A THRESHOLD VALUE ANALYSIS OF PROPOSED FOREST RESERVES[#]

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ABSTRACT

Threshold Value Analysis (TVA) may be a useful input into natural resource decision making when non-market values are involved. The decision rule under a TVA is to protect a natural resource if the (non-marketed and unquantified) benefits so arising are deemed to be greater than a threshold value defined by the (marketed and quantified) developmental benefits foregone. In this paper, threshold values are calculated for a range of forest protection options being considered under the Regional Forestry Agreements being negotiated in New South Wales. A static analysis is first undertaken. This is then enhanced by the incorporation of factors that affect the alternative streams of value through time. Extensive sensitivity testing to demonstrate the impact of assumption variations is reported. To put into context the threshold values so calculated, the benefit transfer approach is used to provide estimates of forest protection values.

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1. Background

The economic efficiency of alternative allocations of natural resources can be assessed through the application of benefit cost analysis (BCA). In a BCA, the various implications for the well-being of the community of alternative resource allocations are estimated in dollar terms and aggregated. The technique's application is often problematic because the estimation of non-market benefits and costs in dollar terms can be difficult. Whilst methods designed to provide such monetary estimates are available – for instance, contingent valuation, choice modelling and hedonic pricing – they can be expensive and time consuming to implement. In addition, their application has on occasion been controversial (Bennett 1996).

In circumstances where BCA is problematic, one way to provide decision makers with information that will assist in the assessment of the economic efficiency aspects of alternative resource allocations is through a Threshold Value Analysis (TVA).

TVA is best explained in the context of a decision involving an extractive option and a protection option for a natural resource. Whilst the costs of foregoing the extractive option can usually be estimated from market information, the benefits arising from the protection option are likely to be non-marketed and not so readily estimated. In a TVA, the value that the non-market benefits of protecting the resource would need to reach for it to be in the community's best interest to forego the extractive benefits is estimated.

So whilst the decision rationale under the BCA is:

> *protect the resource if the estimated benefits to society derived from its protection exceed the estimated benefits derived from its development,*

the decision rational under the TVA is:

> *protect the resource if the decision makers assess that the benefits to society from its protection exceed the estimated benefits derived from its development.*

The TVA therefore involves the estimation of the marketed benefits of resource extraction and the setting of that estimate in a format that is useful to decision makers:

> *are the benefits of protecting the resource greater than the value of the extraction benefits that will be given up?*

Central to the TVA is the estimation of the benefits of the extractive option that are foregone when the preservation option is selected. This opportunity cost is the difference between the (monetary) value of extractive benefits under the extractive option and the (monetary) value of the extractive benefits yielded by the preservation option.

Under a TVA, the burden of estimating the non-market value to the community of protecting the resource is therefore placed before the decision makers in a way that makes the implications of their decision quite clear. Hence, if the decision is made to protect the resource, it is explicitly recognised that the benefits of resource protection are judged to exceed the “threshold” of extractive benefits foregone. Conversely, if it is decided to allow the extraction of the resource, then it is clear that the decision makers have concluded that the protection benefits of the resource are below the “threshold”. One way of assisting decision makers in their assessment of whether the preservation values are in excess of the threshold is through the analysis of forest protection benefit estimates generated by other studies. This is known as the process of benefit transfer.

In August 1997, the New South Wales National Parks and Wildlife Service commissioned a TVA of certain proposals to protect areas of forest in the Eden Region of New South Wales. The decision being informed by the TVA was whether to allow the continued harvesting of the forest resources involved (an “extractive” option yielding monetary benefits) or to have the resources set aside in conservation reserves (a “protection” option yielding non-market benefits). The TVA was required as an input into the deliberations of the Economic and Social Technical Committee established under the Scoping Agreement between the Commonwealth and State Governments for the establishment of a Regional Forestry Agreement.

In this paper the TVA performed is outlined. Two potential areas of forest reserves - known as “protection options” – are considered:

1. Scenario A: Put forward by conservation stakeholders, involving 57,506 hectares of additional conservation reserve established with 20,000m3 of sawlog and 265,000 tonnes of pulpwood production per annum.
2. Scenario B: Developed by New South Wales National Parks and Wildlife Service and State Forests, involving 42,747 hectares of additional conservation reserve established with 22,500 m3 of sawlog and 318,000 tonnes of pulpwood production per annum.

These protection options were considered relative to a “reference option” which is defined as “full forestry production outside current legal reserves”. Hence the opportunity cost calculation that is central to the TVA relates to the differences between the extractive values under each of these protection options and the extractive values generated under the reference option. The extent of the timber outputs that could be produced from the areas defined under each option - including the reference option - was determined by the State Forests of NSW using the FRAMES model. The extraction values relating to each option were estimated on the basis of the Australian Bureau of Agricultural and Resource Economics’ (ABARE) FORUM model.

This paper is structured in three parts. In the first part, a “static” TVA is outlined. This is the basic form of a TVA under which the foregone extractive benefits of the forest areas being considered for reservation are estimated. Within this part of the paper, the fundamental principles underpinning the TVA are explained in brief.

In the second part of this paper, a “dynamic” TVA is presented. Whilst based on the fundamentals of the “static” TVA, the dynamic version takes into account the potential for the streams of benefits from forest protection and forest extraction to change asymmetrically over time. The second part therefore begins with an explanation of these differential rates of change over time and a description of the model that incorporates them into a TVA. The remainder of the part involves the application of the model to the case at hand. Some benefit transfer results are included in section 3 in order to place the threshold values into some "order of magnitude" perspective.

2. Static Threshold Valuation Analysis

2.1 Threshold Valuation Principles

The opportunity cost suffered as a result of taking forest areas out of production for protection purposes is made up of lost producers' and consumers' surpluses. By excluding areas of forest from timber production, the overall supply of timber products is reduced. This results in the formation of a new market equilibrium. The price of timber products would rise and the level of output would decline. Those producers whose output is cut lose producer surplus. Consumers are also worse off. Their surplus declines because of the higher price paid and the reduction in quantity available. There are some off-setting gains. Those producers who maintain their access to production forests achieve higher prices for their products and so experience a rise in producers' surplus.

