How Often Should Native Forests be Logged? A Case Study on the Eden Management Area

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Abstract

The question of how often to log is examined applying two different methods – one optimises over time the value of its timber harvested and the other considers the forest as a multi-use resource. The former, applied to data for the Eden area gives an optimal rotation period of 25 years, the latter suggests that it is optimal never to harvest pristine native old growth forests.

Introduction

In recent years there has been much debate surrounding the use of our natural environment. Politically, the issue of environmental degradation has been of major significance, reflecting growing community concern over environmental issues. In 1992, the Federal and State governments signed the National Forest Policy Statement. This statement included a moratorium agreement which stated 'until assessments are completed, forest management agencies will avoid activities that may significantly affect those areas of old growth forest or wilderness that are likely to have high conservation value'.

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In 1994, heated debate arose over the Federal Resource Minister's renewal of export woodchip licences against the advice of the Federal Minister for the Environment. For over three months, the logging debate was front page news with public protests held by both Conservation and Timber Industry groups. The Federal Government lost much of its environmental credibility over the debacle, and was confronted with legal action over its renewal of licences. In an attempt to soothe public anger, the Federal Government established a programme of reassessment based on Preferred Logging Areas.

In New South Wales, controversy has arisen over the New South Wales Forestry Commissions' decision to ignore the Preferred Forest Areas reassessment programme. This defiance of Federal Government policy has meant that logging has continued in virtually all of the forest areas in the South-East Forests. An AGB McNair poll published in the Sydney Morning Herald in February 1995 found that around 65 percent of people surveyed opposed logging of previously unlogged areas.

The question central to this debate is: how often should our native forests be logged, if at all? Traditionally this question has been addressed by examining only the economic returns of the forest's timber. This investigation expands previous work by incorporating economic, environmental and intergenerational concerns of how often to log into an optimal harvest analysis. The harvesting operations in the Eden Management Area are examined as a case study. The resulting optimal harvest period is used to assess the sustainability of the New South Wales State Forestry Commission's current management practices in the Eden area. It is hoped that this analysis may then be used as a more general methodology for assessing logging operations throughout Australia.

Australia's Old Growth Forests

Although the use of Australia's Old Growth forests has been the source of much heated debate,[1] it is interesting to note that no generally accepted definition of what constitutes an 'Old Growth forest area' exists. Amongst the myriad of characteristics that Old Growth areas possess, there are a few easily identifiable characteristics that most of these areas exhibit. These include a high degree of structural diversity produced by a number of vegetation strata, low levels of disturbance to the natural environment and a predominance of large, mature aged trees.[2]

The Commonwealth Government of Australia, in its 1992 National Forest Policy Statement, defines old growth forests as a 'forest that is ecologically mature and has been subjected to negligible unnatural disturbance [such as logging, roading and clearing]'.[3] This definition focuses on forests in which the upper stratum, or overstorey, is in the late mature to over mature growth phase, however, it places only limited emphasis on the 'non-timber' values associated with a mature standing forest.

Within this analysis however, Old Growth areas are identified in accordance with standard New South Wales State Forestry Commission (State Forests) policy. State Forests recognises Old Growth areas as areas that are 'both negligibly disturbed and ecologically mature and have high conservation and intangible value[s]'.[4] The majority of trees within the forest must also be in the latter stages of their growth cycle. So that consistency is maintained with State Forests practises, this definition shall be used throughout this analysis to identify Old Growth forest areas.

This analysis focuses on the logging occurring within the Eden Management Area (EMA). The EMA is an area of around 783,566 hectares of forest located in the Eden, Bombala and Narooma districts in the south-eastern corner of New South Wales. The area is comprised of 244,937 hectares of state forest, 18,000 hectares of crown land, 325,000 hectares of private land and around 154,621 hectares of proposed or existing national park and reserve areas.

Considerable research on the EMA's flora and fauna has been undertaken, and there exists a wide and varied literature on each. It is believed that the area supports around 1100 species and sub-species of vascular plant life, with Eucalypts the dominant species of the area. It has also been reported that the area supports around 408 terrestrial vertebrate species, including 70 mammal species, 267 bird species, 47 species of reptiles and 24 species of frogs. Of the above groups, 39 of the vascular plant species and around 23 of the vertebrate species have been recognised as being threatened or endangered.[5]

In the latest Environmental Impact Statement for the EMA it was proposed that, over the next three years, timber demand will require the harvesting of 185,000 cubic metres of sawlogs for timber mills in southern New South Wales and 1,512,000 tonnes of pulpwood for the Harris-Daishowa (Australia) Pty Ltd woodchip mill at Eden.[6] This commitment to continued logging in the EMA has raised grave concerns as it is felt that current logging regimes are not being conducted in a sustainable manner and that such continued pressures will threaten the existence of our limited old growth resources and the diverse ecosystems they provide.[7]

State Forest has attempted to refute these allegations in many ways. They have recently tightened standards and introduced new measures to ensure that valuable forest areas are protected. Their proposed operations have also been investigated within the recent Environmental Impact Statement (EIS) for the Eden area. Although the general conclusion of the EIS was that logging was being conducted in a sustainable manner, many still express concern that these new measures are insufficient.

