced peak power demand by 135MEGW, and reduced carbon emissions by 36KT. Indirect benefits from a 2^oF temperature reduction produced a 15% total energy savings. Strategic shade tree usage accounted for $5.2 million of total annual rate savings, 62MEGW in reduced peak power demand and 12KT in reduced carbon emissions.

Chicago. The total effect of combined strategies led to an annual rate payer savings of $30 million, a 398MEGW reduction in peak power demand, and a 58KT reduction in carbon emissions. Simulations indicated no temperature reduction in Chicago, but the associated indirect strategies produced 18% of total annual savings. The shade tree scenario accounted for $13.5 million of the annual rate savings, 128MEGW of reduced peak power demand and reduced carbon emissions by 26KT.

Houston. The annual rate payer savings for combined strategies was $82 million. The combined scenario reduced peak power demand by 734MEGW while reducing carbon emissions by 170KT. Indirect benefits reduced air temperatures by 2^oF and accounted for 19% of total energy savings. The shade tree scenario produced $28 million in annual savings, contributed 247MEGW in reduced peak power demand and 58KT reduction in carbon emissions.

Sacramento. Combined effects of reduction strategies led to an annual rate payer savings of $30 million, while reducing peak power demand by 449MEGW, and carbon emissions by 59KT. Indirect benefits reduced air temperature 3^{o}F, attributing 19% to total energy savings. The shading effect of trees accounted for 32% of rate savings, 40% of reduced peak power demand and 30% of annual reduction of carbon emissions.

Salt Lake City. In Salt Lake City the combined strategy reduced energy payments by $4 million annually, peak power demand by 85MEGW and carbon emissions by 9KT. Indirect benefits contributed 22% to total energy savings while reducing ambient air temperature by 3^{o}F. Of these savings and reductions, tree shade accounted for $1.1 million in energy savings, 33MEGW for peak power demand and 3KT in carbon emissions.

The next study addresses the connection between energy savings and leaf area index (LAI) in the city of Terre Haute, Indiana (Jensen et al. 2003). LAI is the one sided green leaf area per unit ground area for broadleaf canopies, or the projected needleleaf area per unit ground area for needle canopies (www.uni-giessen.de/~gh1461/plapada/lai/lai.html 2007). To estimate LAI, satellite photography was used in conjunction with modeling techniques. The data was regressed against household cooling expenditures throughout the city on various land use types. Results suggest that as LAI increases, expenditures on energy for cooling purposes decreases. On average the study found a daily household savings of $0.31 per 1 m^2 increase in LAI.

During the summer of 2004 McPherson et al (2005a) conducted a stratified random sample of the trees in Charlotte, NC, inventorying the results as the basis for a benefits and costs analysis (STRATUM reference city). The inventory estimated that the City of Charlotte manages over 85,000 public trees, a 1:7 tree per resident ratio and offers shade to 0.75% of total city area. The value of Charlotte's urban forest was estimated by the benefits from storm water reduction, energy savings, carbon sequestration, pollutant reduction, and aesthetic and amenity values. These benefits provide an annual gross total benefit of $5.9 million, roughly $69 per tree. Individual benefits varied in value from $2.76 million in aesthetic and amenity values to $198,500 in carbon sequestration values. Energy savings were estimated to be $914,000, approximately $11 per tree. When the costs of maintenance and infrastructure damage are considered, the BCA ratio was 3.25.

McPherson et al (2006) used the same metrics to value the urban forest in Charleston, SC (STRATUM reference city). Inventories estimated an urban forest of 15,244 trees. Storm water benefits from this forest were estimated to be $171, 406 annually. The benefits from shade associated energy savings provided an annual savings of $120,991. Carbon sequestration removed 1,563 tons of carbon annually, valued to be $23,452. Charleston's urban forest also provided $36,270 in benefits from pollution reduction. In addition to these values, the urban forest contributes another $395,000 in benefits from aesthetics and increased property values. Aggregate annual benefit estimates for Charleston's urban forest are $717,034, roughly $47 per tree. The City of Charleston spends $700,000 annually on maintenance and upkeep costs, an average of

$35 per tree. Researchers calculated a benefit-cost ratio of 1.35, lower than that of Charlotte, but still indicating an overall benefit from the forest.

The final study presented in this review estimates the impact that shade tree planting has on residential energy consumption in Houston, TX (Hitchcock et al. 2007). A building energy model with six tree placement strategies was used to estimate the impact that an average house in Houston could expect from an average tree on energy expenditures. Placements strategies included: north, south east, and west facing tree plantings and along two multiple planting combinations; tree placement on all sides of the home and a second with trees on all sides except the northern side. The impact of energy savings was measured in cumulative kWh savings and peak demand reductions over a 30 year period. Results indicate that planting a tree on the west facing side of the home produced the most savings, around 5,784 kWh of cumulative savings and a 0.16 kW reduction in peak demand in the 24th year.

Markets

In this sub-section various attempts to foster initiatives promoting urban forestry and energy savings from tree use are described. In most cases these programs involve public funding.

Government Buyer, Individual Seller

Sacramento Municipal Utility District (SMUD, www.smud.org). SMUD is a non-profit electrical utility servicing the Sacramento area. SMUD has been involved in promoting urban forestry initiatives that save homeowners on energy bills and strengthen the urban forest of Sacramento. Since 1990, SMUD has been actively involved with the Sacramento Tree Foundation in planting over 400,000 trees in Sacramento County (Sacramento Municipal Utility District 2007). SMUD also offers a program allowing homeowners to receive a shade tree free of charge, tips on planting and caring for trees and a list of effective shade trees depending on size characteristics preferred and soil and climate type. Another innovative application found at the SMUD website is the Tree Benefit Estimator, http://usage.smud.org/treebenefit/calculate.asp (8/10/07). This gives a homeowner or interested party an estimate of savings and carbon sequestration to be expected from mature trees in an urban or suburban setting. This calculation takes into account regional climate differences, tree number, and tree characteristics including age, specie, orientation, and distance from a dwelling.

Trees for Tucson. This is a non-profit program through Tucson Clean and Beautiful that promotes the use of desert trees in the Tucson area to beautify, provide habitat, conserve energy, and collect pollutants. In conjunction with Tucson Electric Power, the program provides free trees for community and school projects and reduced priced trees to homeowners and homeowner groups for street planting and energy conservation locations (Tucson Clean and Beautiful 2007). The program varies the species by time of year and only provides those that are well suited for desert environments. To ensure proper maintenance of the planted trees, the program offers workshops on proper care and planting techniques.

TREE POWER. This is a nationwide tree planting program among public utilities. TREE POWER allows each utility to design a tree planting program based on individual resources and community needs. Typically, a local program provides tree plantings for homeowners, schools, non-profit organizations, multi-family complexes and public spaces (American Public Power Association 2007). Each portion of the program has specific guidelines and procedures, but all programs actively work with individuals to ensure proper planting and tips for maintenance. Homeowners have an added benefit of being eligible for a rebate to offset planting costs.

