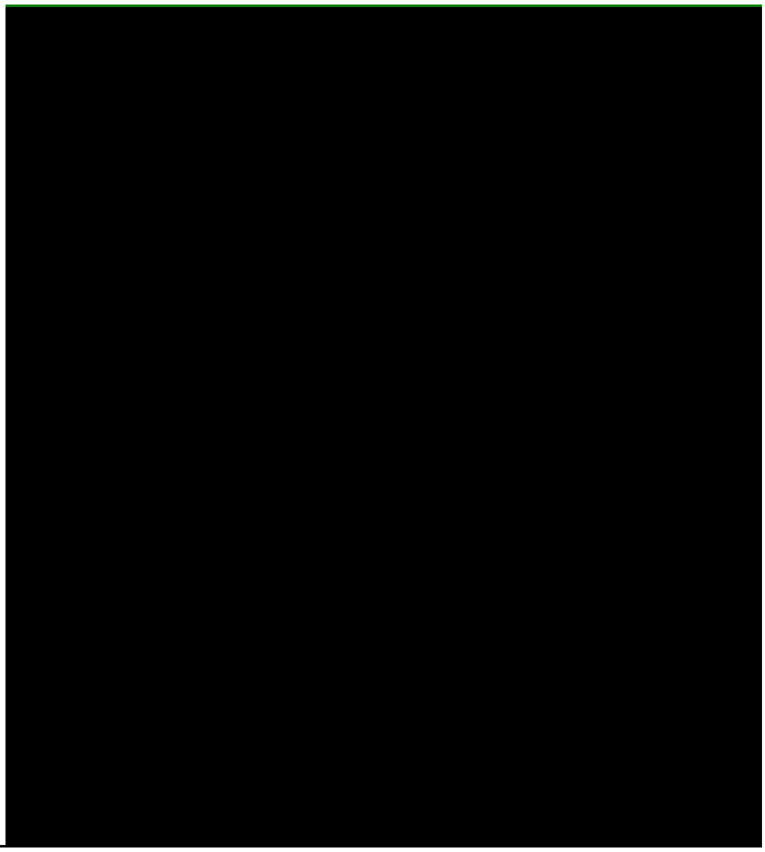
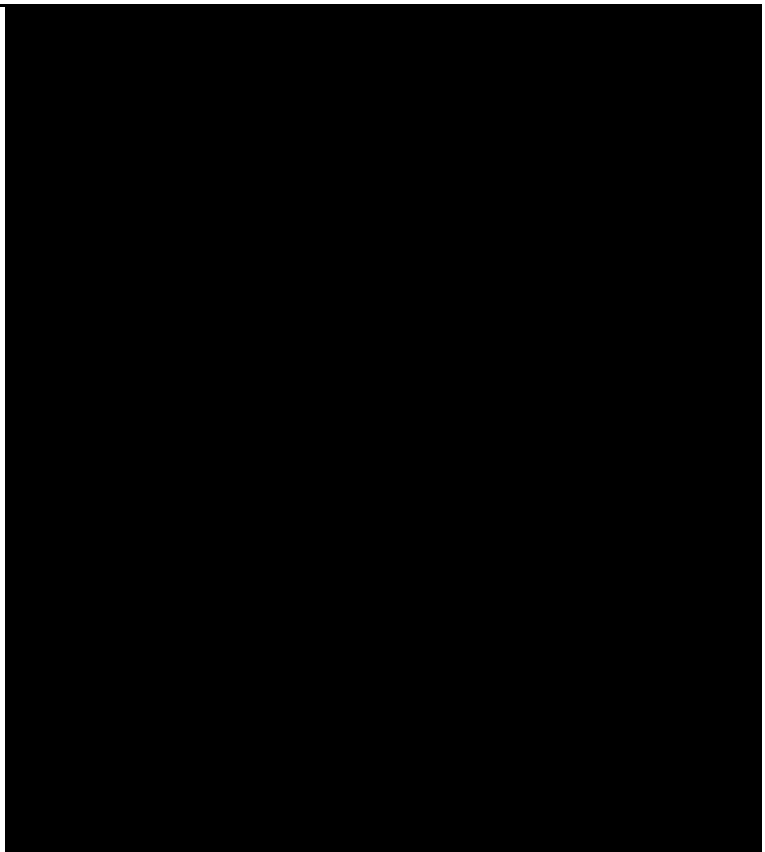