Both the producers' surplus and consumers' surplus losses are legitimate elements of the opportunity costs of reserving forest areas. One exception must be considered. This arises when either the producer or consumers' surplus involved is expatriated overseas. The norm in BCA - and hence for TVA - is to consider gains and losses from a national perspective. Hence benefits and costs that are enjoyed and suffered overseas are not considered relevant. For instance, in the forest TVA, price rises paid by overseas consumers would not be included as an opportunity cost but price rises paid by domestic consumers would be. Similarly, if producers' surpluses are expatriated overseas by foreign shareholders, they would not be included as foregone benefits.

2.2 Estimation of foregone producers' surplus

The foregone producers' surplus resulting from the reservation of forests is defined as the difference between the marginal costs of production and the price received for the units of output that would have been sourced from the reserved forests. The ABARE model, FORUM, affords the estimation of the value of this opportunity cost.

FORUM uses linear programming to allocate available forest resources – as detailed for each option by the State Forests model FRAMES - between alternative points of processing and final market options. Its objective function is to maximise the net present value (producers' surplus) of forest outputs through time. For each time period, this involves the subtraction of the costs associated with forest management, harvesting, transportation and milling from the revenues generated from the sale of saw logs and woodchips.

The model allows the calculation of the net present values yielded by alternative forest management options. To calculate the opportunity cost associated with each protection option, a three-stage process is necessary. First, FORUM is run to estimate the net present value of forest resource use under conditions that reflect the status quo (the reference point). Second, FORUM is re-run to estimate the producers' surplus for the proposed protection option. Finally, the difference between the two producers' surplus estimates is calculated as the foregone producers' surplus.

FORUM does, however, have certain limitations. The marginal costs of production embodied in the model are not all inclusive. Specifically, the opportunity costs of the land on which the forests are growing are omitted. Similarly, the costs of infrastructure developments on that land are not considered. In addition, the costs relating to the management of the forests that are incurred in the head office of State Forests are not included. The implication of these omissions is that the producers' surplus estimates generated by FORUM will be overstated.

The (raw) foregone net values of production under each of the reservation options are displayed in Table 1. In order to account for the expropriation of producers' surpluses overseas, the net values of production can be adjusted to include only the tax paid on profits by foreign owned producers. Details of this adjustment process cannot be given because they involve commercial in confidence data. Rather, the adjusted foregone producers' surplus values for the two reservation options are reported along with the raw estimates in Table 1. Estimates under two discount rates (i) are reported.

Table1 : Foregone producer surpluses (million $ 1997)

	Scenario A		Scenario B	
i	Raw	Adjusted	Raw	Adjusted
5%	92.43	37.21	34.67	2.74
8%	72.47	29.21	28.21	3.12

2.3 Estimation of foregone consumers' surplus

The foregone consumers' surplus for the preservation options under consideration relates only to the timber products that are consumed by Australians. Hence, the consumers' surplus generated by export sales is not relevant to the threshold valuation exercise. The approach taken here therefore is to consider only the change in consumers' surplus generated by the domestic sale of saw logs.

Bennett (1991) estimated the consumers' surplus effects resulting from forest management options for Fraser Island. It was found that the lost consumers' surplus ranged between 5 and 10% of the concurrent losses in producers' surplus, depending on the degree to which the price of sawn timber could be expected to rise following supply reductions. On the basis of this result, lost consumers' surpluses resulting from the two reservation options for the Eden forests are reported in Table 2. All estimates are based on an assumption that consumers' surplus losses are in the order of 8% of sawn timber producers' surplus losses.

Table 2: Foregone consumer surpluses (million $ 1997)

i	Scenario A	Scenario B[1]
5%	0.49	-1.2
8%	0.39	-0.89

2.4 The threshold

Aggregating the lost producer (adjusted for profits expatriated overseas) and consumers' surplus yields an estimate of the total surplus foregone due to the alternative forest reservation options. These estimates are presented in Table 3.

Table 3: Foregone extractive values (million $ 1997)

i	Scenario A	Scenario B
5%	37.70	1.54
8%	29.60	2.23

The data in Table 3 can be interpreted for each cell in the following manner. Using a discount rate of 5%, the present value of the cost to the Australian community that would result from the implementation of Scenario A is $37.7m. In terms of the threshold value analysis, this implies that unless the community is judged to enjoy the additional benefits of forest protection arising from this option to an extent that is greater than $37.7m, then timber extraction should be permitted. The critical question facing the decision makers for the Scenario A option (at a 5% discount rate) is therefore:

Is the present value of the benefits of protecting the forests under Scenario A worth more than $37.7m?

3. Dynamic Threshold Value Analysis

3.1 Differential rates of change

The TVA undertaken in the first part of this paper uses data that reflect a static state of the world in that the demands for both the extractive and protective uses of the forest areas are assumed to be constant through time. This is clearly not the case in reality. A more appropriate analysis involves these values changing through time to reflect changes in economic and social circumstances. Importantly, recognition should be given to the ways in which the rates of change applying to extractive and protection values differ. In this part, such a dynamic analysis is undertaken. A

[1] Note that the negative foregone consumer surpluses reported for this option occur because sawn timber producer surplus rises under this management regime even though overall producer surplus falls.

consideration of the factors that may underpin differential rates of change is outlined first.[2]

Extractive values

The extractive uses of the forest involve the conversion of natural resources into intermediate products that in turn satisfy demands for the production of final products. For instance, hardwood timbers are cut and converted into structural timbers in order to satisfy the demand for products such as house frames. Wood chips are harvested to produce pulp and thence paper and card. In all cases, the outcomes are "producible" goods. This implies that the supply of these goods (both at the intermediate and final stages) can be enhanced over time. Furthermore, substitutes for both the final and the intermediate products exist. This improves the potential for supply enhancement over time. Hence, any increase in the demand for house frames can be met by enhanced production from existing hardwood forests, especially with the introduction of more advanced growing, harvesting and milling methods resulting from technological improvements. In addition, those increases in demand may also be met by supplies of laminated softwoods or even alternative, non-timber products such as steel.