The Green Movement is proposing that, regardless of current State Forest policy, logging is still occurring at devastating rate, 'a rate at which the natural environment cannot hope to regenerate the damage that is being done'.[8] In fact, it is not just the 'environmentalists' that are concerned that current protection policies are inadequate. 'The Department of Conservation and Land Management (CaLM) do not consider that any [EIS's] have adequately assessed soils and hydrology. The Department of Water Resources and Fisheries, and the Environmental Protection Authority (EPA), condemn [the EIS's] for their inadequate assess[-ment of] the aquatic environments. The Australian Museum and the National Parks and Wildlife Service (NPWS) consider their fauna surveys and impact analysis invalid. CaLM and NPWS do not consider that the proposed reserves are determined on a valid criteria. NPWS does not consider the flora surveys and impact assessments to be adequate. The Department of Planning and the EPA have both been highly critical of the economic assessments'.[9]

One of the major points of contention in the recent logging debates has been practice of woodchipping. Regardless of its controversial nature, this practice is problematic because it discriminates against mature or old growth forests, which provide the most desirable timber for these operations. In 1990, the Public Accounts Committee of NSW reported that '90 % of the trees logged in the Eden area were mature age (old growth) and go directly to the pulpmills'.[10] Today State Forest acknowledges that the ratio of trees logged to those woodchipped is as high as 1:10[11] and due to the lack of information available on the extent and composition of our remaining old growth forests, such practices raise great uncertainty as to the future of these resources.

Indeed, this lack of accurate information is a problem common to the Nation's forests. The Australian Heritage Commission is quoted as saying that 'There is a lack of detailed information about the types, extent and location of the old-growth forests remaining in Australia. Thus it is not possible, at present, to say exactly how many types of old growth forests exist, or how rare the various types may be'.[12]

Thus there are many considerations besides the value of timber, which need to be addressed when assessing current logging operations. In fact, a large portion of the debate between 'anti' and 'pro' logging groups arises from the uncertainty surrounding the extent of our remaining old growth resources. When this uncertainty is coupled with the 'traditional' problems of assessing any environmental assets, accurate economic assessment becomes complicated. Indeed, the general feeling amongst most of those concerned with the future of our forest resources is that there has been a considerable lack of acceptable reporting. This analysis will attempt to go some way in remedying this problem by evaluating the use of our forests in the south-east of New South Wales, as well as formulating a framework which may then be applied to other areas for investigative purposes.

Current Practices

Currently, State Forest harvests timber according to an 'optimal rotation' type strategy. This practice incorporates the notion of sustainability with that of maximising harvest revenue. In fact, rotation is a strategy based on continual harvesting practices, where the harvesting of the resource is performed in such a way as to maintain the resource at a certain standard throughout time. Thus acceptable rotation procedures should ensure that the resource is managed sustainably. In fact, when individuals express concern over the 'sustainability' of logging operations, they are referring to whether the rotation strategy in use is optimal. It is the aim of this analysis to assess whether State Forests operations are being conducted in accordance with the notions of optimal (and hence sustainable) rotation.

More formally, optimal rotation is the problem of selecting a sequence of management actions so as to maximise the present value of net benefits from the flow of harvestable timber and other 'amenity'[13] benefits over time.[14] For simplicity, this analysis looks only at the management action of when (if ever) to harvest the timber resource stored within the forest and will not consider any alternate management activities.[15]

In the latest EIS for the Eden area, State Forests profess to using a rotation period of 40 years.[16] This does not mean however, that an area is harvested only once in 40 years. Current policy dictates that, at any one time, foresters may only remove half an area's useable timber. Indeed, it is believed that by leaving select trees throughout the coupe, the area is better able to recover from the effects of logging. Thus, around twenty years after the initial harvest, foresters re-enter a coupe and again remove half the areas useable timber. During this twenty year 'regeneration' period, it is proposed that the areas remaining trees seed new trees, and those taken in the initial harvest are hence 'replaced'. This process of re-entering the forest every twenty years and removing half the area's useable timber then continues indefinitely. This practice means however, that an area may actually be facing a rotation period as short as 20 years. In fact, depending upon the prevailing demand for timber, it may be that the area is logged every 14 to 16 years, rather than the prescribed 20 years.[17]