Benefit Transfer Threshold Value Analysis of Non-Use Values of Forest Preservation
Upper and Lower North East Regions

A project undertaken as part of the NSW Comprehensive Regional Assessments



BENEFIT TRANSFER THRESHOLD VALUE ANALYSIS OF NON-USE VALUES OF FOREST PRESERVATION

UPPER AND LOWER NORTH EAST REGION

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ENVIRONMENTAL AND RESOURCE ECONOMICS

A project undertaken as part of the
NSW Comprehensive Regional Assessments
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EXECUTIVE SUMMARY

This working paper describes a project undertaken as part of the comprehensive regional assessments of forests in New South Wales. The comprehensive regional assessments (CRAs) provide the scientific basis on which the State and Commonwealth Governments will sign regional forest agreements (RFAs) for major forest areas of New South Wales. These agreements will determine the future of these forests, providing a balance between conservation and ecologically sustainable use of forest resources.

The basic idea behind the Threshold Value Analysis (TVA) is to estimate the value that the benefits of protecting the ecosystems in the proposed reserves would need to reach for it to be in the community's best interest to have the reserves established.

The TVA is consistent with the notions of economic efficiency that underpin benefit cost analysis (BCA). A complete BCA of the choice to establish the forest reserve would involve the estimation of all the benefits of forest protection AND the foregone benefits of the extractive uses of the forest areas – known as the opportunity costs of forest protection. The decision rationale under BCA is:

dedicate the forest reserves if the estimated benefits to society derived from their protection exceed the estimated benefits derived from extractive uses of those forests that are foregone.

However, in this case, the benefits of forest protection are not to be estimated. The BCA logic is thus converted to a threshold value logic. The decision rational under TVA is:

dedicate the forest reserves if the decision makers believe that the benefits to society from their protection exceed the estimated benefits derived from extractive uses of those forests that are foregone.

The TVA therefore involves the estimation of the foregone extractive benefits of the forest area proposed for reservation and the setting of that estimate in a format that is useful to decision makers:

are the benefits of protecting the forests greater than the value of the extractive benefits that will be given up if the reserves are established?

The burden of estimating the value to the community of protecting the forests 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 reserve the forests, it is explicitly recognised that the benefits of forest preservation exceed the "threshold" of extractive benefits foregone. Conversely, if it is decided to allow the extractive use of the forests, then it is clear that the decision makers have concluded that the protection benefits of the forests are below the “threshold”.

The analysis contained in this report has two basic components. These include a “static” threshold value analysis and a “dynamic” threshold value analysis. The static TVA is the basic form of TVA under which the foregone extractive benefits of the forest areas being considered for reservation are estimated. Although the dynamic analysis is based on the fundamentals of static TVA, the dynamic TVA takes into account the potential for streams of benefits from forest protection and forest extraction to change asymmetrically overtime.

The static analysis indicates that for the 129,000 cu m pa option assessed, the threshold is in the order of a present value of $13m. The comparable figure for the 104,000 cu m pa option is $40m.

The dynamic analysis allowed consideration of differential growth rates between the protection and the harvesting benefit streams to be incorporated. The threshold value for the current year for the 129,000 cu m pa option must exceed approximately $120,000 for forest protection to be socially desirable. For the 104,000 cu m pa option, the forest protection benefits must exceed approximately $380,000 in the current year.

An analysis of the extent and composition of forest protection benefits estimated in other studies indicate that only moderate increases in visitation numbers in the proposed forest protection areas and relatively small numbers of people to support the proposals would be required for these threshold values to be exceeded.

1. Background

In September 1998, Environmental and Resource Economics was contracted by the NSW Department of Urban Affairs and Planning to provide a Benefit Transfer (BT) and Threshold Value Analysis (TVA) of proposed forest reserves in the Upper North East (UNE) and Lower North East (LNE) Regional Forestry Agreement (RFA) Regions.

The main aims of the consultancy are to provide an analysis of the relative values of the costs and benefits of proposed forest reserves in the two RFA regions. Two primary components of this analysis have been identified:

1. Examine the **opportunity costs** of the forest reserves. This is the amount of community benefit that will be lost if the reserves were to be established. It amounts to the surpluses that would be enjoyed by the community if forestry operations were allowed to proceed. These surpluses are enjoyed by both the producers and consumers of the timber products that would be harvested from the forests at issue if they were NOT set aside as reserves.
2. Provide some perspective on these "opportunity costs" by the presentation of information relating to the value of the **benefits** enjoyed by the community that arise from the forests if they are set aside as forest reserves. Of particular interest is the composition of these benefits, especially the non-use values of forest protection.