These characteristics imply that the value of the benefits derived from extractive uses of the forest can fall through time. The nature of the fall is dependent on the rate of technological advancement. Given that be_0 is the extractive value enjoyed in the current year, then be_t is the extractive benefit in year t. In undiscounted terms:

$$be_t = be_0 (1 + \alpha e)^t$$

where αe is the rate of growth in the extractive benefit per annum.

Because of technological change, αe is negative. Furthermore, for negative αe:

$$(1+ \alpha e) = \frac{1}{(1 + r)} \quad .$$

where r is the rate of technological change in the extractive industry, given that for small values of αe, r will approximate αe.

Hence:

$$be_t = \frac{be_0 (1)^t}{(1 + r)^t}$$

Figure 1 illustrates this function.

[2] The analysis that follows is based on the work of Krutilla and Cicchetti (1972) and the subsequent Australian application carried out by Saddler, Bennett, Reynolds and Smith (1980).

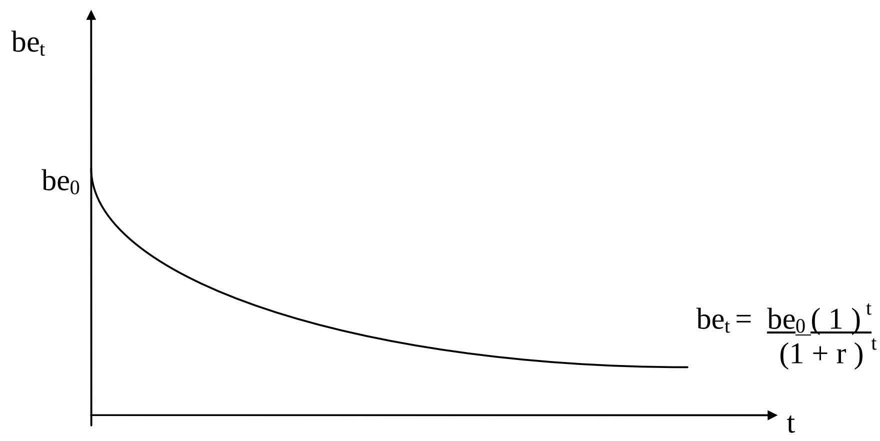

Figure 1: Extractive benefits through time

When the value of time is incorporated into this expression using a discount rate of i, then the present value of the stream of benefits from the extractive use of the resource, PVe becomes:

$$PVe = \sum_{t=1}^{T} \frac{be_0 (1)^t}{(1+i)^t (1+r)^t} \qquad \text{............ (equation 1)}$$

where T is the time span under consideration

The implication of this is that the discounting process as applied to a stream of extractive benefits is accelerated. Hence, the present value of the stream of extractive benefits under the dynamic model will be less than that calculated under the static model. The static model therefore overestimates the extent of the opportunity costs associated with protecting the forest. The threshold value that the protective values must exceed for forest protection to be a superior resource allocation to forest extraction is lowered under the dynamic model. The process involved is demonstrated in Section 3.2.

Protective values

The situation where protective uses of the forest resource are involved is in marked contrast to the case described above for extractive values. For protective uses, the services provided by the forest enter directly into the utility function of the individual. That is, the benefits of forest protection are enjoyed directly by people. Furthermore, the services supplied by protected areas are not producible. Hence, their supply cannot be increased in response to increasing demands. It is also the case that once the supply has been reduced (say due to extractive use) it may be the case that the reduction is irreversible. That is, the regrowth of the forest after harvesting may not be able to supply the same services as the original, old growth forest.

The implication of these characteristics is that substitutes for the protective use of the forest are not as readily forthcoming as they are for the extractive use products. Hence, as demand increases through time for the protective use, the benefits so derived will increase. For an initial protective benefit of bp_0, the protective benefit in year t, bp_t, is given by:

$$bp_t = bp_0 (1 + \alpha p)^t$$

where αp is the rate of growth of the protective benefit and is positive. Because αp is likely to be positive, bp_t will be an increasing function over time. Figure 2 illustrates this function.

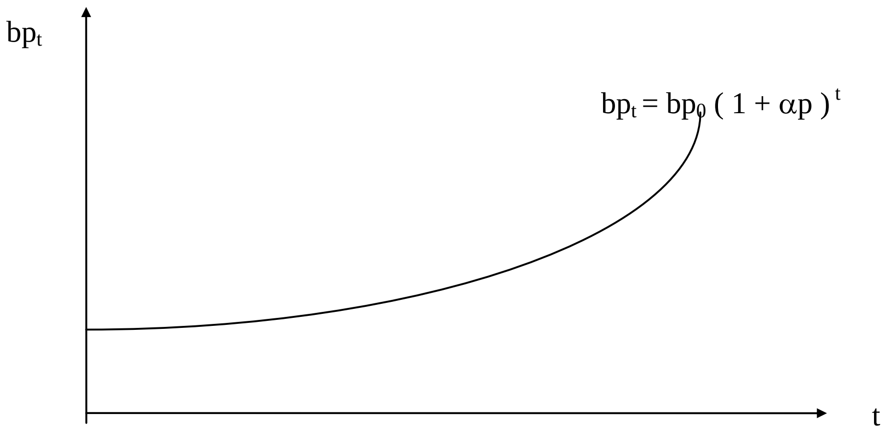

Figure 2: Protective benefits through time

A feature of this relationship is that the growth rate acts to counteract the effect of the discounting process. If αp is greater than i, the discount rate, then the present value of the stream of protective values through time is infinite. Under the more reasonable scenario of αp being positive but less than i, the effect is one of moderating the rate at which future values are discounted.

$$PVp = \sum_{t=1}^{T} \frac{bp_0 (1 + \alpha p)^t}{(1 + i)^t} \quad \text{............. (equation 2)}$$

A number of factors influence the rate of growth of protective benefits. These are, in essence, the factors that drive and constrain increases in the demand for protective values. It is likely that, because of these factors, αp will be non-uniform. In other words, because the factors driving and constraining demand increases will change through time, the rate of growth of protective benefits will vary through time.

To understand the way in which αp varies through time, it is therefore important to understand the nature of the protective benefit and the factors that affect it. A stylised demand curve for protected forest areas in the initial year is depicted as D_1D_1' in Figure 3. The supply of these areas is depicted as SS'. This is a vertical line because the supply of these areas cannot be increased through time.

