Economic value
Great Barrier
Reef
non-GBRMP

Total economic values:
The Great Barrier Reef Marine Park and other marine protected areas

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Queensland Government
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Executive Summary

The purpose of this report is to explore the economic values of the range of goods and services supplied by natural environments such as the Great Barrier Reef Marine Park (GBRMP). These goods and services have economic value because they are used in a variety of ways by society. However, many of these are not reflected in the existing market system as having dollar values and thus decisions may be made that do not reflect their real value to society.

This report adopts a well-accepted framework for considering the many values of the GBRMP and other marine natural environments, that is, the concept of total economic value (TEV).

The report is based on a literature review of published information. A small number of studies were identified where economic valuation techniques have been applied to estimate dollar values for ecosystem services such as coastal protection and biodiversity conservation. These studies indicate that comprehensive economic valuation for the GBRMP is still far in the future.

A number of studies that estimate a TEV (or at least some combination of direct and indirect use values) are reported. Estimates of the value of coral reefs by the hectare include one at US$120 a year, one at around $6000 a year, and estimates of net present values (NPV) ranging from US$1000 to US$ 1 million. This indicates that values associated with coral reefs may be considerable. However, the areas studied and the methodologies used vary widely.

Annual direct use values for the GBRMP were reported as follows:

- Commercial fishing, based on gross catch, A$136 million (KPMG 2000)
- Commercial tourism, based on gross expenditure, A$454.5 million (KPMG 2000) to A$647 million (Driml 1999)
- Recreational fishing, based on willingness to pay, A$52 million to A$124 million (Blamey 1991)
- Education and research, based on gross expenditure, A$19.39 million (Driml 1994).

Indirect use values for the GBRMP were reported as follows:

- Option and existence value (<u>partial only</u>) A$45 million a year (Hundloe et al 1987).

Some values for other marine protected areas are estimated as follows:

- Bioprospecting in Montego Bay US$70.9 million NPV
- Shoreline protection of Montego Bay, Jamaica, US$65 million NPV, Philippines US$22 billion NPV.

- Maintenance of migration and nursery habitats in Galapagos US$7/ha/yr
- Waste assimilation in Galapagos US$58/ha/yr
- Existence value of the Galapagos (spiritual and artistic) US$0.72/ha/yr.

These studies indicate that where the effort is made to identify and quantify environmental goods and services and apply recognised economic valuation techniques, then significant dollar estimates are generated. Consequently, systematically applying such techniques to the GBRMP would be likely to generate significant dollar values.

Abbreviations

GBR	Great Barrier Reef
GBRMP	Great Barrier Reef Marine Park
GBRMPA	Great Barrier Reef Marine Park Authority
GBRWHA	Great Barrier Reef World Heritage Area
IUCN	International Union for the Conservation of Nature
NPV	Net Present Value
TEV	Total Economic Value
WCPA	World Commission on Protected Areas

1 Introduction

The purpose of this report is to explore the economic values of the range of goods and services supplied by natural environments, particularly pertaining to the Great Barrier Reef Marine Park (GBRMP). These goods and services have economic value because they are used by society in a variety of ways. However, the existing market system does not reflect all of these in dollar values, so decisions may be made that overlook the real value of natural environments to society. Studies of economic analyses that have given dollar values to some environmental goods and services illustrate that economic well-being is indeed supported by services from the environment. However, there are significant gaps in being able to place quantifiable dollar values on environmental goods and services.

This report adopts a well-accepted framework for considering the many values of the GBRMP and other marine natural environments, that is, the concept of total economic value (TEV). In this context, "economic value" refers to any goods or service that enhance the welfare of society. Economic value does not refer just to financial returns. Use of the TEV concept leads to an appreciation that direct uses of natural environments can generate considerable economic value. Importantly, the framework also requires the identification of components of the economic value of the goods and services provided by natural environments that are not normally observed in the market place or measured in dollar values. The values recognised in the framework are necessarily values to humans (anthropocentric values). A limitation of the framework is that it does not address the goals of sustainability and equity.

This broad appreciation of economic value is important in managing natural environments, to allow a balance to be struck between promoting the obvious dollar values associated with direct uses of these areas and maintaining the economically important, but less obvious, values associated with conservation of the environment. Natural environments will have dollar values to some extent whether or not marine areas are protected. However, where areas are protected from unsustainable uses, the level of these values may be higher and there may be a greater likelihood of maintaining these values into the future. Protection of some areas may have flow-on benefits, that is, ecological and, therefore, economic benefits for other less protected areas.

Literature on economic values of the GBRMP and other marine protected areas reveals that while a number of studies place dollar values on components of use that relate to the GBRMP, there are significant gaps in relation to the TEV. For this reason, the literature review was extended to studies of other marine protected areas, to consider the dollar values that have been allocated to comparable environmental goods and services. A small number of studies were identified where economic valuation techniques have been applied to estimate dollar values for ecosystem services such as coastal protection and biodiversity conservation. These studies indicate that comprehensive economic valuation for the GBRMP is still far in the future.

This report begins by discussing economic values of protected areas, including the identification of environmental goods and services, the concepts of market and non-market values and the TEV framework. A short discussion on how to use these values in decision-making is included.

In the second part of this report, the results of the literature review are presented together with a short discussion of each component of the TEV for which a dollar value was found.

2 Economic values of natural areas — central concepts

2.1 Environmental goods and services

Positive economic values reflect the benefits people experience from a wide variety of goods and services including those provided by a natural area.

The attributes of the natural environment provide the basis for all of human life. Clean rivers and streams provide water to drink, the process of photosynthesis ensures that we have clean air to breathe, and the presence of plant and animal life provides food, clothing and potential shelter. The attributes of the environment, therefore, can be thought of as providing a wide variety of "goods and services" which are valuable to people, for the purposes of survival, material gain and increasingly, also for enjoyment through recreation and leisure activities.

Goods are physical, tangible objects, and may be natural (biological resources) or man-made (Bannock et al 1988). Goods provided by the environment include, for example, plants and animals used for food, timber which may be used for firewood or construction, and other fibers which may be made into clothes or paper.