When harvesting, it is usual that around one third of the timber in any area cannot be removed. This is due to a combination of factors, however, in general timber must be left to meet wildlife reserve and filter strips requirements, and because the wood is either too young or not of good enough quality to justify its removal from the area. The problem with these selective harvesting practices is that they generally remove the best trees from the area and as a result only very poor quality forest is left. Biologically, this is important because it enhances the rate of degeneration of the area and the result is often very low grade forest persisting into the future.[18]

A forest area that has been designated for harvesting is called a 'coupe' and each coupe is logged according to the prevailing rotation strategy. A coupe is usually around 50 hectares in size, however, some coupes can be as small as 15 hectares, depending upon the management strategies used and the fundamental characteristics of that area. It is usual that around 23 coupes will be harvested at any one time and thus there is usually around 23 different crews working at any one time to meet the prevailing timber demand. Each crew generally works in four to five different coupes a year and, on average, harvests around 200 hectares of forest each year.

The harvesting technique used by a logging crew depends upon the specific characteristics of the coupe being harvested. Under the current management regime, timber may be removed from a coupe via one of three possible harvesting techniques. These include the 'fully integrated', 'integrated' and 'conventional' saw logging techniques. Presently, the most preferred method of harvesting is the fully integrated method, although this technique can only be used where conditions are 'average' to 'moderate'.[19] Fully integrated harvesting removes timber via a selective logging process which allows crews to access to the desired pulp and sawlogs whilst still having some concern for minimising the effect on the area's natural environmental by leaving certain 'strategic' trees. Fully integrated harvesting only removes one sawlog for every ten pulplogs (on average) and although this is the most expensive method of logging to use, the practice is preferred because it yields the highest overall volume of timber whilst creating the least degree of environmental degradation.[20]

The Economics of Rotation

Over the past few decades, there has been a multitude of 'optimal harvesting rules' suggested within the forestry literature. These analyses have ranged from purely biological to purely economic and anywhere in between, however, today very few of these analyses are believed to be correct. One famous author wrote 'I have been reading a couple of dozen different analyses ranging over the last two centuries that grapple with optimal steady state rotation periods. The economic analysis in most of them is wrong. In some it is very wrong. In others it is not quite right. In at least one case, the remarkable German article by Martin Faustmann, the analysis does come close to an essentially correct solution.'[21] In the following, the 'correct' Faustmann solution shall be examined and extended to incorporate such factors as the forests standing values.

In 1976, Paul Samuelson wrote an article in which he reviewed 'recent' work on optimal rotation theory. He proposed that the correct method for analysing the optimal rotation period for a plot of land was based on capital theory and applying this method meant maximising the present value of the future stream of payments from the forest. This is in fact what Martin Faustmann suggested in his seminal article, published in 1849.

In deriving his results, Samuelson uses certain assumptions, and these are used to form the basis of the simple rotation model for the Eden forests. Following is a basic derivation of the Faustmann model.[22]

Assumptions:

1. The forest is made up of homogeneous trees. This enables us to simplify the analysis by making it necessary to look only at the harvestable timber from one tree.
2. Timber prices are known and constant into the future and this price will not depend upon the age or size of the trees harvested.
3. The future timber yield from a coupe is known and harvesting will continue into the future indefinitely. Harvesting will cause no change in the fertility of the land and the same management techniques shall be used throughout time.
4. Any risks to the timber stock, from forest fires, disease and so on, are ignored.
5. The interest rate is known with certainty and is assumed to be constant throughout time. Furthermore, the harvesting enterprise must be able to borrow and lend indefinite amounts at any time.
6. It is assumed that harvesting operations are not subject to taxation.
7. Capital markets must function perfectly. If this assumption is violated, then 'we will not be able to deduce optimal forestry decisions independently of knowledge about owners' personal preferences concerning consumption outlays at different dates'.[23]

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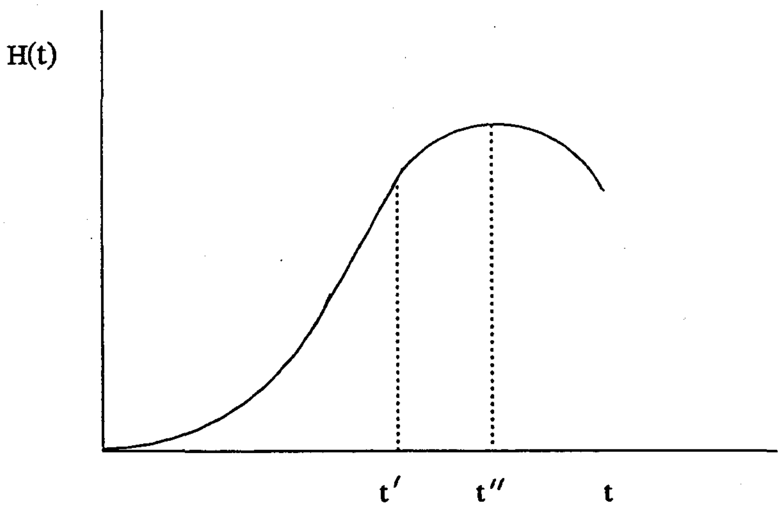
These assumptions follow loosely from those used by Kula in a text written on Economics and the Forest.[24] There is however, one additional assumption which Samuelson also makes, and which shall be used in the basic model for Edèn.

