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A Review of Ecosystem Valuation Techniques

How much is the air we breathe worth? Is it worth more or less depending on its cleanliness? What should the price be for clean water to drink, cook with, shower or swim in, and catch fish out of? These are some of the questions that ecosystem valuation is used to answer. Ecosystem valuation can be defined as the process of expressing a value for ecosystem goods for scientific observation and measurement (S.C. Farber et al, 2002). By quantifying the contributions of ecosystem services to human welfare as well as changes in environmental quality, ecosystem valuation has become a valuable tool in determining environmental policy. R.B. Howarth and Stephen Farber suggest in their article titled "Accounting for the Value of Ecosystem Services" that "environmental systems provide material and experiential benefits that contribute directly to human well-being, and it is meaningful and important to quantify these benefits in understandable terms" (Howarth, 2002).

An ecosystem consists of the organisms, energy flux, and cycling of nutrients in a physical and chemical environment (Ricklefs, 3). Ecosystems provides many services such as gas regulation, climate control, water regulation, treatment, and supply, erosion control and sediment retention, soil formation, nutrient cycling, pollination, habitat, food production, raw materials, genetic resources, recreation, and cultural opportunities (R. Costanza et al, 1998).

There are market and non-market values associated with ecosystem services. A market value is the price that a consumer would pay for a good or service that is being bought or sold as a commodity. It is the dollar amount that is paid for a good such as clean water or a load of timber. A non-market value is one that cannot be traded directly in markets and there are not market prices to evaluate. Within non-market values, there are use and non-use values.

Use values include activities that are not sold or traded in markets, but are taken directly from the ecosystem services. Examples of use values include swimming in the Gulf of Mexico, surfing in the Pacific Ocean, fishing off the beaches in New England, hiking and mountain climbing in the Appalachian Mountains, and snow skiing in the Rocky Mountains.

When people valuate ecosystems they take into account non-use values as well as use-values. Non-use values include option value, existence value, bequest value, and altruistic value.

1. Option value refers to the value that people place on having the option to use the resources derived from that ecosystem at a later point in time. For example, a resident of Atlanta might place a high value on the Grand Canyon because although they are not able to see it often, they would like to be able to travel to see it later.
2. Existence value refers to the value of knowing that something merely exists even though there may be no desire to ever go see it, just knowing that it is there is important. An example of existence value could be the value that an individual places on kangaroos in Australia. This particular person could hate to fly in airplanes and be absolutely certain that he or she will never go to Australia to see the koalas, but they still would like to know that they exist there.

3. Bequest value is the value of preserving something for generations yet to come. This could occur with something such as the rainforest. An individual may have no desire to visit the rainforest and be personally indifferent to preservation efforts, but they may be highly adamant about preserving it for their children or grandchildren to have the opportunity to use or visit.

4. Altruistic value is the value that an individual places on an ecosystem good or service solely because they know that others enjoy it. Yosemite National Park could be a place of altruistic value for someone if they valued it just because they knew that it was a favorite rock climbing spot of many other people, and they wanted to make sure that existed for other people to get pleasure from it.

It is important to have the ability to value the psychological enjoyment that people get from ecosystem goods and services as well as the goods and services themselves. Although sometimes it seems as though things such as ecosystems should not be valuated because it turns them into commodities, it is necessary to give them a common currency with other marketed goods so that ecosystems are not underrepresented in governmental policy making.

There are several methods for valuating ecosystems. Each one has strengths and weaknesses, and certain methods are most appropriate for specific situations depending on the type of information that is desired. There are revealed preference approaches and stated preference approaches. The revealed preference approaches extrapolate the individual's willingness to pay or except by examining the choices that he or she makes within a market. The choices are distinguishable only the quality of the environment or by the goods and services that the ecosystem provides, hence the different choices reveal the value of those attributes. The revealed preference approaches are: market price method, productivity method, hedonic pricing method, travel cost method, substitute cost method, replacement cost method, and damage cost avoidance method.

