Institute of Actuaries of Australia

Valuing the Wilds and Fields
Techniques for Valuing Ecosystem Goods and Services

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Executive Summary

Purpose of paper

Many actuaries are interested in the environment, and how they can use their actuarial training to help decision making in regard to the environment. The Energy & Environment Committee noted that much of the work for which conservation groups are asking for assistance involved valuing the environmental impacts of various activities. Moreover, some actuaries are already involved in doing cost benefit analyses for governments, developers or NGO's. Some of these analyses involve activities that have environmental impacts.

A sub-group of the E&E Committee was therefore formed to investigate techniques for valuing environmental impacts, and this paper is the result of those investigations.

What are ecosystem goods and services?

This paper is about economic valuation methods for valuing ecosystem goods and services (EGS). Ecosystem goods and services are those goods and services provided by the environment, generally shared by all of us, but not actively traded or quantified in monetary terms. They include such things as:

- The scenic value of a national park
- The biodiversity value of a marine reserve
- The carbon sink value of an old growth forest
- The bird habitat value of a healthy river.

Economists, and particularly environmental economists, have made enormous advances in valuing these EGS over the last 20 years.

Target audience for paper

Because the techniques for valuing ecosystems are based around maximising benefits of changes in social welfare, as opposed to net cash-flows, they are a new class of valuation methods for actuaries. They are underpinned by economic rather than financial theory. By change in social welfare we mean the overall net change for society allowing for winners and losers. This paper is, by definition, rather technical and esoteric for actuaries who are new to the area.

We recommend this paper to:

- Actuaries who are interested in providing assistance to environmental groups.
- Actuaries providing advice to governments or developers about projects that have an environmental impact (i.e. actuaries doing cost benefit analyses for public policy).
- Actuaries who are interested in the approach used by economists to valuations, as opposed to the valuation approach used for financial analyses.
- Actuaries who have a general interest in the methods that could be used in assessing the environmental impact of economic decisions.

Actuaries who are looking for new opportunities for work, using our existing skill set, will find this paper of limited use.

Limitations of this paper

This paper does not, of itself, provide enough information to use any of the techniques described. An actuary who is considering using these techniques will find a wealth of information about the methods on the internet. However the paper can give a broad overview of the methods and their strengths and limitations.

The techniques themselves

The primary problem with all of the techniques used to value EGS is that they are data intensive. They rely on market information to determine people's preferences about the environment which can then be translated into a measure of the effect on their welfare when a change occurs. Because direct markets of the environment do not exist, they often use relationships between markets or activities that do exist and the environment. One class of methods uses surveys to determine people's preferences. The techniques use a blend of surveying, statistics, market analysis, economic theory and occasional heroic assumptions. While these are not things with which actuaries are unfamiliar, the techniques all require a basic shift away from a cash-flow ideology to an economic (social welfare maximisation) approach.

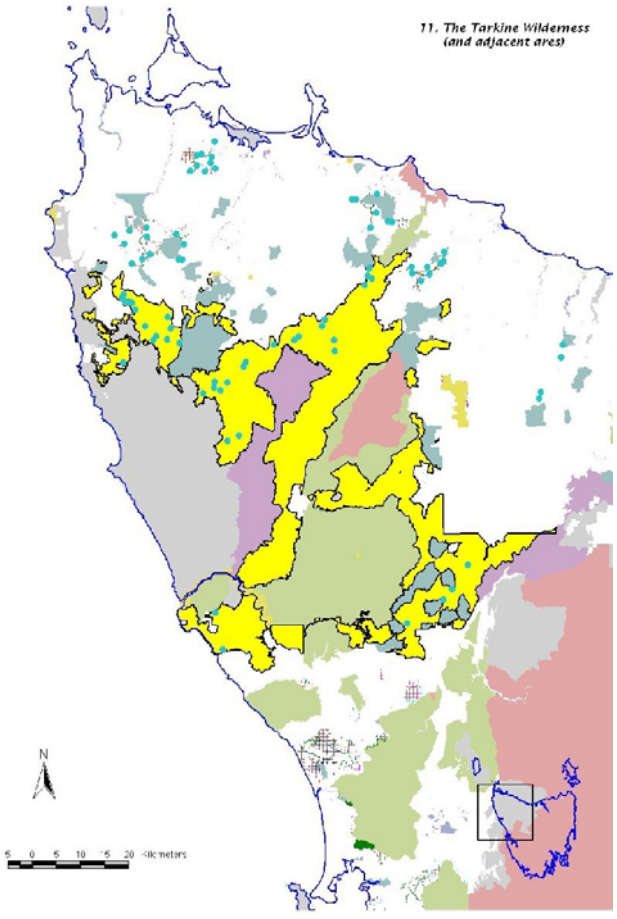
All of the valuation techniques described have been used in North America and Europe, where they have contributed to economic appraisals used by governments and others in making ecosystem management decisions. Often the decision is about other proposals and not specifically about the ecosystem but the incidental effects on ecosystems have to be considered.

Valuation Case Study

In order to understand the valuation methods more deeply, the authors attempted to apply them to valuing the EGS of a real, contested area – the unprotected parts of the Tarkine Forests in North West Tasmania. Without investigating additional data (either surveys, real estate studies or scientific analysis) it was impossible to apply any of the methods properly to the Tarkine. This may illustrate why valuation of EGS has been slow to develop and get widespread use. However the case study was very helpful in giving the authors hands on experience with the methods.

There is real scope for a deeper understanding of the Tarkine's EGS through application of the techniques described in this paper. For example, through conducting a choice modelling survey, or through a hedonic analysis of the investment choices made by tourism operators in the area. By observing results from valuations of other rainforests, we can assume that the unprotected forests of the Tarkine have a very high production function of nature services (e.g. soil and water services), but this paper did not have the data to quantify these values for the Tarkine.

The case study showed that actuaries can make a good contribution to such valuations, provided that we undertake the shift in thinking to a social welfare maximisation model. In first applying the techniques, actuaries should work closely with those with experience in the area, as well as with scientists and environmental economists.



The yellow area is the state forest currently not protected from logging.

I. Introduction

1. Purpose of Paper

When economists, investment bankers or actuaries are asked to value a proposed development, which may have an impact on the environment, it is comparatively straight forward to project future cash flows associated with the development. This can then feed into a cost benefit analysis. But what value should be placed on the environmental impact of the development? For many years, this aspect of valuations went unquantified, with such things simply listed as "unquantifiable". Often, it was easier to quantify environmental benefits after we had lost them, when we have to replace them or fix them, than when we are using their services.

This paper examines current techniques in economic appraisals that involve ecosystem goods and services (EGS). Ecosystem goods and services are those goods and services provided by the environment, generally shared by all of us, but not actively traded or quantified in monetary terms. Ecosystem services are defined as "the products of the role that ecological systems play in providing a sustainable environment for life support, such as clean water, food, habitat and recreational opportunities" (Curtis 2004). They include such things as:

- The amenity value of a national park
- The biodiversity value of a marine reserve
- The carbon sink value of an old growth forest
- The bird habitat value of a healthy river.

For the rest of this paper, we use the phrase Ecosystem Goods and Services (EGS) to describe these services and others not mentioned. The examples in the following sections will help to clarify just what EGS are.

Recently, economists and scientists have been studying how EGS can be valued and a whole school of valuation techniques have emerged. Many of the techniques will be new to actuaries, such as revealed and stated preference techniques. This paper outlines the various valuation techniques and then illustrates the theory through a case study valuing different management options for the Tarkine forest in Tasmania.

2. Why Value Ecosystem Goods and Services?

EGS valuations are becoming more common as governments, corporations and individuals understand the benefits contributed by ecosystems and the importance of correctly including them when making decisions about their use. Most governments, planning tribunals, international funding organisations and even some local councils require EGS valuations as part of assessing new developments.

Some conservationists have questioned the valuation of EGS. They argue that attempting to quantify EGS misses the big picture and puts EGS in danger of becoming nothing but an expression of human preference and losing other non-human-centred values. The conservationist William J Lines, in arguing against EGS valuations, asks the question - How should a parasite value its host?

However as Professor Jeff Bennett points out in his paper The Economic Value of Biodiversity "*meanwhile decisions regarding the fate of nature will continue to be made. When decisions are made whether by individuals or society at large, trade-offs are made either explicitly or implicitly.*

For instance, if it is decided to log a forest and by so doing reduce the probability of a species surviving, then it has been decided that the value of the timber harvested (and the house frames, furniture or paper that are produced from that timber) is greater than the potential loss of biodiversity. The trade-off between monetary value of the timber harvest and the non-monetary value of the biodiversity loss has been made. A valuation of the loss has been assessed albeit implicitly.

The ethical issue of whether to place a value on EGS is therefore more a question of whether the values are explicit or are kept implicit in decisions and are allowed for by some other means such as public participation" (Bennett 2004).

3. EGS Valuation within Context

Many EGS valuations will not be done in isolation, but will be done in the wider context of a Cost Benefit Analysis (CBA). CBA is the method most commonly used to assess the potential effects, from the point of view of society as a whole, of development projects which will exploit ecosystem services.

For example, the table below gives an example of a Cost Benefit Analysis for a proposed new dam.

CONSTRUCTION OF A DAM	
COSTS	**BENEFITS**
Construction	Electricity generation
Operation and maintenance	Irrigation water supply
Loss of inundated land ecosystem**	Reservoir recreation**
Loss of river recreation**	Flood control**
Damage to river ecosystem**	

The costs and benefits which are ecosystem goods and services are marked **. Note that both the costs and the benefits include some EGS. The costs of loss of river recreation and loss of ecosystem are losses of ecosystem services which require the EGS valuation methods discussed in this paper. Similarly the benefit of flood control can be thought of as an EGS with no cash flows.

The non-EGS costs and benefits (cost of construction, future sales of irrigated water) involve standard estimates of producer and consumer surplus, many of which can be estimated with reference to markets and financial cash flows.

4. Existing Guidelines on CBA and EGS Valuations

For actuaries wishing to perform Cost Benefit Analyses, either with or without EGS components, the only potential source of guidance is Guidance Note 552 relating to the considerations that bear on the work involved in carrying out economic valuations of economic assets.

Under this actuarial guideline, an economic asset is defined as any resource, property etc that can potentially generate future cash flows and / or income. Economic value is defined as the present value or valuation date cash equivalent (allowing for time and risk) of all future cash flows and / or values that are expected to be derived from ownership or use of an economic asset.

This is different to an economist's view of value, which focuses on impacts on overall social welfare. By focusing on cash flows, rather than social welfare, the actuarial guidance note is of little or no use to those actuaries considering impacts on EGS.

A second, and more important, source of guidance are the various documents produced by federal and state treasuries and environment departments. The Department of Finance has issued guidelines for the Commonwealth. States have also made their own guidelines. In NSW, for example, the NSW Treasury has put out 'Guidelines for Economic Appraisal' that establish a framework for undertaking Cost Benefit Analyses of capital works projects. The objective of the guideline is to ensure consistency of Cost Benefit Analyses used by the NSW Government.

A key requirement is that major economic and demographic parameters used in the analysis are standardised by the adoption of Treasury forecasts. Sensitivity testing is also required.

Most of these government guidelines now mandate the assessment of EGS. For example, an annexure attached to the NSW Guidelines deals specifically with the assessment and valuation of environmental impacts. It is recognised that there is no one common valuation method that can be applied to EGS, and that there are a variety of methods that can be used depending on available data and circumstances. Hence no specific valuation method is prescribed for EGS, but all of the methods described in this paper would be suitable.