In the body of this report, the results of the UNE analysis are reported. Comparable results for the LNE are reported in Appendix 2.

2. A benefit cost approach

Ideally, each proposal to establish a forest reserve could be assessed using a comparison of its benefits against its opportunity costs. Under his approach, a reserve would be established only if the forest protection benefits so achieved are greater than the opportunity costs incurred. Because reserves are only established when net benefits are to be enjoyed by the community, the resource allocation that results is said to be more economically efficient.

However, several difficulties emerge with this "benefit-cost" approach. Most importantly, the benefits of forest protection are difficult to estimate in the same unit of measurement that is used to estimate the opportunity costs, ie money. Whilst such estimates can be made – and indeed have been made in the context of other resource use decisions that have involved environmental consequences – they are costly to generate. The decision has been taken not to undertake a benefit estimation exercise for the UNE RFA process. A simple comparison of benefits and costs is therefore not possible in the current context.

3. The threshold value approach[1]

The pursuit of the two components of this study is therefore to be approached from a different angle. It is relatively straight forward to estimate the opportunity costs of forest protection in monetary terms. The timber products that are foregone are bought and sold in markets. Market data can be used to estimate their value. These costs are the subject of other studies being performed for the UNE RFA process[2].

3.1 Static analysis

In the context of the decision regarding forest protection, these opportunity costs can be viewed as the value that the benefits of protecting the forests must exceed for it to be in the best interests of the community overall for the forests to be reserved from timber production. In terms of a decision rule, only if the benefits of forest protection exceed this "threshold" of opportunity costs should the forests be reserved. This is known as the "threshold value" approach to decision making.

3.2 Dynamic analysis in outline

Whilst this simple threshold value decision rule provides a useful perspective for the decision-maker, it can be modified to provide a more complete picture of the forest protection choice. The modifications relate to the differential rates of change that the opportunity costs and benefits follow through time. In general, forest protection benefits are likely to increase through time whereas the opportunity costs will most probably remain static. These differential growth rates are largely the result of the degree to which substitute goods are available for both the timber and non-timber forest products. Timber products are easily substituted. Plastics and steel can be used instead of construction timbers. Paper can be sourced from plantations of introduced species. The value of timber products, and hence the opportunity costs of forest protection, will thus remain relatively constant. The non-timber, or protection values, of forests are, however, much more difficult to substitute. For instance, habitat for endangered species cannot be readily

[1] The principles underpinning the threshold value approach have been outlined in the report of a consultancy prepared by Environmental and Resource Economics for the Resource and Conservation Assessment Council in May 1996. The consultancy was entitled "The Economic Efficiency of RACAC Resource Allocation Options: A Conceptual Framework".

[2] See Gillespie Economics (1998)

“manufactured”. Recreation in constructed or artificial sites may not be considered as providing the same experience as time spent in a protected forest reserve.

The approach taken is therefore to consider these alternative rates of growth in the streams of benefits and costs over time. This results in a threshold value comparison that relates to the current year’s forest protection values. The different rates of growth are consolidated into an indicative figure for a current year comparison. That is, the choice depends on whether decision-makers consider the current year’s forest protection benefits to exceed a threshold value. That threshold value incorporates the differential growth rates displayed by the two streams of value[3].

4. Threshold Values for the Upper North East

4.1 Static analysis

The producer surpluses associated with the alternative forest reservation options under consideration in the UNE are presented in Table 1.

Table 1: Producer surpluses per annum under alternative forest management options

	Base case (1997-98 output) $m	129,000 cu m per annum production $m	104,000 cu m per annum production $m
20% normal profit	17.97	17.08	15.50
10% normal profit	29.43	28.16	25.28

Source: Gillespie Economics (1998)

The producer surpluses displayed in Table 1 are calculated on the basis of two alternative assumptions regarding the extent of normal profits. Normal profits must be netted out from the surpluses generated by producers. This is because they represent a cost to society. That cost is the return to capital that could have been generated if the funds invested in the production process had been used elsewhere in the economy. The normal profit therefore reflects the opportunity cost of capital invested. In the same way as wages paid to employees are the opportunity costs of labour, normal profits are the opportunity costs of the capital invested by

[3] The methodology underpinning the dynamic threshold value approach is detailed in an appendix to this report.

the owners of the timber mills. The two alternative rates of return considered as normal profit are 10% and 20%.

