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Valuing Ecosystem Services: A New Paradigm Shift

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Abstract

The ways in which economists value natural resources has been, and continues to be, a constantly evolving process. At first, only transactions that took place in the marketplace were considered. However, it was not long until it was realised that this concept was an incomplete way to value natural resources and hence the concept of non-market valuation was introduced. These non-market valuation methodologies prevailed for about 50 or 60 years, but, at the present time, it is being realised that the current methodologies are incomplete and it is time for another new paradigm shift. The market and non-market valuation calculations currently used only include anthropocentric (human related) values and have omitted ecocentric ecosystem service values such as the pollination of crops that takes place by bees and flies. The question we are posed with now is how to calculate the true value for ecosystem services in given this new paradigm shift?

Keywords
Ecosystem services
Non-market valuation
Consumer surplus

JEL Classification
Q57

Natural resources are those resources that naturally occur, such as our land, air, water, flora and fauna. They are not only the individual fish and birds, but the ecosystems that they live in. Let us say, for example, that we like to go to a park for a picnic. This park is composed of many natural resources; the grass we walk on, the worms that aerate the soil, the birds that eat the worms, and the trees that provide us with shade, etc.

Resource managers make decisions as to how to manage our natural resources. To do this, they need to know the value of this area in different situations, i.e., for a picnic area or for logging. To compare these competing uses, benefit-cost analysis would typically be conducted to look into all benefits and costs for each of the various options. Whichever option provides the highest net benefit will most likely be selected as the preferred option.

Prior to the 1960s, benefit-cost analysis studies typically involved only market values (Champ et al., 2003; Carson, 2000). For example, let's say the resource manager is deciding between two management options for a piece of land: a picnic area and a forest for logging. If it is used for picnicking, a picnic area should be cleared and tables set up. Costs would include the price of land clearing, table purchase, and grounds maintenance. If the cost of the project were $100,000 over 20 years and there is no fee charged for picnicking, the market benefits are zero and costs outweigh the benefits. On the other hand, if the area is used for logging, costs include land clearing, tree planting, tree and area maintenance and tree harvesting. If we assume the trees are ready to harvest in 20 years, costs over this time period are $300,000, and benefits are $400,000, then there is an overall market benefit of $100,000. The picnic area, therefore, yields a market cost of ($100,000) while the logging option yields a market benefit of $100,000. If nothing else is considered, the logging option would be preferred as it yields a higher net benefit as outlined in Table 1.

Table 1: Management Decision Using Market Values Only

Management Options	Benefits	Costs	Net Benefits	
Option 1: Picnic Area	$0	$100,000	-$100,000	
Option 2: Logging Area	$400,000	$300,000	$100,000	Option 2 would be the preferred option since: $100,000 > -$100,000

It did not, however, take long for a paradigm shift, when people realised that anthropocentric (human related) non-market values also needed to be included in the benefit-cost calculations. Just because people were not paying for the picnic area did not mean there was a zero benefit value for it. If there were no value, people would not go there. And therefore, anthropocentric non-market values started to be built into these benefit-cost analyses. Some of the more common methodologies used today to calculate these anthropocentric non-market values include the contingent valuation method, the travel cost method, choice modelling and the hedonic pricing method.

Non-market values include both use-values and non-use values. Use-values are simply those values obtained from the use of a resource. More formally, if someone is physically participating in an activity that occurs on the land, they have a use value for it. These uses include recreation activities such as picnicking, walking, swimming, bird watching, and photography, to name a few (Pearce and Turner, 1990; Freeman, 2003).

In addition to use values, non-use values must also be considered. Non-use values are sometimes called passive use values or preservation values. Three types of non-market non-use values are commonly studied: existence value, bequest value, and option value. Existence value is the value one gets from knowing something exists, i.e., knowing that the blue whale exists and is important to people even if they never see one in their lifetime. Bequest value is the value received from knowing that something will be around for future generations. For example, someone may have a granddaughter that likes to go tramping and even though they may never go tramping themselves, they know that the Milford Sound is an area that their grandchild may wish to visit someday and is available to them. Option value means having the option to visit a place if the opportunity arises. Perhaps a person has always heard stories about the beautiful scenery at the Milford Sound and would someday like to go there, but due to financial circumstances, they may not currently be able to go. As long as they have the option to go there sometime in the future, if they have the means, they consider it is worth something to them to have it protected in the meantime (Pearce and Turner, 1990; Freeman, 2003).