In addition, other government departments now provide databases of actual EGS valuations to assist practitioners in preparing EGS valuations. The most powerful EGS database is called Envalue and is maintained by the NSW Environmental Protection Authority. Envalue includes hundreds of examples of valuations of EGS, using all of the valuation methods described in this paper. It describes the applicability of the examples to various situations. Use of Envalue is free and can be found at www.epa.nsw.gov.au/envalue

5. The legislative context for EGS valuations

The federal government has acknowledged the importance of studying the value of EGS through the establishment of a Biological Diversity Advisory Committee (BDAC) and ongoing funding of the National Land and Water Audit. A national workshop on Valuing Biodiversity was held in October 2003 with the aim of furthering the science of valuing EGS in Australia. However there is still no formal legal requirement for the valuation of EGS to be taken into account by governments or developers, other than the general guidance notes discussed above, which do not mandate particular approaches, but only that the matter is considered.

The most important legislation regarding EGS is the Environmental Protection and Biodiversity Conservation Act (EPBC Act) that came into force in July 2000. The EPBC Act regulates the assessment and approval of:

- Activities by persons on Commonwealth land;
- Activities by Commonwealth Government agencies;
- Activities that have a significant impact on "matters of environmental significance".

The current definition of "matters of environmental significance" includes:

- World Heritage sites;
- Ramsar wetlands, important for the survival of migratory birds;
- Nationally listed threatened species and ecological communities;

The EPBC Act thus gives controls over a small group of specified areas in Australia, but not over most ecosystems or EGS. There are also circumstances where approval is not required. An example is where there is a Regional Forestry Agreement ("RFA") in place, logging of forests may occur if it is in accordance with the RFA's plan.

Thus valuation of EGS is still not legally mandated in Australia, despite its growing usage.

6. Why should actuaries learn about these techniques?

Actuaries are specialists in market based valuations and the valuation of intangibles such as brand or goodwill. Our approach to valuations is to look at generated cash-flows and hence profits that will accrue to corporations. Until recently we have had little or no experience with economic valuations (say for governments or public policy) that involve looking at social welfare in total. EGS valuations fall into this subset of valuations.

However recently, working with conservation groups, developers and governments, some actuaries have been involved with valuations of infrastructure projects and this requires valuing EGS as part of the valuation. Other actuaries have expressed an interest in helping conservation groups to measure and value environmental goods and services which may be at risk. This requires actuaries to educate themselves both about the economic definition of social welfare, as well as educate ourselves about environmental goods and services themselves.

EGS valuation techniques require a mix of statistical, economic, scientific and environmental qualifications. Actuaries have a reasonable background in two of these four areas, but start from a long way behind specialist environmental economists, and economists per se. However our broad training in statistics and economics, as well as our comfort with working with uncertainty give us a good platform for learning the techniques. As a profession, however, we must also recognise the enormous wealth of experience of environmental economists who have developed, pioneered and applied the techniques described in this paper.

II. Introduction to EGS Valuation Methods

7. The components of EGS

The choice of EGS valuation method will depend on the data available and what ecosystem goods and services are to be valued. For example, consider two tracts of forest – one a national park with high visitation rates, and one a fenced off water catchment area. Both forests have significant ecosystem goods and services, but they are slightly different, as shown below:

Different ecosystems have different EGS	
HEAVILY VISITED NATIONAL PARK FOREST	**OFF LIMITS WATER CATCHMENT FOREST**
Tourism and Recreation	Water purification
Scenic Amenity (e.g. for nearby residents)	Undisturbed habitat for flora and fauna
Biodiversity	Biodiversity
Carbon sink and potential climate stabilization	Carbon sink and climate stabilization
Flood and soil control	Flood and soil control
Pollination of plants and honey production	Pollination of plants and honey production
Provision of genetic resources for medicine	Provision of genetic resources for medicine
"Insurance" for future generations i.e. protecting benefits that we may not have even identified yet.	"Insurance" for future generations

Now suppose that we are considering valuing the impact of introducing forestry into these two areas. In the case of the national park, the impact on tourism and recreation services may dominate and there is probably a large amount of data available on visitation rates and so on. But in the case of the remote water catchment forest, the water purification services dominate, and the EGS valuation focus may be on what it would cost to produce clean water any other way.

As can be seen from the table, both forests have many EGS in common, and thus there is no clear cut match between one particular area and one particular method. In the detailed discussion of each method we will explain the type of situation where the method is most applicable, and the type of EGS for which it is most applicable. In order to fully value the full range of EGS from an area, it may be necessary to use a combination of methods. The total value may be obtained by adding the results together or it may be necessary to allow for overlapping (or double counting) because some methods value the combined effect of several EGSs added together. (For example, a heavily visited national park that was also a major water catchment area could have two valuation components, focussing firstly on the recreation value and secondly on the water purification value, with the results added together. However allowance would be needed for the impact that visits would have on the water purification process).

Benefit Transfer

Often the valuer has difficulty obtaining data for the site to be valued. Benefit Transfer is a method in which estimates of economic benefit are "transferred" from a site where a study has been already been carried out to a site of policy interest. This method is particularly useful if time is of the essence and/or data are unavailable. A model is derived to extrapolate the values quantified in an area where data are available. To do this linear relationships (not necessarily linear) are established between the attributes of the area to be valued and the area that has already been studied. Benefit Transfer can be applied where the reference site has been valued using either traditional or preference-based methods.

8. EGS Valuation Methods

There are nine distinct EGS valuation methods, listed in the table below. The methods are normally grouped into three distinct types:

1. **Direct Market Valuation**. Sometimes there is a direct market for EGS. This means that governments, individuals or companies buy ecosystems for the purpose of preserving their goods and services. Such purchases are common in North America but are, as yet, very rare in Australia.

2. **Stated Preference Valuation**. Stated preference techniques are just that – people are asked about how much value they place on the nature services or their priorities for the management of nature. This requires a survey, usually custom designed for the valuation.

3. **Revealed preference Valuation**. Revealed preference techniques are when we figure out what value people place on an asset indirectly, through some other behaviour involving money.

This table gives a simple example to illustrate these three classes of EGS valuation. Note, of course, that the amounts shown are not the valuations themselves, but are illustrative of alternative ways of approaching the valuation process.

Direct Market	Stated preference	Revealed preference
Mr Millionaire paid $3 billion to purchase and preserve Kakadu.	Mr Average said he would pay $3,000 to see Kakadu saved	Mrs Average "spent" $2,000 in food, accommodation and lost wages to visit Kakadu

9. Examples of each method

Papers on EGS valuation methods can be rather theoretical. It is helpful to consider, before proceeding to the detail of each method, how the methods have been used in real life situations. The following table should give a practical feel for each method. All of the examples listed come from real life valuations.

METHOD	EXAMPLE OF USE	EGS FOCUS
Direct Market		
Land prices	A market model was built based on recent government purchases of land bought in order to preserve the EGS.	Biodiversity and habitat focus.
Prospecting (looking for scientific benefits)	A market model was built based on prices paid by pharmaceutical companies to bio-prospect in similar regions.	Provision of genetic resources for medicine.
Taxes / Subsidies	A market model was built based on government taxes on activities harmful to the EGS such as pollution.	All of the EGS.
Stated Preference		
Contingent Valuation	A survey of 1000 people asking how much they would be wiling to pay to preserve an ecosystem.	All of the EGS.
Choice Modelling	A survey of 1000 people asking them how they would compare a variety of management regimes.	All of the EGS.
Revealed Preference		
Hedonic	Real estate prices for farms with varying soil qualities was used to determine the value of soil quality	Water, soil and air quality
Production Function	The impact on wheat productivity of different soil biota was used to value the soil quality	Water, soil and air quality
Replacement	The alternative cost of investing in water treatment plants was used to value an undisturbed water catchment forest	Species habitat; water and soil quality
Travel Cost	A survey of visitors to a national park determined how much they had spent to visit the park	Tourism, recreation and aesthetic qualities

Each of these methods are discussed in detail in the following sections.

10. Direct Market Based Methods

Market based techniques are rarely applied to EGS simply because the public good nature of the benefits have precluded the operation of markets in most instances. However, recently markets have developed for some EGS, particularly in the US.

Market based valuation techniques require that the EGS must be bought and sold in markets. For these marketed EGS – such as the rights to prospect for biodiversity or biodiversity-based commercial ecotourism experiences – if there are sufficient observations of market trades, it is possible to use standard economic techniques to estimate values for both buyers and sellers. Examples of market trades that can be used to derive a model of consumer surpluses might include:

- Price on tradeable rights to prospect for biodiversity or biodiversity based commercial ecotourism experiences.
- Financial incentives that protect EGS. These include the payment of targeted subsidies and the levying of taxes on practices that destroy EGS.
- Land purchase price where land is purchased with the aim of preserving EGS.

Example 1 – Prospecting

Bio-prospecting is where companies (normally pharmaceutical companies) have the right to investigate different eco-systems for their potential medicinal or scientific benefits. Recent registrations and applications of bio-prospecting contracts and agreements between states and pharmaceutical industries represent important benchmarks of monetary indicators for these types of biodiversity values. The most noted of these agreements is the pioneering venture between Merck and Co., the world's largest pharmaceutical firm, and 'Instituto National de Biodiversidad' (INBio) in Costa Rica.

In 1991, Merck paid Costa Rica about $1 million and agreed to pay royalties whenever a new commercial product was explored. Since then, INBio has signed contracts on the supply of genetic resources with Bristol-Myers Squibb, other companies and non-profit organisations.

Another illustration of the market value of genetic diversity refers to the commercial agreement signed in 1997 between Diversa, a San Diego biotechnology company, and the US National Park Service. Diversa paid $175,000 for the right to conduct research on heat-resistant micro-organisms found in hot springs in Yellowstone National Park.

More recently, a Brazilian company, Extracta, signed a $3.2 million agreement with Glaxo Wellcome, the world's second largest pharmaceutical company, to screen 30,000 samples of compounds of plant, fungus and bacterial origin from several regions in the country.

At the most basic level of life diversity, the market value of bio-prospecting contracts signed between the pharmaceutical and agriculture industries and governmental agencies sheds some light on the economic value of genetic diversity.

The pricing basis used by the pharmaceutical industry or agricultural industry in these examples enables a market model of consumer surplus to be built.

Example 2 – Land Purchase Prices

In 1984 the US Department of Interior acquired some 8,000 acres of seabird cliff habitat within the Pribilof Islands chain in Alaska. The cliffs are known for supporting over 2.5 million seabirds. The land parcels involved were purchased in 1984 from two Alaskan Native Corporations at a total price of $5.1 million. The purchase price was established by an act of Congress and yields an average unit price of $640 per acre.

A subsequent real estate appraisal, made by the U.S. Fish & Wildlife Service, determined the highest and best use of the property to be for marginal home sites and reindeer grazing. This appraisal estimated the value of the lands to average about $83 per acre.

The important precedent set in this case is that Congress set a value for the property in the public interest roughly eight times greater than that set by standard appraisal based on financial considerations from the point of view of an individual or corporation. The price paid by government could be viewed as reflecting the EGS of the area, as well as other factors.

Example 3 – Tradeable Water Rights

Since the 1970s, it has become apparent that the water resources within the Murray–Darling Basin (MDB) have been increasingly over-allocated. As a result, the Australian and State governments within the MDB have instituted a variety of reforms to limit the amount of water used and to maximise the benefits of that water. One such reform has been the establishment of markets for tradeable water entitlements.

According to Krijnen (Krijnen 2005), these markets have been operating in Australia on a limited scale since the early 1980's, however movement towards a Basinwide scheme really began in 1994 with the adoption by the Council of Australian Governments (CoAG) of a strategic framework for reform of the Australian water industry.

A market trading system for water rights can be used to derive a model of consumer preferences in the valuation of an EGS which contains rivers or water bodies.

Example 4 – Carbon Credit Trading Markets

In a similar fashion, carbon credit trading markets can be used, once they are in full operation, to value the "Carbon Sink" asset of any EGS containing Carbon Dioxide absorbing and Oxygen producing trees.