Services are defined as intangible, non-transferable economic goods, as distinct from physical commodities, although these are difficult to define unambiguously (Bannock et al 1988). Many attributes of natural environments are used indirectly, and provide less tangible services. The primary anthropocentric values associated with natural environments are those arising from *ecosystem services* (Daily 1997). Moberg and Folke (1999) have listed ecosystem services arising from coral reefs, for example, as including the following:

Physical structure services
- shoreline protection
- build up of land
- promotion of mangroves and seagrass growth
- generation of coral sand

Biotic services within ecosystems
- maintenance of habitats
- maintenance of biodiversity
- regulation of ecosystem functions and processes
- biological maintenance of resilience

Biotic services between ecosystems
- biological support through mobile links
- export of organic production and plankton to pelagic food webs

Biogeochemical services
- nitrogen fixation
- CO_2/Ca budget control
- waste assimilation

Knowledge about the range of the services provided by ecosystems is not complete, as there are many aspects of ecological interactions that are not well understood, including tolerance levels and long-term response to human disturbance.

Other services provided by natural environments are the wide range of benefits people obtain from their existence, including scientific, artistic, cultural and spiritual benefits. Protected areas can also provide benefits in the form of tourism, recreation and education opportunities.

2.2 Market and non-market values

> *When goods and services are traded in the marketplace, market values can be observed. Many environmental services are not traded in the market place, and their values must, therefore, be estimated by other means.*

In the same way that a distinction can be made between tangible and intangible attributes of natural areas, a further distinction can be drawn based on how these attributes are made available. It is useful to consider whether goods and services enter the market place or not.

Tangible goods are most commonly traded in market places, as ownership or "property rights" are easy to assign to a physical object. Goods that can be owned exclusively by an individual are called *private goods*, and can include fish harvested under license by commercial fishers for example. Private goods can also include permitted tourism activities, such as guided tours.

Ownership of private goods may be transferred in a market place. Exchange is usually made for money, which enables a *market value* to be observed for the item. Market values reflect the worth that people put on the item being exchanged.

Other attributes of natural environments cannot easily be owned by an individual, for example, good quality water or a scenic view. These are termed *public goods*. Pure public goods are "non-rivalrous", in that consumption of the goods does not decrease the amount available for consumption by others, and also "non-excludable", as it is not possible to exclude any person from consuming the good or service. Public goods cannot be traded in a marketplace, and market prices cannot be observed.

Generally speaking, ecosystem services and the social and cultural benefits provided by natural areas have the characteristics of public goods, and do not enter the market place. However, in reality, the characteristics of public and private goods are often not distinct, but form a continuum.

It should be noted that it is possible to assign property rights to some goods and services from natural environments by establishing ticketing, permit and licensing systems. However, many services to which property rights could be assigned in this way continue to be provided free of charge, for example in many places, there are currently no entrance fees to visit national parks. Again, no market price can be observed. In any case, true market prices would only become obvious if permits and licenses were tradeable.

Goods and services that do not enter the marketplace, for whatever reason, are often very valuable to society however. The values associated with these goods and services are termed *non-market values*.

Market failure is the situation where imperfections in the market mechanism prevents the most economically efficient provision of goods and services (Bannock et al 1988). One type of recognised market failure is where goods and services are not priced properly, or at all, due to a lack of property rights or their inherent nature as public goods. To adjust for this, market values may be estimated for these non-market goods and services (see section 2.4). Alternatively, decision-making must explicitly recognise these non-market values (see section 2.5).

2.3 Total economic value

> *Total economic value is a valuation framework that incorporates market and non-market costs and benefits associated with direct, indirect, and other uses arising, for example, from protected areas.*

The concept of total economic value (TEV) may be used to describe the full range of values of the natural environment to people, in theory, in common monetary terms. In theory, these values may then be included in evaluating different management options.

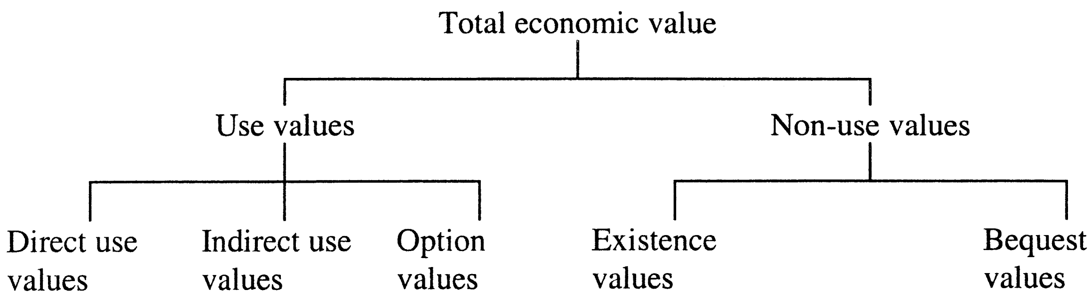
The IUCN World Commission on Protected Areas (WCPA) recommends the use of the total economic value (TEV) framework as an approach to economic valuation (WCPA 1998).

The TEV framework provides a valuation methodology based on the values associated with the uses and non-uses, of an area[1]. "Non-uses" or "passive uses"refers to values that arise from an area but are separated in space or time from the area. For example, non-use value exists if someone living in a city is willing to pay for the conservation of a natural area that they do not visit.

Components of total economic value are shown in Figure 1.

[1] Note that the classification of values into use and non-use, the treatment of option value, and the definitions of components of non-use values do differ amongst authors who write about the TEV. The WCPA presentation of TEV is used here.

FIGURE 1: **Total economic value**



Source: WCPA 1998, page 11.

Direct use values will mostly be associated with consuming private goods, and will usually be observable as market values. This type of direct use value will include, for example, the value associated with harvesting fish from an area. However it is also possible for direct uses to include non-market uses, for example, visiting an area for recreation.

Indirect use values include many of the values associated with ecosystem services such as maintenance of habitats and waste assimilation. Most of these values will be non-market values. These ecological processes are not used directly, but they do support direct uses. Therefore, while ecosystem services may not have apparent economic value, the loss of these services may result in monetary losses felt by businesses dependent on their existence, and broader losses to the economy and society.

Option value is included by the WCPA (1998) as a separate component of use values, to indicate a value society places on the option of having a flow of goods and services from protected areas in the future, producing direct and/or indirect use values. Option value includes the potential value of increased information in the future, for example, information from genetic resources (WCPA 1998).

Non-use values include *Existence value* — the value of knowing that a natural area is retained in its natural state, and this can include amenity enjoyed through books and photographs, spiritual values, cultural and heritage values, community values and vicarious use value, which is the satisfaction derived from knowing other people enjoy a natural amenity (Hufschmidt et al 1983).