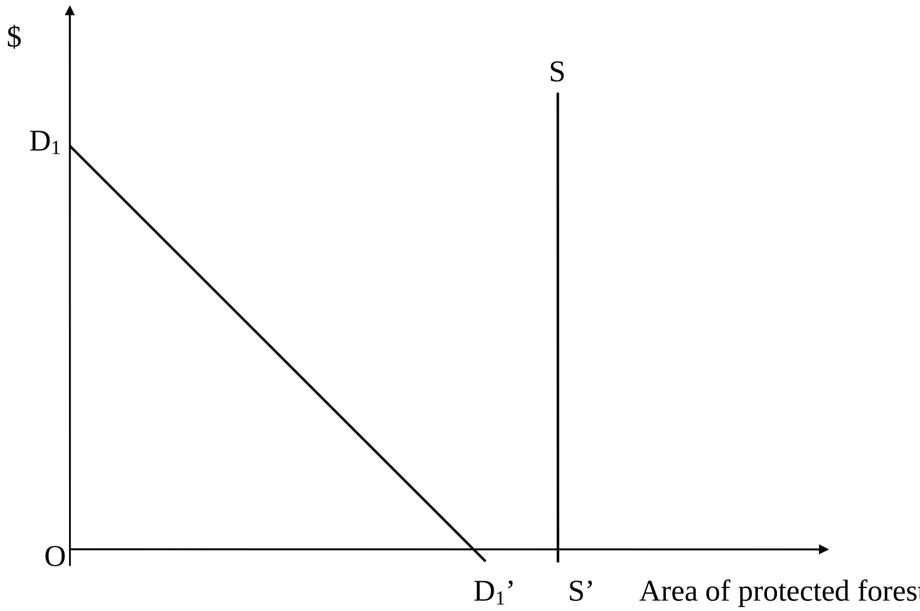

Figure 3: Initial year benefits of protection

The benefits of protecting the forests (bp_0) are defined by the consumers' surplus so generated. This is the area below the demand curve (D_1D_1'O). Through time, the demand curve D_tD_t' shifts to the right and the benefits of protection increase. Two parameters drive this shift and the consequential growth in benefits. The first determines the extent to which D_tD_t' shifts up the vertical axis. This is the rate of growth in the willingness to pay for any given level of protected forest (w). The second determinant governs how far D_tD_t' shifts along the horizontal axis. This is the rate at which demand would grow given a zero price (c).

If it is assumed that w is proxied by the rate of growth in per capita income in the economy and that c can be observed from current trends in the growth of forest protection services consumption, then a preliminary estimation of the present value of protective benefits through time can be achieved from the equation:

$$PVp = \sum_{t=1}^{T} \frac{bp_0 (1 + w + c)^t}{(1 + i)^t} \quad \text{............. (equation 3)}$$

However, the increases in protective benefits are unlikely to grow at a constant rate. It is likely that the growth rate will slow. As far as direct use of the protected areas is concerned, the primary reason for this slowing is the carrying capacity of the areas. This is defined as the time when the demand curve D_tD_t' shifts along the horizontal axis to equal the level of supply. Shifts of demand beyond that point will cause the protective benefits to rise but at a slower rate. Figure 4 demonstrates how consumers' surplus growth is limited by the capacity constraint.

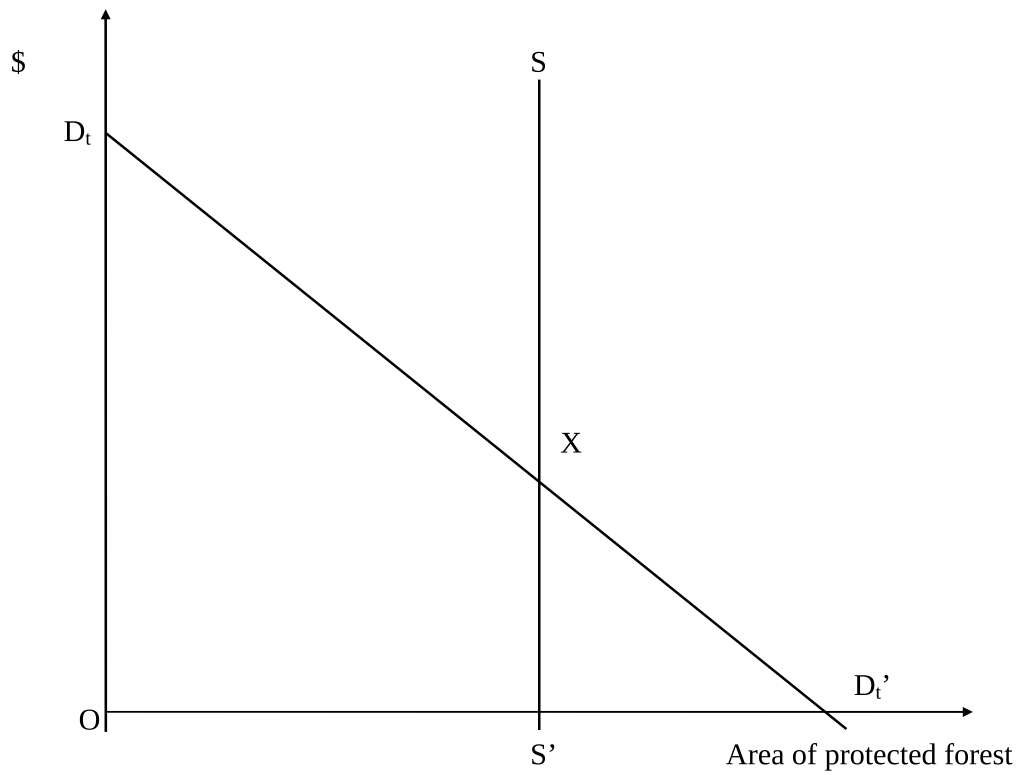

Figure 4: Protective benefit in subsequent year t.

Given demand at D_tD_t', the consumers' surplus is restricted to the area D_tXS'O. Whilst this is larger than the previous year's benefit, the growth rate is smaller than had the capacity constraint not been evident.