Individual Buyer, Individual Seller

DTE Energy. This is a nationwide, publicly traded energy company with primary utility holdings in Michigan. DTE operates an environmental stewardship program with several on-going projects. DTE is a member of the U.S. Department of Energy's Climate Challenge Program. In 1995 DTE began a tree planting program with the goal of 10 million trees planted by 2000 within Michigan. The milestone was reached and extended to another 10 million trees, a goal reached in 2002 (DTE Energy 2007). DTE also established a Tree Grant Program to fund tree planting initiatives in Michigan communities. To date the program has awarded a total of $450,000 to 95 communities throughout the state. DTE also offers information to individuals interesting in tree planting efforts by providing information on which type and when and where to plant trees to promote residential shade, energy conservation, and beautification.

Summary

- The analysis of urban forest benefits in this section are all based on energy savings estimates.
- Research shows that increases in urban forests reduces ambient temperature and generates energy savings through increased shade and wind protection
- These energy savings ranged from a mean annual savings of $114 per household in Toronto, OR to an annual energy savings of $71.7 million in Los Angeles.
- Several public utilities and local programs are active in promoting energy savings via tree plantings.
- For more information about a specific study in this section, please refer to the Appendix.

Section VI: Organizations

This section highlights several organizations and programs that are active in issues related to ecosystem services. Some of these organizations seek to raise awareness and promote ES and smart growth development, others provide training, education, and funding for projects involving ES protection, and others are active in ES valuation and market development.

Select Organizations and Programs

Alliance for Community Trees (ACTrees, www.actrees.org 8/10/07)

Founded in 1993, ACTrees is a coalition of over 100 organizations dedicated to supporting citizen based initiatives that support urban forest planting, maintenance, conservation and education projects. A primary project of ACTrees is the NeighborWoods program promoting tree canopy restoration in urban communities. ACTrees receives support from The Home Depot Foundation and to date has dispersed over $600,000 in funding and provided trained organizers to assist in community planting initiatives (www.actrees.org 2006).

American Forests (www.americanforests.org 8/10/07)

American Forests is the oldest citizens' non-profit organization in America and promotes the goals of forest restoration and active support of urban forest issues. These goals are accomplished through several programs including: The Global ReLeaf program and CITYgreen. The first program is an education and outreach program to plant and care for trees in rural and urban communities throughout the world. To date Global ReLeaf has been involved with more than 500 projects planting over 25 million trees worldwide. The second project, CITYgreen, is a GIS based land use application that analyzes ecosystem services in an area and computes a dollar based estimate of these services. This program can provide estimates for storm water runoff, air quality, energy savings, carbon sequestration, and tree growth (www.americanforests.org/ 2007).

Database of State Incentives for Renewables and Efficiency (DSIRE, www.dsireusa.org 8/10/07)

Established as a joint project between the North Carolina Solar Center and the Interstate Renewable Energy Council in 1995, DSRIE provides information on energy incentive programs at the federal, state, local, and utility levels. Using an interactive map, the website allows the user to navigate through a database of the programs offered for renewable energy and energy efficiency state-by-state. This website offers information on both financial incentives and rules and regulations (www.dsireusa.org 2007).

Earth Economics (www.eartheconomics.org 8/10/07)

Earth Economics is a Puget Sound based non-profit ecological economics research group. The goals of Earth Economics are: fostering an economic perspective towards ecosystems and community development, providing technical help with ecosystem valuation, and enhancing international trade agreements that properly value ecosystem services. Project focus includes: Puget Sound, Hurricane Katrina, Toxics, Finance and Trade, Marine environments, Forests, and Skill Sharing. The Earth Economics website contains several downloadable publications on a range of topics from ES assessments of King County and Washington State, Smart Development, and Trade Policy (www.eartheconomics.org).

Ecosystem Valuation (www.ecosystemvaluation.org 8/10/07)

Ecosystem Valuation is a publicly funded website to provide information and awareness about the concepts and application of ES valuation to the layperson. The website contains information on the basics of valuation and its importance, valuation methodologies and applications, and useful links providing more specific information. The site also enables the user to elicit feedback to improve understanding and functionality. The site is maintained by faculty from The University of Maryland and The University of Rhode Island, respectively (www.ecosystemvaluation.org 2007).

European Urban Forestry Research & Information Center (EUFORIC, www.sl.kvl.dk/euforic/ 8/10/07)

This center promotes the development and further research of urban forestry in Europe. Primary among its goals is strengthening the network of urban foresters in Europe. To accomplish this networking, EUFORIC promotes research and collaboration among urban foresters and use of this research to influence policy decisions in Europe.

Forest Trends (www.forest-trends.org 8/10/07)

Forest Trends is a Washington D.C. based international non-profit organization concerned with forest sustainability and valuation. The primary objectives of Forest Trends include: expanding the value of forests to society, promoting sustainable forest management and conservation through ES market development, support for projects, organizations, and companies developing these markets, and enhancing the livelihoods of local communities living in and around forests. In order to accomplish these objectives the organization works primarily to convene stakeholders, provide sound analysis of problems, and facilitate market transactions (www.forest-trends.org 2007).

Green Acres (www.state.nj.us/dep/greenacres 8/10/07)

Green Acres is a program administered by the New Jersey Department of Environmental Protection, designed to protect environmentally sensitive lands within the state. These lands become part of the state's park, forest or wildlife areas. A significant portion of this program is the provision of urban green space for recreation, and preservation. Green Acres consists of four programs, State and Open Space Acquisition, Local Governments and Nonprofit Funding, Stewardship, and Planning and Information Management. To date, Green Acres has used $1.4 billion from bonds to protect 1.2 million acres of open space (www.state.nj.us/dep/greenacres).

Gund Institute for Ecological Economics (www.uvm.edu/giee 8/10/07)

The Gund Institute for Ecological Economics at The University of Vermont is actively involved in research related to healthy and sustainable ecosystems. Current research involves: inclusion of science in economic decision-making, valuation of ecosystems and the services they provide, community participation in economic design and development, and measurements of ecosystem health and sustainability. Current on-going projects include the Ecosystem Services Database, Ecovalue and The Baltimore Ecosystem Study (www.uvm.edu/giee/ 2007).

Kaboom Inc. (www.kaboom.org 8/10/07)

This is a non-profit organization that fosters partnerships with city officials and private enterprise to build playgrounds and pocket parks in inner city areas around the U.S. Several of these initiatives have received funding from corporate partners such as Home Depot, Nike, and Target. In many cases Kaboom Inc. acts as a liaison for communities in search of sponsorship and funding opportunities. Members of Kaboom offer three keys for a successful development: a strong working committee incorporating significant community interests, a well defined project goal and timeline, and clear fundraising goals and parameters (Knee et al. 2001).