The other important component of non-use values is *Bequest value,* which is the value of knowing a natural environment will be passed on for the enjoyment of future generations.

TEV, therefore, incorporates the concepts of market and non-market values, and if all of the market and non-market values as discussed earlier were added together, this would equal TEV.

Non-Market values PLUS Market values = total economic value

2.3.1 Limitations of the TEV framework

There are several important factors that should be borne in mind when undertaking any valuations using the TEV framework (WCPA 1998).

- TEV is an anthropocentric concept. Economics attempts to reflect the worth of natural areas to people.

Many people also recognise an "intrinsic" value of species and ecosystems, independent of any direct or indirect utility to humans. This value essentially reflects the right of individual species to exist and be protected from human threats to their survival. One point of view is that the anthropocentric economic values derived using the TEV approach should be considered to be in addition to the intrinsic values of an area. Pearce et al 1989, argue that all values are ultimately anthropogenic and that the intrinsic values are fully reflected in existence values.

- It is extremely unlikely that anyone will be able to estimate feasible dollar values for all components of the TEV.

There are obvious limitations involved with assigning monetary values to society's uses of the natural environment. Some attributes are extremely difficult to value, for example, what is the value of photosynthesis (which produces oxygen) or the spiritual value of an area? The attributes are also complex and interrelated, which means considering them as separate goods or services is difficult. For example biodiversity underpins all ecosystem services as well as being a value in itself.

- There are likely to be conflicting values identified through the TEV, as well as problems of missing values and double counting.

Natural areas can be used for a wide variety of activities, and some of these activities have the potential to conflict with each other. The most notable conflicts occur between conservation and other uses.

- Any measure of TEV will reflect the condition of the resources and the mix of uses (and non-uses) being undertaken at that time.

Measures of TEV cannot infer anything about the sustainability of activities (or otherwise). Other information about the state of the environment and the goals of management are needed to provide this context. Additionally, TEV makes no assessment of the equity of the current mix of users (and non-users) and the distribution of costs and benefits arising from those uses. For example, if all costs were borne within Australia and, due to imports and international ownership of businesses, the benefit stream were directed outside of Australia, the TEV would not reflect this distribution.

The TEV is a useful concept for recognising values. The ability to measure these is constrained. However, if components of the TEV are measured, this provides important information on trade-offs required to allow for different levels of direct use.

2.4 Estimating and interpreting dollar values for non-market goods and services

Methods now exist to estimate dollar values of non-market environmental goods and services. Benefit transfer involves applying results from valuation in one study to other situations.

As they cannot be observed from the market place, non-market values have to be determined by other means. A common method of estimating dollar values for changes to ecosystem services is via changes to linked market goods, for example the economic loss to commercial fisheries of damage to mangroves. Another method is to estimate the cost of developing a technological replacement to an ecosystem service, for example water treatment. Other methods used are the *travel cost method* to estimate tourism and recreation values via willingness to pay entry fees to natural areas where there are no actual fees, and *contingent valuation* and *choice modelling* techniques, to estimate willingness to pay for a policy change that would affect ecosystem services. There is now a considerable body of work worldwide on the theory and practice of valuation and many methods are now employed routinely. See Pearce et al 1999, the New South Wales Environmental Protection Agency's database ENVALUE[2] or the United States Environmental Protection Agency's *Guidelines for Preparing Economic Analyses*[3] for more information on valuation techniques.

While valuation techniques are continually being refined to overcome their limitations, it is important to recognise that regardless of the technique chosen, accurate information on the ecological relationships, processes and productivity affecting (and affected by) the particular activity is also required. Economic analysis and valuation are only ever as good as the ecological information on which they are based, yet there are so many uncertainties about ecological relationships, and this renders economic analysis more difficult.

2.4.1 Benefit transfer

When valuation estimates from one study are used in a different context, this is called "benefit transfer" (World Bank 1998). Benefit transfer is one way of obtaining estimates of values without the expense and time required to do a specific study. However, the goods or service being valued must be very similar, both at the original site and at the site of application. The populations being surveyed must also be demographically similar.

This means that for sites that have unique sets of natural attributes, benefit transfer has limited application. The ability to transfer the results of studies conducted on other marine areas to the GBRMP, which is acknowledged as unique in the world, may, therefore, be limited. Also, most other significant coral reefs and associated tropical marine ecosystems are located in countries operating under different economic conditions than those influencing the GBRMP, particularly in less-developed nations. In

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2 www.epa.nsw.gov.au/envalue/

3 http://yosemite1.epa.gov/ee/epa/eed.nsf/pages/guidelines

addition, the populations visiting the GBRMP may be significantly different from those visiting these other sites.

For these reasons, it is not recommended that the results of studies for other areas in the world that are presented in the following section be applied to the GBRMP. Rather, these studies give an indication of dollar values that could be estimated for similar goods and services in the GBRMP.

2.4.2 Interpreting dollar values

It is important in interpreting dollar values to consider what exactly is being valued. For example, when market values are evident or estimated, it is relevant to note the distinction between *gross values* and *net values*. Gross values represent for example the total value of sales of fish or takings by tour operators. Net values result when the cost of catching fish or providing tour services is subtracted from the gross value. It is important that when the dollar values of different activities or goods and services are compared, they are compared on the same basis.

Where market values reflect actual monetary transactions, additional *flow-on effects* of these transactions can be observed in an economy. For example, the money earned from the sale of fish may be returned to the local or regional economy in exchange for goods and services such as fishing vessel repairs, or other inputs to fishing. This will, therefore, increase the output of other sectors of the economy.

The impacts of monetary transactions will also be felt in terms of changes in the level of employment. For example, the demand for tours of natural areas provides employment opportunities for tour operators and their employees. Operating tours can create opportunities for employment in associated businesses like accommodation, and vice versa. The wages of these employees are also returned to the economy as they are spent on goods and services such as groceries and housing, for example.

The flow-on and support effects throughout the economy of non-market goods and services from natural environments are not so easily recognised, although they could be providing the very basis for commercial activities. The sustainability of economic activity generated through market goods and services depends on the sustainability of critical ecosystem services.

2.5 Use of economic values in decision making

The "constrained optimisation", or "least cost", approach to decision making allows economic information to be incorporated into decision making along with ecological, social, cultural and other information.

There are several ways in which economic values can be used to assist decision-making.