Conclusions on Direct Market Valuations

Market valuation techniques have their uses in situations of bio-prospecting and government purchases. However, for the majority of cases, market based techniques are rarely applied to estimate the value of EGS simply because the public good nature of the services have precluded the operation of markets in most instances.

For future years, this tendency may change because of the potential for initiatives such as the development of secure tradeable rights to biodiversity through the Convention on Biodiversity or through the World Trade Organisation Trade Related Aspects of Intellectual Property (TRIPS) agreement to stimulate more market activity. This will enable models of consumer surplus to be built.

Revealed Preference Methods

11. Introduction to Revealed Preference Techniques

Revealed preference valuation methods are surrogate approaches whereby the value of EGS is inferred from the valuation of other goods and services that are connected in some way.

These revealed preference techniques include:

1. production function
2. hedonic
3. replacement
4. travel cost,

and rely on observation of people's actions in markets that are directly impacted by changes in the EGS.

Technical Concerns

Revealed Preference methods depend upon a connecting relationship. This relationship must be sound for the method to be credible. Different approaches are valid in different situations. For instance the travel cost method might be useful in valuing the recreational value of a park but no good at all to value soil quality where there is no sound connecting relationship.

All assumptions made regarding the connecting relationship to the EGS need to be stated and their impact fully understood. As with any method the veracity of data is always an issue.

Established use of Revealed Preference Techniques

Soil quality and water are the two EGS most closely linked to marketed goods and services and so it is these that have been most often valued using revealed preference techniques. The majority of these have used the hedonic pricing methods, while a smaller number have used the production function and hedonic pricing methods.

The travel cost method is especially suitable to value the recreational value of sites and has been very widely used and accepted all around the world.

12. Replacement Cost Technique

This technique estimates the cost of replacing the EGS that the ecosystem currently provides, i.e. how much would it cost to replace the lost natural services benefit with a substitute? Expenditure actually incurred on replacement is a measure of the minimum willingness to pay to continue to receive a particular benefit.

Replacement costs can often be estimated relatively simply and the technique is widely applied. Weaknesses of the replacement method are that

- There may not be a replacement good or service that is a good substitute for the original EGS.
- The method assumes that the benefit of the replacement exceeds the cost as otherwise the cost would not be incurred.
- The cost is only a minimum estimate of the benefit.
- Replacement costs should exclude normal wear and tear costs.

Where has it been used?

Yapp (1989) examined the costs of replacement and repair of public assets such as roads, rivers, and water storages affected by land degradation damages. Three such examples include:

1. the annual costs of restoring roads after silting in Jerramungup, Western Australia, were $40 000 in 1982;

2. the annual cost of repairing erosion-related damage to public utilities in New South Wales in 1983 was $10.7 million;

3. the annual cost of restoring damage due to surface water salinity in New South Wales towns was $2.8 million in 1987. These values were taken as a measure of the minimum willingness to pay for the use of undamaged assets.

The cost of replacing parkland lost in construction of the Sydney Harbour tunnel are a measure of the benefit from maintaining the flow of parkland amenities (Beder undated).

Expenditure to restore strip-mining sites to their original condition can be used to estimate the benefits of maintaining the land environment. This provides information for decisions on mining (Thampapillai 1988).

Limitations

When valuing using replacement cost techniques the accuracy depends upon the replacement being perfect or the mitigation, prevention, or aversion strategy being total and complete when using those methods. If not perfect, the result will often be an undervaluation.

Moreover, the method often fails to net out the cost of protection from the benefit secured from the protection. Thus it also suffers from a number of conceptual limitations.

The decision to undertake any mitigation, prevention or aversion strategy must be made on a rational basis. This may not be the case where an action is taken for political reasons. For example where the true value of an EGS is less than the amount spent restoring it. This would give an over-valuation (c.f. you don't mend ladders in your stockings if it's cheaper to buy new ones).

Some economists believe that, because of these conceptual limitations, the replacement technique has limited use for valuing EGS.

13. Production Function Technique

In many situations competitive market prices do not exist for the EGS but do exist for an associated output. In these cases, the value of a change in the input can be derived from the change in the revenue of the associated output. An increase in producer surplus is a measure of the benefit of a desirable change and a decrease in producer surplus is a measure of an undesirable change.

For example, soil conservation can decrease erosion or decrease the salinity of the soil. In both cases the increase in agricultural output is a measure of the benefit from conservation action. Similarly, the decrease in output that accompanies salinity is a measure of the cost of land degradation.

Production function techniques estimate the impact of a specified change on the productivity of this environment (or associated environment). The value can be derived from the change in the revenue of the associated output.

The methods have the appeal of relying on actual/observed behaviour however there is a strong dependence on the relationship between the EGS and the surrogate market. Production function technique cannot be used to estimate the cost of non use of EGS e.g. guarantee that a particular species is kept free from extinction. However, it can be used to estimate:

- The cost of genetic and species diversity (through input to production processes e.g. pharmaceutical and agricultural industry).

- Natural areas and landscape diversity (through provision of natural habitat).

- Ecosystem functions and ecological services flows (through ecological values such as flood control, nutrient removal, toxic substance retention and biodiversity maintenance).

Where has it been used?

Torell et al (1990) assessed the market value of the water component of EGS on the High Plains aquifer, a water ecosystem that underlies parts of Colorado, Kansas and neighbouring states. The water service component of EGS was valued from $9.50 per acre-foot (the volume of land up to one foot below an acre) in New Mexico to $1.09 per acre-foot in Oklahoma.

Walker and Young (1986) who have studied the value of soil erosion on (lost) agriculture revenue in the Palouse region in the US estimated a cost of $4 and $6 per acre.

14. Hedonic Pricing Technique

Under the hedonic pricing technique an estimate of the value of a change in EGS is inferred from the price of a related marketed good or service. Economists use the term “hedonic pricing” for the method of valuing a characteristic of a good from the price paid for it.

Again using soil quality as an example, the price of land for farming activities may be affected by the quality of the soil. If there are enough property sales it is possible to infer the relationship between the quality of the soil and the price of land and hence the value of soil quality.

Alternatively, consider two houses. The house characteristics are identical except that one suffers noise or air pollution. The cost of the noise or air pollution is the difference in the house prices. To apply this idea, prices and characteristics for many purchases of the good are systematically compared.

Measurement of a characteristic can be difficult. However often a characteristic can be coded in a yes/no or 1/0 manner, as in the example above where a house does or does not suffer from air pollution (and in the first example below).

Example 1 – Valuation for a Cost Benefit Analysis of a Pipeline Scheme

In 1991 hedonic pricing was used to value the benefits of a water-supply pipeline to farms in Western Australia, (Coelli, Lloyd-Smith Morrison and Thomas 1991). The difference in sale price between properties with and without a water supply was found. This characteristic measured the value of a water supply to farmland value and was then used to value the water supply in a cost benefit analysis of the pipeline scheme. Note that the water supply pipeline is not an ecosystem service (the pipeline is man-made) but this example illustrates hedonic pricing well.

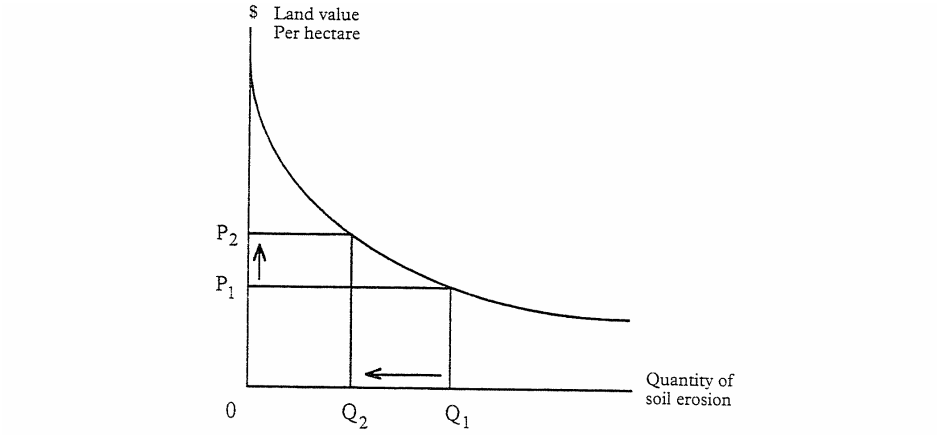
Example 2 – Valuation of the soil quality component of EGS

King and Sinden used hedonic pricing to estimate the changes in land value due to the changes in the conservation status of the land.

Data were collected on fifty mixed farming properties in a specific region of NSW. The information included the actual price paid for the land (in dollars per hectare) and a quantitative measure of soil erosion as the conservation status of the land.

From this data they derived a pricing function for the land which showed that variations in price per hectare were statistically related to variations in erosion. Increases in price were associated with decreases in erosion and decreases in price were associated with increase in erosion.

The change in price paid was then calculated for selected improvements in the conservation status of the land. These changes in price represent the premium buyers had paid for better-conserved land. For example the reduction in quantity of soil erosion from Q1 to Q2 in the diagram below leads to an increase in price from P1 to P2.



The increase in price was then compared with the cost of the necessary conservation works to assess whether the benefits of soil conservation – valued as the increase in land value – exceeded the costs.

Example 3 – Valuation of the EGS of a maple-birch forest

A paper from the Journal of Forest Economics (Scapa, Buongiorno, Hseu &Ast 2000) set out to value the EGS of Wisconsin maple-birch forests using the hedonic method. The purpose was to try to derive an EGS valuation using actual choices by forest owners about their preferred management approach to the land.

Under this study the EGS value was defined as the difference between what the owners actually logged from their forest stands and what they could have achieved had they been profit maximizers. Thus an owner who preserved 100% of their forest stand was revealed to be valuing EGS very highly, whereas an owner who logged most of their forest was revealed to value it lowly.

The EGS value was found to be highest for national forests at about $50per hectare pa which was ten times the timber revenues.

Further analysis was undertaken to assess if particular attributes of the forest led to higher EGS values. Attributes such as diversity of tree species (which are likely to provide the best animal habitat), autumnal colour, distance from water, distance from roads and proximity of population were considered. Among these the number of trees of various sizes and species had the highest statistical significance – but no other features proved statistically significant.

Summary of hedonic pricing

The hedonic pricing technique is a very versatile valuation method. It has been applied to value visual characteristics of cars, tractor engines and electrical appliances as well as valuations of EGS. Carefully used hedonic pricing is a method of wide application.

The technique does require a level of statistical skill to estimate the function that is the basis of the pricing model. Its widespread popularity is due largely to its use of actual land or house prices and actual measurements or characteristics. But note that its data requirements are heavy and many Australian markets are traded too thinly to yield enough data.

15. Travel Cost Technique

Under the travel cost method the price that people are willing to pay to get to a site is used to derive a demand profile of their enjoyment from being at the site. The travel cost technique is a very powerful technique for valuing the recreational and amenity component of EGS.

The method uses actual visitation rates and cost per visit data to derive a demand curve for visits to the area. The recreational component of the EGS is then valued as the area under the demand curve. The curve also shows the impact of a range of entrance fee levels on the assumption that people respond to travel and entrance fees in the same way.

More complex scenarios can be valued. For instance, where recreation values vary with both travel cost and a characteristic of a site such as fishing quality, different values can be assessed for each site. The change in net social benefit from a change in a characteristic can be valued. For instance, assuming fishing quality is related to fishing stocks and that these increase with water quality, then fishing quality would increase with a pollution control programme. The value of the programme can thus be estimated from the increased value of the recreational fishing.

Example – Valuing the recreational EGS component of Victorian National Parks

In 1999 the travel cost method was used to perform an economic assessment of the recreational values of Victorian parks. Visitation rates were available for most parks but not for all. Where good data was unavailable a model was derived to extrapolate the recreational values from the traditional travel cost valuation. Regression techniques were then used to identify linear relationships between the estimated average values per visitor day at these parks and the attributes of the park.