The lost producer surpluses associated with the two alternative management options (relative to the base case) are set out in Table 2. The annual lost producer surplus is also presented as a present value calculated over a twenty year time period at two alternative discount rates, 5% and 8%.

Table 2: Foregone producer surpluses ($m) under alternative forest management option

OPTION

	129,000 cu m			104,000 cu m		
	Per annum	Present value (5%)	Present value (8%)	Per annum	Present value (5%)	Present value (8%)
20% normal profit	.89	11.13	8.77	2.48	30.89	24.33
10% normal profit	1.26	15.75	12.41	4.15	51.71	40.74

In addition to the producers' surplus that is lost as a result of forest areas being set aside as conservation reserves, some losses are incurred by the consumers of timber products. This occurs because of increases in the price of timber products. Bennett (1991) estimated the effect on consumer surplus from forest management options on Fraser Island amounted to approximately 8% of concurrent producer surplus losses. Following this result, lost consumer surpluses for the options considered for the UNE are set out in Table 3.

Table 3: Foregone consumer surpluses ($m) under alternative forest management options

OPTION

	129,000 cu m		104,000 cu m	
	Present value (5%)	Present value (8%)	Present value (5%)	Present value (8%)
20% normal profit	0.89	0.70	2.47	1.95
10% normal profit	1.26	0.99	4.14	3.26

Aggregating the foregone producer surplus and the lost consumer surplus yields an estimate of the total surplus foregone due to the alternative forest reservation options. These figures are set out in Table 4.

Table 4: Foregone timber harvesting benefits ($m)

OPTION

	129,000 cu m		104,000 cu m	
	Present value (5%)	Present value (8%)	Present value (5%)	Present value (8%)
20% normal profit	12.02	9.47	33.36	26.28
10% normal profit	17.01	13.40	55.85	44.00

The data in Table 4 can be interpreted for each cell in the following manner. Using a discount rate of 5% and an assumption that a 20 % rate of return is the normal profit level in the rest of the economy, the present value of the cost to the Australian community from the reduction if forest output to 129,000 cu m per annum is $12.02m.

This implies that the community's conservation benefit resulting from the reduced forest output (129,000 cu m pa) would need to be greater than $12.02m for it to be in the best interest of the community to set up the forest reserves that production level involves.

If the conservation value of the reserves was judged to be less than $12.02m, the forest reserves should not be established.

The relevant question under a static analysis is therefore:

Is the present value of the benefits of protecting forests under the 129,000 cu m option worth more than $12.02m.

The threshold values displayed in Table 4 range markedly according to the different underlying assumptions used. For instance, the threshold value for the 104,000 cu m pa option ranges from

$26.28m to $55.85m. Much of that range is due to the assumption regarding normal profit levels. The value is less sensitive to the selection of the discount rate.

4.2 Dynamic Analysis

The methodology underpinning the dynamic threshold value analysis is briefly described above and detailed in the Appendix. To estimate the threshold value for the current year's benefits of forest protection, the present values of the timber harvesting opportunity costs presented in Table 4 must be divided by the present values of the forest protection benefits growing from an initial value of $1. These latter present values are presented in Tables A1 and A2 of the Appendix.

The resultant dynamic threshold values are set out in Tables 5, 6, 7 and 8.

Table 5: Current year threshold values for forest protection benefits: 129,000 cu m pa (20% normal profit)

i = 5%	c = 7.5%	c = 10%	c = 12.5%
m = 40	k = 40	k = 30	k = 25
w = 3%	$83,670	$77,830	$66,143
w = 4%	$65,132	$62,612	$53,948
w = 5%	$50,317	$50,055	$43,750

i = 8%	c = 7.5%	c = 10%	c = 12.5%
m = 40	k = 40	k = 30	k = 25
w = 3%	$136,599	$117,237	$95,670
w = 4%	$109,814	$96,627	$80,888
w = 5%	$88,228	$79,104	$66,618

Table 6: Current year threshold values for forest protection benefits: 129,000 cu m pa (10% normal profit)

i = 5%	c = 7.5%	c = 10%	c = 12.5%
m = 40	k = 40	k = 30	k = 25
w = 3%	$118,365	$110,104	$93,571
w = 4%	$92,141	$88,575	$76,320
w = 5%	$71,183	$70,812	$61,892

i = 8%	c = 7.5%	c = 10%	c = 12.5%
m = 40	k = 40	k = 30	k = 25
w = 3%	$193,243	$165,852	$135,342
w = 4%	$155,351	$136,695	$114,430
w = 5%	$124,814	$111,907	$94,242