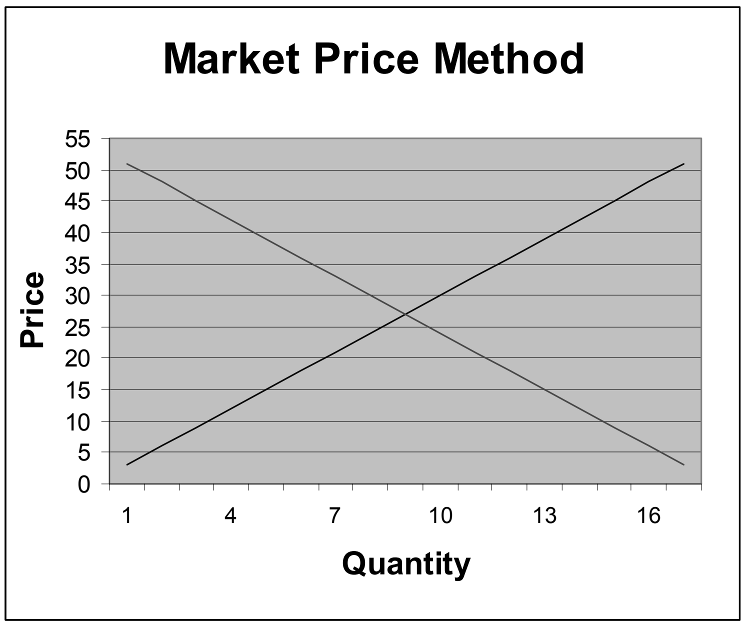
The stated preference approaches of ecosystem valuation survey individuals to find out what they state as their value of the ecosystem attributes, good, and services. The most common measures of value in the stated preference approach are willingness to pay and willingness to accept. The stated preference approaches are: contingent valuation, conjoint analysis, and the contingent choice method.

For both revealed and stated preference methods of ecosystem valuation it is essential to understand the differences between willingness to pay and willingness to accept. The difference is that willingness to pay is how much a person is willing to pay for a small improvement in environmental quality, and willingness to accept is how much a person is willing to accept for a small reduction in environmental quality (Field, 2002). A major difference is that willingness to pay is limited by income, but willingness to accept has no limitations.

Revealed Preference Approaches:

Market Price Method

The market price method uses the prices of goods and services that are bought and sold in commercial markets to determine the value of an ecosystem service. This method values changes in either quantity or quality of a good or service. By measuring the change in producer and consumer surplus after the application of a change in production or price, the value can be determined (www.ecosystemvaluation.com, 2003). To determine a producer and consumer surplus, a demand function must be estimated and then the standard market price must be subtracted from the level demanded. This concrete method uses the producers' and consumers' actual willingness to pay that is demonstrated through the price or a good or service purchased in the market (Kahn, 1998).

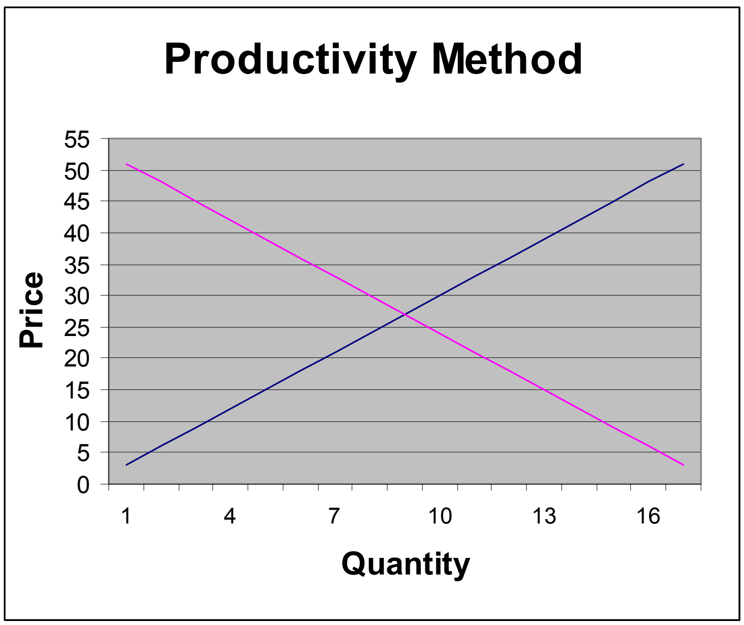


The graph above illustrates the market price method. To determine a producer and consumer surplus, a demand function must be estimated and then the standard market price must be subtracted from the level demanded. This graph shows the producer and consumer surplus, and after the application of a change in production or price, the consumer or producer surplus will change, and the value can be determined.