The value of c in equation 3 must therefore be carefully defined through time to account for the impact of the capacity constraint. Four different phases through time can be expected for the value of c:

1. From the outset to the time at which the supply constraint is reached (t = 0 to k), c could be expected to be maintained at current levels;
2. After the capacity constraint is reached, c could be expected to decline over time (as c*) until it falls to equal the rate of growth of the population, c_m (t = k+1 to m);
3. For a further period of time, c remains equal to the rate of growth of the population, c_m (t = m + 1 to z); and,
4. The final phase (t = z+1 to ∞) involves no growth at all.

For an initial year's protective benefit, bp_0 (now called B), the full model of the present value of the growing stream of benefits becomes:

$$PV_p = B \sum_{t=0}^{k} \frac{(1+w+c)^t}{(1+i)^t} + B \sum_{t=k+1}^{m} \frac{(1+w+c^*)^t}{(1+i)^t} + B \sum_{t=m+1}^{z} \frac{(1+w+c_m)^t}{(1+i)^t} + B \sum_{t=z+1}^{\infty} \frac{(1+w+c_m)^{z-m}}{(1+i)^t} \quad \text{...Equation 4}$$

The effect of this process is overall to decrease the impact of the discounting process on the extent of the present value of protective benefits. The exact magnitude of this impact is determined by the values of all the parameters that define the model. The process involved is described in section 3.3.

3.2 Re-estimating foregone extractive values

Applying equation 1 to re-estimate the foregone extractive values detailed for the static analysis detailed in sections 2.2, 2.3 and 2.4 requires an additional piece of information - the rate at which substitution is possible between the existing output of the Eden forests and alternatives. This rate, to a large extent, is driven by the rate of technological advance. Estimates of this rate are very difficult to derive. In the past, substitution for hard wood products has been made possible by numerous technological advances, primarily relating to the use of plantation softwoods in the construction industry and in the production of papers and packaging. As a conservative estimate, it is assumed that the rate of technological change affecting the timber products industry will be in the order of one per cent per annum.

In Table 4, the foregone extractive values relating to the reservation options are displayed given a one per cent change in technology every year, at two discount rates.

Table 4: Foregone extractive value under technological change ($m ‘97)

i	Scenario A	Scenario B
5%	34.63	1.82
8%	27.54	2.41

3.3 Forest protection values over time

As detailed in section 3.1, the calculation of the present value of a stream of forest protection benefits depends not only on the magnitude of the initial year’s protection benefit and the discount rate but also the factors that influence the extent to which the benefit grows through time. The model detailed as equation 4, sets out the role of the various parameters in influencing the present value calculation. To implement the model, the values these parameters may take must be explored.

w

The rate at which willingness to pay for protected forests increases is defined in w. It is an estimate of the rate at which the demand curve shifts up the vertical axis through time. Krutilla and Cichetti (1972) argue that this rate should be a reflection of the rate at which per capita real income is growing. In Australia, this rate has in recent times averaged between 3 and 5% per annum. The model estimated below uses the 3%, 4% and 5% rates to test for sensitivity of the results to this parameter specification.

c

The rate of growth of consumption of protected forest benefits at a zero price, up to the carrying capacity, is defined as c. There are few studies that have investigated this rate. Krutilla and Fisher (1975) report US data indicating a range from 10 to 45%. Saddler *et al* (1980) use a more conservative range of estimates between 7.5 and 12.5%. This is in line with the more recent findings of Worboys (1997).

k

The carrying capacity of the protected forests is defined as k. This is a difficult parameter to estimate because there are little data regarding current use levels and even less regarding what can be regarded as a carrying capacity. Necessarily, the latter is a subjectively defined parameter because of differing perceptions of what is the carrying capacity. The approach used by Saddler et al (1980) is advocated here. The carrying capacity is assumed to be at 20 times the current use level. Combining this judgement with the assumed values for c and it can be calculated that k is 40 years when c is 7.5%, 30 years when c is 10% and 25 years when c is 12.5%.

m

The time at which the rate of growth of consumption falls to the population growth rate is defined as m. There is little on which to base this estimate. 50 years is used by Saddler et al (1980) for Australia over 10 years ago. Hence 40 years is used here.

z

The time at which no further growth is experienced. Again, an assumption is made that this occurs at 50 years.

c_m

Population growth rates in Australia are assumed to be stable at around 0.6% in thirty years time

*c**

The rate of growth in consumption is assumed to decline between time period k and time period m. This rate c* is therefore determined by the parameters k, m and c_m. The decrease in c*, using a straight line decay function is:

when c = 7.5%	c* decreases at	0.0 %	per annum (note: k=m)
=10.0%	“	0.94 %	“
= 12.5%	“	0. 79 %	“

i

The discount rate i is sensitivity tested using 5 and 8%

The model is implemented by calculating the present value of $1 initial year’s benefit from the protected forest areas under the range of parameter values specified above. Through this process, the sensitivity of the results to changes in the values of the parameters can be tested. The results of the model calculations are presented in Tables 5 and 6.

Table 5: Present Value of $1 initial year’s protection benefit (i=5%)

i = 5%	c = 7.5%	c = 10%	c = 12.5%
m = 40	k = 40	k = 30	k = 25
w = 3%	$143.67	$154.45	$181.74
w = 4%	$184.56	$191.99	$222.82
w = 5%	$238.90	$240.15	$274.76

Table 6: Present Value of $1 initial year's protection benefit (i=8%)

i = 8%	c = 7.5%	c = 10%	c = 12.5%
m = 40	k = 40	k = 30	k = 25
w = 3%	$69.33	$80.78	$98.99
w = 4%	$86.24	$98.01	$117.08
w = 5%	$107.34	$119.72	$142.16

Hence:

- at a discount rate of 8% (i);
- with incomes rising at 4% (w);
- consumption of protected forest areas rising initially at 10% (c); and,
- consumption falling to equal the growth in population in 40 years time (m);

the present value of $1 worth of current year forest protection benefits is approximately $98.

3.4 The initial year's threshold

In section 3.2, the present values of the extractive benefits foregone as a result of the reservation option were presented. To estimate the threshold value for protection benefits in the initial year, these extractive values, as opportunity costs of forest protection, are divided by the present values of protective benefits growing from an initial value of $1 as calculated in the previous section. These dynamic threshold values are displayed in Tables 7 and 8.