The method is powerful where park statistics are available and benefit transfer techniques can be used where they are not (although this adds uncertainty to the result). Note that the method does not value all attributes of EGS, only the recreational and amenity component. While this may correlate closely to biodiversity values (for example, people are more interested in visiting undisturbed wilderness forest than disturbed scrub) it cannot be assumed to reflect true EGS values.

Section 25 of this paper gives a worked example of the application of the travel cost method, performed by the authors and applied to a Tasmanian national park as part of the case study.

IV. Stated Preference Methods

16. Introduction to stated preference techniques

Stated preference techniques are survey based methods. Their development stemmed from limitations in the market based and revealed preference techniques. Using stated preference techniques a sample of people are asked about their preferences for different strategies for managing a natural asset. A number of different methods have been developed to inquire about people's preferences.

Like the revealed preference techniques it is a surrogate valuation approach. In the absence of data relating to observed behaviour, it uses surveys to estimate people's likely actions in circumstances outlined in the questions.

There are several common elements to a stated preference survey:

- A statement of the problem
- A potential solution (that has a cost)
- A payment scenario
- An elicitation question(s)
- Debrief questions (were there any problems with the survey).

Commonly used payment scenarios include levies on water or land rates or income taxes, increases to entrance fees, user fees or electricity charges, voluntary donations and increases in tax and prices. Different payment scenarios or vehicles affect the choices people make and hence the values derived from the survey. This is known as the "payment vehicle effect". Given awareness of the danger of payment vehicle bias it can be managed.

Steps in constructing stated preference surveys

1. Identify the key issues of interest - Which EGS does the area provide and what are the options to protect it.
2. Identify the current level of knowledge and understanding of EGS in the community.
3. Prepare descriptive material to define the EGS to people.
4. Select the population group to be surveyed, to be representative of the population.
5. Identify the current situation and potential improvement scenarios to be presented to the survey respondents.
6. Specify how improvements will be made and who is responsible.
7. Specify payment scenarios (eg taxes, higher prices, levies, donations).
8. Design structure of choices to be given to people.
9. Remind people of their income constraints.
10. Remind people of alternatives to spend their money.
11. Offer different choice formats (especially a "no choice" or other opt-out format).
12. Ask debriefing questions to identify potential problems in the survey delivery or format.

Technical concerns

The result of the survey purports to be a full valuation of the proposed change to EGS in the area. Yet often there is a lack of information to support a full EGS valuation. For people to respond meaningfully to surveys they need information on current EGS and likely future EGS under the options. But often biophysical scientists cannot closely predict the ecological outcomes of alternative resource management options. In particular information needs to be balanced, not be biased by a pro development or pro conservation stance.

Respondents can sometimes behave strategically and deliberately mis-state their preferences in an effort to affect policy decisions. For instance if you believe you will not actually have to pay for a change you may deliberately overstate the amount you would be willing to pay in an effort to influence policy. Equally you may deliberately underbid the amount you are willing to pay if you believe there is a good chance that the change will happen anyway and your underbidding will have the effect of keeping the set cost down.

Careful formulation of benefits and payment vehicles will minimise bias. For instance if respondents are being surveyed about a park they are more likely to reveal their true preferences if it is clear that levies would go to the upkeep of the park. If it is not clear they are more likely to behave strategically.

This is new territory for actuaries who are initially likely to be less comfortable with this group of valuation methods that rely on creating their own data. Although surveys are commonplace nowadays the skill of building unbiased survey material is not generally part of our training or experience. However the subsequent analysis is certainly within our skill base.

Established use of stated preference techniques

Stated preference valuation methods are well recognised and widespread although survey design must improve to ensure the ongoing validity of the techniques. Surveys are often repeated over a number of years, which is a way to test the validity of the results as well as to monitor progress on an environmental issue. In this sense, stated preference valuation methods could easily form a part of an actuarial control cycle.

Where there are no surrogate markets (as required for a revealed preference method), stated preference methods are currently the only valuation approach available. One very positive aspect of this approach is that it can act as a vehicle for community participation in the policy making process in a way that minimises the possibility of special interest manipulation.

17. Contingent Valuation Technique

Under the Contingent Valuation Method (CVM) a sample of people are asked the amount they would be willing to pay to secure an improvement in a particular EGS. Alternatively, in the dichotomous choice form, they are asked if they are willing to pay a pre-determined amount. The single shot nature of CVM makes it hard to pinpoint the reasons for choices made or the values chosen.

Example – Valuing potential damage to the EGS of Kakadu National Park

The best known CVM study in Australia was of the Kakadu Conservation Zone in 1990. The objective of the study was to estimate the dollar value Australians would place on the Conservation Zone and Kakadu National Park if mining were not permitted in the Zone, compared with their valuations if mining were permitted, with possible environmental damage. This was a dichotomous choice survey, where respondents were asked if they would be willing to pay an amount to prevent possible EGS damage from mining in the Conservation Zone.

Because the extent of EGS damage from proposed mining was in dispute, the survey group was split in two. A different description of the EGS impact was presented to each group: the first (minor impact) stated that there would be very little damage and that the damage would be limited; the second (major impact) described the risks of damage as significant and the impact substantial. Pictures as well as descriptions of the impact were provided. Because the survey was dichotomous, rather then open ended, respondents were asked if they would be willing to pay a specified amount, rather than being asked an open question about how much they would be willing to pay. This method avoids some of the strategic bias inherent in open ended CVM.

In addition to specific CVM questions, the survey also asked respondents a series of attitude questions ranging from the importance of recreational activities within national parks, the relationship between jobs and natural resources, the importance of Aboriginal cultural concerns, and the financial benefits to Australia. Respondents were also asked whether they thought governments paid attention to individual views on natural resources; the importance of forests and Australia's timber resources; and four behavioural questions – whether they recycled household materials, purchased environmentally sound products, watched environmental programmes on TV or were members of a conservation organisation. Background information covered age, sex, education level, income, job status, industry, occupation, country of birth, whether or not a Northern Territory resident. 2,534 people were interviewed from around Australia.

For both the major and minor impact scenarios, the analysis indicated that preservation should be chosen over mining.

The results of the Kakadu Conservation Zone contingent valuation method survey received substantial criticism, revolving around what concept the respondents had about what was being valued, strategic bias, and limited understanding by respondents. Largely as a result of this study, CVM has been questioned in Australia, although it is still used extensively overseas.

Example 2 – Valuing the impact on EGS of the Exxon Valdez Oil Spill

A high profile CVM study was done of the damage caused by the 1989 Exxon Valdez oil spill. This led to a highly charged debate about whether CVM surveys can provide economic measures of people's values for EGS that they may never actively use.

In an effort to appraise the validity of CVM measures of EGS, in 1992 the Bush Administration's General Counsel for the National Oceanic and Atmospheric Administration (NOAA), Thomas Campbell, appointed a distinguished panel of social scientists, chaired by two Nobel laureates, Kenneth Arrow and Robert Solow. The Panel provided an extensive set of guidelines for CVM survey construction, administration, and analysis. In the Panel's view, "… the more closely the guidelines are followed, the more reliable the result will be" [Arrow et al, 1993, p.4609]. In addition, the Panel distinguished a subset of items from their guidelines for special emphasis and described them as *burden of proof* requirements:

"… if a CVM survey suffered from any of the following maladies, we would judge its findings 'unreliable':

- *a high non-response rate to the entire survey or to the valuation question*
- *inadequate responsiveness to the scope of the environmental insult*
- *lack of understanding of the task by the respondents*
- *lack of belief in the full restoration scenario*
- *'yes' or 'no' votes on the hypothetical dichotomous choice variants that are not followed up or explained by making reference to the cost and/or the value of the program"* .

18. Choice modelling technique

Choice modelling involves asking a sample group to choose their preferred alternatives from a list of strategies for managing a particular EGS. Each strategy is described in terms of its expected effect on the EGS as well as the amount the respondent would pay under each strategy. By analysing the choices made it is possible to infer the trade-offs that people are willing to make between money and improved EGS.

Stated preference techniques for valuing EGS have become more popular since the development of choice modelling. This is partly because choice modelling helps to frame choices about management of EGS much better than CVM.

Framing effects occur when people use their background information to make choices (such as ethics and beliefs, information about substitute goods, information about budget constraints and choice of payment vehicle). Framing effects are not necessarily bad. It is after all normal for people to frame choices within their experience of the world. However a problem does arise if stated preference choices in surveys are framed in such a way that people make different choices to those they would make in real life. The influence this has on the survey results is called a "framing effect" and of course researchers work to minimise these framing differences to ensure a true valuation is obtained. Choice modelling is a better tool to minimise framing effects than CVM.

Example 1 – Valuing the EGS of the Fitzroy river basin

Choice modelling was used by John Rolfe, Jill Windle and others to value different strategies for managing water in the Fitzroy River Basin. The Fitzroy River Basin in Central Queensland is the second largest in Australia (after the Murray Darling) and is dominated by agriculture (grazing, dryland cropping, irrigated cotton and horticulture) and by mining (coal, magnesite, nickel and historically gold and silver). The basin is home to 185,000 people. Four Choice Modelling surveys were conducted in 2000, 01, 02 and 03 to assess the trade-offs between the economic benefits of water resource development and the EGS impacts. As well as looking at two EGS impacts (water quality and vegetation health) the survey also looked at aboriginal cultural sites, which is not an EGS.

An example of the choice set presented to respondents in the 2001 survey is shown below.

Options A, B and C - Please choose the option you prefer most by ticking ONE box.					
		Fifteen-year effects			
How much I pay each year	Healthy vegetation left in floodplains	Kilometres of waterways in good health	Protection of Aboriginal Cultural sites	Unallocated water	**I would choose**
Option A					
$0	20%	1500	25%	0%	
Option B					
$20	30%	1800	35%	5%	
Option C					
$50	40%	2100	45%	10%	

Each choice set provided respondents with three profiles. The first (Option A) described a scenario for fifteen years in the future based on current trends. This scenario would cost nothing to the respondent. The other two profiles describe better EGS outcomes but with a cost attached.

The choice information was analysed using a multinomial logistic regression model. The probability that a respondent would choose a particular EGS outcome was related to the levels of each attribute making up the profile and the socio-economic characteristics of the respondent.

The design of the CM study involved a number of logistical and framing challenges in terms of condensing key factors into a number of attributes and levels, and then defining and describing them concisely to respondents. For example, in the 2001 survey, the following information was provided about the EGS service of healthy vegetation:

"Vegetation along river systems and in floodplains is often rich in biodiversity, acts as wildlife corridors, and may include a diverse range of vegetation types such as wetlands. Vegetation acts to filter soil and nutrient flows.

More than 50% of floodplain areas are cleared, and in areas of fertile soils this proportion is much higher. Much of the remaining vegetation is in poor condition

If healthy vegetation is left in the floodplain it:

- *Protects waterways from erosion and runoff*
- *Filters sediment, nutrients and chemicals*
- *Protects land from erosion and salinity*
- *Provides a habitat for wildlife*
- *Enhances biodiversity.*

If current tends continue there will be 20% of vegetation left in good condition in 15 years time."

This shows how the survey designers attempt to educate respondents about the EGS being considered in order to help them make their choices.

The results of this survey supported the introduction of the Vegetation Management Act 1999 in Queensland to regulate clearing on freehold land and the proposal to phase out future clearing of remnant vegetation by 2006.

Example 2 – the EGS of the Tarkine Forest

The authors developed a simple choice modelling survey for the Tarkine which was undertaken by a group of actuaries. The outcomes are presented in Section 27.

V. Case Study – deciding the future of the Tarkine

19. Overview of the situation

The Tarkine is an area of about 350,000 hectares in North West Tasmania. This is equivalent to a rectangle of about 50 km by 70km. It is a state forest i.e. owned by the people of Tasmania. Much of the Tarkine is wilderness area including about 170,000 hectares of temperate rainforest. However there is a mining pipeline through the heart of the Tarkine (the Savage River Pipeline) which is in active use.