Katoomba Group (www.katoombagroup.org 8/10/07)

This is a multinational working group comprised of experts in forestry, energy, and finance devoted to developing ES markets, education and advocacy. Of primary concern to Katoomba is addressing the challenges that face market development, primarily: legislation, institutions, pricing strategies, and monitoring. To further advancement of ES markets, the Katoomba group developed the Ecosystem Marketplace. Ecosystem Marketplace is a platform designed to bring together interested parties to buy and sell ecosystem services, providing up to date market transactions in Biodiversity, Carbon and Water Markets. Aside from this service, Ecosystem Marketplace provides ES publications, news articles, resources and updates (www.katoombagroup.org/ 2007).

Parkway Partners Program Inc. (PPP, www.parkwaypartners.com 8/10/07)

PPP is an organization working to develop corporate sponsored community development projects stressing environmental responsibility, education, and community and economic development in inner-city New Orleans, LA. This non-profit organization seeks to build playgrounds and parks, preserve urban forest, and transform vacant lots into community gardens and pocket parks. Through its 16 years of community development, PPP offers three keys to success: understand the communities needs, understand the corporate climate in your area, and be creative (Knee et al. 2001).

Resources for the Future (RFF, www.rff.org 8/10/07)

Created in 1952, RFF was the first environmental think tank in the U.S. Today the non-profit and non-partisan organization conducts economic research on environmental policy related to energy and natural resources. RFF is comprised of two divisions: Quality of the Environment and Natural Resources. Under these umbrellas specific research is conducted addressing issues in pollution control, energy policy, land and water use, climate change, biodiversity, hazardous waste, and environmental issues in the developing world (www.rff.org 2007).

In addition to these activities, RFF publishes a quarterly magazine, *Resources*, that provides articles addressing current problems and stories pertaining to environmental, energy, and natural resource issues. In the current issue, *Resources*: *Spring 2007, Issue 165*, there are several articles addressing ES. These include: how people value ES (Krupnick and Siikamaki 2007), the importance of correctly valuing ES (Alpizar et al. 2007), and field testing ES payment schemes (Lynch and Shabman 2007). This issue can be found at: www.rff.org/rff/Documents/RFF-Resources-165.pdf (8/10/07).

Sacramento Tree Foundation (SacTree, www.sactree.com 8/10/07)

SacTree sustains, supports and enhances the urban forest of Sacramento through a series of programs targeting different aspects of the urban forest from education and awareness to tree health and planting initiatives (Sacramento Tree Foundation 2005). Currently SacTree actively manages eight programs: Community Shade, Mistletoe, NATURE, NeighborWoods, Greenprint, Seed-to-Seedling, Save the Elms, and Shade Tree. To ensure success, the foundation operates under the auspices of four strategies: be a responsible advocate for Sacramento's urban forest using the best available science, improve funding resources through increased membership and grant writing, improve overall performance through proper training, communication and objective measurements of project success, and improve volunteer recruitment and training (www.sactree.com/ 2005).

Theodore Roosevelt Conservation Partnership (www.trcp.org 8/10/07)

This is a recreation advocacy group made up of a coalition of partners with goals of increasing access to hunting and fishing opportunities, habitat conservation, and increased funding for wildlife management (www.trcp.org/ 2007).

Trees Forever (www.treesforever.org 8/10/07)

This Iowa based organization promotes tree planting activities in the states' communities through grant programs and hands-on assistance. Several projects that Trees Forever promotes are partnerships with utility companies designed to plant trees as a method of energy conservation. These include Alliant Energy Branching Out and The Aquila Program. Aside from these projects, Trees Forever also works with communities and municipal utility providers to develop tree planting programs (www.treesforever.org 2006).

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Appendices

Table 1a: Environmental Services: Water
Published Articles Reviewed

Year	1992	1993	1993
Author	Steinnes	Jordan & Elnaghee	Paterson et al.
Title	Measuring the Economic Value of Water Quality: The Case of Lakeshore Land	Willingness to Pay for Improvements in Drinking Water Quality	Costs and Benefits of Urban Erosion and Sediment Control: The North Carolina Experience
Location	Northern MN	Georgia	Asheville, Durham, & Wilmington, NC
Method	HPM	CVM	CVM
Data Type	market appraisal of leased lakefront lots on 53 different MN lakes	phone survey of residents, stratified into county water users and private well owners	mailed survey stratified by 3 regions (mountain, piedmont and coastal)
N	NA	192	467
Response	NA	35%	41%
ES	Water clarity	Water quality	Water quality
Units	total lot value/per 1 foot increase in water clarity	annual household WTP for decreased risk of nitrate contamination to public water users and private well users	annual household WTP to maintain state programs for sediment control
Value	$206	$121 & $149	$20
2006 Dollars	$296	$179 & $220	$28
Population	NA	6.5 million	NA
Area	NA	NA	NA
Aggregate Value (2006 dollars)	NA	$407.4 million	$19.8 million
Aggregation Method	NA	households * % of public water users and private wells * annual WTP	urban households * annual WTP
Costs (2006 dollars)			
Discount Rate			
Timeframe			
BC ratio			

Table 1a (con't)

Year	1995	1995	1995
Author	Streiner & Loomis	Stevens et al.	Breaux et al.
Title	Estimating the Benefits of Urban Stream Restoration Using the Hedonic Price Method	Public Attitudes and Economic Values for Wetland Preservation in New England	Using Natural Coastal Wetlands Systems for Wastewater Treatment: An Economic Analysis
Location	Northern CA	New England	Louisiana
Method	HPM	CVM	BCA
Data Type	property sales in various CA communities from 1983-1993	mailed survey stratified by 5 wetlands type	treatment cost analysis
N	521 & 478	NA	NA
Response	NA	34%	NA
ES	stream restoration	wetlands preservation	waste water treatment
Units	total property value increase by restoration package type (environmental, combined, and engineering)	annual per person WTP for wetlands preservation, by type, within 25 miles of respondent's residence	value per acre
Value	$52,200, $19,080, $12,300	$74-96	$775-$2,000
2006 Dollars	$109,090, $39,830, $25,680	$103-$134	$1,025-$3,042
Population	NA	9.6 million	NA
Area	NA	NA	570 acres
Aggregate Value (2006 dollars)	NA	$337.5-$436.5 million	$592,000-$1.7 million
Aggregation Method	NA	6.5million * response rate * average per person WTP	cost *acre
Costs (2006 dollars)			
Discount Rate			9%
Timeframe			30 years
BC ratio			NA

Table 1a (con't)