Economic efficiency is aimed at maximising the value of resource usage and is said to be achieved when it is not possible to make someone better off without making someone else worse off. A conventional economic efficiency approach involves measuring the values of all potential resource uses and assessing different "trade-offs" between uses for the "best" outcome. In economics, the concept of *opportunity cost* is important. This means the cost of using resources in a particular way is the opportunity cost of foregoing those resources in their next best use. In an ideal world, a proposed project or policy could be assessed using a benefit-cost analysis framework. The benefits of the proposal could be measured and compared with the opportunity cost of those resources, to see if a net economic benefit would result.

There are a number of difficulties with this approach where there are significant non-market values. There may be changes in values that are extremely difficult to measure in quantitative units let alone in dollar terms (for example changes in the level of biodiversity maintenance).

Another method of incorporating the full range of economic values in decision-making is to use a *cost effectiveness analysis* approach. This may also be called a *constrained economic efficiency* or *least cost* approach. This approach is particularly relevant to protected areas and other natural environments where non-market values are acknowledged to be significant. This approach allows ecological, social and cultural information and notions of sustainability to be included in decision making, to compensate for the limitations of relying on dollar values where the full TEV cannot be estimated.

Using this approach, ecological information is used to develop criteria that are used to determine ecological targets or constraints. These targets or constraints can be set so as to promote a precautionary approach aimed at achieving sustainability and inter-generational equity. As such, the targets or constraints can aim to adequately protect and provide for ecosystem services to ensure a continued flow of these services.

Within these targets or constraints, economic analysis is used to find the optimal economic value of the mix of direct uses permitted. This would, therefore, be the solution that meets the targets or constraints with least cost. Different management options and their implications for direct uses are considered, and the alternative that involves the maximum benefit, or least cost in terms of foregoing direct uses, will be the alternative which is preferred. Using this approach, it is necessary to observe the market values for direct uses and to estimate dollar values for non-market direct uses. It is not as important, however, to attach dollar values to all non-market goods and services.

The remainder of this report will apply the concepts outlined above to discuss the economic values of the Great Barrier Reef Marine Park and other marine protected areas.

3 Economic values of the Great Barrier Reef Marine Park and other marine protected areas

This section of the report is based on a literature review of economic studies of the GBRMP and other marine protected areas. Where dollar values were identified for such marine systems, they are reported and discussed here. At the outset, it is worth noting the different units in which dollar values are reported. Some of the studies report annual values of goods and services for whole systems. Other studies report annual values for each hectare of reef, and in most cases these studies are concentrating on coral reefs. It is not advised to simply multiply such values by the area of the GBRMP as the GBRMP is made up of many habitat types, of which coral reefs are a minority (6 percent). Some studies report values as a Net Present Value (NPV), and these refer to annual values capitalised, that is discounted and added up, over a number of years. Such values cannot be directly compared with annual values.

As noted in the benefits transfer discussion, the dollar values from other areas are presented here mainly for illustrative purposes and great caution would need to be taken to apply any of them to the GBRMP because they refer to different ecosystems, are in different currencies and usually refer to different socio-economic environments.

3.1 Estimates of TEV for reef and mangrove systems

In the literature review conducted for this study, a small number of studies were identified which have attempted to estimate TEVs (or at least values that incorporate some indirect as well as direct use values) for marine and mangrove ecosystems.

3.1.1 Reef systems

De Groot (1992) estimated a TEV for a coral reef system of the Galapagos Islands at US$120 a year for each hectare, which translates to a NPV of US$2400 a hectare and US$2.8 billion for the entire system.

Gustavson (1998) estimated the NPV of tourism, fishing and coastal protection of Montego Bay, Jamaica at US$273 million to $US702 million. The area of Marine Park is 1530ha, implying a value of US$397,000 to US$1,020,000 for each hectare of protected area.

For Indonesian coral reefs, Cesar (1996) estimated a NPV for fishing, tourism and coastal protection of US$1373 to US$11,619 a hectare.

Costanza et al (1998) made an estimate of TEVs for all the earth's ecosystems, based on considerable extrapolation from published studies, and these estimates need to be treated with caution. For coral reefs, Costanza et al estimated a value of US$6076, each year for each hectare.

The value of Florida Keys National Marine Sanctuary was valued in 1990 at US$50,000 a hectare NPV and at US$44.6 billion NPV in total (NOAA 1995).

Davis (2001) undertook an economic analysis of the Solitary Islands Marine Park in NSW and concluded that the park produced annual net benefits of A$5,746,700.

3.1.2 Mangrove systems

For mangrove systems in Bintuni Bay, Indonesia, Ruitenbeek (1992) estimated a value of US$4800 a hectare and a total of US$961 to US$1495 million for the entire system (quoted in Cartier & Ruitenbeek 1999). Only 15 percent to 35 percent of this amount is direct use value, so the majority of value is not usually identified as market values. This study does not include cultural value to the local Irarutu tribe.

An earlier study of mangroves in India estimated a TEV of over US$11,000 a hectare (Dixon 1989).

Similar estimates of $US15,000, US$11,000 and US$13,000 a hectare were made for mangrove systems in Trinidad, Fiji and Puerto Rico respectively, but these estimates may only include direct uses of fishing, forestry and tourism (Hamilton and Snedaker eds quoted in Brown et al 1993).

3.2 Estimates of components of the total economic value

Given the few estimates of a complete TEV for marine and coastal systems found, the literature review also attempted to identify as many dollar value measures as possible for components of the TEV for the GBRMP and other relevant marine areas. The review revealed that although the GBRMP is one of the most studied marine areas in the world, many of the area's values remain undescribed in dollar terms. No measure of the complete TEV for the GBRMP has been published, and an estimate has not been produced for the purposes of this report. There are however studies available which have produced estimates for various components of the TEV for the GBRMP, based on market and some non-market values.

The estimates obtained from GBRMP-specific studies are in some cases derived from older data, particularly some of the non-market valuation studies. Market value estimates are relatively easy to update, whereas methods of estimating non-market values are more complex and can require a new study, to reflect changes in situation, perceptions and attitude, therefore,these results should be interpreted as order of magnitude only.

A number of other studies have identified values for components of the TEV for other marine areas and are drawn upon in this review. These studies have concentrated on the value of coral reef and mangrove ecosystems, and data for most other marine and coastal ecosystems (e.g. seagrass beds, lagoon areas and estuaries) is extremely limited. Some of the reported studies have placed dollar estimates on non-market values.