Much of the Tarkine is already preserved in national parks, conservation areas and other reserving systems. Crucially, however, some 105,000 hectares are not protected, and this area includes much of the rainforest. The table below gives some idea of the make-up of the Tarkine.

Description of Area	Hectares (000)	
Protected already:		**245**
Rainforest	80	
Other forest	90	
Other conserved areas	75	
Not protected:		**105**
Deep Red Myrtle rainforest	18	
Other rainforest	57	
Other forest	30	
Total Tarkine area		**350**

* *Note that it has been extremely difficult for the authors to get a consistent description of either the Tarkine or a break down by forest type of protected and non-protected areas. Claims vary from Forestry Tasmania (which states that "89% of the so-called Tarkine area is in reserves or generally unavailable for harvesting") to the Tarkine National Coalition (which says that the Tarkine is an area of 477,000 hectares, nearly half of which is threatened). The authors have taken the definition of the Tarkine used in the Australian Geographic magazine.*

There are two conflicting options for the management of the Tarkine. It is the aim of this case study to see whether the techniques of EGS valuation would be useful in assessing these two options:

- The current management approach to the Tarkine is to extract the wood from the unprotected areas i.e. progressively log them. Pulpwood and saw logs are taken from the area. This use is called the Extractive Option in the rest of the Case Study.

- The alternative management approach is to create a Tarkine National Park from the forest and to build a tourism business around this. This is called the Full Protection Option in the rest of the Case Study.

Both options have strong advocates, and all of these advocates argue that their preferred option maximises the economic value of the Tarkine. This case study assesses whether the EGS valuation techniques outlined in the previous three sections can shed any light on the economic value of the two options.

Note that under both options, a large part of the Tarkine is, and will continue to be, protected. These areas are available for aesthetic, biodiversity and cultural values, with associated costs for basic access, fire fighting, pest and disease control. Because there is no conflict over the management of the protected areas, we have not considered them further in this paper. However, the existence of the protected areas adjacent to the unprotected areas has to be taken into account when considering the impact that the extractive option will have on the ecosystem services over the whole area.

THE EXTRACTIVE OPTION

Under the Extractive Option, revenue and economic activity are generated by the logging of the unprotected areas of the Tarkine. Forestry Tasmania, as the manager of the land on the public's behalf, receives a royalty for selling pulpwood (for woodchips) and timber from the forest. Three companies buy the timber from Forestry Tasmania - Britton Brothers, Corinna Timbers and Gunns Ltd. Most of the timber is then exported as woodchips or rough sawn timber. Section 21 gives a breakdown of planned usage for 2004 logging coupes within the proposed Tarkine National Park.

After the forest is cleared or selectively harvested, it is then either converted to plantation or re-sown with a mix of fast growing hardwoods. Some of the plantations are then sold as managed investments to investors taking advantage of tax deductibility.

The benefits of the Extractive Option are straightforward to quantify under a traditional economic valuation. They include the producer surpluses to the State from the royalties received less the costs of production, and the producer surpluses generated further downstream. They also include the subsequent leases for land converted to plantation.

THE PROTECTION OPTION

Conservation groups have proposed the establishment of a Tarkine National Park. The Tarkine was first put forward for listing on UNESCO's World Heritage List by the International Union for the Conservation of Nature (IUCN) in the early 1990s. This was followed by a formal proposal by The Wilderness Society (TWS), in the early 1990s also. Groups that support World Heritage listing for the Tarkine include; IUCN, The Wilderness Society, Australian Conservation Foundation (ACF) and the World Wide Fund for Nature (WWF).

The proposal is to establish a nature based tourism industry around the Park, including tours, walking trails and eco-lodges. Areas of high environmental value would be protected as part of the National Park. The biodiversity of the Tarkine, which is discussed further below, would be strengthened by the additional 105,000 hectares protected.

The benefits of the Tourism Option include revenues from planned tourism operations centered on the Park, as well as biodiversity, landscape, historic and aboriginal values. This case study looks at the usefulness of the valuation techniques above in assessing these last four values.

20. Cost Benefit Assessment of the Tarkine

A full economic Cost Benefit Assessment of the two options would look at the following items and attempt to quantify each of them:

Extractive Option	
Benefits	**Costs**
Producer surplus from harvesting timber	Change in EGS Valuation: Cost to biodiversity Cost to recreation and scenic amenity Cost to water quality Cost to soil quality Cost to air quality Potential damage to mining pipeline
Full Protection Option	
Benefits	**Costs**
Protection of existing EGS Valuation	Lost producer surplus Additional cost of reserve management

It is clear from this list that it is impossible to understand the true economic impact of each option without understanding:

1. The base-line value of ecosystem goods and services (EGS) being generated by the unprotected parts of the Tarkine.

2. The impact of forestry operations on these unprotected ecosystem goods and services (EGS).

In other words, the EGS valuation techniques described above are highly relevant to the problem.

But could the EGS valuation techniques ever be applied in real life? So far, such techniques have not been used to make decisions about forestry operations in Tasmania, although they are increasingly being used by governments to make decisions on infrastructure. The aim of this case study is to assess the applicability and ease of use of these valuation methods to the Tarkine Cost Benefit Analysis. The aim is not to determine a "value" for the unprotected parts of the Tarkine, simply because data has not as yet been collected that would be needed under any of the methods to do this properly.

Data available to assess the options

The valuation method for valuing the royalties from logging the unprotected areas is straightforward and uses information which is readily available in the public domain. The valuation techniques are well accepted and there is debate only at the margin – for example around the choice of long term pricing trends for pulp wood.

The main source of data for the Extractive Option is Forestry Tasmania's Three Year Wood Production Plans for the area. These plans show volumes of timber and pulpwood that will be extracted from each coupe, and the main type of extraction (clear felling, or selective clearing). In addition, we have relied heavily on the report "*Review of the Deep Red Myrtle Resource in Tasmania*" prepared for Forestry Tasmania (Mesibov 2002) which addresses the issue of deep red myrtle supply from the Tarkine.

By contrast, the valuation methods for valuing EGS require significant amounts of customised data – data that is not readily available in the public domain. While the stated preference techniques appeared to require the most data (i.e. a customised survey of the population) even the revealed preference techniques required significant customised data collection (for example, on real estate transactions or on tourist numbers and details).

The authors did not have available either the resources or the need to collect these data, and therefore the following case study is more about what could not be done, than about what was done. However we recommend the following sections to people who are interested in using these valuation methods – if only to point to the potential pitfalls and requirements in applying the methods. We also wish to point to the possible value of the information that they could provide if they could become more widely used and debated.

In considering the Full Protection Option, we did consider a survey of 125 tourism operators in the area. The tourism operators indicated their views about the potential for attracting more visitors to the region, their current employment levels and the type of activity they would prefer to see happen in the Park.

Economic analysis and statistics are available for Tasmania's National Parks in general and for Cradle Mountain Lodge in particular. Much of the data from Cradle Mountain can be extrapolated to a potential Tarkine National Park because of similar levels of landscape and biodiversity values.

21. Valuation of the Forestry Benefit

Because the focus of this paper is on valuation methods for valuing EGS, we have not prepared a full assessment of the non-EGS parts of the Cost Benefit Analysis, which is primarily the impacts on producer surpluses (net profits) of those involved in forestry in the Tarkine.

The 1997 Tasmanian Regional Forest Agreement requires that decisions regarding the deep red myrtle timber and other timbers generally are made in terms of its 'economic accessibility'. The measure of 'economic accessibility' typically chosen for assessing the economic value of a forestry operation is "dollars per cubic meter at mill door". This was the measure used in the "Review of the Deep Red Myrtle Resource in Tasmania" (Forestry Tasmania, 2002). This review examined in detail the deep red myrtle resource available from the Tarkine.

Note that mill door price is not the royalty price received by Forestry Tasmania for the sale of the wood – royalty prices are considerably lower than mill door prices as they do not include production and transport costs. However mill door price gives a better measure of total economic value. For example, royalty prices to Forestry Tasmania are in the order of $15 per tonne for pulpwood, but mill door prices may be in the order of $55. The relationship varies depending on many factors including distance and volume.

We were supplied with a list by the Tarkine National Coalition of the logging coupes which they believe are inside of the proposed Tarkine National Pak and which are planned to be logged within the next three years. This list included 40 logging coupes with an average size of 61 hectares per coupe. These coupes were identified by their Forestry Tasmania Coupe ID. We matched these 40 coupes with coupes listed in Forestry Tasmania 2004-05 to 2006-07 Three Year Wood Production Plan in order to extract the forecast production volumes for each coupe.

The Three Year Plans are rolling plans that undergo a major review prior to the end of each financial year. We therefore focussed on the first year of the Plan (2004-05) which we assumed to be more accurate and complete than years further out.

In order to get a feel for mill door price, we reviewed various plantation prospectuses as well as publications by Forestry Tasmania. The table below shows the 2004 planned production volumes from the coupes identified by the Tarkine National Coalition as inside the proposed Tarkine National Park. The saw log quantities are shown in cubic metres and the pulpwood quantities are shown in tonnes. One tonne and one cubic metre can be considered approximately equal for green wood.

2004-05 Planned Production Volumes under the Extraction Option							
	Cat 1 and 3 eucalypt sawlog and veneer log	**Cat 2 (second grade) sawlog**	**Cat 4 (special species such as myrtle)**	**Cat 8 (eucalypt sawlog of lower quality)**	**Total Sawlog**	**Pulpwood**	**Total**
2004-05 Planned Production Volume	22,000	9,100	4,500	12,400	48,000	147,300	**195,300 Cu/m or Tonnes**
Assumed mill door price	$109	$75	$103	$60		$50	
Measure of economic value	$2.4m	$0.7m	$0.5m	$0.7m	$4.3m	$7.4m	**$11.7m**

Mill door price is not, of course, a measure of the producer surpluses generated by the logging industry in the Tarkine. An analysis of producer surplus would involve looking at the costs of extracting and processing the timber at all stages from forest to export ship. However, these mill door prices are likely to give an upper bound for the total producer surpluses, and are used by the Tasmanian Government in decisions regarding economic value. Based on this, one measure of the economic value of the Extraction Option could be considered in the order of $12 million per annum, assuming that future years are designed to extract a similar value.

Despite the special features of the Tarkine temperate rainforest, some 75% of the planned extracted volume (or 63% by value) is destined for pulpwood. Under the Forestry Tasmania 2004-05 Plan, 87% (by area) of the coupes inside the Tarkine will be clear-felled (as opposed to selectively logged). Following logging, 41% of the logged coupes will be converted into plantation (single species) forests, with the rest regenerated with a mix of eucalypt hardwood.

Given the intensity of the extraction method (87% clear-felling) and the subsequent conversion of over 40% of the logged areas into monoculture plantations, it is clear that many ecosystem goods and services could suffer under the extractive option. Many scientists believe that water and soil services are particularly adversely affected by conversion to plantation forests. Biodiversity and scenic amenity will also be affected.

VI. Case Study Results – Revealed Preference Methods

22. Replacement cost technique

The principle behind the replacement cost technique is that when the Tarkine's forests are logged rather than protected, there is a cost to replacing the ecosystem goods and services that have been impaired. For example, the potential cost of implementing a captive breeding programme to maintain biodiversity, especially of the threatened species such as the Giant Freshwater Crayfish.

The replacement cost technique applies only to the extent that benefit exceeds cost. Therefore a captive breeding programme is unlikely to be viable unless a threatened species has some unique, economically valuable, or sentimental quality. As previously discussed in Section 12, there are conceptual problems with the replacement technique, but we consider it here for completeness.