Year	1996	1999	2000
Author	Michael et al.	Morrison et al.	Mahan et al.
Title	Water Quality Affects Property Prices: A Case Study of Selected Maine Lakes	Valuing Improved Wetland Quality Using Choice Modeling	Valuing Urban Wetlands: A Property Price Approach
Location	Maine	New South Wales, AU	Portland, OR
Method	HPM	CA	HPM w/GIS
Data Type	property information and lake characteristics for 34 lakes in 6 markets throughout Maine between 1990 and 1994	drop-off and pick-up survey w/ pretest	residential sale prices in Multnomah County, OR
N	NA	416	14,485
Response	NA	76%	NA
ES	water clarity	wetlands preservation	water resource value
Units	average price increase per foot of frontage for a 1m increase in water clarity	one-time WTP for increased wetlands area, bird breeding, and endangered species protection without job loss	marginal price increase per 1000 ft decrease in distance from a water resource (wetlands, stream, and lakes)
Value	\$11-\$200	\$86-\$93	\$260, \$436, \$1,644
2006 Dollars	\$14-257	\$86-\$93	\$353, \$593, \$2,236
Population	NA	NA	NA
Area	NA	5,000km^2	NA
Aggregate Value (2006 dollars)	NA	NA	NA
Aggregation Method	NA	NA	NA
Costs (2006 dollars)			
Discount Rate			
Timeframe			
BC ratio			

Table 1a (con't)

Year	2000	2000	2000
Author	Leggett & Bockstael	Loomis et al.	Guo et al.
Title	Evidence of the Effects of Water Quality on Residential Land Prices	Measuring the Total Economic Value of Restoring Ecosystem Services in an Impaired River Basin: Results from a Contingent Valuation Survey	An Assessment of Ecosystem Services: Water Flow Regulation and Hydroelectric Power Production
Location	Anne Arundel County, MD	Denver, CO	Xingshan, China
Method	HPM	CVM	Water balance method
Data Type	county waterfront property sales, 1993-1997	mailed survey w/ pre-test	GIS
N	6,707	462	NA
Response	NA	26%	NA
ES	water quality	stream restoration	water conservation and storage
Units	total property value change per decreases in fecal coliform levels to 200 count per 100 mL	monthly WTP per household for 45 miles of stream restoration	annual economic value as a function of improved hydroelectric power generation, P * H
Value	$12 million	$21	$646,000
2006 Dollars	$15 million	$27	$646,000
Population	NA	281,531	NA
Area	NA	45 mil32	2,316km^2
Aggregate Value (2006 dollars)	NA	$23.8-$91.2 million	NA
Aggregation Method	NA	households * % response rate * annual WTP	NA
Costs (2006 dollars)			
Discount Rate			
Timeframe			
BC ratio		NA	

Table 1a (con't)

Year	2001	2003	2004
Author	Guo et al.	Brox et al.	Brown
Title	Ecosystem Functions, Services, and Their Values: A Case Study in Xingshan County of China	Estimating Willingness to Pay for Improved Water Quality in the Presence of Item Nonresponse Bias	The Marginal Economic Value of Streamflow from National Forests
Location	Xingshan, China	Southern Ontario	US
Method	Water balance method	CVM	Benefits Transfer
Data Type	GIS w/ economic simulations	mailed survey w/ cluster sampling	various
N	NA	3,070	
Response	NA	41-46%	
ES	water conservation and storage	water quality	in-stream and off-stream water use
Units	price per 1000 cubic feet	additional monthly WTP on water bill to improve water quality	marginal price per acre foot
Value	\$43,253	\$7.63	\$5-\$84
2006 Dollars	\$43,253	\$7.63	\$5.5-\$92
Population	NA	259,164	NA
Area	2,316km^2	6,800km^2	NA
Aggregate Value (2006 dollars)	NA	\$23.7 million	\$7.9 billion
Aggregation Method	NA	households * monthly WTP	mean annual supply from each region * MV per acre foot
Costs (2006 dollars)			
Discount Rate			
Timeframe			
BC ratio			

Table 1a (con't)

Year	2004	2004	2006
Author	Olewiler	Homes et al.	Batker et al.
Title	The Value of Natural Capital in Settled Areas of Canada.	Contingent Valuation, Net Marginal Benefits, and the Scale of Riparian Ecosystem Restoration	Special Benefit from Ecosystem Services: Economic Assessment of the King County Conservation District
Location		Western, NC	
Method	Benefits Transfer	CVM/BCA	
Data Type	Various	computerized survey w/ custom bidding and incentive payment	Various
N	NA	96	NA
Response	NA	NA	NA
ES	Water resources	Riparian restoration	Water resources
Units	annual value per hectare	WTP per foot	total annual value
Value	$7,800	$19-$90	$4-$161 million
2006 Dollars	$7,800	$22-$105	$4-$161 million
Population	NA	NA	NA
Area	16,225km^2	2-6 miles	712,336 acres
Aggregate Value (2006 dollars)	NA	$284,000-$3.2 million	$4-$161 million
Aggregation Method	NA	households * WTP	Summation
Costs (2006 dollars)			
Discount Rate		5%	
Timeframe		10 years	
BC ratio		3.33-15.65	

Table 1a (con't)

Year	2007
Author	Cho et al.
Title	Measuring the Contribution of Water and Green Space Amenities to Housing Values: An Application and Comparison of Spatially Weighted Hedonic Models
Location	Knox County, TN
Method	HPM
Data Type	Digital parcels, GIS, maps
N	15,500
Response	NA
ES	Amenity
Units	mean price increase for 1000 ft. decrease in distance
Value	$497-$6,032
2006 Dollars	$582-$7,063
Population	382,032
Area	526 sq. miles
Aggregate Value (2006 dollars)	NA
Aggregation Method	NA
Costs (2006 dollars)	
Discount Rate	
Timeframe	
BC ratio	

Table 1b: Environmental Services: Water

Markets Discussed

Title	Coatepec	PSA	FONAG
ES	Water resources	Hydrological services	Water resources
Location	Mexico	Costa Rica	Quito, Ecuador
Organization	Government	Government	Government
Population	NA	NA	1.5 million
Area	NA	NA	520,000 ha
Method	sustainable agriculture and land use	contracts and management plans	watershed conservation
Payment	User fees	User fees & international grants	User fees
Units	Acres	NA	NA
Amount	420,000	NA	NA
Value	NA	NA	$301,700
Value (2006) Timeframe	NA	NA	$338,000
Start Year	2001	1997	2000

Title	PILOT	Mexican Forest Fund	NYC Watershed
ES	Water resources		Water quality
Location	Massachusetts	Queretaro, Mexico	Catskills
Organization	Massachusetts Water Resources Authority	Central Water Authority	NYC Water Authority
Population	NA	NA	19 million
Area	NA	NA	NA
Method	Land acquisition	Land use management	land acquisition, comprehensive planning, watershed agricultural and forestry programs
Payment	User fees and direct payments	Government payments	NA
Units	%	Hectares	Acres
Amount		126,000	70,000
Value	$62 million	$19 million	$1 billion
Value (2006) Timeframe	$62 million	$20.8 million	$1.2 billion
Start Year	1985	2002	1997