Table 7: Current year threshold values for protective benefits: Scenario A

i = 5%	c = 7.5%	c = 10%	c = 12.5%
m = 40	k = 40	k = 30	k = 25
w = 3%	$241,038	$224,214	$190,546
w = 4%	$187,635	$180,373	$155,416
w = 5%	$144,956	$144,201	$126,037

i = 8%	c = 7.5%	c = 10%	c = 12.5%
m = 40	k = 40	k = 30	k = 25
w = 3%	$397,230	$340,925	$278,209
w = 4%	$319,341	$280,991	$235,223
w = 5%	$256,567	$230,036	$193,725

Table 8: Current year threshold values for protective values: Scenario B

i = 5%	c = 7.5%	c = 10%	c = 12.5%
m = 40	k = 40	k = 30	k = 25
w = 3%	$12,667	$11,783	$10,014
w = 4%	$9,861	$9,479	$8,168
w = 5%	$7,618	$7,578	$6,623

i = 8%	c = 7.5%	c = 10%	c = 12.5%
m = 40	k = 40	k = 30	k = 25
w = 3%	$34,761	$29,834	$24,345
w = 4%	$27,945	$24,589	$20,584
w = 5%	$22,452	$20,130	$16,952

Again using the scenario of:
- a discount rate of 5% (i);
- with incomes rising at 4% pa (w);
- consumption of protected forest areas rising initially at 10% pa (c); and,
- consumption falling to equal the growth in population in 40 years time (m);

then the current year threshold value for the protective benefits provided by the Scenario B option is $ 1.82m/191.99 = $9,479. The comparable value for the Scenario A option is $180,373.

In other words, the protective benefits of the forests reserved under the Scenario B option in the current year, given the situation outlined by the assumed parameter values, would need to be greater than $9,479 for the reservation decision to be in the best interests of the Australian community. For the Scenario A option, the current year benefits of the forests protected under that option would need to exceed $180,373 for the option to be desirable from a community wide perspective.

The data in Tables 7 and 8 demonstrate the sensitivity of the threshold values to the range of parameter assumptions that have been made. Of particular note are the impacts made on the threshold values by the choice of:
- discount rate (the increase in discount rate from 5% to 8% causes the threshold value to approximately double)
- income (cutting the rate of income growth from 5% to 3% causes the threshold value to rise by approximately 50%)
- consumption trends (reducing the rate of growth of protected forests from 12.5% per annum to 7.5% per annum results in an increase in the threshold value by approximately 40%)

Clearly, the selection of these parameter values is of great importance to the decision making process. However, once they have been chosen, the critical decision for policy makers is whether the protective benefits of the alternative options that will be enjoyed in the space of the current year are worth their threshold values. This determination would be benefited by some quantification of those protective benefits, however, such an exercise is outside the scope of this study. Rather, an analysis of benefit estimates generated by other studies is used to provide some perspective for the threshold value estimates.

4. Benefit transfers

The decision regarding the setting aside of forest areas from timber production still requires an understanding of the likely magnitude of the current year's forest protection value. It is this understanding that enables the threshold value to be assessed.

To provide some understanding of the forest protection values, the results of other studies that have estimated similar values can be analysed. The benefits estimated in these other studies can be considered in terms of their suitability for "transfer" to the Eden context. This process of "benefit-transfer" must be undertaken with considerable caution. The physical circumstances in which the original values were estimated may be very different from those existing in the current context. Furthermore, the population of people who enjoyed the originally estimated benefits may have different value structures to those whose values are important in the Eden forests situation. These differences must be taken into account when transferring benefit estimates from one context to another.

4.1 Types of values

In order to understand better the nature of the forest protection benefits under consideration, a further element of the process is the identification of their various components. Forest protection benefits can be classified broadly into use and non-use values.

Use values involve beneficiaries experiencing first hand the forest ecosystem. Non-use values are enjoyed even without that direct contact. Use values are mostly associated with tourism and recreation activities such as sight seeing, camping or bush walking.[3]

Non-use values are more complex in their classification. Passive use values do not involve direct contact with the environment and as such are non-use values but they do involve a "second-hand" experience. Hence, those people who enjoy reading books or watching films that are based on the environment enjoy a passive use value. Likewise, people who benefit from scientific advances that have been made through research undertaken in a protected forest are also passive users as are those who enjoy high quality water supplies that have originated in protected forest catchments.

Other non-use values do not even involve this type of indirect contact. These are known as existence benefits and they are held by people who simply enjoy the knowledge that some forest areas have been set aside in reserves even though they have no wishes to visit them. Existence benefits may be held because of a desire on the part of one person that others may experience either the passive use or use values provided. These are vicarious values. Where this desire extends to members of future generations, this value has been described as bequest value.

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[3] Note that this type of benefit may extend to what is known as "option value" when there is uncertainty regarding either the availability of the resource or the strength of demand for it. However, it is difficult to predict *a priori* if option value is positive or negative. Quasi option value is enjoyed when a decision to irreversibly alter an environment can be delayed in order to collect more information regarding the net benefit that the community would enjoy from establishing a reserve.

4.2 Disaggregating values

It is often difficult to determine the exact composition of the total value of the benefits arising from forest protection. It is clear that the various components of the use and non-use values are heavily interrelated. For instance, the generation of existence benefits is dependent on people learning about a protected area. This may occur because of direct use or from the products of passive use (say the viewing of a television programme featuring a protected area). Those enjoying use values may also hold bequest values for their children. Hence, from a theoretical perspective the distinctions between classifications are fuzzy.

Quantifying the structure of forest protection benefits is even more challenging. Most forest protection value estimation exercises use stated preference techniques. These techniques rely on respondents to a questionnaire indicating their reactions to hypothetical scenarios. For instance, respondents may be asked if they are willing to pay a tax surcharge for certain proposed forest reserves to be established. It is very difficult to construct plausible and realistic scenarios in such questionnaires that target anything but the aggregate of all values that arise from the protection of forests. Even questions which relate directly to the recreation use of a proposed reserve (say asking about the willingness to pay an entrance fee) cannot be guaranteed to stimulate responses that segregate use values apart from non-use values. Respondents may, for instance, be willing to pay an entrance fee to use the reserve and to know that the reserve is available for others to enjoy and as a place for wildlife to inhabit.