Returning to the picnic–logging example, let us assume that we are now going to include non-market values and that we have calculated (by one of the various methods available) the use value of the picnic area to be $5 for each visit a person makes to the picnic area. If there are 5,000 visits to the picnic area annually, after 20 years, this picnic area would yield a use value benefit of $500,000 (for simplicity sake, let us ignore inflation and future discounting throughout this example). The non-use value for the picnic area is $2,000 annually for all people, or $40,000 for 20 years. We have also calculated the anthropocentric non-market non-use value for the logging area to be $1,000/annually for all people, or $20,000 over 20 years. This would change the total benefits of the picnic area to $540,000 and of the logging area to $420,000. With this new information, we see the overall benefit of the picnic area is $440,000 while the overall benefit of the logging area is $120,000. In this situation, we would select the picnic area as that provides $320,000 more benefits over the 20 year period than logging (Table 2).

Table 2: Management Decision Using Market and Anthropocentric Non-Market Values

Management Options:	**Benefits**	**Costs**	**Net Benefits**	
Option 1: Picnic Area	$540,000	$100,000	$440,000	Option 1 would be the preferred option since: $440,000 > $120,000
Option 2: Logging Area	$420,000	$300,000	$120,000	

For the past 60 or so years, it has become common practice to use both market and, what we are calling here, anthropocentric non-market values to aid in benefit-cost analysis calculations. However, over the past 30 years, we have also been in the process of another evolving paradigm shift. We have now realised that by using our current methodologies, all anthropocentric non-market values have been accounted for, but ecocentric non-market values have not; most specifically, many ecosystem service values have not been accounted for.

Ecosystem service values include all market values, anthropocentric and ecocentric non-market use-values, and anthropocentric and ecocentric non-market non-use values that function in nature and are necessary to sustain ecosystems. Without these services, life on earth would not exist (Daily, 1997; Daily et al, 1997). According to Daily, 1997, there is a minimum of 13 ecosystem service functions and services needed to sustain life on earth:

- *Purification of air and water*
- *Mitigation of floods and droughts*
- *Detoxification and decomposition of wastes*
- *Generation and renewal of soil and soil fertility*
- *Pollination of crops and natural vegetation*
- *Control of the vast majority of potential agricultural pests*
- *Dispersal of seeds and translocation of nutrients*
- *Maintenance of biodiversity (from which humanity has derived key elements of its agricultural, medicinal and industrial enterprise)*

- *Protection from the sun's harmful ultraviolet rays*
- *Partial stabilisation of climate*
- *Moderation of temperature extremes and the force of winds and waves*
- *Support of diverse human culture*
- *Providing of aesthetic beauty and intellectual stimulation that lift the human spirit*

Costanza *et al.*, 1997, provide us with a similar list that consists of 17 basic functions and services perceived to be the bare minimum needed to sustain life on earth:

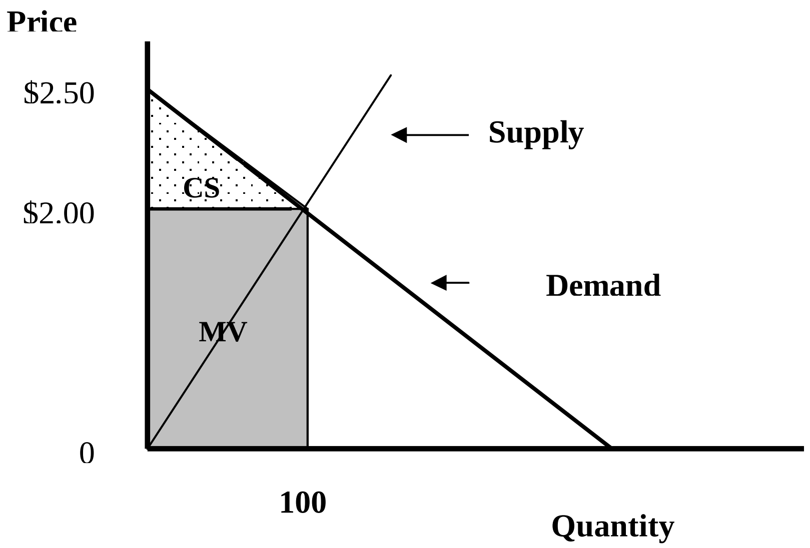
Cultural	*Recreational*	*Genetic resources*
Raw materials	*Food production*	*Habitat refugia,*
Biological control	*Pollination*	*Waste treatment*
Nutrient cycling	*Soil formation*	*Gas regulation*
Water supply	*Water regulation,*	*Disturbance regulation*
Climate regulation	*Erosion control and sediment retention.*	

As can be seen, these ecosystem functions and services include market values, such as the provision of fish that anglers bring to market, use-values such as recreation values and breathing in the oxygen that trees expel, as well as non-use values such as providing shelter for endangered species.

The process to calculate ecosystem service values, or the value of a particular area's entire ecosystem, is complicated. First, we would still calculate the market values of the ecosystem the same. Therefore, in our picnic-logging example, market values are still $0 in benefits and $100,000 in costs for the picnic area, and $400,000 in benefits and $300,000 in costs for the logging area. Next, we would calculate the anthropocentric non-market values. These would also be calculated the same; $540,000 for the picnic area and $20,000 for the logging area. Note that some people do believe that these anthropocentric non-market values will be phased out and only ecocentric non-market values will be considered (another possible paradigm shift). But for now, we will include them. Next, we need to calculate the ecocentric non-market values. This is the most complicated of the processes, and the one that is still without a consensus for calculation.

In the 1997 Costanza et al. article, ecosystem service values of the world were calculated. In it, they state that many people try to calculate individual willingness-to-pay for ecosystem services by following the contingent valuation method used in the calculation of anthropocentric non-market values. They do this by asking people how much they are willing-to-pay for ecosystem services. Costanza et al., 1997 uses this method for their calculations. However, diagrammatically this article suggests that this estimate may be incorrect. Typically, when you are estimating willingness-to-pay, you are trying to see what the value of a good is, over and above what they are paying – the consumer surplus value or CS in Figure 1 below. In this figure, we see that the cost of entrance to the park is $2. At this price, 100 people enter the park providing a market value of $200 ($2 x 100). This value is represented by the grey box in Figure 1 labelled MV. However, many of these people were willing-to-pay more than the $2 entrance fee. This extra amount they are willing to pay over and above the $2 is their consumer surplus and indicated as the triangle CS in Figure 1. Consumer surplus in this example would be $25 (($2.50-$2.00) x 100 x 1/2). Therefore, the total benefit of the park is $225 ($200 + $25). When using a graph such as this, it is assumed that there is a substitutable good available for the good in question and that the supply curve is represented by an upward sloping line (Costanza *et al.*, 1997).