Table 1b (con't)

Title	Ecosystem Marketplace	Great Miami River Watershed Water Quality Credit Trading Program	Perrier Vittel
ES	Wetlands	Water quality	Water quality
Location	Worldwide	Southwest Ohio	France
Organization	The Katoomba Group	The Water Conservation	Perrier Vittel
Population	NA	1.5 million	NA
Area	NA	4,000 sq. miles	11,500 hectares
Method	Protection and preservation	Watershed management	watershed management and conservation easements
Payment	Markets	non-point source pollution credits	above market land price
Units	Acres	1 pound of P or N	Hectares
Amount	NA	NA	1500
Value	$373 million	$305-$376 million	$9 million
Value (2006) Timeframe	$373 million	$314-$388 million	NA
Start Year	1996	2005	NA

Table 2a: Environmental Services: Air Quality
Published Articles Reviewed

Year	1978	1990	1992
Author	Nelson	Portney & Mullahy	Hall et al.
Title	Residential Choice, Hedonic Prices, and the Demand for Urban Air Quality	Urban Air Quality and Chronic Respiratory Disease	Valuing the Health Benefits of Clean Air
Location	Washington, DC	National	Southern CA
Method	HPM	CVM	COI, CVM, & WTA
Data Type	various cross sectional	National survey	dose-response relationship, benefits transfer
N	NA	368	NA
Response	NA	NA	NA
ES	Air quality	Air quality	Air quality
Units	average WTP per 1 microgram/m3 improvement in PM	annual WTP for a 1% reduction in sinusitis	average value of a statistical life measured against reductions in PM and O3
Value	$60-70	$1,000	$2.7 & $6.4 billion
2006 Dollars	$312-365	$2,800	$4.2 & $9.9 billion
Population	NA	135 million	NA
Area	NA		NA
Aggregate Value (2006 dollars)	NA	$3.8 billion	$4.2 & $9.9 billion
Aggregation Method	NA	average annual WTP * % reduction in number of illnesses	NA
Costs (2006 dollars)			
Discount Rate	NA	NA	NA
Timeframe	NA	NA	NA
BC ratio	NA	NA	NA

Table 2a (con't)

Year	1994	1995	1995
Author	McPherson et al.	Smith & Huang	Kim et al.
Title	Chicago's Urban Forest Ecosystem: Results of the Chicago Urban Forest Climate Project	Can Markets Value Air Quality? A Meta-analysis of Hedonic Property Value Models	Measuring the Benefits of Air Quality Improvement: A Spatial Hedonic Approach
Location	Chicago, IL		Seoul, South Korea
Method	BCA	HPM	HPM
Data Type	tree inventories, LAI	meta-analysis/benefits transfer	on-site sample stratified by city district
N	4.1 million	86	609
Response	NA	NA	39%
ES	air quality, energy savings, carbon sequestration, temperature reduction	Air quality	Air quality
Units	Per tree	average WTP per 1 microgram/m3 improvement in PM	household WTP for a permanent 1ppb improvement in SO2 emission
Value	$402	$110	$2,300
2006 Dollars	$595	$162	$3,200
Population	6 million	NA	10.6 million
Area	1292mi^2	NA	NA
Aggregate Value (2006 dollars)	47.3 million	$3.2-37.6 million	NA
Aggregation Method	summation	NA	NA
Costs (2006 dollars)			
Discount Rate	7%	NA	NA
Timeframe	30	NA	NA
BC ratio	Various	NA	NA

Table 2a (con't)

Year	1997	2000	2000
Author	Alberini et al.	Carlsson & Johansson-Stenman	Rabl & Spardaro
Title	Valuing Health Effects of Air Pollution in Developing Countries: The Case of Taiwan	Willingness to Pay for Improved Air Quality in Sweden	Public Health Impacts of Air Pollution and Implications for the Energy System
Location	Taiwan	Sweden	Europe
Method	CVM	CVM	Value of statistical life and years of life lost
Data Type	in-person survey sub sample from a larger sample	2 part phone and mailed survey	national survey
N	832	3107	NA
Response	87%	96%	NA
ES	Air quality	Air quality	Air quality
Units	median WTP to avoid a 1 day acute illness	monthly WTP for a 50% reduction in air pollution	cost/kg of air pollution
Value	$20	$24	$0.18 & $9
2006 Dollars	$29	$24	$0.18 & $9
Population	NA	NA	NA
Area	NA	NA	NA
Aggregate Value (2006 dollars)	376 million	NA	NA
Aggregation Method	NA	NA	NA
Costs (2006 dollars)			
Discount Rate	NA	NA	NA
Timeframe	NA	NA	NA
BC ratio	NA	NA	NA

Table 2a (con't)

Year	2000	2003	2005
Author	Nowak et al.	Murty et al.	Chay & Greenstone
Title	Brooklyn's Urban Forest	Hedonic Property Prices and Valuation of Benefits from Reducing Urban Air Pollution in India	Does Air Quality Matter? Evidence from the Housing Market
Location	Brooklyn, NY	Delhi & Kolkata, India	
Method	Benefits estimate	HPM	HPM
Data Type	UFORE, field data	Household survey	County level
N	610,000	1,250 each	NA
Response	NA	NA	NA
ES	Air quality	Air quality	Air quality
Units	Net annual reduction	household WTP for PM reduction to 200 micrograms/m3	household WTP for a 1 microgram/m3 reduction in PM
Value	$1.3 million	$451, $1,915	$243
2006 Dollars	$1.6 million	$451, $1915	$277
Population	NA	2.3 & 3.1 million	19 million
Area	2083 ha	NA	NA
Aggregate Value (2006 dollars)	$853 million	$605,000 & 1 million	$52 billion
Aggregation Method	Compensatory value	households * WTP	mean housing increase * population
Costs (2006 dollars)			
Discount Rate	NA	NA	NA
Timeframe	NA	NA	NA
BC ratio	NA	NA	NA

Table 2a (con't)