However, this method only takes into account use-values and marketed goods or services that have an actual price. It does not consider services such as the value of water purification and soil fertility and does not typically work well on a large scale.

Productivity Method

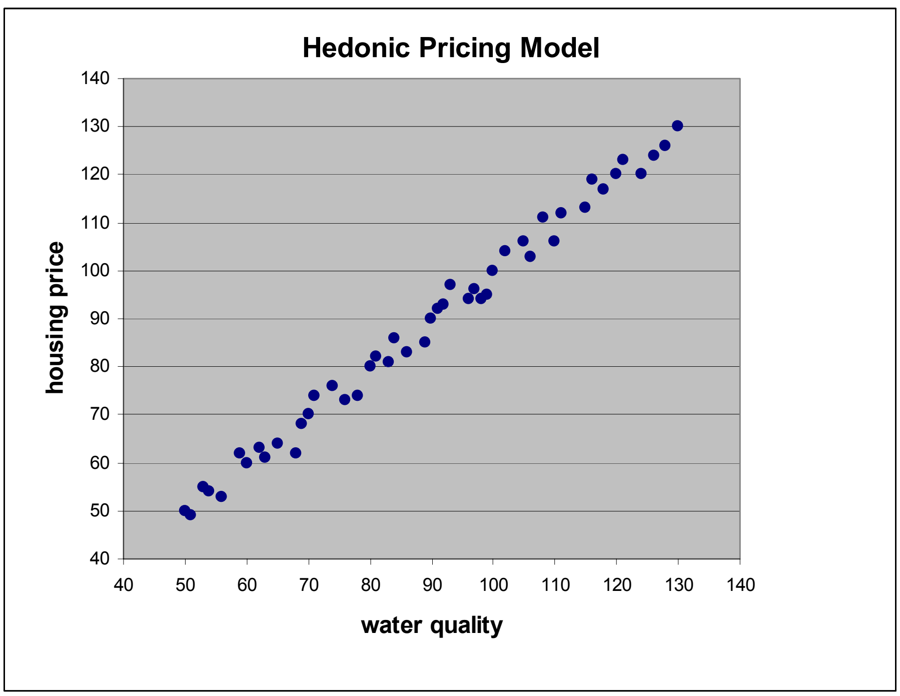
The productivity method measures the contribution that a non-market ecosystem service has on a marketed commodity. This method is most useful in cases where a resource is a perfect substitute for another input for production and in cases where the producers are the only ones to benefit from changes in quantity or quality of the resource, and consumers are not affected (www.ecosystemvaluation.com, 2003).



To measure this contribution, the production function for the commodity needs to be established, as in the graph above, then the changes to the function must be observed after a change in the ecosystem service, and the economics changes must be measured. Changes in the quality or the quantity of the ecosystem services will change the cost of the inputs and alter the production function of the commodity. The changes can be seen through shifts in the consumer or producer surplus.

Hedonic Pricing Method

The hedonic pricing method estimates the non-market values for ecosystem characteristics and services by comparing the market prices of two goods or services that only differ by the ecosystem characteristics and services (R.S. de Groot et al, 2002).   If the only difference between the goods or services is the ecosystem characteristic, then it is extrapolated that the difference in the prices must be the value of that ecosystem characteristic or service.