8. 'Finally we must assume that each kind of land suitable for forests can be bought and sold and rented in arms length transactions between numerous competitors; or, if the government owns public land, it rents them out at auction to the highest of numerous alternative bidders and conducts any of its own forestry operations so as to *earn the same maximum rent* obtainable at the postulated market interest rate.'[25]

Before proceeding any further, a few simple functions must first be introduced. Following an analysis presented by Dasgupta on optimal forestry,[26] it is assumed that a tree's growth can be represented as in Figure 1.

Figure 1: Stylised Growth Function of an Individual Tree



In the above figure, t represents time and H(t) the amount of useable timber over time. In this analysis, H(t) is analogous to capital theory's production function. The points shown above correspond to different phases of the trees growth. Up until t', the tree is growing at an increasing rate. After t', timber growth is still increasing, however now it is now doing so at a decreasing rate. At t'' the timber growth moves into decline and it is

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assumed that the trees timber starts to decay and deteriorates until it is worthless.

Given H(T), the price P of the trees useable timber and a positive social rate of discount, r, it is possible to calculate the present value of a tree's harvestable timber. Faustmann suggests that the optimal harvest period be chosen to maximise the present value of the future stream of revenue from the tree.

Up until the 1970's, most forestry problems were generally examined within a Faustmann style framework. In 1976 however, Richard Hartman published an article suggesting an alternative means of evaluation.[27]

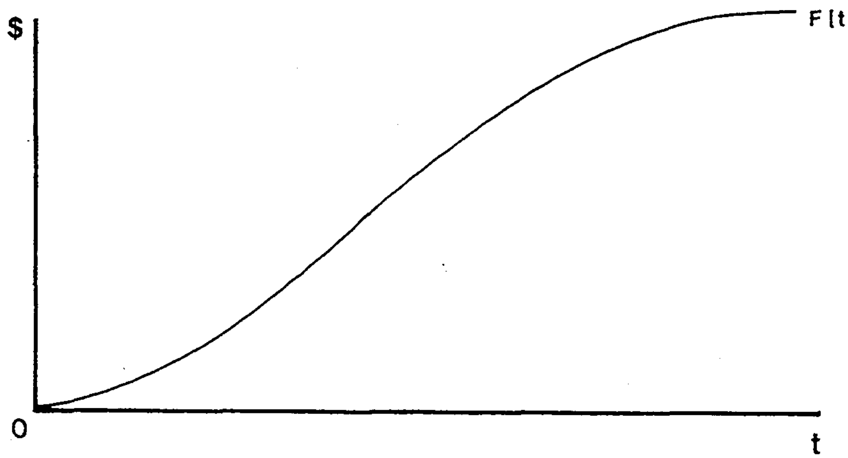
Hartman criticised the accuracy of previous optimal rotation calculations because they only considered the value of a tree's harvestable timber. He proposed that the standing value of the forest must be considered if the optimal harvest period was to be correctly determined. Hartman reformulated the Faustmann framework to incorporate this standing value and extended the analysis so that a forest, rather than a single homogeneous tree, was being considered.

Unlike the harvest value of a forest, which is measured as a stock, the standing value of the forest must be measured in a different way. As standing value incorporates the externalities that the forest provides throughout its lifetime, these externalities must be valued as a flow of over time. Typically, previous economic analysis has confined itself to analysing rotation where the timber value curve is positive. However, with the introduction of the forest's flow value, the rotation analysis can no longer be constricted in this manner.

To include this notion of standing value, Hartman uses two general functions. The first is for the simple stock value of the forest's timber. The second incorporates the flow of standing values from the forest. This function includes the value of recreational and other services of the forest. Both these functions are dependant upon the stage of life that the forest has reached. Hartman suggests that the standing value function has the shape depicted in Figure 2.