Year	2005	2006	2006
Author	McPherson et al.	Wang et al.	Nowak et al.
Title	Municipal Forest Benefits and Costs in Five US Cities	Air Quality Improvement Estimation and Assessment Using Contingent Valuation Method: A Case Study in Beijing	Air Pollution Removal by Urban Trees and Shrubs in the United States
Location	U.S. Cities	Beijing, China	U.S. Cities
Method	BCA	CVM	Benefits estimate
Data Type	STRATUM, tree inventories	in-person survey stratified by 8 city districts w/ pre-test	computer modeling, LAI
N		1,371	55 cities
Response	NA	91%	NA
ES	storm water runoff, energy savings, air quality, CO2 reduction, aesthetics	Air quality	Air quality
Units	Per tree	annual household WTP for 50% air pollution reduction over 5 years	Per ton national median externality value
Value	$1.37-$3.09	$19	$116,000-60.7 million
2006 Dollars	$1.41-$3.18	$19	$116,000-60.7 million
Population	NA	2.3 million	NA
Area	NA	NA	NA
Aggregate Value (2006 dollars)	$369,000-1.2 million	$434 million	$3.8 billion
Aggregation Method	Summation	households * WTP	Summation
Costs (2006 dollars)			
Discount Rate	NA	NA	NA
Timeframe	1	NA	NA
BC ratio	1.37-3.09	NA	NA

Table 2b: Environmental Services: Air Quality

Markets Discussed

Title	US Acid Rain Program	Chinese SO2 Trading Program	Dutch NOx Trading Program
ES	Air quality	Air quality	Air quality
Location	US	China	Netherlands
Organization	government, individual polluters	government, individual polluters	government, individual polluters
Population	NA	NA	NA
Area	NA	NA	NA
Method	Cap & trade	Cap & trade	Cap & trade
Payment	Bankable allowance permits	Bankable allowance permits	Bankable rate-based credits
Units	Tons	Tons	Tons
Amount	NA	NA	NA
Value	$1 billion	NA	NA
Value (2006) Timeframe	$1 billion	NA	NA
Start Year	1995	2000	2001

Title	France	Japan	Pollution Levy System
ES	Air quality	Air quality	Air quality
Location	France	Japan	China
Organization	Government	Government	Government
Population	NA	NA	NA
Area	NA	NA	NA
Method	Command & control	Command & control	Command & control
Payment	Fee based	Pollution tax	Fee based
Units	Metric ton	m^3	Metric ton
Amount	NA	NA	NA
Value	$30	$0.62-565	$150
Value (2006) Timeframe	$37	$0.77-69	$185
Start Year	1990	1982	1991

Table 2b (con't)

Title	Santiago PM Trading Program	Slovakian SO2 Trading Program	Sweden
ES	Air quality	Air quality	Air quality
Location	Chile	Slovakia	Sweden
Organization	government, individual polluters	government, individual polluters	Government
Population	NA	NA	NA
Area	NA	NA	NA
Method	Cap & trade	Cap & trade	Command & control
Payment	Tradable permit	Tradable quota	Tax & rebate
Units	Kg/day	Tons	Metric ton
Amount	4,000	NA	15,300
Value	$1,100-11,500	NA	$90 million
Value (2006) Timeframe	$1,360-14,200	NA	$112 million
Start Year	1992	1998	1992

Table 3a: Environmental Services: Recreation
Published Articles Reviewed

Year	1991	1993	1994
Author	Rockel & Kealy	Berrens et al.	Moore et al.
Title	The Value of Nonconsumptive Wildlife Recreation in the United States	Valuation Issues in an Urban Recreational Fishery: The Spring Chinook Salmon in Portland, Oregon	The Economic Impact of Rail-Trails
Location	U.S.	Portland, OR	CA, IA, FL
Method	TCM	CVM	EIA
Data Type	random sample, multistage stratified national telephone and follow up survey based on US Census Bureau design	random sampled and stratified (day of week, angler class & site) on-site survey	stratified random sample (day type), on-site screener & mailed detailed survey
N	1,155	219	1,705
Response	NA	72%	79%
ES	Recreation	Recreation	Recreation
Units	annual WTP/per person for site access	WTP/per person for one extra available fish	per person/day expenditures
Value	$198-3,731	$8	$4, $9, & $11
2006 Dollars	$484-9,100	$14	$6, $13, & $16
Population	28 million	NA	400,000/135,000 & 170,000
Area	Na	NA	NA
Aggregate Value (2006 dollars)	$21.2-402 billion	NA	
Aggregation Method	average WTP * number of participants * average number sites	NA	annual visitation * per person expenditure
Costs (2006 dollars)			NA
Discount Rate	NA	NA	NA
Timeframe	NA	NA	NA
BC ratio	NA	NA	NA
Economic Impact (2006 dollars)			$435,000/$932,000 & $592,000
Jobs			NA

Table 3a (con't)

Year	1995	1995	1995
Author	Siderelis & Moore	Gren et al.	Lockwood & Tracy
Title	Outdoor Recreation Net Benefits of Rail-trails	Economic Values of Danube Floodplains	Nonmarket Economic Valuation of an Urban Recreation Park
Location	FL, IA, CA	Eastern Europe	Sydney, AU
Method	TCM	Benefits transfer	TCM/CVM
Data Type	randomly, stratified sample (time, day of week, season & trail section), on-site screener, mailed follow up survey	NA	random location on-site intercept w/ pretest, mailed offsite
N	1,705	NA	598 & 105
Response	79%	NA	52 & 53%
ES	Recreation	Recreation	Recreation
Units	Per trip CS/person	Annual value/acre	Per visit CS & annual WTP
Value	$21, $16, $2	$60	$7.50 & $26
2006 Dollars	$31, $24, $3	$86	$10.50 & $36
Population	135,000/172,000/409,000	NA	3.1 & 1.2 million
Area	26,16, 8 miles	1.7 million km^2	NA
Aggregate Value (2006 dollars)	$5.9, $12.5 & $2.8 million	$338 million	$46 & $43 million
Aggregation Method	per trip CS * annual visitation	NA	per trip CS * annual visitation & annual WTP * population
Costs (2006 dollars)			$8.3 million
Discount Rate	NA	NA	NA
Timeframe	NA	NA	NA
BC ratio	NA	NA	NA
Economic Impact (2006 dollars)			NA
Jobs			NA

Table 3a (con't)

Year	1998	1998	1999
Author	Fadali & Shaw	Schutt	Lindsey & Knaap
Title	Can Recreation Values for a Lake Constitute a Market for Banked Agricultural Water?	Trails for Economic Development: A Case Study	Willingness to Pay for Urban Greenway Projects
Location	Lake Walker, NV	Ontario	Indianapolis, IN
Method	CA	EIA	CVM
Data Type	2 samples, on-site & mail survey, mail only survey	user registries and on-site survey	mailed survey
N	573	7,220	197
Response	67%	38%	47%
ES	Recreation	Recreation	Recreation
Units	Per season WTP for recreation access	Per person/day expenditures	annual WTP/household to support a greenway foundation
Value	$83	$20	$11
2006 Dollars	$107	$26	$14
Population	120,000	410,000	320,000
Area	NA	762km	20miles^2
Aggregate Value (2006 dollars)	$5.1 million	NA	NA
Aggregation Method	value per acre foot * WTP	NA	NA
Costs (2006 dollars)	$771,000-$2.9 million	NA	
Discount Rate	NA	NA	NA
Timeframe	NA	NA	NA
BC ratio	NA	NA	NA
Economic Impact (2006 dollars)	NA	$79 million	
Jobs	NA	1,138	