Many of the examples given here were reported in a World Bank Research Committee Project "*Marine System Valuation: An Application to Coral Reef Systems in the Developing Tropics*", which estimated values for coral reefs in Montego Bay, Jamaica (Cartier and Ruitenbeek, 1999). On reviewing the literature for the Montego Bay study, the authors found that economic studies of coral reefs overwhelmingly focussed on tourism and recreation values. The authors of that project have endorsed the TEV approach.

3.3 Direct use values

Direct use values have been estimated for commercial fishing, tourism, recreational fishing and research in the GBRMP. No dollar value estimates have been identified for other direct uses of the GBRMP. There are numerous studies with dollar values for tourism and fishing in other marine areas – too numerous to include in Table 1; however some tourism studies are described below. Estimates of dollar values for the more rarely quantified direct uses are included in Table 1 (over page) for other marine areas, where these have been identified in the literature.

3.3.1 Commercial fishing

3.3.1.1 GBRMP

Commercial fishing is a major use of the Park. The commercial fishing catch in the Great Barrier Reef Marine Park in 1997 was 14,372 tonnes. The prawn catch is by far the largest in volume, making up 5444 tonnes of the total catch. Prawns also represent the most valuable component of the gross value of the catch. In 1997, prawns accounted for $68 million out of a total catch value of **A$136 million** (KPMG 2000).

Another estimate of the gross financial value of commercial fishing in the GBRMP was produced by Driml (1999). The results of this study estimated that in 1995–96 a gross value of **A$143 million** was generated from commercial fishing activities.

These two quite similar estimates do not take into account any of the costs of production, including any financial and ecological costs. They reflect only gross private financial returns, not the net economic returns from the fishing, which are likely to be much smaller.

The wider economic impact of the commercial fishing sector has been analysed in several studies, and has been shown to be significant. KPMG (2000) estimates that due to flow-on or multiplier effects, every dollar of gross output from the commercial fishing sector results in $0.60 of output elsewhere in the economy. Similarly, each person employed by the commercial fishing sector results in 0.735 of a person being employed elsewhere in the economy (KPMG 2000).

Table 1: Direct use values, GBRMP and other areas

Use Values, Direct Uses				
	GBRMP		*Other Areas*	
Direct uses	Data source	Valuation[4]	*Data source*	*Valuation*
Commercial fishing	KPMG (2000) Driml (1999)	A$136 m/yr* A$143 m/yr	*Numerous studies*	
Tourism	KPMG (2000) Driml (1999) Hundloe Vanclay & Carter (1987)	A$454 m/yr A$647 m/yr A$653 m/yr	*Numerous studies*	
Recreational fishing	KPMG (2000) Driml (1999) Blamey (1991)	A$118 m/yr A$122 m/yr A$52 m/yr to A$124 m/yr		
Indigenous use	No studies found		No studies found	
Research	Driml(1994)	A$19.4 m/yr		
Education and Research	No education estimates found		*Spurgeon (1992) Belize;* *Spurgeon (1992) Panama;* *De Groot (1991) Galapagos NP*	*US$150,000/yr* *US$2.5 million in 1991* *US$2.73/ha/yr*
Bioprospecting	No studies found		*Cartier and Ruitenbeek (1999) Montego Bay*	*US$70.9 million NPV*
Shipping	No studies found		No studies found	

* m/yr = million a year

3.3.2 Commercial tourism

3.3.2.1 GBRMP

Tourism is the major commercial activity in the reef region. Driml (1999) estimated the annual gross financial value of commercial tourism in June 1996 to be **A$647 million.** This estimate includes tourism on vessels, accommodation on the mainland taken in association with trips to the GBRMP, and stays on commercial island resorts. Tourism on aircraft is excluded, and the author acknowledges that this may result in tourism values being understated.

Using a similar primary data source but a different method for estimating associated mainland expenditure, KPMG (2000) estimated that the gross financial value of commercial tourism in 1997– 98 was worth **A$454.5 million**.

As with the fisheries, it is important to recognise that the whole of this amount is not likely to remain in Queensland or even Australia, even so the flow-on effects of commercial tourism are significant. Each dollar spent on tourism creates an extra $0.90 in other sectors of the Queensland economy, notably in the finance, trade and food

[4] Note for this and subsequent tables, these values are not standardised to a particular year, but are presented as reported in the published studies.

manufacturing sectors. A total of 7421 people are directly employed in commercial tourism activities, with a further 5469 people being employed indirectly.

Hundloe, Vanclay and Carter (1987) estimated the total expenditure of visitors to the reef region to be a minimum of **A$653 million** a year. This study also attempted to estimate a total expenditure for visits specifically to coral sites ($44.4 million a year). There is, however, a difficulty in separating the attractions (attributes) of the region in this manner and thus it is likely that this is an underestimate of expenditure attributable to the attraction of the GBRMP.

3.3.2.2 Other Areas

There are many studies of tourism values of coral reefs and other marine environments. Unfortunately, most report only gross values based on expenditure and do not report net economic values or investigate the long-term sustainability of tourism use in the areas. A few studies that consider net benefits are reported here.

A study of the Virgin Islands National Park in 1981, conducted by Posner, Cuthbertson et al, examined the direct economic costs and benefits associated with tourism **and** recreational use of the Virgin Islands National Park. Total costs of US$2.1 million, were offset by US$23.3 million a year (US$3.3 million direct benefits and US$20 million indirect benefits).

Gustavson (1998) has estimated the NPV of the value of recreation and tourism for Montego Bay Coral reefs. The NPV was found to be US$315 million a year, based on 1996 data. This study included accommodation, food and beverage, entertainment, transportation, retail and miscellaneous services. Unlike other studies, the value of US$315 million is a net value, and, therefore, takes account of the costs of providing recreational goods and services, as well as direct expenditure. The total coral reef area within Montego Bay is estimated to be 42.65ha. Recreation and tourism are, therefore, worth approximately US$7386 million a hectare of coral reef.

It is also possible to separate out the value of different components of tourism and recreation. For example, Dixon et al (1992) estimated the value of dive-based tourism in the Bonaire Marine Park, located in the Carribean Sea. This study found that gross revenue generated in 1991 was US$23.2 million, comprising expenditure on hotels, dive operations, air transport on the local airline and other purchases. This study also explored relationships between coral cover, species density and stress on sites used for diving to identify a function of damage vs diver numbers.