Table 7: Current year threshold values for forest protection benefits: 104,000 cu m pa (20% normal profit)

i = 5%	c = 7.5%	c = 10%	c = 12.5%
m = 40	k = 40	k = 30	k = 25
w = 3%	$232,185	$215,980	$183,548
w = 4%	$180,744	$173,749	$149,708
w = 5%	$139,632	$138,905	$121,408

i = 8%	c = 7.5%	c = 10%	c = 12.5%
m = 40	k = 40	k = 30	k = 25
w = 3%	$379,064	$325,334	$265,486
w = 4%	$304,737	$268,141	$224,466
w = 5%	$244,834	$219,516	$184,865

Table 8: Current year threshold values for forest protection benefits: 104,000 cu m pa (10% normal profit)

i = 5%	c = 7.5%	c = 10%	c = 12.5%
m = 40	k = 40	k = 30	k = 25
w = 3%	$388,745	$361,612	$307,312
w = 4%	$302,617	$290,906	$250,655
w = 5%	$233,784	$232,567	$203,272

i = 8%	c = 7.5%	c = 10%	c = 12.5%
m = 40	k = 40	k = 30	k = 25
w = 3%	$634,662	$544,703	$444,500
w = 4%	$510,217	$448,945	$375,821
w = 5%	$409,923	$367,533	$309,518

The data in Tables 5 to 8 are the values that the forest protection benefits in the current year would need to exceed for it to be in the best interests of the community to set up the forest protection areas under consideration. For instance, for the circumstances:

- A discount rate (i) of 5%
- Incomes rising (w) at 4%pa
- Consumption of forest protected areas (c) rising initially at 10% pa
- Consumption falling to equal population growth in 40 years time (m)

The current year's threshold value for the 129,000 cu m pa option (given a 20% normal profit rate) is $62,612. That is, the value generated by the additional forest reserves set up under the 129,000 cu m pa option would need to exceed $62,612 in the current year for it to be in the best interests of the community to establish those reserves.

Again, the current year's threshold value is sensitive to the array of underlying factors. For the 129,000 cu m pa option, the range is from $43,750 to $193,243.
For the 104,000 cu m pa option, the range is from $121,408 to $634,662.

Key factors causing this sensitivity are:

- Assumed normal rate of return (50% increase in threshold value from 20% to 10% rate of return)
- The discount rate (50% increase in the threshold value with the discount rate increasing from 5% to 8%)

- The growth in income (50% increase in the threshold value with the growth in income decreasing from 5% to 3%)
- Consumption trend (25% increase as the growth rate falls from 12.5% to 7.5%)

The selection of the values these factors take is thus of great importance to the decision making process. Taking mid range values gives the following threshold values:

129,000 cu m pa:	$118,500
104,000 cu m pa:	$378,035

5. 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 UNE 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 UNE-LNE 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.[4]

[4] Note that this type of benefit may extend to what is known as "option value" when ther 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

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.

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

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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.

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 confirm 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:

129,000 cu m pa: $118,500

104,000 cu m pa: $378,035

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

Table 10: Disaggregated dynamic threshold values for the current year’s forest protection values

	129,000 cu m pa option	104,000 cu m pa option
Recreation use value	$32,000	$102,000
Option value	$26,000	$83,000
Existence value	$25,000	$79,000
Bequest value	$36,000	$113,000

In other words, for the forest protection areas under the 129,000 cu m pa option to be set up, the additional recreational use values that must be generated are in the order of $32,000 in the current year. For the 104,000 cu m pa option, the comparable figure is $102,000.

To put this in perspective, a number of travel cost studies carried out in northern NSW travel cost studies (Bennett 1996) have shown that the value of a day’s recreation is in the order of $40. This in turn implies that for the 129,000 cu m pa option to be socially desirable, an additional 800 days of recreational use would be required. Hence, if more than 800 days of extra visitation would be generated by the declaration of the reserves defined by the 129,000 cu m pa option, the reserves should be established.

Similarly, 2,330 days of visitation would be required to justify the declaration of reserves up to the 104,000 cu m option.

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 the 129,000 cu m pa option would require around 1,200 people to support the proposal. For the 104,000 cu m pa option, 3,800 supporters would be required. Of course, it must also be the case that the forest protection values offered by the proposed forest reserves in the UNE are similar to those offered by the unreserved National Estate Forests in the south east.