It is assumed that the standing value curve initially increases at an increasing rate. This reflects the fact that, in the initial period of growth, the externalities generated by the forest increase greatly. The standing value curve then reaches a point where it is still increasing, however, it is now increasing at a decreasing rate. This reflects the fact that although the externalities produced by the forest continue to increase over time, the magnitude of these externalities is limited by the size of the forest area. It is postulated however, that the standing value function continues to increase, although at this decreasing rate, throughout time. This is argued because of the current emphasis on virgin and old growth areas.[28]

Figure 2: Stylised Standing Value Function



In 1983, William Strang proposed one major amendment to Hartmans model.[29] Strang uses the same assumptions used in the Hartman model, the only difference being that the forest area is no longer taken to be initially barren. It is now assumed that the forest has already been standing for a period of A years at time t = 0. Altering the model in this way allows us to correctly consider the logging of an already old growth forest.

As can be seen from the above discussion, the way in which a complete forest system should be examined is very different to the way in which a single tree, or even a single purpose timber resource, is analysed. So far, the multiple use nature of Eden's forests has been discussed, and a model which embodies the characteristics of the EMA's forests has been identified. In the following, this model shall be applied to the Eden area to gain a rotation solution for the dominant forest league of the region.[30]

Data

Economic literature suggests many methods for incorporating externalities into an analysis. In practice however, the method used will not only depend upon the type of analysis being undertaken, but will also depend upon who

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is undertaking the article and the budget and time constraint imposed upon the analysis. Given the nature of the question being addressed within this analysis, there are several methods that could have been applied to value the EMA's externalities.[31] In the following analysis, no one method has been formally applied, the reason being lack of resources and the time constraint on the problem at hand. In an ideal situation however, it would be preferable to use a combination of hedonic pricing, contingent valuation, travel costing and so on to gain a more accurate representation of the problem at hand. In the following formulations, all externality values are based on proxy style measurements only.[32] The way in which the various externalities within this analysis are considered is described below.

The Soil Erosion Prevention Benefit Function:

A standing forest generates water retention and soil erosion prevention benefits throughout its lifetime. Although water retention benefits are relatively complicated to estimate,[33] it is far less difficult to value the soil erosion prevention benefits provided by a standing forest. This benefit may be estimated by examining the drainage costs incurred when a forest area is logged. These costs should then be used as a proxy for the soil erosion prevention value provided by the standing forest.

The figures shown in Table 1 were provided in a personal communication from Charles Bell of the Department of Conservation and Land Management (CaLM).[34]

Table 1: After Logging Components of Soil Erosion Prevention

Component's of Site Treatment	Hours Spent on Treatment
road drainage	1 hour
reaping and re-topsoiling logdump	2 hours
snig track drainage	3 hours
bark disposal	1 hour
bridge and extra drainage costs (depending upon the site)	1 hour
additional items	$200

Each of these activities costs around $50 per hour to complete. Thus, the total amount spent on an average size[35] and quality site after fully integrated harvesting to prevent soil erosion is around $500. This figure may be used as a proxy for the soil erosion prevention benefit (per coupe) provided by the standing forest each year it is left standing.[36]

In formulating the soil erosion prevention benefit function for the standing forest, any relationship between the forest's growth and the size of the benefit provided shall be ignored. Thus it is possible to formulate the soil erosion prevention benefit function for a standing forest as a simple annuity. To gain the present value of this annuity a five percent discount rate is applied.

The Aesthetic Value Index Function

The aesthetic value of a forest is one of the most subjective aspects of any analysis. As many authors have noted, the value of the forest to a hunter, a botanist and a bushwalker, although all significant, may be very different in size and nature. For this reason, this thesis attempts to place no singular value on the aesthetics of the forest, but rather formulates a basic aesthetic value index curve and examines the effects on the optimal rotation period of changing the value assigned to the standing forest.

The aesthetic value index function for the EMA is formulated in a similar way to that proposed by Calish, Fight and Teeguarden.[37] The aesthetic value index curve is formulated by indexing the different stages of the forest's growth cycle. It is possible to formulate an index curve valued between zero, where the forest is initially barren, and one, where the forest has reached maturity. In formulating this index curve, it is assumed that the forest provides the maximum aesthetic benefit at maturity. This assumption seems appropriate considering the current emphasis on the value of old growth forest areas.

To derive the aesthetic value index curve, the relevant forest growth function is divided by the absolute volume of timber of the mature forest. Thus the growth function is transformed into an equation bounded between zero and one and this function may then be used as an aesthetic index for the forest over its growth cycle.

The Tourism Revenue Function

The total value of tourism revenue generated by a forest's existence is almost impossible to measure. Tourism helps support the area's local businesses, and the flow on effects of this revenue permeate a number of industries and regions. Although data on the revenue provided by tourism for Eden's local communities was not available, information relating to the profits of forest tours in the Eden area was. These figures are used as a proxy for the minimum tourism revenue generated by the standing forests. It should be realised however, that this revenue figure will be far below the actual figure for tourism revenue in the EMA.