3.3.3 Recreation

3.3.3.1 GBRMP

Non-market valuation techniques have also been applied to estimate the value of recreation in the GBRMP. As recreation includes both tourism and possibly recreational fishing, these results are not reported separately in Table 1. In 1987, Hundloe, Vanclay and Carter estimated the annual value of recreation to the reef region, using the travel cost method. This method indicates the willingness of visitors to pay to enter areas for recreation where there are no entry fees, based on how much visitors pay for travel to the area. Their results showed that the net economic value for domestic and international tourists visiting the reef region was A$144 million a year, with net economic value for Australian visitors A$117.5 million, and for international visitors A$26.7 million. This figure includes all visitors to the reef region. It is worth noting that the net economic value for only those visitors that intended to see, or had seen, coral sites, was A$106 million a year.

A number of studies have measured the net economic benefits to visitors, by asking their willingness to pay (WTP), in addition to all other costs, to visit reefs or islands in the GBRMP. Studies in the past have elicited amounts of A$8 for each adult visitor to coral sites in the GBRMP (Hundloe, Vanclay and Carter, 1987), A$15.12 a person (1979 dollars) a visit to Green Island (Economic Associates, 1983) and A$36.29 a person for recreation at Heron Island (Sloan, 1987, 1983 dollars).

While the range of these values is large, the studies illustrate that visitors to the region experience significant benefits which are not captured in the present markets.

3.3.3.2 Other areas

As indicated in the studies reported above, recreation values are often included with tourism values, although this may lead to an underestimate of recreation values of local communities.

3.3.4 Recreational fishing

3.3.4.1 GBRMP

One way of generating a dollar estimate for the non-market value of recreational fishing is via the gross amount spent by fishers using private boats. Based on expenditure in June 1996, this value was estimated at **A$122 million** by Driml (1999). KPMG (2000) estimated a value for 1995–96 of **A$118 million**, which is quite close to the estimate reported by Driml. KPMG estimated a gross value of recreational fishing and boating in 1997–98 of $108 million. The decline in value over the period is due to a decline in the estimated number of boats used in the marine park. In 1995–96, for example, 26,767 boats were used in the park, in contrast to the 1997–98 estimate of 23,909 boats.

These studies illustrate that the value of recreational fishing and boating in the marine park is worth in excess of A$100 million to the region annually.

As part of their study, KPMG (2000) also estimated the flow-on effects of recreational fishing and boating activities. For every dollar of output from recreational fishing and boating, an additional $1.09 of output is created in other sectors through flow on effects. This means that for 1995–96, A$129 million of additional output was created.

Recreational fishing and boating does not formally employ anyone directly. However KPMG (2000) have calculated that 1756 people are employed indirectly in other sectors as a result of recreational fishing and boating activities.

Most economists agree that the more valid way to value recreational use is in terms of what recreational visitors would be willing to pay for access for recreation. A study by Blamey (1991) estimated that the net economic benefits based on willingness to pay of recreational fishing for the GBRMP area was in the range of A$52 million to A$124 million dollars.

3.3.5 Indigenous uses

3.3.5.1 Other areas

Overseas studies have indicated that the use of coastal resources by indigenous communities is often significant. In the Philippines, seafood provides over 50 percent of animal protein in the diet of the local people (Spurgeon, 1992). Economic value can be attributed in terms of the cost of obtaining alternative foods.

3.3.6 Education and research

The net economic value of research is difficult to determine as it requires following through results of research as they are implemented (through better planning and management as well as more marketable discoveries), placing an economic value on any implementation, then comparing this with the costs of research. In the absence of such information, public agency research budgets can provide an indication of what society is dedicating to research, and presumably society values the expected results by at least that much. Similarly, the net economic value for education, where the result is an increase in knowledge, a social good itself, is only partially reflected in the budget directed to the activity. The amount of money devoted to research and education may be constrained by budget restrictions, and be in no way close to the level of funding which is considered to be ideal. No studies estimating the information or financial returns from investment in marine research or education activities have been located.

3.3.6.1 GBRMP

Driml (1994) estimated a scientific research budget of **A$19.39 million** in 1991– 92 for the Great Barrier Reef Marine Park. This included only the research and monitoring budget of GBRMPA, and the budget of the Australian Institute of Marine Science and is, therefore, an underestimate of public expenditure on research in the GBRMP.

3.3.6.2 Other Areas

Similar estimates are available for other coral reef areas, for example an education and research value for Belize Coral reefs was estimated by Spurgeon (1992) as US$150,000 a year. This estimate was based on annual expenditures by the UK Coral Cay Conservation expedition. Spurgeon also estimated an education and research value of Panamanian coral reefs of US$2.5 million in 1991, based on a percentage of the Smithsonian Research Institute's budget for work in Panama.

A study by de Groot (1992) estimated an education and research value of Galapagos National Park of US$2.73 a hectare a year. This estimate was based on research expenditures, and expenditures on field courses, fellowships, training courses, education facilities and materials.

3.3.7 Bioprospecting

Coral reefs and other marine ecosystem components may contain substantial resources in the form of biological information, which can be used for educational or medical purposes. Bioprospecting is the term given to looking for this biological, or genetic, information.

3.3.7.1 GBRMP

Bioprospecting is conducted in the GBRMP but no dollar value estimates have been made of its current value.

3.3.7.2 Other Areas

A study recently carried out valued this information for the Montego Bay coral reef at an NPV equivalent of US$70.9 million (Cartier and Ruitenbeek, 1999). This estimate was obtained from a model that incorporated drug values, local bioprospecting costs, institutional costs, discovery success rates for marine extracts, and a hypothetical bioprospecting program. Value for each species was estimated to be around US$7775 a species. To provide some perspective, the GBRMP contains in the order of tens of thousands of species.

Many studies of bioprospecting in the terrestrial environment have been carried out. These studies have resulted in many estimates of the value of a successful plant species, for example, US$390 million a year for a successful rainforest plant species based on 1990 US drug sales (Pearce and Puroshothaman, 1992). This estimate was extended in a later study to show that the annual global value of an untested species is US$819, also when based on drug sales (Aylward, 1993). The results of these and similar studies are highly dependent on the underlying assumptions, for example success rates, species/area relationships, costs of research etc.

However, as the marine environment is still relatively uninvestigated, it is thought that a significant number of marine species are still to be identified. Marine ecosystems are generally acknowledged to be more likely to yield successful compounds suitable for further study. Therefore, economic values for each marine species are somewhat higher than for terrestrial species.