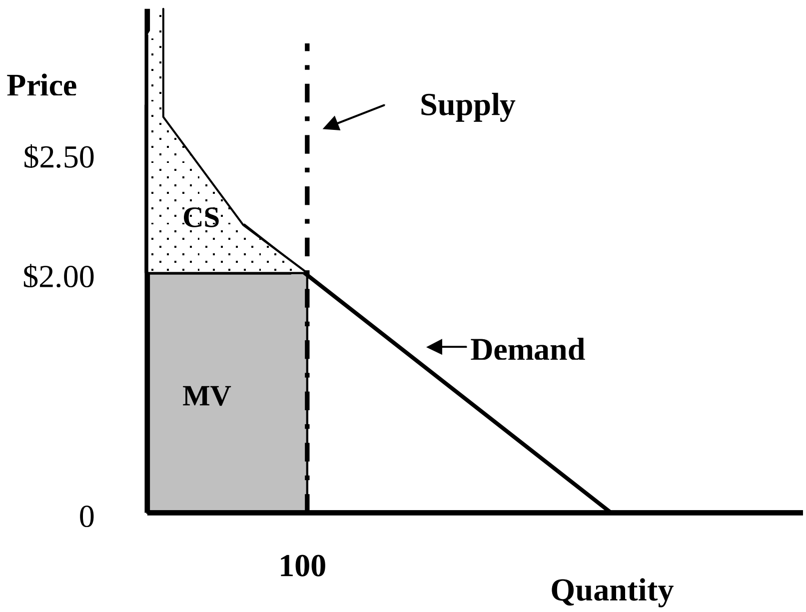
Figure 1. Consumer Surplus for Entrance to a Park that Charges a $2 Entrance Fee



However, this graph may not properly represent the consumer surplus value for ecosystem service values, as there may not be a substitutable good. If we go back to our picnic-logging example, we might find that people who live in this area live in apartments with no yards. If there is no picnic area on this land, then there is no picnic area available to them (there are no substitutes). If this is the case, Costanza et al., 1997 suggests that the consumer surplus value would take a different shape (Figure 2). There is now a limited supply (only one picnic area) and the shape of the supply curve would be a vertical line. Because of this limited supply, as the quantity decreases, the consumer surplus of the good would increase.

Some people have suggested that if this is the case, we should get rid of all substitutes, so what is left over will always command a higher consumer surplus value. For example, if there are 30 kiwi left in the country, the consumer surplus is, say, $10 per bird. But if there are only four kiwi left, the consumer surplus becomes, say, $10,000 per bird and it is therefore better to have fewer birds to achieve a higher consumer surplus! Perhaps this is the rationale that causes some people to believe that anthropocentric non-market values will be phased out and only ecocentric non-market values will be used in the future.

Figure 2. Consumer Surplus for the Entrance to a Park with No Park Substitute



From their literature review, Costanza et al., 1997, then attempted to estimate values of ecosystem services. Ecosystem services were split into their 17 categories of basic functions listed above, and land areas were divided into biomes (e.g. marine, terrestrial, forest, grassland, wetland, lake, etc). Each biome was given a value per hectare and total global flow value calculated by using the willingness-to-pay consumer surplus benefit transfer values. They note the total area of the earth is 51,625 ha x 10^6 and the annual global value of ecosystem services of the entire earth to be $33,268 x 10^9 in 1994 $US. While this article has brought much debate across the world, it has also been used commonly to estimate ecosystem service values for other areas.

In 1999, Patterson and Cole estimated the value of ecosystem services in the Waikato Region of New Zealand. In their report, market values were adapted from Hughes (1998) while non-market values were adapted from Costanza et al., 1997. Values for 13 ecosystem types were estimated: horticulture, agriculture, cropping, scrub/shrubland/tussock, forests, wetlands, coastal zone, coastal marine area, estuarine, seagrass/agalbed, mangroves, lakes, and rivers. Their estimation resulted in the annual ecosystem service value of the Waikato Region to be $9,360 (millions in 1997 $NZ). This is a benefit transfer type method and is a quick and easy process that can be used to get a general look at a particular ecosystem. However, I do believe that when time and funding is not an issue, the valuation should be calculated in detail for the specific ecosystem in question.

Gretchen Daily, 1997, suggests that those ecocentric ecosystem services and functions that can not be calculated by other means (market valuation, anthropocentric non-market valuation) should be calculated as avoid costs, and I agree with her. Avoided costs are the costs that we do not have to pay for when nature is providing us with a particular good. I think that the best way to conceive this is to imagine an area (the land for the picnic-logging area for example) being completely bulldozed over and pavement laid down in its place. If this were to happen, what ecocentric ecosystem services would disappear? In going through Costanza's 1997 list, focusing on ecocentric values only: there will no longer be plants to produce oxygen, no biological control taken place by insects, nutrients are no longer being recycled, rain will just run off the area potentially flooding the area around it, nothing is being pollinated as there are no plants to pollinate and there are no insects there to pollinate anything anyway, genetic resources have been removed, the climate is not being regulated in the way that it was (perhaps only the suns rays are reflecting heat off the black pavement), wastes are not being treated, water is not being regulated, and fauna can no longer use the area as a refugia.