What is possible is to draw on the range of studies that have attempted to estimate various types of values in different forest decision situations and generate indicative proportions of total benefits for each benefit type. This provides some guidelines for decision-makers in their efforts to understand more fully the type and magnitude of benefits a forest protection is likely to generate.

Walsh, Bjonback, Aiken and Rosenthal (1990) have estimated the proportion of the total value generated by forest quality protection programmes. This was achieved through an application of the contingent valuation method (CVM) together with a sequence of questions whereby respondents were asked to allocate their stated willingness to pay values across four categories of benefit; recreation value, option value, existence value and bequest value. These proportions and the willingness to pay values are set out in Table 9.

Also presented in Table 9 are the proportions of total value that were derived in a study wilderness values (Walsh, Loomis and Gillman 1984)

Table 9: Proportional disaggregation of forest protection values

	Walsh et al (1990)		Walsh et al (1984)			
			1.2m acres		10m acres	
Value category	Allocation %	WTP per person pa (US$-1988)	Allocation % of total value	WTP per h'hold pa (US$-1980)	Allocation % of total value	WTP per h'hold pa (US$-1980)
Recreation use	27.4	13	46	14	62	14
Option value	21.9	10	16	4.04	11	9.23
Existence value	21.1	10	19	4.87	13	11.14
Bequest value	29.6	14	19	5.01	14	11.46
Total non-use value	72.6	34	54	13.92	38	31.83

The two studies reported give different pictures of the proportional disaggregation of the total forest protection value. The earlier study found that the ration of use to non-use values was in the order of 1:1 for lower levels of wilderness protection (1.2m acres protected), rising to almost 2:1 for greater levels (10m acres protected). However, the more recent study estimates the ratio at approximately 1:3. The analysis of forest protection values undertaken by the Resource Assessment Commission for the forest and timber inquiry (see Bennett and Carter 1993) supported the 1:3 ratio and it is this that will be taken as applicable for the current analysis. Similarly, whilst the "disaggregation" categories used by Walsh et al (1990) do not conform exactly with that described above, and as such can be regarded as less than complete, the proportions estimated will be adopted for this analysis.

Taking the mid range threshold values for the current year's forest protection values:

Scenario A: $261,633
Scenario B: $20,692

the disaggregated thresholds (indicative) are set out in Table 10.

Table 10: Disaggregated dynamic threshold values for the current year's forest protection values (approximate)

	Scenario A	Scenario B
Recreation use value	$72,000	$5,700
Option value	$57,300	$4,500
Existence value	$55,200	$4,300
Bequest value	$77,400	$6,100

In other words, for the forest protection areas under Scenario A to be set up, the additional recreational use values that must be generated are in the order of $72,000 in the current year. For Scenario B, the comparable figure is $5,700.

To put this in perspective, a number of travel cost studies carried out in northern NSW (Bennett 1996) have shown that the value of a day's recreation is in the order of $40. This in turn implies that for Scenario A to be socially desirable, an additional 1,800 days of recreational use would be required[4]. Hence, if more than 1,800 days of extra visitation would be generated by the declaration of the reserves defined by Scenario A, the reserves should be established. Similarly, 140 days of additional visitation would be required to justify the declaration of reserves defined under Scenario B.

Another helpful source of data for comparison against these threshold values is Loomis, Lockwood and Delacy (1993). In that study, the protection of unreserved National Estate Forests in south eastern Australia was valued at approximately $100 per individual per annum. Given that this value reflects the total value of protecting forest areas, the implication is that to protect the forest areas defined under Scenario A would require around 2,600 people to support the proposal in the current year. For Scenario B, 200 current year supporters would be required.

4. Conclusions

The threshold values estimated in this paper demonstrate that the protection of the Eden region forests under the Scenario A and B options investigated cause costs to the Australian community. These costs are the opportunity costs associated with the surpluses that could otherwise have been generated from forest extraction. The more forests that are protected, the greater are those costs. Hence, the threshold values estimated for the Scenario A option are generally greater than those for the Scenario B option.

For the Scenario A option, the protection value thresholds (in the current year) of the forests which are proposed under that option for reservation range from $126,037 to $397,230 (mid point $261,633). The range for the Scenario B option is from $6,623 to $34,761 (mid point $20,692). So whilst the Scenario A option is the most costly to society in terms of the opportunity costs incurred, it also offer the most by way of forest protection values. The Scenario B option is less costly but offers less forest protection. Decision makers must consider the likely magnitude of the forest protection values generated in the current year relative to their threshold values estimated here. The likely extent of these forest protection values have been put into some context through the use of the benefit transfer technique.

A number of caveats must be recognised in considering these results.

- The threshold values estimated have been subjected to some sensitivity analyses. It has been demonstrated that the estimates are sensitive to a number of parameters. The values of the parameters used for this analysis may vary outside the range of values specified. Hence, the actual values may differ from those reported here.
- The lost producer surplus values estimated for this analysis have been adjusted to reflect the extent to which some surpluses may be expatriated overseas.
- Due to the difficulty of assigning costs to activities, certain costs (including overheads) associated with the State Forest's management of the Eden hardwood

[4] Mid points of the threshold value ranges are used for these comparative analyses.

resource have not been subtracted from the producer surpluses foregone. This implies that the threshold values are lower than those reported here.

- The process of transferring benefit estimates from one study to another context can be problematic.

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A THRESHOLD VALUE ANALYSIS OF PROPOSED FOREST RESERVES

Jeff Bennett

1. **Benefit Cost Analysis and Threshold Value Analysis**

2. **The Eden case study**

3. **Static analysis**
    - **Foregone producers' surplus**
    - **Foregone consumers' surplus**

4. **Dynamic analysis**
    - **Extractive values**
    - **Protective values**

5. **Benefit Transfer**

1. BCA and TVA

- **BCA:**

  protect the resource if the estimated benefits to society derived from its protection exceed the estimated benefits derived from its development

- **TVA:**

  protect the resource if the decision makers assess that the benefits to society from its protection exceed the estimated benefits derived from its development.

OR:

are the benefits of protecting the resource greater than the value of the extraction benefits that will be given up?