During the three month period, starting the end of January and going through until the end of March, the Wilderness Society ran overnight forest tours to the Eden area. These tours visited forest areas which were under threat from logging. The tours were open to the general public and cost around $60 per head. During this period, these tours raised around $4500 profit.[38]

This figure is used as a proxy for tourism revenue over time. Ms. Potts felt that these tours could run continuously throughout spring and summer and could thus operate for around six months of the year. Assuming that the tour's costs remain constant throughout time,[39] the revenue derived from the tours would be around $9000 per year. This figure gives the revenue derived from tours throughout the EMA and thus this figure must be divided by the total forest area so that the revenue figures derived are in per hectare terms. Thus the basic tourism revenue function may be formulated as a simple annuity as follows.

The Existence Value Function

It may also be the case that individuals value the forest's existence, whilst harbouring no desire to actually visit the forests. This fact is evident when public support for anti-logging rallies is examined. Demonstrations throughout Australia were held at the start of this year,[40] and substantial crowds attended these protests. This action may thus be taken as an indication of individuals revealed preference for standing forests.

During this period, the Sydney branch of the Wilderness Society received over $27,000 specifically for the continued support of their anti-logging work in the EMA.[41] Although this figure gives only a rough indication of the total value of individuals preferences for standing forests, this figure can be used as a proxy for the existence value of the forests. If it is assumed that the existence value of the forest increases with its age, then the previous growth function may be used to formulate an existence value function dependant upon the age of the forest. It is further assumed that once the forest reaches maturity, the existence value will also reach a maximum.

After the forest reaches maturity, the EV function remains constant at $27,000. So that the Existence Value is in per hectare terms, the function must be divided by the area of old growth in the EMA. As this figure is unavailable, an estimate is gained by considering the per hectare value of the forest league under investigation.[42]

Results

Before exploring the results gained from the previous analysis, it should be realised that the externalities examined above represent only a tiny fraction of the true number of externalities provided by the old growth forests in the Eden area. The assumptions used and the data given produce only a rough approximation of the areas true standing value. Nevertheless, the analysis gives a good indication of how optimal rotation for the Eden area is affected by the inclusion of various forest standing values.

Basic data for the EMA suggests that the Faustmann optimal rotation period for a representative tree from the Stringybark / Silvertopash forest league is twenty five years. This rotation period is consistent with State Forest's current policy of harvesting a forest area every twenty years, as are the majority of results gained by altering the growth function used to portray this representative tree. It should be noted however, that changing the growth function does shorten the Faustmann optimal rotation period somewhat. As the Faustmann model ignores the opportunity costs incurred when old growth areas are harvested, the reliability of these results are questionable.

Table 2: Faustmann Optimal Rotation Results

Species	Optimal Rotation Period
E.Pilularis	25 years
E.Regnans	21 years
E.Obliqua	21 years
E.Delegatensis	18 years
E.Grandis	18 years
E.Diversicolor	16 years

Accepting the Hartman-Strang model, the question of how often to log is extended so that the multiple use nature of the Eden forests is considered. Given these conditions, it is found that harvesting an area of mature forest simply for its timber is never optimal. This result is supported even when the lead species and hence the forest's growth rate is changed. Thus, when the multiple use nature of the Eden forests is considered, State Forest's current management practices are inappropriate.

Table 3: Multiple Use Optimal Rotation Results

Species	Optimal Rotation Period
E.Pilularis	infinite
E.Regnans	infinite
E.Obliqua	infinite
E.Delegatensis	infinite
E.Grandis	infinite
E.Diversicolor	infinite

In the above analysis, the choice of standing (or conservation) value does affect the final results gained.[43] If a standing value of $236.66 per hectare *at maturity* is assigned to the EMA's old growth forests, then the 'never harvest' result is gained.[44] If at maturity the standing value of the forest is less than this amount, then an optimal rotation result will be gained. Indeed, as the forest's standing value decreases, the length of the rotation period derived from the model will also decrease. When the standing value reaches zero, it becomes optimal to harvest the forest immediately. Intuitively, this result is easily understood. When the forest area exhibits no standing values, the analysis simplifies to the standard Faustmann analysis. Thus, for a mature forest with no standing value, the value of the timber at maturity is far in excess of the value to postponing the harvest. Thus, it will pay to harvest the forest immediately and gain a barren plot of land on which to start the next timber 'plantation'.

The model's optimal harvest result is also susceptible to how far past maturity the forest is. As the standing value of the forest is increasing and the timber value of the forest (after maturity) is decreasing over time,[45] the switching value required to give a 'no harvest' solution thus decreases through time.[46] This is illustrated in table 8 below.