5. Conclusions

The threshold value analyses presented in this report indicate the values that the forest protection benefits arising from the management options under consideration must exceed for it to be in the best interests of the wider community for the reserves to be established.
The static analysis indicates that for the 129,000 cu m pa option, the threshold is in the order of a present value of $13m. The comparable figure for the 104,000 cu m pa option is $40m.

The dynamic analysis enables a consideration of differential growth rates between the protection and the harvesting benefit streams to be incorporated. In addition, it enables the calculation of a threshold value for the current year. For the 129,000 cu m pa option, the current year’s forest protection benefits must exceed approximately $120,000 for forest protection to be socially desirable. For the 104,000 cu m pa option, the forest protection benefits must exceed approximately $380,000 in the current year.

An analysis of the extent and composition of forest protection benefits estimated in other studies indicate that only moderate increases in visitation numbers in the proposed forest protection areas and relatively small numbers of people to support the proposals would be required for the threshold values to be exceeded.

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APPENDIX 1

The Dynamic Threshold Value Approach

The dynamic threshold value approach takes into account the differential growth rates for the alternative streams of benefits that can be produced by a forest area. Those two alternatives are here termed extractive and protective uses.

Extractive values
The extractive uses of the forest involve the conversion of natural resources into intermediate products which 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 enhances 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 demand increases may also be met by supplies of laminated softwoods or even alternative, non-timber products such as steel.

The result of these characteristics is 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 (ie without taking into account the time value of money):

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

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

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

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

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 A1.1 illustrates this function.

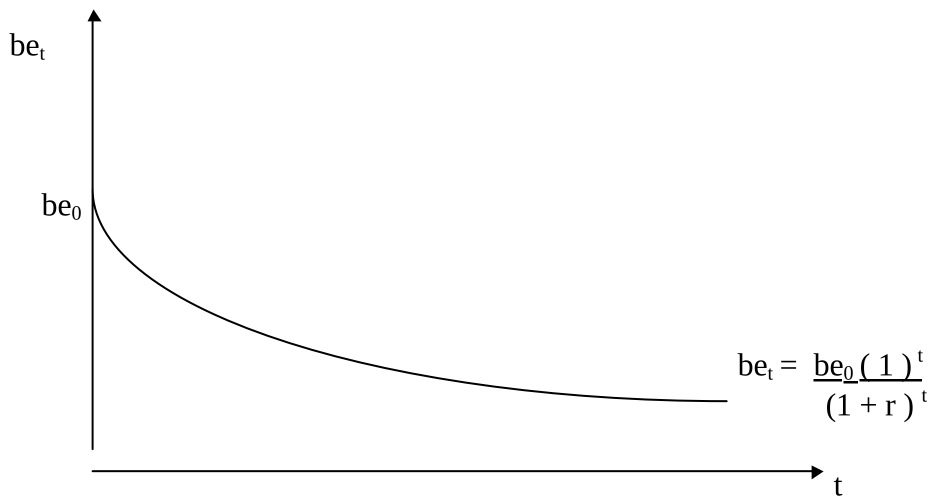

Figure A1.1: Extractive values over time

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:

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

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 threshold value approach will be less than that calculated under the static approach. The static approach therefore overestimates the extent of the opportunity costs associated with protecting the forest. The threshold value for the protective values to exceed for forest protection to be a superior resource allocation to forest extraction is lowered under the dynamic approach.

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 A1.2 illustrates this function.