3.3.8 Shipping

3.3.8.1 GBRMP

The GBRMP is an important shipping route, stretching as it does for over 2300km along Australia's eastern seaboard. While the outer reefs create calmer waters for navigation, the need to navigate through reefs is a shipping hazard. The use of the GBRMP by ships does pose a potential hazard to the reef, although potential damage costs are reduced by the requirement for compulsory pilotage. No estimates are known of the contribution of the GBRMP to shipping gross or net returns.

3.4 Indirect use values — ecosystem services

The list of ecosystem services from coral reefs proposed by Moberg and Folke (1999) has been used to organise the findings of the literature review in Table 2. This is not necessarily a complete listing of ecosystem services; other authors have included services such as "moderating microclimate" and "regulation of local energy balances", but have not provided dollar estimates. Unfortunately, the table has more blank cells than cells with dollar estimates. However, some significant dollar amounts have been estimated for just some of the ecosystem services of the natural environments.

Table 2: Indirect uses, ecosystem services and experienced amenity, GBRMP and other areas

Use values for indirect uses				
	GBRMP		Other Areas	
Ecosystem Services	Data source	Valuation	Data source	Valuation
Physical structure services				
Shoreline/coast protection			*Gustavson (1998) Montego Bay;* *McAllister (1991) Philippines;* *Costanza et al (1989) Louisiana*	*US$65 million NPV* *US$22 billion NPV* *US$2400 an acre NPV*
Build up of land				
Growth of mangroves and seagrass				
Generation of coral sand				
Biotic services – within ecosystems				
Maintenance of migration and nursery habitats			*de Groot (1992) Galapagos NP*	*US$7/ha/yr*
Maintenance of Biological diversity	Hundloe, Vanclay & Carter (1987)	A$15.6 m (maintenance)	*de Groot (1992) Galapagos NP*	*US$4.96/ha/yr (maintenance)*
Regulation of ecosystem functions and processes				
Biological maintenance of resilience				
Biotic services – between ecosystems				
Biological support through mobile links				
Export of organic production and plankton				
Biogeochemical services				
Nitrogen fixation				
CO_2/Ca budget control				
Waste assimilation, organic matter storage and recycling			*de Groot (1992) Galapagos NP*	*US$58/ha/yr*
Experienced amenity				

Amenity of adjacent settlements			*Posner, Cuthbertson et al (1981) Virgin Islands*	*US$5 m/yr* (increase in land values)*

* m/yr = million a year

3.4.1 Shoreline/Coastal Protection

Moberg and Folke (1999) discuss a range of physical structure services of coral reefs including shoreline protection, the build up of land, promoting the growth of mangrove and seagrasses and the generation of coral sand.

Coral reefs provide physical protection to coastlines, by acting as a barrier that helps to dissipate wave energy before it reaches the shoreline. Reefs can, therefore, reduce coastal erosion substantially. Many highly productive seagrass beds, reef lagoons and mangroves only exist because of the calm conditions experienced behind reefs (Spurgeon, 1992). Often, these areas can be highly significant and valuable in terms of commercial fishing. Conversely, mangroves protect coral reefs from the impact of onshore activities, as they filter run off and provide protection from sedimentation. Mangrove removal has been blamed for erosion and more severe storm impacts in many parts of the world.

Mechanisms to estimate the value of coastal protection, a function of reefs, may consider the levels of economic activity with and without the protection of a reef. This is called the "change in production" approach. Another approach is to consider the replacement cost of installing an artificial structure to give protection to the shore and nearshore areas.

3.4.1.1 Other Areas

Gustavson (1998) estimated a NPV of US$65 million (1996 dollars) for coastal protection offered by Montego Bay coral reefs. This estimate was based on the change in productivity and value of land at risk or vulnerable to coastal erosion along the foreshore, and is a maximum value. The estimate is also dependent on the incidence of erosion in the absence of the reef, which is acknowledged as speculative. The coastline of the Montego Bay reef is 34km long (as compared with approximately 2300km of GBRMP coastline) and it was assumed that the first 30m of shoreline would be at risk if the 42.65ha of reef were not present to provide protection.

McAllister (1991, reported in Spurgeon 1992), estimated the cost of replacing fringing reefs in the Philippines with concrete tetrapod breakwaters at US$1 million a square kilometre, for 22,000km, or US$22 billion NPV equivalent. This estimate is also perhaps a maximum value, as it ignores cheaper forms of replacement and any differences in erosional sensitivity and economic activities taking place along the shoreline.

Costanza et al (1989, quoted in Brown et al 1993) calculated the value of the protection of the coast from storms by coastal wetlands in Louisiana USA at US$2400 an acre NPV.

3.4.2 Maintenance of migration and nursery habitats

The marine and coastal areas, including the GBRMP provide numerous habitats that are important to different parts of the life cycle of many marine mammals, fish, shellfish, crustaceans and other invertebrates. Many of these species are also of commercial importance. For example, mangroves serve as nurseries by providing food for juvenile fish along with shelter from larger predators.

3.4.2.1 Other Areas

De Groot (1992) estimated a habitat/refugia value for Galapagos National Park of US$7 a year for each hectare, by assuming that 10 percent of the value of fish catch in the Galapagos depends on the nursery function of inlets and mangrove lagoons.

3.4.3 Maintenance of biological diversity

Biological diversity underpins the provision of all other functions and services provided by a natural environment. This diversity exists at the ecosystem, habitat, species, population and genetic levels. Marine ecosystems included in the GBRMP are coral reefs, intertidal areas and mangroves, estuaries, soft sediment communities in the inter-reef and GBR lagoon areas, pelagic and deep ocean systems. The WHA has great ecosystem diversity.

Marine systems have particularly high genetic diversity. Marine systems generally exhibit more genetic diversity than terrestrial systems, while terrestrial systems exhibit more species diversity (Cartier and Ruitenbeek, 1999). The GBRMP is, however, renowned as one of the most biologically diverse regions on the planet.

Because the complex ecological relationships (which are poorly understood), biological diversityis difficult to value, and few studies have attempted to do this.

While not directly relevant to marine ecosystems, the possibility of estimating an economic value for an individual species is illustrated in a study by Narain and Fisher (1994) who estimated that a one percent decline in the population of the Anolis Lizard on Greater and Lesser Antilles results in a loss of US$670,000 in value of crop production, as the lizard performs a vital function by feeding on crop destroying insects. Similar relationships in marine environments, particularly relating to predator-prey relationships, may be expected but calculating the value of such interactions between all the thousands of GBRMP species which often have not been identified let alone marketed is impossible.