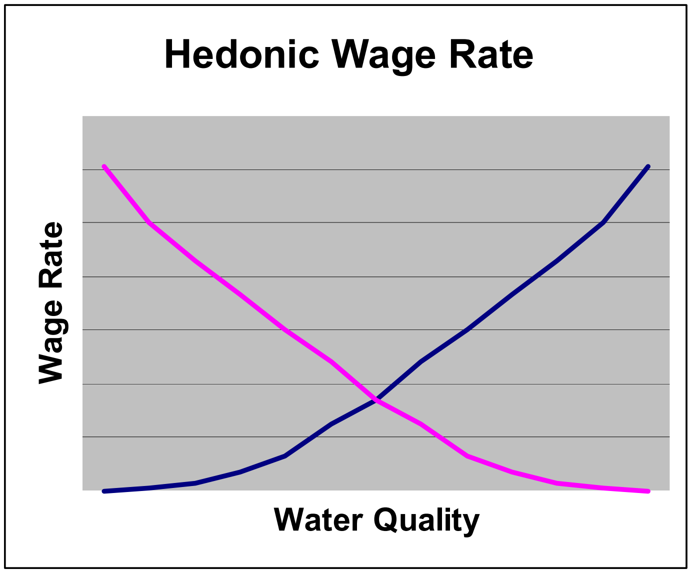
This graph shows the correlation between housing prices and water quality. The positive relationship show that increases in water quality result in increases in housing prices. To determine the effect of improved water quality on housing prices, a line of best fit is drawn through the data, and the slope of that line is calculated. The slope tells how many units the price will increase with each increase in improved water quality.

The hedonic pricing model was one valuation method used in a study by Matthew A. Wilson and Steven R. Carpenter. The study was designed to determine the value of freshwater ecosystem services in the United States. Two properties were identified that were identical with the exception of the water quality for wetlands, rivers, stream, and lakes. The differences in property vales were logged for each one, with value differences ranging from $101 to $1439 per unit measured. Thus it was determined that the value of water quality also fell within that range for each specific freshwater ecosystem type that was observed.

The hedonic pricing method is a concretely observable valuation method, but it has some weaknesses as well. It is very difficult to find two sites that are exactly the same except for the single specific ecosystem characteristic. Ecosystem services often overlap with each one affecting the other, so it may not be possible to isolate a single characteristic. For example, in the case of water quality, a factor such as pH could also affect soil fertility. Decreased soil fertility would decrease the property value, but it would be difficult, if not impossible to distinguish between the values of the two ecosystem services with the hedonic pricing method alone. A combination of two or three valuation methods would be more appropriate for a case such as this one.

Hedonic Wage Method

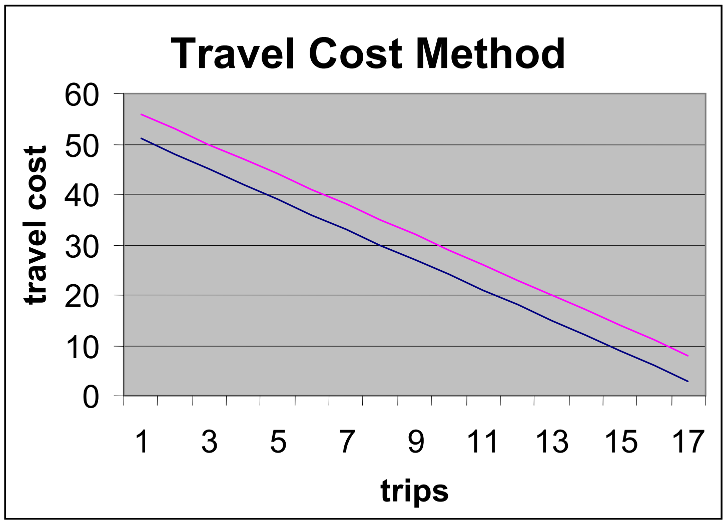
The hedonic wage method is used to value an ecosystem based on the differences in wage rates that people are willing to accept based on an ecosystem attribute or service. This applies to choosing between jobs with wage differences in two cities or in different locations within a city. If two jobs are the same with the exception of the wage rate and an ecosystem attribute, then this method can be used.



For example, as can be seen in this graph, if an individual is choosing between the a high paying job in a city with poor water quality and a lower paying job in a city with better water quality, then the difference in the wage rates is how much the water quality is worth to that individual. The difference in wages between a city with poor water quality and a city with good water quality will be equal to the amount required to compensate the individuals for the disutility associated with poor water quality, and that wage difference will also represent the value of water quality (Kahn, 1998). Both the hedonic pricing and the hedonic wage methods are good methods to use to estimate the health and preference costs associated with an ecosystem function such as water purification.