The potential loss of biodiversity under the Extractive Option is unknown. What is known is that:

- The Tarkine contains one of the world's most significant tracts of temperate rainforest (second in size only to those in British Columbia in western Canada) (Tarkine National Coalition article).
- Temperate rainforest is the rarest of the rainforests and more highly threatened even than tropical and sub-tropical rainforests. Temperate rainforest remains only in fragments in Australia, New Zealand, Chile, Western Canada and the United Sates.
- The Tarkine's rainforests form the largest continuous tract of rainforest in Australia. The three main rainforest regions in Australia are the Wet Tropics of Queensland, the Central Eastern Rainforest Reserves (NSW & Qld) and the Tarkine.
- Like other rainforests, the Tarkine is a haven for biological diversity. Worldwide, "closed tropical rainforests occupy 7% of the Earth's surface, yet they contain more than half the world's biota" (Curtis 2004).
- The Tarkine contains 54 species of flora and fauna which are listed as either vulnerable or endangered. (Tarkine National Coalition article)
- Relationships have been drawn between deforestation and species loss. For example in Costa Rica, "a study region of 15km radius was virtually completely forested in the 1940s and now retains 27% forest cover … it appears that between 4 and 28 species [of the original 300] have gone locally extinct since the deforestation began" (Daily 1999)

Our knowledge of the complex inter-relationships in ecosystems that allow a species to survive is insufficient to know which species to target with a captive breeding programme, or how to successfully implement such a programme without further research.

The research required before a reasonable value could be placed on a captive breeding programme to protect the Tarkine's biodiversity includes:

1. An inventory of the Tarkine's 54 threatened species. How many are endemic to the Tarkine? How many occurrences of each species occur within the Tarkine? This list of 54 includes, for example:

    - the Tayatea (Giant Freshwater Crayfish), the world's largest freshwater crustacean, which grows up to 1m long and lives up to 40 years;

    - wedge tail eagle (Australia's largest eagle, of which there are only 200 pairs left); slender tree fern which grows up to 6m high, of which there are only two known living examples in their natural habitat.

2. An in-depth study of these particular species which are candidates for a captive breeding programme. This would include: their eating, breeding, movement patterns, interdependencies with other species, sensitivity to temperature, humidity, light, soil or river nutrients.

3. A study on the relationship between deforestation / logging disturbance and species loss for threatened species in the Tarkine, such as the three listed above. Note that both the Extractive Option and the Protection Option leave a large area of the Tarkine protected, so it is possible that selective logging could be done in such a way as not to critically endanger targeted species.

Only then could a realistic replacement cost be placed on the captive breeding programme (i.e. the cost of replicating an environment sufficient for sustainable breeding these threatened species).

The replacement cost method applied to a captive breeding programme, say for crayfish, in the Tarkine would provide a lower bound for the value of the Tarkine's EGS. The only service it would be valuing is biodiversity, and protecting a single species is a small part of preserving biodiversity since there are three levels at which biodiversity is important: genes, species and ecosystems (Beder).

There is the potential for circularity in the application of the replacement cost method. It applies only to the extent that benefit exceeds cost, and yet the reason for applying the technique is to estimate benefit. This can be seen by trying to apply the method to one of the other nature services than biodiversity. Trees help to regulate the balance of O_3 for UVB protection. Therefore to the extent that the Extractive Option reduces tree cover, one could theoretically replace the regulation of O_3 by an alternative means such as a chemical process in a custom made factory. In this case it is likely that the beneficial impact would be far outweighed by the replacement cost. Does the benefit of preserving crayfish outweigh the cost of researching and implementing a captive breeding programme?

To avoid circularity, the replacement cost technique should be applied as a revealed preference technique, i.e. after the event, so strictly speaking it is not useful for valuing the Tarkine, before a decision has been made to either log or protect the forest. Strictly, people/enterprises reveal their preference for biodiversity by funding its replacement cost, so in this case environmental groups or fisheries might reveal their preference for crayfish by committing to fund a captive breeding programme. The uniqueness of species and of the reasons for wanting to sustain them makes it very hard to benchmark against other captive breeding programmes.

So overall the replacement cost technique was not useful for this case study, and would be better suited to extracting compensation for damaged wilderness rather than planning for possible damage.

23. Production function technique

As stated earlier, the principle behind the production function technique is that there is a biophysical relationship between inputs and outputs which can be used to infer values. In broad terms, therefore, the data required to apply the technique is:

1. the demand for a marketed output; and
2. a relationship between the level of output to changes in the availability of an EGS input.

Examples of EGS where the technique could (in theory) be applied to the Tarkine are:

- nutrient recycling
- species or habitat protection
- ecosystem resilience (or capacity to retain productivity following disturbance)
- watershed protection or flood control
- carbon storage (assuming that there will be a direct price for carbon emissions)
- biodiversity's value as a global insurance policy to avoid the value of forest goods and services being lost.

The values derived are usually expressed as a dollar amount per annum per hectare of forest that will be lost following clearing or logging. However, care is needed to understand the assumptions being made, for example:

1. A programme of sustainable logging or the clearing of part of a large forest may be deemed to have little impact on overall biodiversity because the total sample of species and habitat is still likely be to maintained.

2. On the other hand, some ecosystem services, such as carbon storage, may be deemed to be provided on a proportionate basis, so that if x% of the forest is cleared then x% of the service is lost.

3. If the whole of a forest area is to be affected by a development but the change will occur gradually over time, then the impact per hectare will be small initially. However, as the affected area is increased over time until the loss of a production function threatens the continuing viability of the desired output, then the loss of ecosystem services would increase exponentially over time.

4. The value of a forest for bio-prospecting could be viewed as very small because of the development of genetic engineering that can create a substitute for the desired gene. In addition, there is a current abundance of areas that have yet to be fully explored to understand their biological product potential. The potential private value derived from the plant or animal may be small for the pharmaceutical or genetic engineering company but the overall value to society as a whole may be much greater.

Often it is impossible to establish a direct market value for an output. The technique has to make use of one of the other valuation methods to establish a surrogate value. For example, the contingent valuation method is often used to establish a willingness to pay to prevent an output being affected.

In theory, the production function should not cover indirect values, such as existence or aesthetic values. However when methods such as CVM are used, it may not be possible to separate the direct and indirect values. If the people being surveyed do not have a detailed understanding of how an ecosystem functions, then they will be using their overall perception of relative value of types of land, for example, a dense rainforest could be valued more highly than a more open type of forest even though the latter may have much higher biodiversity as is the case with the South Western Australia region.

Examples of the level of values that have been placed on certain production functions that could be translated to the Tarkine are as follows:

Private value of biodiversity	US$0.02 to $2.5 per hectare in land regarded as a hot spot for biodiversity
Social value of the same biodiversity	US$31.60 to $311.8 per hectare in same area of land
Watershed protection	US$10 to $20 per hectare
Carbon storage	Carbon valued at around $34 per tonne in 2000. Conversion of temperate forest to plantation could reduce carbon storage of forest and soil by 100tC/hectare.
Total ecosystem services (see more details below)	$236 pa/hectare for National Park in North Queensland (including some non-use values) compared with $182 pa/hectare for freehold land in the same area.

A very comprehensive study of the value of ecosystem services has been undertaken by I Curtis (2004) in relation to the Wet Tropics region of Queensland. The method relates the value of ecosystem services to the unimproved value of land as determined by local government ratings. A relative value of the range of services provided by each type of land is established using the opinions of a panel of experts derived from a Delphi Study. It should be possible to translate the methods used in this study to the Tarkine. Transferring the relative values of different types of land from the North Queensland study (for example a change from $236 to $182 per hectare if the land is developed) would give a loss of $5.67 million per annum for the unprotected Tarkine (105,000 hectares). However this would be an over-simplification, as the results as they are presented cannot be directly applied to the Tarkine.

Data Required

In summary, the data required in order to apply the production function technique to the Tarkine could include:

- details of the ecosystems of the forest that are protected as well as those to be logged;
- details of the land use in surrounding areas;
- local government values of the land or some values from a national perspective of services provided by various types of forest land.

The main difficulty with the production function technique is the lack of market values or some other systematic basis for placing values on ecosystem attributes.

24. Hedonic pricing technique

As described earlier, under hedonic pricing, the value of a change in the value of EGS is inferred from its relationship to the price of a marketed good or service. Its application depends upon there being a sound connecting relationship between the EGS being valued and the marketed good or service, and in particular:

- participants in the market must perceive the EGS as important in determining the price of the marketed good or service;

- participants must have the opportunity to observe and react to the actual level of the EGS.

Can hedonic pricing be applied to the Tarkine?

The examples in Section 14 discussed where hedonic pricing has been used in the US and in Australia to value the EGS from forests and national parks. Could such method be applied to the Tarkine?

The first example (where the non-timber values of the maple birch forests in Wisconsin were valued) used the actual decisions made by forest owners (both private and public) regarding management of their land. It compared the actual net logging royalties derived from each coupe with the maximum potential royalties that could have been derived, if the owner had chosen to log the land. The model is premised on the assumption that the value of EGS obtained by forest owners should be at least equal to the difference between the value of what they could have logged had they tried to maximize timber revenues, and what they actually logged. That is, the difference in net revenues provides the lower bound of the EGS value of the forest.

The results obtained were that EGS value was highest for national forests, about US$50 per hectare per year. This represents about ten times the logging royalties. The estimated EGS value was similar for all non-national forests, at about US$20 to US$24 per hectare per year, about four times larger than logging royalties.

It could be argued that the existing choices made between protected and un-protected areas in the Tarkine reflect a form of hedonic choice, and that the differences between the potential logging royalties from the whole Tarkine area, versus the actual logging royalties (due to pre-existing decisions about protection and so on) represent a lower bound for the EGS value of the forests. However there are crucial differences from the Wisconsin study. There is no active market in the Tarkine. The Tarkine is state forest and there would not be the diversity of forest owners / managers operating in a competitive environment for a consensus regarding optimum logging levels to be reached.

Therefore this form of hedonic pricing can not be applied to the Tarkine.

A second example of hedonic pricing given in Section 14 involved the impact of EGS in a National Park on property values. By modelling unimproved property values in the area, any increase in property value attributable to the National Park can be identified. The sum of these components over all affected properties represents an estimate of the amount the property owners are prepared to pay for the amenities provided by the National Park.

The unprotected parts of the Tarkine, however, are bounded by conservation areas, grazing land, and sparsely populated lands elsewhere. There are no adjacent urban areas so that no component of the Tarkine's value can be attributed to the amenities it provides to residents of adjoining lands.

The most promising potential application of hedonic pricing to valuing the EGS of the Tarkine might be to consider the investment by tourism operators in the area, and how this is affected by nearby forestry operations. A survey conducted by the Tarkine National Coalition in May 2004, answered by 125 tourism operators based around the Tarkine, found that 89% "strongly agreed" or "agreed" to the statement that *"The Tarkine's unique natural values should be preserved"*. Tourism operators made written comments such as "We rely solely on nature. If the resource (wilderness) is destroyed, so are we". However the survey failed to ask questions which could have been used as the basis for a hedonic valuation of the EGS. Such questions might have included:

- Decisions made regarding tourism investment which were affected by the perceived actual or potential future condition of the EGS of the Tarkine.

- Actual expenditure on tourism investment, correlated by proximity to conserved, un-protected or logged areas.

- Expected profits (and hence producer surplus) from the tourism operation under different EGS scenarios.

The survey also suffered from a low (and voluntary) response rate – 125 operators out of 500 surveyed, but clearly demonstrated the potential value of tourism to the area, and the possibility of using hedonic valuation methods based on tourism business choices to value the EGS.

25. Travel cost technique

The Travel Cost Method (TCM) is the most common method used to measure the tourism and recreational value of an area. The method does not measure the full EGS provided by an area, only the perceived value that visitors place on their nature based experiences. According to Van Hooten (1995) this value represents the smallest component (some 20 to 25%) of a wilderness area's total EGS. Thus any value derived for the Tarkine using this method should be considered a small component of the total EGS value.