Table 3a (con't)

Year	2000	2001	2001
Author	Siderelis & Gustke	Tyrvainen	Shrestha & Loomis
Title	Influence of On-site Choices on Recreation Demand	Economic Valuation of Urban Forest Benefits in Finland	Testing a Meta-analysis Model for Benefit Transfer in International Outdoor Recreation
Location	Asheboro, NC	Joensuu and Salo, Finland	Worldwide
Method	TCM	CVM	Benefits transfer/Meta-analysis
Data Type	random sample, on-site survey w/ mailed follow up	mailed survey w/ pre-test	Multiple
N	1,013	325 & 225	682
Response	NA	65% & 45%	NA
ES	Recreation	Recreation	Recreation
Units	Per trip CS/person	monthly WTP/per person for site access	average CS/per trip
Value	$44	$9.5-12 & $7-17	$35-40
2006 Dollars	$58	$9.5-12 & $7-17	$45-51
Population	800,000	48,000 & 28,000	NA
Area		NA	NA
Aggregate Value (2006 dollars)	$46 million	$974,000-1.9 million & $129,000-1.3 million	NA
Aggregation Method	per trip CS * annual visitation	WTP per visit * average visits * 12	NA
Costs (2006 dollars)			NA
Discount Rate	NA	NA	NA
Timeframe	NA	NA	NA
BC ratio	NA	NA	NA
Economic Impact (2006 dollars)			NA
Jobs			NA

Table 3a (con't)

Year	2003	2003	2006
Author	Betz et al.	Kaval & Loomis	Mates & Reyes
Title	A Contingent Trip Model for Estimating Rail-trail Demand		The Economic Value of New Jersey State Parks and Forests
Location	Athens, GA	Canada & U.S.	New Jersey
Method	TCM	Benefits transfer	Benefits transfer/TEV
Data Type	random sample, mailed surveys	Multiple	Multiple
N	268	1,239	NA
Response	39%	NA	NA
ES	Recreation	Recreation	Recreation
Units	Estimated per trip CS/person	Average CS/per person/day	Per person WTP/day for recreation access
Value	$18	$40	$21
2006 Dollars	$22		$22
Population	416,000	NA	14.2 million
Area	NA	NA	NA
Aggregate Value (2006 dollars)	$9 million	NA	$324 million
Aggregation Method	predicted annual trips * estimated CS/per trip * households * response rate	NA	per person WTP per trip * population
Costs (2006 dollars)		NA	NA
Discount Rate	NA	NA	3%
Timeframe	NA	NA	Unlimited
BC ratio	NA	NA	Na
Economic Impact (2006 dollars)		NA	NA
Jobs		NA	NA

Table 3a (con't)

Year	2006	2007	2007
Author	Chaudhry	Bowker et al.	Cho et al.
Title	Valuing Recreational Benefits of Urban Forestry - A Case Study of Chandigarh (India) City	Estimating the Economic Value and Impacts of Recreational Trails: A Case Study of the Virginia Creeper Rail Trail	Measuring the Contribution of Water and Green Space Amenities to Housing Values: An Application and Comparison of Spatially Weighted Hedonic Models
Location		Southwest, VA	Knox County, TN
Method	TCM/CVM	TCM/EIA	HPM
Data Type	NA	stratified random sample (season, exit and day type), exit counts, on-site screener & detailed survey	digital parcels,GIS, maps
N	NA	1,036	15,500
Response	NA	72%	NA
ES	Recreation & green space development	Recreation	Amenity
Units	CS per person/visit & household WTP	per trip CS/group	mean price increase for 1000 ft. decrease in distance
Value	$7.50 & $4	$23-$39	$662-$840
2006 Dollars	$8 & $4		$775-$983
Population	NA	101,000	382,032
Area	NA	34 miles	526 sq. miles
Aggregate Value (2006 dollars)	$739,000 & $3.2 million	$2.5-4.3 million	NA
Aggregation Method	NA	primary trips * per trip CS	NA
Costs (2006 dollars)	NA		
Discount Rate	NA	NA	
Timeframe	NA	NA	
BC ratio	NA	NA	
Economic Impact (2006 dollars)	NA	$1.7 million	
Jobs	NA	27	

Table 3b: Environmental Services: Recreation

Markets Discussed

Title	Abruzzo Tourism Project	Cleveland Metro Parks	Thomas Hanraddy Fields
ES	Recreation	Recreation	Recreation
Location	Italy	Cleveland, OH	Elizabeth, NJ
Organization	Ministry of Cultural Property and Activities	Cleveland Metro Parks	Green Acres
Population	NA	40 million	17,800
Area	150,000 acres	19,650	2 acres
Method	small business development	land acquisition/conservation	Land restoration
Payment	Public grants	Public funds	Public funds
Units	NA	NA	NA
Amount	NA	NA	NA
Value	NA	NA	NA
Value (2006) Timeframe	NA	NA	NA
Start Year	NA	NA	1997

Title	The Pocket Park Program	Central Richmond Greenway	Southside Community Park
ES	Recreation	Recreation	Recreation
Location	Lakewood, NJ	Richmond, CA	Richmond, CA
Organization	Public Works Department	Parks Field Office	Parks Field Office
Population	NA	87,000	87,000
Area	NA	32 acres	4 acres
Method	land acquisition/restoration	green infrastructure	land acquisition
Payment	Public funds	public funds/community labor	Public funds/grants
Units	NA	NA	NA
Amount	NA	NA	NA
Value	NA	NA	NA
Value (2006) Timeframe	NA	NA	NA
Start Year	1996	NA	NA

Table 3b (con't)

Title	Vincent Park	At Kw'o:kw'e:hala Eco Retreat
ES	Recreation	Recreation
Location	Richmond, CA	British Columbia
Organization	Parks Field Office	At Kw'o:kw'e:hala Eco Retreat
Population	87,000	NA
Area	3 acres	NA
Method	land acquisition/restoration	Recreation retreat
Payment	public-private partnership	Private transaction
Units	NA	Day
Amount	NA	$145-1245
Value	NA	NA
Value (2006) Timeframe	NA	$145-1245
Start Year	1999	NA