Travel Cost Method

The travel cost method determines the value of an ecosystem based on the amount of money spent to reach the particular destination. It is used to value sites that are used for recreation purposes. It can estimate the benefits or costs associated with changes in entrance fees to recreational areas, removing an existing site or adding a new site, or changes in environmental quality at a site (www.ecosystemvaluation.com, 2003). The amount of money spent traveling to the site, including money spent on transportation whether it be a plane, train, or bus ticket, or gas expenses and wear for a personal automobile, and time spent en route to the site – although this can difficult to put a price on and may require other methods of valuation.



The graph above shows the increase in willingness to pay with increase environmental quality. The difference in consumer surplus is the value of the increased environmental quality.

There are some challenges facing the use of travel cost method of ecosystem valuation. It can be difficult to determine the value of one particular destination if a single trip encompasses many different destinations.

Cost Analysis Methods of Ecosystem Valuation:

The cost analysis methods of ecosystem valuation are used to determine the value of an ecosystem based upon the hypothetical scenarios where the ecosystem has been damaged or cannot properly perform the environmental services. The methods are damage cost avoidance, replacement cost method, and substitute cost method. The are typically used in conjunction with each other because the research results would not be thorough enough to make any policy decisions if only one of these methods were used since the methods are somewhat sequential.

Damage Cost Avoidance Method

The Damage Cost Avoidance Method is used to determine how many expenses are avoided by preserving an ecosystem and its services. Estimate potential damages, then calculate either potential damage costs or the cost of avoiding a problem (www.ecosystemvaluation.com, 2003). For example, a study by R.S. de Groot et al reports that the preservation of natural watersheds in New York, avoided the construction of a $6 billion water treatment plant, so this implies that the watershed is worth $6 billion.

Replacement Cost Method

The replacement cost method is used to determine the cost of replacing ecosystem services. In this case, it is necessary to identify another method for providing the same services and calculate the cost the cost of construction for that project. This would also apply to the water treatment example in New York because if these watersheds were lost it was determined that the cost would be $6 billion dollars to construct a water treatment facility that would perform the same environmental task.

Substitute Cost Method

This method uses the cost of providing substitutes for ecosystem services. Once again, the New York City water treatment example applies because of the interconnectedness of the avoidance, replacement, and substitute cost method of ecosystem valuation. (de Groot et all, 2002)

Stated Preference Methods of Ecosystem Valuation: Contingent Valuation Method

The contingent valuation method is used to determine the value of an ecosystem by finding out how much survey respondents are willing to pay for particular ecosystem attributes or services. This method is the only one capable of including non-use values into the total economic value of an ecosystem (Holmes et al, 2002). The method is termed contingent valuation because it seeks responses from people about how they would act if they were placed in a certain contingent situation (Field, 2002). Since these ecosystem goods or services cannot currently be bought or sold in a market, contingent valuation methods ask people what price they would pay if that were the case. The payment options could consist of a new tax, an entrance fee to a park or observation area, monthly/annual preservation or maintenance fee, or a single charge. This method has become one of the most popular and widely used methods to value public goods (Field, 2002).

The typical procedure for a contingent valuation begins with targeting the specific ecosystem function or services that are being evaluated and determining specific parameters that can clearly be described to the survey respondents. It is crucial to clearly present all of the information regarding the exact location of the ecosystem, the size, its attributes and services, the current condition, and the possible future outcomes. Once all of those guidelines have been established, random samples of people from the community are surveyed in order to get a representative opinion from the community. Next the questions need to be designed. The questions must be clear and lack any ambiguity in the description of the ecosystem services and the method of collecting funds. The respondents also need to be made aware that the survey is solely for research purposes and that they will not be held accountable for the amount that they say they are willing to pay. The surveys can be administered by phone, mail, Internet, or in focus groups. However, a study by M.D. Kaplowitz and J.P. Hoehn in 2001 revealed that focus groups and individual surveys often produce different information. One or two individuals who set the tone for the rest of the group can sometimes dominate focus groups. The few influential members may dissuade the other participants from sharing a dissenting opinion, so the results from the study recommend that surveys be conducted on an individual basis.