Table 4: Forest Age and Switching Value[47]

Time After Maturity	Switching Value ($/ha)
at maturity	$236.66
10 years	$33.39
20 years	$23.52
30 years	$16.54
40 years	$11.11
50 years	$7.29

The above table illustrates how the model's solution depends upon the age of the forest. If the forest is at maturity, then a relatively large standing value per hectare is required before the no harvest solution is gained. If the forest is already past maturity, even by only a few decades, then only a very low standing value per hectare is required before the no harvesting result is gained. This analysis aims to examine logging in the EMA's old growth forests. As the area's old growth forests are generally past maturity, only a very low standing value is required for the no harvesting regime to be optimal.

Conclusion

The question central to this debate is: how often should our native forests be logged, if at all? Traditionally this question has only been addressed by examining the economic returns of the forests timber. This article expands previous work by incorporating economic, environmental and intergenerational concerns into the optimal harvest analysis for the forests. Specific reference is made to the harvesting operations in the Eden Management Area. The resulting optimal rotation period can be used to assess the sustainability of New South Wales State Forestry Commission management practices in the Eden area.

The question of how often to log may be examined by applying a number of different methodologies. The first methodology examined is the Faustmann Optimal Rotation model. When data for the Eden area is applied to this model, a rotation period of twenty five years is gained. This result is consistent with current State Forest harvesting practices which advocate the removal of the timber from an area every twenty years. The Faustmann model however, ignores the important relationships present in the complete forest ecosystem and extrapolates the optimal harvest period for the forest from the timber value of a single tree.

Recent literature on the rotation period for multiple use forests is also reviewed and the multiple use nature of the Eden forests is examined. A framework to determine the optimal rotation period for the forests in the Eden area is derived and in formulating this framework, proxy functions for some of the area's multiple use values are derived. Considering the deficiencies of previous models, the framework presented is an important first step in correctly accounting for the multiple use nature of Australia's native forest resources. Applying the model developed gives an infinite optimal rotation period for the Eden area's old growth resources. This result is susceptible to changes in the age of the forest. Examining switching values for the forest at different ages shows that, if the forest is even 10 years past maturity, a conservation value of only $33 per hectare will give the 'no harvest' solution. If the analysis is accepted, this model's results suggest that it is never optimal to harvest our pristine native and old growth forests.

Notes

1. This is evidenced by, for example, the various pro and anti logging demonstrations that occurred in both Sydney and Canberra at the start of this year.
2. Sustaining our Forests, 1994.
3. Commonwealth of Australia as cited in Sustaining our Forest 1994, p. 13.
4. 10 Questions: The Latest Forest Facts, 1993, p. 14.
5. Eden Management Area EIS 1994 pp. 3-59/60. Although State Forest proposes that the EMA has been studied extensively and that there is little scope for further research, many believe that the extent of current knowledge is far from complete.
6. Eden Management Area EIS 1994, p. ES6. Although these are the official estimates of timber demand over the next three years, many are concerned that these figures are underestimates, and that once approval is given to meet these targets, over production will occur due to the minimal monitoring and penalties imposed on logging operations in the area. Wilderness Society, New South Wales Branch, 1995.
7. Wilderness Society, New South Wales Branch, 1995.
8. Quotation from the Public Rally for the Forests at Town Hall, January 1995.
9. Pugh 1994 as cited in Sustaining our Forests 1994. This was a quote from an unpublished internal document that the author was able to secure when writing her book.
10. New South Wales Public Accounts Committee Report on the Forestry Commission 1990.
11. pers. comm. with Brian Brooker of State Forest. This figure is supported by the 1994 EMA EIS, which states that the current ratio of sawlogs to pulpwood logs is around 1:8.5 for the Eden forests Eden Management Area EIS pp. 2-15.
12. Australian Heritage Commission as cited in Resource Assessment Commission, 1992 p. 143.
13. At this point, we shall not identify exactly what these 'amenity values' comprise of. It is sufficient to understand that amenity value is a concept which incorporates the non-timber benefits that can be derived from a forest.
14. Bowes and Krutilla, 1989, p. 106.
15. There are many alternative management actions that may be pursued, such as combining plantation works with limited harvesting of poor quality native timber to support current demands for pulpwood, phasing out of harvesting from previously unlogged areas and looking at alternative paper supplies such as industrial hemp.
16. Eden Management Area EIS 1994. This means that current logging practices are to remove all the useable timber from an area at least once every 40 years. Implicit in this rotation policy is the judgement that a rotation period of 40 years will maximise the flow of net benefits to State Forest over time.
17. from pers. comm. with Brian Brooker of State Forest.
18. '10 Questions ...' National Association of Forest Industries, 1994.