Table 4a: Environmental Services: Energy
Published Articles Reviewed

Year	1986	1992	1994
Author	Heisler	Akbari & Taha	McPherson et al.
Title	Energy Savings with Trees	The Impact of Trees and White Surfaces on Residential Heating and Cooling Energy Use in Four Canadian Cities	Chicago's Urban Forest Ecosystem: Results of the Chicago Urban Forest Climate Project
Location	National	Toronto, Vancouver, Edmonton, Montreal	Chicago, IL
Method	Energy saving analysis	Energy saving analysis	Energy saving analysis
Data Type	research summaries, tree placement	computer simulations, housing prototypes, weather data	computer simulations, housing attributes, weather data, tree inventories
N	NA	NA	NA
Response	NA	NA	NA
ES	Energy savings	Energy savings	Energy savings
Units	Mean savings %/yr	mean $/yr, %/yr	mean savings $/yr
Value	20-25%	Savings $79, 8-10%	$50-90
2006 Dollars	NA	$114	$68-122
Population	Na	NA	6 million
Area	NA	NA	1292 mi^2
Aggregate Value (2006 dollars)	Na	NA	NA
Aggregation Method	NA	NA	NA
Costs (2006 dollars)	NA	$7-72/tree	NA
Discount Rate	NA	NA	NA
Timeframe	NA	NA	NA
BC ratio	NA	NA	1.4-1.96

Table 4a (con't)

Year	1996	1998	1998
Author	Simpson & McPherson	Rosenfeld et al.	Simpson & McPherson
Title	Potential of Tree Shade for Reducing Residential Energy Use in California	Cool Communities: Strategies for Heat Island Mitigation and Smog Reduction	Simulation of Tree Shade Impacts on Residential Energy Use for Space Conditioning in Sacramento
Location	CA	Los Angeles, CA	Sacramento, CA
Method	energy saving analysis	energy saving analysis	energy saving analysis
Data Type	SPS, housing attributes, weather data	DOE-2	computer simulations, housing attributes, weather data, tree inventories
N	NA	NA	254
Response	NA	NA	NA
ES	Energy savings	Energy savings	Energy savings
Units	mean savings $/yr	total annual energy savings	annual/per tree energy savings
Value	$30-110	$58 million	$14
2006 Dollars	$39-141	$71.7 million	$17
Population	NA	NA	NA
Area	NA	NA	NA
Aggregate Value (2006 dollars)	NA	$337.4 milliion	NA
Aggregation Method	NA	Summation	NA
Costs (2006 dollars)	NA	$55/tree	NA
Discount Rate	NA	3%	NA
Timeframe	NA	0	NA
Present Value (2006)		$618	NA
BC ratio	NA	NA	NA

Table 4a (con't)

Year	1998	1999	2002
Author	Simpson	Dwyer & Miller	Brack
Title	Urban Forest Impacts on Regional Cooling and Heating Energy Use: Sacramento County Case Study	Using GIS to Assess Urban Tree Canopy Benefits and Surrounding Greenspace Distributions	Pollution Mitigation and Carbon Sequestration by an Urban Forest
Location	Sacramento, CA	Stevens Point, WI	Canberra, AU
Method	Energy saving analysis	Energy saving analysis	Energy saving analysis
Data Type	computer simulations, housing attributes, weather data, tree inventories	CITYgreen	DISMUT computer modeling
N	NA	NA	NA
Response	NA	NA	NA
ES	Energy savings	Energy savings	energy savings, pollution reduction, hydrologic, CS
Units	annual/per tree energy savings	total annual energy savings	total annual value of urban forest
Value	$8-16	$127,000	$20 million
2006 Dollars	$10-20	$154,000	$22.4 million
Population	NA	40,000	300,000
Area	NA	55,000 acres	NA
Aggregate Value (2006 dollars)	$21 million	NA	NA
Aggregation Method	Summation	M	NA
Costs (2006 dollars)	NA	NA	NA
Discount Rate	NA	NA	NA
Timeframe	NA	NA	5
BC ratio	NA	NA	NA

Table 4a (con't)

Year	2002	2003	2005
Author	Konopacki & Akvari	Jensen et al.	McPherson et al.
Title	Energy Savings Calculations for Heat Island Reduction Strategies in Chicago and Houston (Including Updates for Baton Rouge, Sacramento, and Salt Lake City).	The Relationship Between Urban Leaf Area and Household Energy Usage in Terre Haute, Indiana, US	City of Charlotte, North Carolina Municipal Forest Resource Analysis
Location	Baton Rouge, Chicago, Houston, Sacramento, Salt Lake City	Terre Haute, IN	Charlotte, NC
Method	Energy saving analysis	Energy saving analysis	Energy saving analysis
Data Type	DOE-2.1E, housing attributes, weather data	LAI gap analysis, GIS	STRATUM, tree inventories
N	NA	NA	NA
Response	NA	NA	NA
ES	Energy savings	Energy savings	Energy savings
Units	total annual savings	daily savings per m2	mean benefits/tree
Value	$1.1-28 million	$0.31	$69
2006 Dollars	$1.2-31.4 million	$0.34	$74
Population	NA	69,600	NA
Area	NA	NA	NA
Aggregate Value (2006 dollars)	NA	NA	$6.3 million
Aggregation Method	NA	NA	summation
Costs (2006 dollars)	NA	NA	$1.9 million
Discount Rate	NA	NA	NA
Timeframe	NA	NA	NA
BC ratio	NA	NA	3.25

Table 4a (con't)

Year	2006	2007
Author	McPherson et al.	Hitchcock
Title	City of Charleston, South Carolina Municipal Forest Resource Analysis	Impact Analysis of Shade Trees on Residential Energy Consumption
Location	Charleston, SC	Houston, TX
Method	Energy saving analysis	Energy saving analysis
Data Type	STRATUM, tree inventories	Tree Benefit Estimator, CITYgreen, and EnergyGauge
N	NA	NA
Response	NA	NA
ES	Energy savings	Energy savings
Units	mean benefits/tree	cumulative kWh savings over 30 years
Value	$47	5,784
2006 Dollars	$47	NA
Population	NA	NA
Area	NA	NA
Aggregate Value (2006 dollars)	$717,000	NA
Aggregation Method	Summation	NA
Costs (2006 dollars)	$700,000	NA
Discount Rate	NA	NA
Timeframe	NA	30
BC ratio	1.35	NA

Table 4b: Environmental Services: Energy
Markets Discussed

Title	Sacramento Municipal Utility District	Trees for Tucson	TREE POWER	Climate Challenge Program
ES	Energy	Energy	Energy	Energy
Location	Sacramento, CA	Tucson, AZ	US	Michigan
Organization	Sacramento Municipal Utility District	Tuscon Clean & Beautiful	public utilites	DTE energy
Population	NA	NA	NA	NA
Area	NA	NA	NA	NA
Method	tree plantings, education, information	trees planting, information, maintenance	tree planting program	tree planting program, information
Payment	rebates, discounts, free trees	discounts, free trees	Rebates	free trees, rebates
Units	Trees	Trees	Trees	Trees
Amount	400,000	NA	NA	10 million
Value	NA	NA	NA	$450,000
Value (2006) Timeframe	NA	NA	NA	$450,000
Start Year	1990	NA	NA	1995