After all of the surveys are administered and the results are collected, the data can be analyzed to determine and average willingness to pay for the ecosystem services and quality and an overall value can be extrapolated from the information. In a study by Thomas P. Holmes et al on estimating the local economic benefits of riparian ecosystem restoration of the Lower Tennessee River watershed, the administrators of the survey used a computerized survey instrument to eliminate any bias. It also allowed for random questioning combinations based on the distance of the restoration and the bid increments. The use of the computer as a survey instrument in this study was also beneficial beyond just the sampling; it kept the information organized so that it could easily be integrated into a GIS mapping approach of economic value estimates (Bergstrom et al, 1997).

Although contingent valuation is the most widely used method for incorporating non-use values into the economic valuation of ecosystems, it has some weaknesses. While the questions of the contingent valuation survey can range in classifications from multiple-choice to open-ended questions, the respondents can sometimes have difficulty placing a value on the ecosystem for several reasons. First, they are not accustomed to valuing them and it becomes difficult to place a monetary value on them. In other words, it can be difficult to determine a standard for measurement of the ecosystem because of the importance to many life-sustaining functions, the discount rate, and the potential irreversibility of damages done to ecosystems. All of these standards are challenging to put a dollar value on, yet these are important factors to consider when valuing ecosystems. Also, many respondents place a high value on the fact that ecosystems are invaluable to them. The ecosystem is worth a lot to them for aesthetic reasons that are difficult to measure without a standard such as is available for market goods. Another difficulty with contingent valuation surveys is that the respondent's willingness to pay is reliant upon his or her income. A large margin of difference between the incomes of the people surveyed can result in a wide range of responses in their willingness to pay, and this needs to be considered during the analysis of the results. Likewise, survey respondents can be highly sensitive to the method in which the funds are said to be collected for the preservation or maintenance of the ecosystem. Respondents may be willing to donate a fairly large amount of money to a fund, but will only agree to a minute increase in taxes even if the total amount will be the same in the long run.

Lastly, the difference between willingness to pay and willingness to accept needs to be examined in contingent valuation surveys. It is common that people will be willing to pay a much smaller amount to preserve an ecosystem, but say that they are wiling to accept a much larger amount as compensation for damages for to the ecosystem. These dissenting results between willingness to pay surveys and willingness to accept surveys are another factor that must be kept in mind when trying to determine the value on non-market ecosystem goods and services.

Conjoint Analysis

Conjoint analysis is the valuation method that is used to determine specific preferences between different levels of characteristics of an ecosystem attribute. It allows individuals to choose between two hypothetical environments, plots of land, or houses, etc based on a list of characteristics that distinguish them from each other based on a ranking system of each attribute. This method allows for the researchers to see which of the two choices teach respondent prefers, and it shows which characteristics they value the most. An example of this could be two different pieces on land for sale on a lake. A list of characteristics of the properties could include differences in water quality, air quality, and soil fertility, animals that inhabit the area, the different types of trees, and so forth. The respondent would choose which piece of property he or she preferred along with a ranking of the attributes that led to the decision of preference.

Conjoint analysis will also allow policy makers to see a ranked order of which environmental issues the community believes to be the most imminent. This would be an excellent guide to the order that the issues should be addressed. It will give government officials an itinerary of environmental issues, and it will let them know what the community values most.

Although unlike contingent valuation, it does not always result in a dollar figure that residents are willing pay, it does create a guideline for environmental policy making. Conjoint analysis can also ask the respondents to rank characteristics that have predetermined prices. With the prices already set for research purposes, the survey administrators can extrapolate values that the respondents are willing to pay. An advantage to conjoint analysis over contingent valuation is that is does not require the respondents to make a trade-off between money and environmental quality, but instead asks them to rank environmental preferences (Kahn, 1998).