Can TCM be applied to the Tarkine?

TCM uses the actual numbers of visitors to an area along with estimates of where they travelled from. It is thus very suitable for valuing existing tourist destinations, including national parks and wilderness areas. It is not very suitable for the Tarkine, which does not yet exist as a National Park or World Heritage Area, and is thus not promoted as such. More importantly, visitor numbers are not monitored in the way they would be for an existing tourist destination.

Visitation numbers exist for the North West of Tasmania as a whole (where the Tarkine is situated) and for the major areas around the Tarkine, but not for the Tarkine itself. Therefore our case study could not apply the TCM to the Tarkine. Instead, we have applied the method to Cradle Mountain. Cradle Mountain is a National Park located close to the Tarkine, and like, the Tarkine, it contains outstanding world heritage values. Unlike the Tarkine, it is extensively developed as a tourist destination, with walking tracks, lodges and very developed tourist infrastructure. It is an example of what the Tarkine could be developed to be.

Valuing Cradle Mountain's tourist and recreational value using TCM

Step One: Data Collection

We collected the following data for the TCM:

Data item	How collected	Comments
Number of visitors to Cradle Mountain, by state of origin.	The total number of visitors to Cradle Mountain was apportioned in line with a survey of state of origin statistics for all nature based visits to Tasmania.	This would normally be obtained by a survey of Park visitors' post codes, preferably for 1,000 visitors or more, to achieve reasonable confidence intervals.
Population of each state	From ABS statistics. For international visitors, the population was taken as international visits to Tasmania and Victoria.	The underlying population of each state is used to give the "visitation rate" from each state to Cradle Mountain.
Travel cost depending on state of origin	Estimated as 31 cents per km from the state of origin to Cradle Mountain plus $180 (interstate) or $30 (from Tasmania).	The 31 cent estimate is from other TCM surveys that have been used in Australia and includes both car running costs and travel time costs. The distance was assumed to start at the capital city in each state.

Once these data were collected, the values were input into an excel spreadsheet and the TCM value of Cradle Mountain was calculated with about one hour's work. It is thus apparent that, if visitor numbers and a point of origin estimate are available, the TCM is very easy and routine to apply.

Step Two: Spreadsheet construction

1. For each state(s), enter the state population P(s) and the number of visitors to Cradle Mountain V(s). This gives a visitation rate V(s)/P(s) from each state, which is VR(s). In this example, the visitation rate did decline with distance from Cradle Mountain, with a 6% visitation rate from Tasmania and a 0.3% visitation rate from the Northern Territory.

2. For each state visitor, estimate the travel cost TC(s) using the travel cost formula.

3. Graph TC(s) against VR(s). We used Excel's scatter plot function and then asked Excel to fit a trendline to the data. The best fit was a power function with an R^2 of 0.95. You now have a function that relates the cost to visit Cradle Mountain with the number of visitors who do visit. This is called the 'Trip Generating Function" or TGF.

4. For a range of Notional Entry Fees (from $10 to $200), we estimated the revised visitation rate from each state, by calculating the Trip Generating Function at the travel cost plus the notional entry fee ie TGF(TC+NEF). For each notional park entry fee, we then had a new (lower) assumed number of visitors V'.

5. We then graphed these new numbers of visitors to Cradle Mountain against the corresponding Notional Entry Fee. We used Excel's scatter plot function and then asked Excel to fit a trendline to the data. The best fit was a polynomial function with an R^2 of 0.99. You now have a function that relates different levels of park Notional Entry Fee to the impact on total visitor numbers. This is called the "Consumer Surplus function" or CSF. We then integrated the CSF (to get the total area under the graph) which is the total dollar amount of the annual Consumer Surplus of Cradle Mountain.

Results of TCM valuation of Cradle Mountain

This process gave an annual consumer surplus valuation for Cradle Mountain of $23.8 million. This was consistent with other travel costs methods which have been used in Australia recently. For example, TCM valued Fraser Island at $34.5 million per annum (Fraser Island has double the number of visitors as Cradle Mountain but is probably viewed as less high value wilderness). TCM valued the recreational value of all of Victoria's National Parks at $175 million per annum.

If we hypothesise that the Tarkine has been fully developed for tourism, with a tourism infrastructure as described by tourist operators who responded to the 2004 Tarkine Tourism Survey, then we could hypothesise that, eventually, the Tarkine might attract half the visitation rates as Cradle Mountain. This would give a value for the Tarkine at that stage of about $12 million per annum.

Our comments on using TCM to value EGS

The method only gives the tourism and recreational value. It can only be used at a place like Cradle Mountain which is already a tourist and recreation hub. We couldn't use it for the Tarkine which is not yet developed for tourism and recreation. Thus the method was not helpful at all for the Tarkine, other than as a "what may be" scenario.

While the basics of TCM are relatively straightforward for actuaries to apply, there are a lot of conceptual issues that need to be considered. These include the issue of multiple destination for one visitor (e.g. if the person is going to visit both the Tarkine and Cradle Mountain, to which area is the value attributed?). There are also issues in how to handle the "cost" of time spent in the area and in travelling to the area, and the problem of dealing with congestion in the Park, which may be reducing the amenity value of the Park and damaging the EGS.

VII. Case study Results – Stated Preference and Market Based Methods

26. Contingent valuation method

In order to experience conducting a real survey, the authors conducted a mock CVM survey of volunteer participants from the IAA mailing list. The survey (which was answered by 191 participants) cannot be considered meaningful as:

- Actuaries are not a representative cross section of the population
- Only 191 out of over 2000 surveyed chose to answer the survey – a self selecting group
- In order to limit actuaries' time in completing the survey, limited information was given about the EGS and about the effect of protecting or logging it.

Nonetheless, conducting the survey gave us good hands on experience. The survey asked respondents four questions about themselves, and then asked the following question:

Question 1

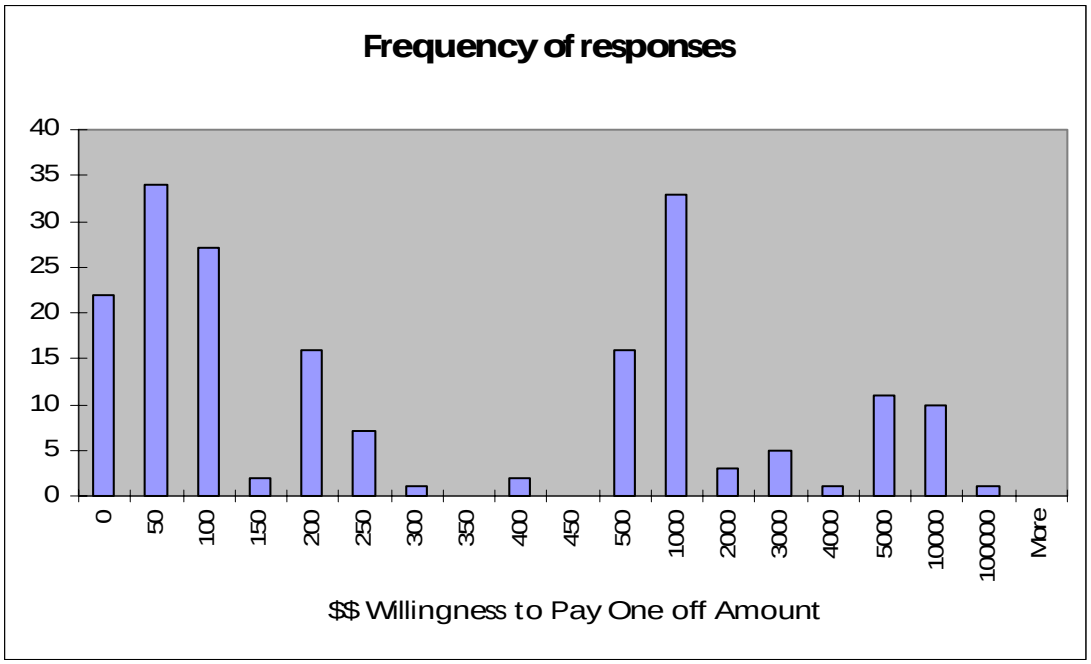
Please read the accompanying notes, sourced from Australian Geographic, on the Tarkine Wilderness Area in Tasmania. How much would you personally pay to achieve the following preservation outcomes for the Tarkine Wilderness area? Assume this is a one-off payment made today. This preservation outcome protects the three major types of wilderness found in the Tarkine and therefore also many of the threatened or endangered species.

100% protection of 200sq km Myrtle Rainforest Corridor – unique in the world	plus 100% protection of 1,500sq km rainforest – the largest contiguous tract in Australia	plus 100% protection of remaining 700 sq km eucalypt forest	and therefore protection of 54 threatened or endangered species.	I would pay….. $..... to achieve these four outcomes

The survey was thus an open ended CVM, rather than a dichotomous choice survey as recommended by Arrow et al. [1993] and as used in the Kakadu survey. Had the survey had dichotomous choice, it would have been analysed using logit regression techniques.

The survey wording failed to provide adequate information about the differing EGS impact under the protection versus logging options. By only giving information about the EGS impact under the protection option, it biased the answers in a certain direction. As the payment vehicle ("a one off payment now") did not carry any reality or likelihood of implementation, it is likely that respondents gave high replies.

The responses had a median response of a $200 one off payment and a mean response of $1,300. The histogram below shows the range of responses. We suspect this pattern is typical of CVM surveys, with a good number of people unwilling to pay anything and some people willing to pay a lot.



The willingness to pay correlated mostly to the age of respondents, which we assume is a good proxy to income. Had the survey been representative, then it may have been used to infer that the average actuary was willing to pay $200 to protect the unprotected areas of the Tarkine. Assuming that actuaries earn, on average, ten times the average wage in Australia, this could imply that the average Australian might value the Tarkine at about $20, giving an Australia wide EGS value of some $400 million, or say $40 million per annum. This, of course, cannot be inferred from this survey.

The survey attracted immediate criticism on the grounds we have listed above, showing actuaries' awareness of many of the problems inherent in poor quality CVM surveying. Readers may wish to review the list of important CVM criteria described in Section [17] for a CVM result to be valid.

CVM is a method that could well be applied to determine the public's view of the options facing the Tarkine's unprotected areas. However, given some scepticism around the method, and the Kakadu precedent, the choice modelling method is likely to be more relevant to the Tarkine. The fact that at least two clear choices are available, makes the situation very suited to choice modelling, and less suited to CVM**.**

27. Choice modelling technique

An attempted choice modelling survey of actuaries was conducted at the same time as the Contingent Valuation survey. The results from the survey suffered from some limitations:

- Actuaries are not a representative cross section of the population.
- Only 191 out of over 2000 surveyed chose to answer the survey – a self selecting group.
- In order to limit actuaries' time in completing the survey, limited information was given about the EGS and about the effect of protecting or logging it.
- There was no information provided about the impact on jobs from each of the different options. This could be argued to be a relevant factor in people's choices, and if provided may have resulted in different choices, and hence different values for EGS.

- The derivation of policy scenarios should ideally have been developed in consultation with state government, environmental groups and local planning officials to make the policy options a realistic reflection of the choices available.
- We did not design the survey in consultation with a statistician to decide on the range of policy options needed to arrive at statistically credible results.
- It is arguable that as the survey was asked straight after respondents had been asked the contingent valuation survey, their choices may have been influenced by the monetary choices they made in that questionnaire, rather than focussing only on the choice set presented here.