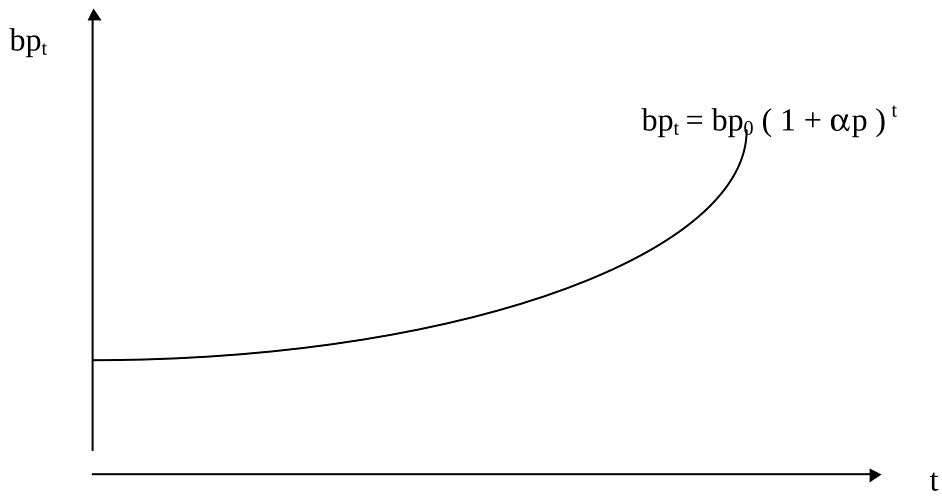

Figure A1.2: Protective benefits through time

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.

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

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 A1.3. 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.

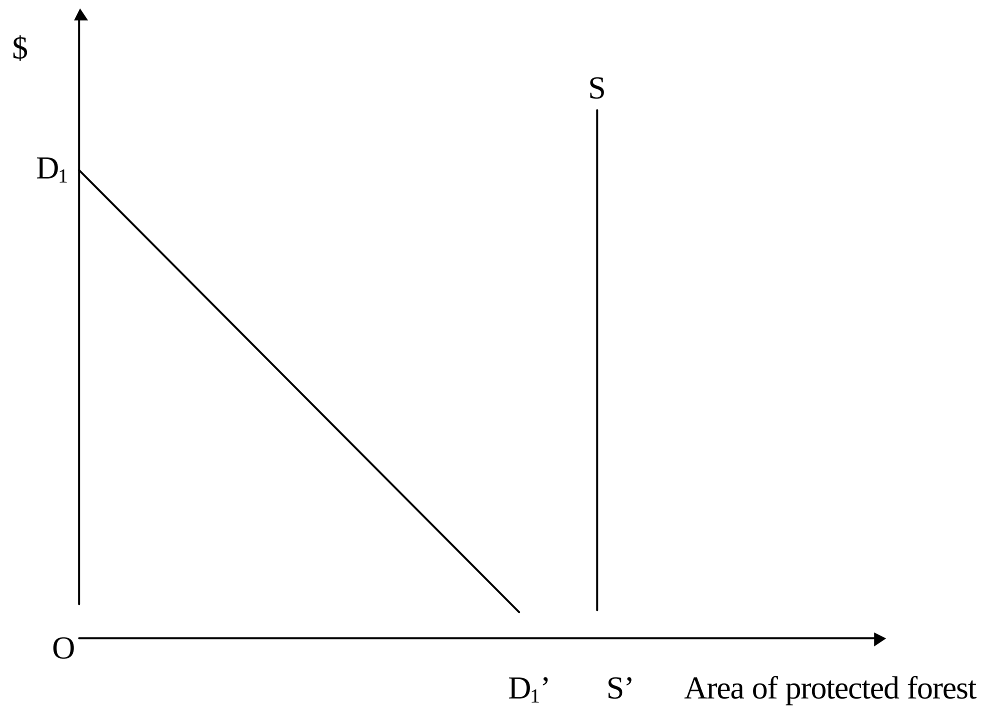

Figure A1.3: Initial year benefits of protection

The benefits of protecting the forests (bp_0) are defined by the consumer 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:

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

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 A1.4 demonstrates how consumer surplus growth is limited by the capacity constraint.