3.4.3.1 GBRMP

The willingness of the Australian population to pay for management of the Crown of Thorns Starfish was estimated by Hundloe et al (1987) at **A$15.6 million** a year. This may be thought of as the willingness to pay to maintain the hard coral parts of the region. However, as it only identifies a single threat and a single group of animals among many of both, it is likely to be a considerable under-estimate of the value of maintaining the biodiversity of the GBRMP.

3.4.3.2 Other areas

De Groot (1992) estimated a value (shadow price) for biodiversity <u>maintenance</u>, in Galapagos National Park, of US$4.96 a year for each hectare, which is based on 10 percent of the values of activities that rely on biodiversity maintenance. This study also estimated a nature protection value of US$0.55 a hectare a year, based on the park budget.

3.4.4 Organic matter storage and recycling, waste assimilation and reception

Organic matter storage and recycling is an important ecosystem service, along with the assimilation and reception of waste. These processes continue to provide important services to society, especially in the case of assimilation of non-point source discharges into waterways and marine areas. An economic value for waste assimilation can be estimated based on the cost of providing infrastructure and technology to perform similar services.

3.4.4.1 Other Areas

For the Galapagos Islands National Park, de Groot (1992) measured the organic waste treatment value of the natural environment. This study estimated a replacement cost for this function of US$58 a hectare, based on the costs of the alternative: artificial purification technology.

3.4.5 Visual amenity and inherited lifestyle values

The visual amenity provided by a protected area can often provide substantial benefits to the community. Apart from contributing to recreation values, visual amenity can also provide benefits to local residents. This may be measured by estimating the component of the value of land adjacent to a protected area that is attributable to the areas existence. The existence of a protected area can have a substantial impact on the lifestyle of adjacent communities. Again, land values may be used as a proxy for estimating these values.

3.4.5.1 Other Areas

A study of the Virgin Islands National Park in 1981, conducted by the Island Resources Foundation, studied land values adjacent to the park, and estimated an increase of US$5 million a year in land values as an indirect benefit attributable to the Parks existence (Dixon 1993).

3.5 Option values

3.5.1 Option value

As noted in section 2 of this report, option value is the value placed on conserving attributes of natural environments so the option exists to enjoy a flow of goods and services of protected areas in the future, producing direct and/or indirect use values. Option value includes the potential value of increased information in the future, for example information from genetic resources. Surveys of people's willingness to pay are often used to gauge option value.

Table 3: Option values for GBRMP and other areas

Use values – option value				
	GBRMP		Other areas	
Option value	Data source	Valuation	Data source	Valuation
Option value	Hundloe Vanclay & Carter (1987)	A$45 m/yr* (partial option and existence value)	*De Groot (1992) Galapagos*	*US$120/ha/yr*

* m/yr = million a year

3.5.1.1 GBRMP

Hundloe, Carter and Vanclay (1987) measured part of the existence value together with the option value for the Great Barrier Reef, via a mail survey of a sample of Australians. This contingent valuation study estimated a **A$45 million** a year consumer surplus, with visitors willing to pay A$4/visit to ensure that the GBRMP was maintained in its current state. This study underestimates these values as it excludes Australians who have not visited the reef and also excludes overseas residents, who are likely to value the area significantly.

3.5.1.2 Other areas

Because it is unique de Groot (1992) set the option value of the Galapagos Islands National Park at US$120 a hectare a year, equal to all other direct and indirect use values measured in his study.

3.6 Non-use values

Table 4: Non-use values for GBRMP and other areas

Non-use values				
	GBRMP		Other areas	
	Data source	Valuation	Data source	Valuation
Existence value	Hundloe Vanclay & Carter (1987)	A$45 m/yr* (partial option and existence value)	*De Groot (1992) Galapagos NP*	*US$0.52/ha/yr "spiritual" US$0.20/ha/yr "artistic"*
Bequest value	No studies found		No studies found	

* m/yr = million a year

3.6.1 Existence and bequest values

Existence value is the value associated with ensuring that an area is protected and will remain so. This can include spiritual values, cultural and heritage values, community values and vicarious use value. Books, videos, paintings and other items provide a source of pleasure that can be enjoyed even by those who are unable to visit the area, or as a reminder of a visit.

3.6.1.1 GBRMP

As noted above, Hundloe, Carter and Vanclay (1987) measured part of the existence value together with the option value for the Great Barrier Reef at **A$45 million** a year. This partial estimate does not include existence values held by Australians who had not visited the GBRMP or people living in the rest of the world who hold existence values for the GBRMP. The potentially considerable expenditure on books, photographs, films and artistic interpretations of the GBRMP has not been calculated.

3.6.1.2 Other Areas

The spiritual and religious values of an area may also be considered part of the existence value of the area. De Groot (1992) estimated a spiritual value for the Galapagos National Park of US$0.52 a hectare a year. This estimate was based on expenditure on donations for conservation.

De Groot (1992) measured the artistic and inspiration value of Galapagos National Park of US$0.20 a hectare a year. This estimate was based on the expenditure on books and films.

3.6.2 Bequest values

No studies measuring bequest values of marine protected areas have been located.

3.7 Summary

In summary, relatively few studies have been developed to measure a wide range of components of TEV for marine protected areas, and only some of these are directly relevant to the values of the GBRMP. Nonetheless, it is clear that significant values are likely to be associated with direct uses in the GBRMP. The commercial value of activities such as tourism and fishing is indisputably large. However, values associated with indirect and non-uses of the GBRMP, including values which are not reflected in the market place, are also likely to be significant, particularly considering that many commercial activities depend upon maintenance of the natural resources.

4 Conclusion

This report illustrates that most published information on the values arising from natural environments show an incomplete picture of the economic importance of both using and maintaining the flow of goods and services from such environments. This may lead to an unbalanced view of the importance of direct uses that generate obvious dollar values and protection of the environment to support the flow of environmental goods and services. Such an imbalance may ultimately reduce a natural area's ability to support the full range of values, including commercial values that make up the natural environment's TEV.

There is an argument for seeking and using more complete economic information in decision - making on natural environment management, in particular, the application of valuation techniques to estimate dollar values for non-market goods - and services. However, there is also an argument for using approaches to decision making that acknowledge the limitations of incomplete measures of economic value, and the limitations of a strictly economics based approach. Economic information can be useful to assist decision making, in combination with the appropriate ecological, cultural and social information.

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