How do we calculate all these avoided costs? Let us start with the first one: there will no longer be plants to produce oxygen. Let us say that the picnic-logging area we have been using as an example throughout this article is 10 hectares in area and this particular area would produce 30 litres of oxygen per day. Our avoided cost is not having to produce these 30 litres of oxygen every day via mechanical means (currently, there are machines that extract oxygen from the atmosphere that are designed for medical or industrial application (OGSI, 2006)). This machine may cost $5,000 to operate for one month, and therefore, our avoided cost would be $5,000 per month.

Next, we can consider the biological control taking place by insects. Native insects naturally suppress potential pest insects and the value of suppression of native insect pests by other insects might be calculated as the sum of the cost of damage from native insect pests with no natural control minus the cost of damage from native insect pests at current levels of natural control all multiplied by the proportion of herbivorous insects controlled primarily by other insects (Losey and Vaughan, 2006).

Another function is nutrient cycling in relation to healthy soils and soil production. There are many steps to nutrient cycling, one major step is decomposition. Decomposition occurs when organisms such as worms, bacteria, fungi and termites decompose plants, animals, and soil microorganisms. Another type of nutrient cycling is when nitrogen is fixed into the soil by leguminous plants. To calculate the value of nutrient cycling would entail determining how much it would cost us to produce the same amount of soil that is of the same quality.

If we were to calculate the avoided costs for all of the ecocentric ecosystem services, we might find that for the picnic area, we would have a value of $20,000 annually. The logging area, on the other hand, would have another value because of the different composition of the forest. The trees planted there would most likely be fertilized and sprayed with insecticides and fungicides, the use of which might reduce the number of native insects and fungi that might naturally repel invasive organisms. Perhaps the value for the logging area would be $15,000 annually. These calculations would modify our previous numbers, but again, we see that the picnic area, with net benefits of $840,000 (again, for simplicity sake, we are ignoring inflation and future discounting throughout this example) is greater than the net benefits of the logging area ($420,000) and therefore the picnic area would most likely be selected as the preferred option.

Table 3: Management Decision Using Market, Anthropocentric Non-Market Values and Ecocentric Non-Market Values

Management Options	Benefits	Costs	Net Benefits	
Option 1: Picnic Area	$940,000	$100,000	$840,000	Option 1 would be the preferred option since: $840,000 > $420,000
Option 2: Logging Area	$720,000	$300,000	$420,000	

While I have not suggested a calculation for all ecocentric ecosystem services, I believe the process should be similar to what I have suggested: the benefits we receive from ecocentric ecosystem services can be calculated as a result of the costs that are avoided.

Conclusions

Today, whenever a change in land use is proposed, a benefit-cost analysis is typically conducted to estimate the value of the natural resource in various situations. Benefit-cost analysis provides information about the benefits and costs of the possible land use changes proposed, as well as the benefits and costs of not conducting the land use change. To conduct a proper benefit-cost analysis, both market values and non-market values must be calculated. Market values are easy to calculate as they are calculated by the money that is exchanged on the market. Non-market values are much harder to calculate, as no money changes hands. The current practice is to calculate anthropocentric non-market values by estimated consumer surplus via one of various methods (contingent valuation method, travel cost method, choice modelling, hedonic pricing method, etc). However, this process does not consider the ecocentric non-market values. Ecocentric non-market values, such as oxygen production and erosion control, should be calculated using an avoided cost calculation. Although difficult to calculate, ecocentric non-market values should be included in a complete benefit-cost evaluation of competing options for resource use.

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