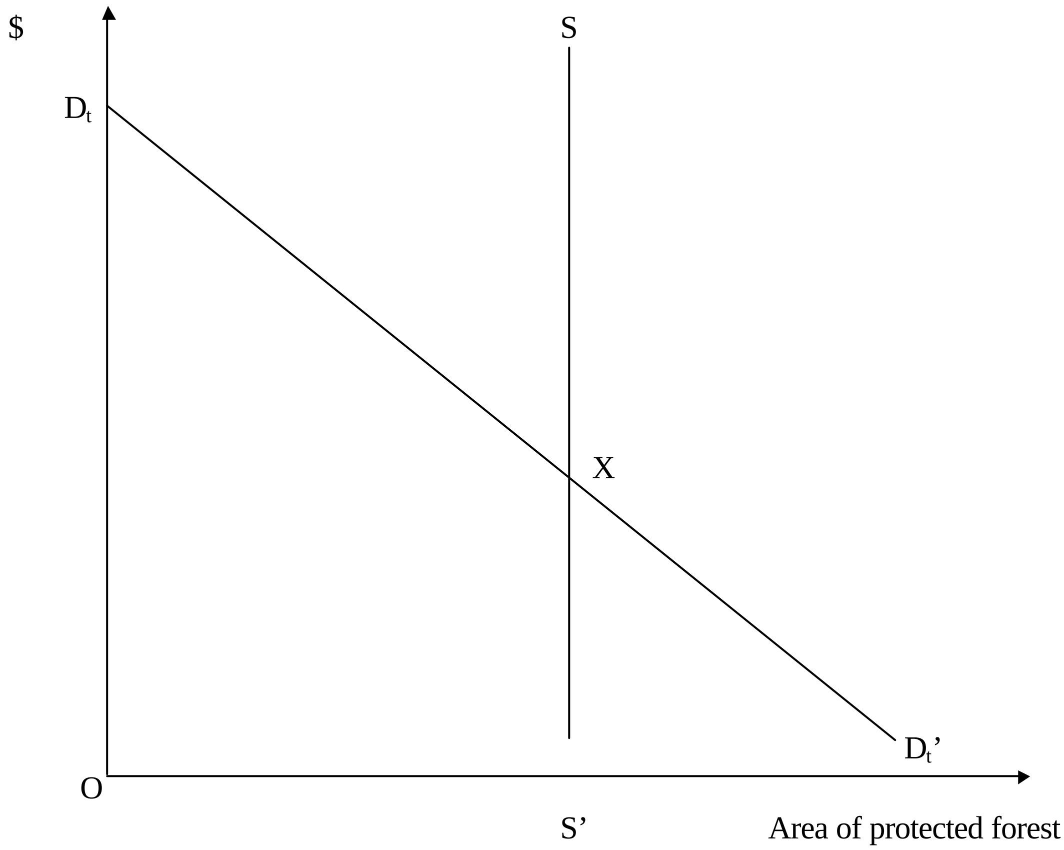

Figure A1.4: Protective benefit in subsequent year t.

Given demand at D_tD_t', the consumer 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 A.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:

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

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.

Hence, 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 A.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. This rate is argued by Krutilla and Cichetti (1972) to 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 A1.1 and A1.2.

Table A1.1: 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 A1.2: 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);

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

APPENDIX 2

LOWER NORTH EAST THRESHOLD VALUE DATA

Table A2.1: Producer surpluses per annum under alternative forest management options

	Base case (1997-98 output) $m	100,000 cu m per annum production $m
20% normal profit	8.46	7.11
10% normal profit	21.67	18.16

Source: Gillespie Economics (1998)

Table A2.2: Foregone producer surpluses ($m) (100,000 cu m option)

	Per annum	Present value (5%)	Present value (8%)
20% normal profit	1.35	16.87	13.30
10% normal profit	3.51	43.87	34.57

Table A2.3: Foregone consumer surpluses ($m) under 100,000 cu m options

	Present value (5%)	Present value (8%)
20% normal profit	1.35	1.06
10% normal profit	3.51	2.77

Table A2.4: Foregone timber harvesting benefits ($m) (100,000 cu m option)

	Present value (5%)	Present value (8%)
20% normal profit	18.22	14.36
10% normal profit	47.38	37.29

Table A2.5: Current year threshold values for forest protection benefits: 100,000 cu m pa (20% normal profit)

i = 5%	c = 7.5%	c = 10%	c = 12.5%
m = 40	k = 40	k = 30	k = 25
w = 3%	$126,818	$117,966	$100,253
w = 4%	$98,721	$94,901	$81,770
w = 5%	$76,266	$75,869	$66,312

i = 8%	c = 7.5%	c = 10%	c = 12.5%
m = 40	k = 40	k = 30	k = 25
w = 3%	$207,125	$177,766	$145,065
w = 4%	$166,512	$146,515	$122,651
w = 5%	$133,780	$119,946	$101,013

TableA2.6: Current year threshold values for forest protection benefits: 100,000 cu m pa (10% normal profit)

i = 5%	c = 7.5%	c = 10%	c = 12.5%
m = 40	k = 40	k = 30	k = 25
w = 3%	$329,783	$306,765	$260,702
w = 4%	$256,718	$246,783	$212,638
w = 5%	$198,325	$197,293	$172,441

i = 8%	c = 7.5%	c = 10%	c = 12.5%
m = 40	k = 40	k = 30	k = 25
w = 3%	$537,862	$461,624	$376,704
w = 4%	$432,397	$380,471	$318,500
w = 5%	$347,400	$311,476	$262,310