A study conducted by T.H. Stevens et al. states that the willingness to pay derived from contingent choice studies are much larger than those from contingent valuation surveys. Their research indicated three reasons why the values derived from conjoint analysis differ from those obtained in contingent valuation surveys. The first reason is that in conjoint analysis substitutes are made very evident which allows the respondents to have a clearer idea of their options of trade-offs for environmental quality. The second reason is the psychological difference in choosing between characteristics with predetermined prices and making decisions about willingness to pay. The final difference is that the survey respondents are able to show indifference in the conjoint analysis more easily than in contingent valuation surveys.

Factor Income Method

The factor income method uses changes in income that result from changes in environmental quality as the determinant for the value of an ecosystem (R.S. de Groot et al, 2002). By assuming that there is a direct correlation between environmental quality and income levels for certain jobs, the factor income method can determine the value of an ecosystem. However, this method is not appropriate unless there has been a change in environmental quality and income. If neither or only one of the variables has changed, this method will be useless. This method is appropriate for jobs such as fishermen who depend on water quality as a substantial factor in the amount of fish they will catch.

A Comparison: Travel Cost, Contingent Valuation, Hedonic Pricing

The travel cost, contingent valuation, and hedonic pricing methods are the ecosystem valuation methods most commonly used. There are different strengths and weaknesses for each method and specific applications where one is more useful than the others. The travel cost is most effective in valuing recreational areas, contingent valuation is most valuable for public goods, and hedonic is most useful for valuing specific attributes of environmental quality between two sites. A study by Matthew A. Wilson and Stephen R. Carpenter in 1999 of freshwater ecosystem services compared the three methods of valuation. Their research reports that the travel cost method and hedonic pricing method are most effective for private goods and services. The contingent valuation method is effective since the nature of the survey allows for many different scenarios to be presented for valuation. All of the methods are somewhat limited because the public has a difficult time placing a value on economic services that they do not clearly understand or recognize (Wilson & Carpenter, 1999).

The Future for Ecosystem Valuation:

The most recent methods of valuing and mapping the value of ecosystems were computer software programs that log and analyze land cover data and satellites that serve the same function. Land cover research and analysis has definitely moved to the forefront of valuation methodologies. Satellite imagery is an important way to monitor and assess ecosystem services, and the main premise of this is that land cover is a proxy measure of ecosystem service (Konarska, 2002). Land Cover maps measure the density of the terrain and organize it into a biome that has a predetermined value. Researchers use GIS to plot and track the state of ecosystems. An article written by P.C . Sutton and R. Costanza in 2002 researched the correlation between light energy and Gross State Products. The correlation is positive and shows that using light emitting energy as a measurement for economic value of an ecosystem is a reliable new method. A dataset was used to measure the non-market economy that was a global land-cover data set developed by the USGS. This information can be accesses at http://edcdaac.usgs.gov/glcc/glcc.html. GUMBO, the global unified metamodel of the biosphere, takes this new method one step further. It was designed by R. Boumans, R. Costanza, J. Farley, M.Wilson, R. Portela, J. Rotmans, F. Villa, and M. Grasso to be able to model the dynamics of the ecosystems and the value of their services. Their article explain how GUMBO is different from other global models in three ways:

1. Ecosystem services are the main focus of GUMBO and it is shown how they affect economic production and social welfare. The figures in this model can be easily manipulated to fit many hypothetical scenarios.
2. Ecological and socioeconomic changes are included in the model and the feedback and interaction between the two is clearly shown.
3. The model includes human capital, natural capital, built capital and the interactions with the environment.

(Boumans et al, 2002)

These approaches using satellite imagery as well as light energy emitted are on the forefront of ecosystem valuation methods using advanced technology.

Summary

Ecosystem valuation has become an important tool in governmental policy-making by giving ecosystems an even standard to be measured with against other items being bought and sold in day-to-day markets. Since the valuation methods are used to determine the fate of many irreplaceable ecosystems, it is vital to understand the different strengths and weakness of each method as well as knowing which methods are most accurate in specific situations. In many cases the best way to place value on the ecosystems accurately is to use a combination of methods. Ecosystem valuation is a critical factor in ensuring that ecosystems will be maintained in a sustainable manner. Putting a dollar or a ranking value on ecosystems does not devalue them, but rather gives ecosystems a currency for which to be preserved by through policy decisions for the future.

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