Nonetheless, conducting the survey gave us some interesting results and good hands on experience in what is involved in such studies. The survey asked respondents four statistics about themselves (Gender, age bracket, offspring, whether visited Tasmania), and then the following questions:

Question 1

Options X,Y and Z. Please choose the option (X, Y or Z) you prefer most by ticking ONE box. How much would you pay? (Eg if you want to protect 30% of the Myrtle Corridor and 70% of the rainforest and 30% of the endangered species, by paying $50 each year, choose option Y)

	A. Protection of 200sq km Myrtle Rainforest Corridor – unique in the world	**B. Protection of 1,500sq km rainforest – the largest contiguous tract in Australia**	**C. Protection of remaining 700 sq km eucalypt forest**	**A + B + C = D. Protection of 54 threatened or endangered species**	**I would choose.. TICK ONE BOX FOR EACH QUESTION**
Option X $0 each year	0%	40%	40%	10%	
Option Y $50 each year	30%	70%	70%	30%	
Option Z $100 each year	100%	100%	100%	60%	

Question 2

Options M,L and N. Please choose the option you prefer most by ticking ONE box. How much would you pay?

	A. Protection of 200sq km Myrtle Rainforest Corridor – unique in the world	**B. Protection of 1,500sq km rainforest – the largest contiguous tract in Australia**	**C. Protection of remaining 700 sq km eucalypt forest**	**A + B + C = D. Protection of 54 threatened or endangered species.**	**I would choose.. TICK ONE BOX FOR EACH QUESTION**
Option M $0 one off	0%	40%	40%	10%	
Option L $600 one off	30%	70%	70%	30%	
Option N $1,200 one	100%	100%	100%	60%	

Questions 2 basically offered the same options as Question 1, but with the question of how much they would be willing to pay as a one-off, rather than on an ongoing basis. The implied discount rate into perpetuity from comparing the two questions is 9%. The purpose of asking this question was to see how policy choices varied between paying a lump sum, and having an ongoing cost.

The purpose of choice modelling is to explain how much people value each of the non-monetary variables in relation to the monetary variable. This is done by fitting a model that tries to explain the choice that people make of policy options, in terms of varying levels of monetary and non-monetary outcomes.

Upon looking at our dataset, and reading up on how to do choice modelling, we realised that what we needed to do was to fit a muti-nomial logistic regression to Q1 by explaining the choice chosen (X, Y or Z) in terms of money, and the variables A, B, C and D, and if possible the socio-economic variables as well. Each of the explanatory variables was fitted as continuous rather than categorical variable.

Unfortunately, after several attempts and fruitless examinations of the data, it was pretty clear that we would not be able to get results that converged to a solution to estimate parameters for the explanatory variables. There was only one choice set that people could choose, and all the explanatory variables were correlated with the each other. We sought the advice of Jill Windle from the Central Queensland University, a lecturer who had used the choice modelling method to assess policy options for the Fitzroy Basin (Queensland). She identified that what was needed was for several different choice sets to have been presented to the survey respondents, not just the single one that we had. This would allow for varying levels of each explanatory variable, to see how each would affect people's choices.

So, it was clear that the data could not be used as intended due to incomplete survey design. Due to lack of time, we could not redo the survey either. Nevertheless, the results from the choice set presented are worth sharing.

Shown below are the number of survey respondents that picked each option for Question 1, and the average response implied for each variable.

Question 1

Options X,Y and Z. Please choose the option (X, Y or Z) you prefer most by ticking ONE box. How much would you pay? (Eg if you want to protect 30% of the Myrtle Corridor and 70% of the rainforest and 30% of the endangered species, by paying $50 each year, choose option Y)

Option	Number of Responses
X	30
Y	34
Z	121
Not Answered	6

Question 1

Options X,Y and Z. Please choose the option (X, Y or Z) you prefer most by ticking ONE box. How much would you pay? (Eg if you want to protect 30% of the Myrtle Corridor and 70% of the rainforest and 30% of the endangered species, by paying $50 each year, choose option Y)

	Average Money	Average Myrtle Corridor Prot	Average Rainforest Prot	Average Eucalypt Prot	Average Species Prot
Average	$75	71%	85%	85%	46%

Of those who responded, most people picked the last policy option, which involved the greatest monetary cost, but which resulted in the best EGS outcome. Trying to get a monetary "value" for all the EGS from this may not be meaningful as:

- this is not the purpose of choice modelling. It is meant to be a policy guidance tool, and a method of explaining which factors are significant in the choice, not an overall valuation tool.
- there might have been a selection bias in that those who responded in the survey, as they were constrained choices presented.
- Of those who responded, most picked option Z, which suggested that some may have been willing to pay more than $100 to achieve better EGS outcomes.

Nevertheless, the survey says that for those that responded, each was willing to pay an average of $75 a year to achieve some EGS outcomes.

Responses from Question 2 are shown below.

Question 2

Choose Option M, L and N – one off cost

Option	Number of Responses
M	57
L	42
N	87
Not Answered	5

Question 2

Choose Option M, L and N – one off cost

	Average Money	Average Myrtle Corridor Prot	Average Rainforest Prot	Average Eucalypt Prot	Average Species Prot
Average	$697	54%	75%	75%	38%

Fewer people selected the most favourable EGS outcome than for question 1. The results suggest that people in fact discount the cost of environmental goods at 12% (i.e. greater than that used in the study for the policy options). This is quite a high rate of discount – but perhaps comparable with required expected returns on the sharemarket.

28. Market based method

To derive the EGS value of the unprotected Tarkine region using market based methods, we would need observations of market supply and price received through transactions to estimate the profits that may be enjoyed by producers. Alternatively, we would need observations of market demand and price paid by consumers to estimate the net benefit (consumer surplus) received by consumers when they purchase the EGS.

From a supply perspective, government offerings of land and tenders to buy nature based regions for protection will provide an estimate of land value per area.

From a demand perspective, bio-prospecting contracts give an indication of expected present value of profit streams that are expected to be derived from the plant or animal species being researched. A value for Tarkine's bio-diversity can be estimated by placing a value on each species of plant or animal in the Tarkine allowing for the number or density of estimated species per area. A number of bio-prospecting contracts have already been agreed upon around the world for particular plant or animal species.

Alternatively from a demand perspective, the Travel Cost Method (discussed earlier) can be used to measure the costs spent by eco-tourists to travel to the Tarkine region and entry fees paid to give an indication of the benefits that eco-tourists enjoy from the nature based experience (through their willingness to pay for them).

Can market based methods by applied to the Tarkine?

Relevant market based transactions are needed to value the region, although, the availability of directly applicable information is very limited.

Some groups like Bush Heritage do acquire land for its EGS but the market is very small. We understand that offers have been made to acquire some state forests in Tasmania for the purpose of protecting the EGS, but we have been unable to substantiate this.

Government sales of nature based lands are not very common; certainly no such offerings have been made for the Tarkine. Government offerings for other forest lands around the world can be used as a basis for the Tarkine valuation, although adjustments would need to be made to allow for the differences between the Tarkine and the land being offered in terms of economic potential of its flora and fauna, and tourism derived incomes among other features.

Secondly, several bio-prospecting transactions around the world have occurred in particular regions. Costa Rica is one unique example in that a symbiotic relationship has emerged between a government organisation and the pharmaceutical industry to prevent the ongoing theft of genetic material. Other examples have included the Neem Tree in India[1], and the Basmati[2] and Jasmine rice in India and Thailand where multiple companies from the developed world engaged in bids to buy the bio-prospecting rights on these plants and patent new food products based on them.

Despite the public information available on these transactions, their usefulness in valuing the Tarkine region is limited for now until such time when the volume of transactions grows to cover a sufficiently large list of plants and animals that inhabit various nature based regions of the world. It is also important to note that even when the volume of transactions grows to a statistically significant number, they will only give an indication of the bio-diversity value, which is a portion of the total value of EGS.

[1] The neem is a tree found throughout the drier areas of India. The neem's many virtues are to a large degree attributable to its chemical constituents. The tree contains a number of potent compounds, notably a chemical found in its seeds named azadirachtin. It is this chemical that has given the Neem tree many uses in the fields of medicine, agriculture and fuel production. These include treatment of a wide range of diseases ranging from leprosy and diabetes to ulcers and skin disorders, it is useful in the preparation of toothpaste and soap, its chemical resistance to termites makes neem a useful construction material.

[2] Basmati is a type of rice has been grown in the foothills of the Himalayas for thousands of years. Its perfumy, nut-like flavor and aroma can be attributed to the fact that the grain is aged to decrease its moisture content. Basmati, a long-grained rice with a fine texture is the costliest rice in the world.

Had sufficient information been available, the Tarkine's bio-diversity can be comprehensively estimated by placing a value on each of its 267 animal species (122 birds, 27 mammals, 11 reptiles, 8 amphibians, 25 fish and 193 invertebrates) and its 444 plant species. Perhaps a quick valuation of the main species is sufficient with generic or linking assumptions made for the other less significant species. Special consideration would have to be given to the Tarkine's 54 species of flora or fauna that are listed as rare, endangered or threatened. This will allow for the research related benefits that may be foregone if these species become extinct, also for the tourist related income that will be lost if they are not protected.

VIII. Summary of Case Study Results and Conclusions

29. Case Study Findings – the Tarkine

As expected, the case study was very helpful in our understanding of the techniques of EGS valuation, but has added little to the discussion about the Tarkine itself. EGS valuation techniques require intensive data collection, sound scientific study and market based observations. These cost time and money. In contrast, valuing the financial or economic outcomes from forestry goods and services uses well established techniques, publicly available data and there is an active market with many participants.

From our study of other forests which have been valued using EGS techniques, it seems clear to us that the unprotected parts of the Tarkine would have a high EGS value, especially when consolidated into a National Park with the large parts of the Tarkine already protected. Many of the EGS goods and services are amplified when large areas are combined, providing additional robustness to the ecosystem. However it is a moot point as to how this compares to the economic value generated each year by forestry operations in the area, without it being quantified properly.

Method	**Potential use for the Unprotected parts of the Tarkine**
Direct Market	
Valuing the Extractive option	A standard economic valuation of the surpluses generated by those producers involved in forestry in the Tarkine could be generated. A simplified upper measure such as economic accessibility (e.g. mill door prices) could also be used.
Valuing the EGS	There is little likelihood of this method being used, given there is no active market in Australia for wilderness areas. Some groups like Bush Heritage do acquire land for its EGS but the market is very small.
Stated Preference	
Contingent Valuation	A CVM study could be conducted for the Tarkine but may be viewed with scepticism in Australia because of other surveys that have been done.
Choice Modelling	A choice modelling survey could be constructed that showed the impact on EGS of the management options. This could work well with the Tarkine.
Revealed Preference	
Hedonic	Market observations are needed for something correlated to the Tarkine EGS. Tourism business spending is the most likely, but has not been measured.
Production Function	It should be possible to translate the methods used in the Curtis study of North Queensland EGS values to the Tarkine, through scientific comparisons of goods and services.
Replacement	Not very useful, as the method is more suitable to assess the cost of EGS damage after it occurs or for areas providing very specific and measurable EGS.
Travel Cost	The tourism survey revealed that the scenic and amenity value of the Tarkine is very underutilised, so a travel cost survey of the Tarkine in its current circumstances would be of little use.

30. Further opportunities for actuaries

Most opportunities for actuaries lie in the area of providing economic cost benefit analyses to governments and companies requiring valuation of activities or projects which have an effect on ecosystem goods and services. Note that, in order to do this, actuaries will need to move away from the concept of only valuing cash flows to the economic concept of maximising social welfare. Some actuaries may also work for directly for government and conservation groups valuing ecosystem goods and services.

In such circumstances, actuaries will need to:

1. Be aware of the need to value impacts on ecosystem goods and services.

2. Identify the most appropriate valuation method (eg the travel cost method for a heavily visited national park or the production function for a water catchment area).

3. Identify the other professionals needed to perform the EGS valuation (eg scientists or survey firms).

4. Consider other valuations which have been done of EGS and whether the results are transferable to the situation.

We hope this paper is useful to actuaries who are performing valuations involving EGS in the future.

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