19. The Forest Products Association uses the following system for classifying coupes. An 'average' coupe contains good ground conditions, relatively high tree density, good quality timber, normal log servicing requirements, normal snigging distances with maximum load. 'Moderate' coupes are said to have some ground condition problems,(including rock and scrub) longer snig distances, lower stand density or greater tree retention and more servicing or cutting for segregation. NSW Forest Products Association, Native Forest Logging Recommended Rates, 1995.
20. Eden Management Area EIS, 1994 pp. 2-15
21. Samuelson, 1976, p. 469.
22. For a more complete analysis and derivation of the Faustmann model, see Dasguptas 1982 book, The Control of Resources.
23. Samuelson, 1976, p. 471.
24. Kula, The Economics of Forestry, 1988.
25. Samuelson 1976 p. 471, italics in original.
26. Dasgupta, 'Forests and Trees' Chapter 9 The Control Of Resources, 1982.
27. Hartman, 1976. This article was published in reaction to Samuelsons' review of the existing forestry literature. Hartman was amazed that, up until that time, no one had accounted for the non-timber values derived from a forest during its growth.
28. This 'current' emphasis was identified as far back as 1976, when Hartman proposed that the standing value of the forest would not decrease over time.
29. Strang, 'The Optimal Forest Harvesting Decision', 1983.
30. For expositional ease, the following analysis divides the forest into common family groups known as forest leagues. The rotation period's for the EMA's major forest leagues are then calculated and used as an indication of the optimal harvest strategy for particular areas in the EMA. Persuing the analysis in this manner does abstract from reality somewhat, however, the results gained are still good indicators of the optimal harvest strategy and without large scale computer modelling and more accurate information, better calculations are not plausible.
31. For example, see the short discussion of Hedonic Pricing, the Contingent Valuation Method, and the Travel Cost Method of valuation provided in Bowes and Kruttila, 1989 or Englin and Mendelsohn, 1991. For a greater understanding of how to value the externalities associated with a standing forest, Michael Lockwoods' work on Contingent Valuation for the South-East forests should also be examined. See Loomis, Lockwood and Delacy, 1993.
32. For the mathematics and the relevant optimising conditions for these equations see Hartley, 1995.
33. To correctly estimate the water retention values provided by a standing forest, dynamic programming techniques must be used. Although this is possible, given the time limit imposed on this research paper, it has not been feasible to undertake the appropriate analysis. For a possible methodology on how to perform such joint timber / water calculations, see Kennedy, Read and Sturgess Optimal Management Policies for Timber and Water Output paper presented at the 57th annual conference to the Australian Agricultural Economics Society.
34. The Department of Conservation and Land Management (CaLM) work in conjunction with State Forest and it is their role to ensure that logging causes only minimal damage to an area's environment.

35. An average size site is taken to be 15 hectares.
36. Charles Bell, pers. comm. CaLM.
37. Calish, Fight and Teeguarden, 1978.
38. Christina Potts, pers. comm. The Wilderness Society.
39. This assumption is in line with the assumption of perfect certainty made generally in the analysis.
40. For example, the anti-logging rallies held at the Domain and at the Town Hall in Sydney.
41. Christina Potts, pers. comm. The Wilderness Society.
42. 'Forest leagues' are used to help identify various forest areas exhibiting certain general characteristics. For the purpose of this analysis, a forest league is defined as an area which consists of tree species all of a similar family or sharing similar family characteristics. In the Eden Management area there are five predominant forest leagues.
43. The choice of aesthetic value (IV) also affects the final rotation period, however, as this value is part of the forests overall standing value, the affect of altering only this value is not examined separately. Discussion of the effect of altering the aesthetic value would only be important if it alone affected the final rotation result gained.
44. This is also assuming that once the forest is harvested, there are no further standing values derived from the forest ever. This is assumed so that once an old growth area is harvested it may be treated as a plantation style resource (and is therefore in line with State Forests current management practices.) The switching value is gained by examining what F(A+T) value will give the no harvest solution, ie what value for F(A+T) will mean that the left hand side of the first order condition will never equal the right hand side of the condition.
45. This is because the timber starts to decay.
46. Another concern is that the value of the forests is being discounted. Discounting biases against future generations and in the models' calculations, the use of a discount rate compared with a no discount regime greatly affects the final results. Indeed, conservationists are implicitly proposing that a negative discount rate be used because, as the natural environment deteriorates over time, the value of the forests to future generations will be greater than the value to current generations. Examining the effects of discounting and the appropriate discount rate to apply to old growth forests is however, enough of an undertaking for a thesis in itself.
47. These values have been derived using E.Pilularis as the predominant forest league.

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