2. The Eden Case Study

A component of the Regional Forestry Agreement process

Two forestry options considered:

- **Scenario A (advanced by the conservation lobby)**
- **Scenario B (advanced by the NSW NPWS and SF)**

Relative to the "reference option" "full forestry production outside current legal reserves"

3. Static Analysis

• Foregone Producers' Surplus

Table1 : Foregone producer surpluses (million $ 1997)

	Scenario A		Scenario B	
I	Raw	Adjusted	Raw	Adjusted
5%	92.43	37.21	34.67	2.74
8%	72.47	29.21	28.21	3.12

• Foregone Consumers' Surplus

Table 2: Foregone consumer surpluses (million $ 1997)

I	Scenario A	Scenario B
5%	0.49	-1.2
8%	0.39	-0.89

• The threshold

Table 3: Foregone extractive values (million $ 1997)

i	Scenario A	Scenario B
5%	37.70	1.54
8%	29.60	2.23

4. Dynamic Analysis

• Rates of change for extractive values

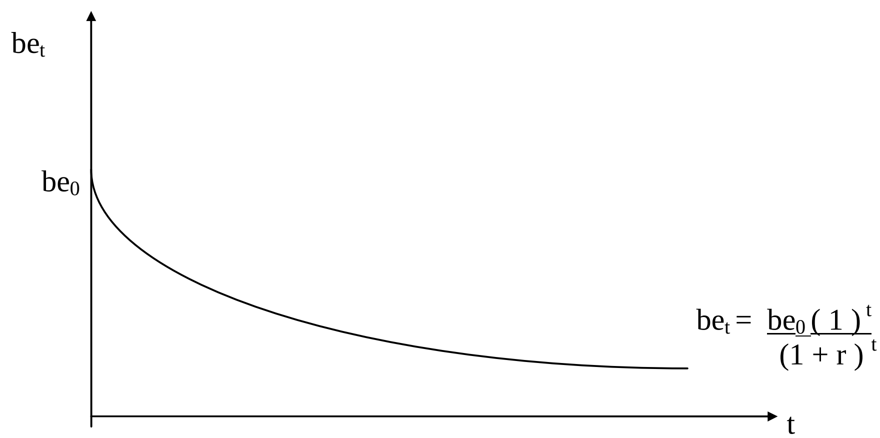

Figure 1: Extractive benefits through time

• Rates of change for protection values

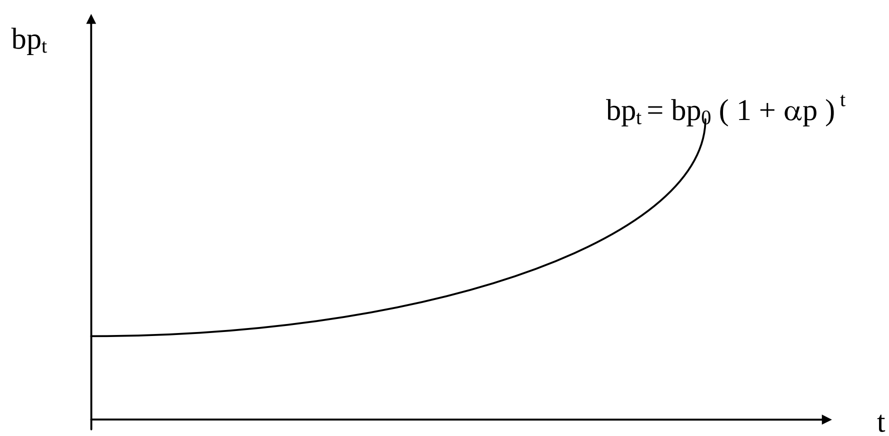

Figure 2: Protective benefits through time

• Re-estimated extractive values foregone

Table 4: Foregone extractive value under technological change ($m '97)

i	Scenario A	Scenario B
5%	34.63	1.82
8%	27.54	2.41

• Re-estimated protection values foregone

Table 5: Present Value of $1 initial year's protection benefit (i=5%)

i = 5%	c = 7.5%	c = 10%	c = 12.5%
m = 40	k = 40	k = 30	k = 25
w = 3%	$143.67	$154.45	$181.74
w = 4%	$184.56	$191.99	$222.82
w = 5%	$238.90	$240.15	$274.76

Table 6: Present Value of $1 initial year's protection benefit (i=8%)

i = 8%	c = 7.5%	c = 10%	c = 12.5%
m = 40	k = 40	k = 30	k = 25
w = 3%	$69.33	$80.78	$98.99
w = 4%	$86.24	$98.01	$117.08
w = 5%	$107.34	$119.72	$142.16

• The initial year's threshold

Table 7: Current year threshold values for protective benefits: Scenario A

i = 5%	c = 7.5%	c = 10%	c = 12.5%
m = 40	k = 40	k = 30	k = 25
w = 3%	$241,038	$224,214	$190,546
w = 4%	$187,635	$180,373	$155,416
w = 5%	$144,956	$144,201	$126,037

i = 8%	c = 7.5%	c = 10%	c = 12.5%
m = 40	k = 40	k = 30	k = 25
w = 3%	$397,230	$340,925	$278,209
w = 4%	$319,341	$280,991	$235,223
w = 5%	$256,567	$230,036	$193,725

Table 8: Current year threshold values for protective values: Scenario B

i = 5%	c = 7.5%	c = 10%	c = 12.5%
m = 40	k = 40	k = 30	k = 25
w = 3%	$12,667	$11,783	$10,014
w = 4%	$9,861	$9,479	$8,168
w = 5%	$7,618	$7,578	$6,623

i = 8%	c = 7.5%	c = 10%	c = 12.5%
m = 40	k = 40	k = 30	k = 25
w = 3%	$34,761	$29,834	$24,345
w = 4%	$27,945	$24,589	$20,584
w = 5%	$22,452	$20,130	$16,952

5. Benefit Transfers

Table 10: Disaggregated dynamic threshold values for the current year's forest protection values (approximate)

	Scenario A	Scenario B
Recreation use value	$72,000	$5,700
Option value	$57,300	$4,500
Existence value	$55,200	$4,300
Bequest value	$77,400	$6,100