DIVERSIFIED SPECIES TECHNICAL NOTE

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The Kauri (*Agathis australis*) Calculator

Summary

A calculator has been developed for the estimation of productivity, yields and returns from kauri (*Agathis australis*) grown in even-aged planted forests. The calculator is based on models of height, basal area and volume developed from 25 planted stands of kauri throughout New Zealand, including one stand in Otago, and one high-performing stand in the Bay of Plenty. The calculator provides a useful tool to determine potential returns from kauri forestry and through testing various scenarios can suggest some regimes for its establishment and management. This basic economic model study showed with some confidence, that the economics of plantation-grown kauri is likely to be quite a lot better than previously thought. Initial calculations indicate that returns on investment from kauri forestry will be strongly influenced by landownership models and by the incorporation of thinning regimes to obtain early revenues over rotations that will generally be longer than for exotic forestry species. Planted on suitable land the forecasted economic return for kauri from the scenarios tested was 5.6-11.7% (excluding transport costs).

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Introduction

Kauri has many natural attributes that make it an ideal forestry species. These include monopodial growth habit (single leader), good growth on selected sites in comparison to other indigenous softwoods and some exotic forestry species, superior wood properties, and natural branch shedding. Kauri timber, highly valued for its appearance and working properties, is now difficult to obtain. Exploitation of the species has left a depleted natural resource. The majority of the natural stands are in widely dispersed populations in the conservation estate on difficult or atypical sites where growth is known to be slow in comparison to kauri planted on good sites.

The potential for plantation forestry using kauri has been discussed by numerous authors. Most of the projected returns or productivity were based on observations from only a few trees or single stands, some of which were natural. A 1996 study produced a preliminary stand productivity model and economic case for plantation-grown kauri. This model was based on two 60 year-old planted stands in New Plymouth that retained extremely high stand density (1444 stems/ha and 1348 stems/ha) at the time. The prediction for continued basal area increment (and therefore volumes) to well in excess of 100 m^2/ha at age 80 years was not supported by later studies. The study indicated negative net worth when using a discount rate of 10% for unthinned stands over rotations of 60-80 years and IRR of 2.3-2.9%. The value of non-timber benefits to achieve positive returns (at 10% discount rate) were estimated to be $901-922/ha for 60-80 year rotations.

While the various studies of growth and productivity have indicated the potential for growing kauri in plantations (Figure 1) for a range of timber outcomes over differing rotation lengths. What has still been lacking has been a thorough investigation of the potential returns to growers and investors based on as large a dataset as was available.

The depleted natural kauri forest has left the New Zealand timber market with a continued interest in kauri timber, but largely without a supply. The obvious solution is to grow it in planted forests, but how fast does it grow, what are the rotation lengths, and what are the returns in timber and value likely to be? The development of the kauri calculator will facilitate answering those questions.

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Figure 1. Example of a well-grown kauri plantation at age 50. Many of the stems in this untended stand are merchantable. At an estimated 1000 stems/ha the stand would suitable for, and benefit from a commercial thinning.

The Calculators

Leith Knowles and Mark Kimberley came up with the idea of the so-called "calculators" around 2001. The first rather simple calculator was developed to compare the economic returns of farming with radiata pine (*Pinus radiata*) plantation forestry. This was followed in 2003/2004 by a much more sophisticated version for Douglas-fir (*Pseudotsuga menziesii*), which employed a stand growth model to explore different kinds of Douglas-fir management (e.g. stocking, thinning and pruning). In 2010 a simpler and web-based calculator for Cypress (*Cupressus spp.*) was released through Future Forest Research (FFR), followed in 2011 by another for *Eucalyptus fastigata*.

The fundamental idea of all the calculators is to estimate the growth and yield of a 1 ha stand using a growth model, and through this estimate the economic return for one rotation. This is achieved through a classical discounted cash-flow analysis. In short, discounting all costs and revenues throughout the stands life to the present, and adding them up to give Net Present Value (NPV). And also use the cash-flows to calculate the internal rate of return (IRR), i.e. the discount rate at which the investment breaks even. NPV and IRR are standard economic statistics used for immediate comparison of alternative investments, and in this case also different management regimes. The calculators, therefore, provide a simple economic decision-support tool. Recently a calculator for New Zealand kauri has been developed, employing the new growth model developed during 2011

One very important factor in estimating the net present worth of planting kauri is putting a price on the wood produced. Only little plantation grown kauri is sold, and the prices achieved are unlikely to reflect a market with full information, i.e. the current prices cannot be considered equilibrium prices. An average stumpage of $135-$171 may at first seem quite high, compared to more traditional values of $30-75 for other species. On the other hand, off-the-mill prices of $1,000 or more per m^3 for kauri wood is normal - and it seems likely that plantation-grown kauri will remain a highly sought-after niche-product in any foreseeable future. Hence, kauri is likely to be worth markedly more than wood from large plantations, for example. Finally, the merchantability/price of kauri wood may even increase over time, as the existing kauri resource is very scarce. Therefore, using a diameter (DBH)-adjusted version of the stumpage estimated in the 1996 study seems reasonable, and not overly optimistic.

The kauri calculator has the same form as previous calculators, with worksheets for growth (graphs and measurements), economics, measurements and stand information (see Figures 2 & 3). Variables of rotation length, site index, mean top height, basal area etc can be varied with new calculations rapidly analysed.

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Actual data from existing measurements can be entered and compared with alternative establishment and management regimes based on averaged or selected data from the dataset.

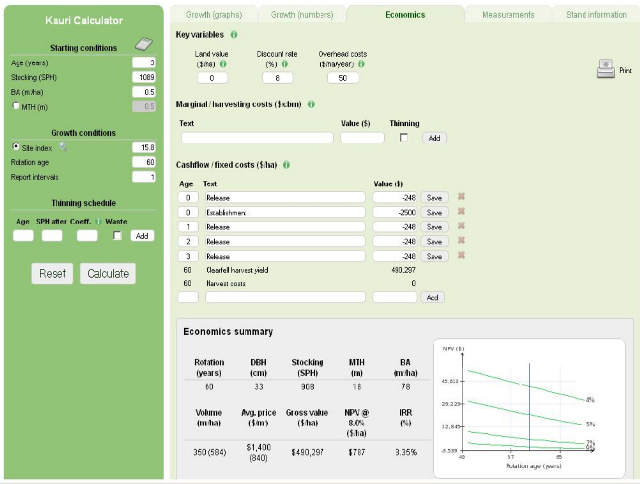

Figure 2. Example of an output page from the kauri calculator with the economic data inputs and outputs.

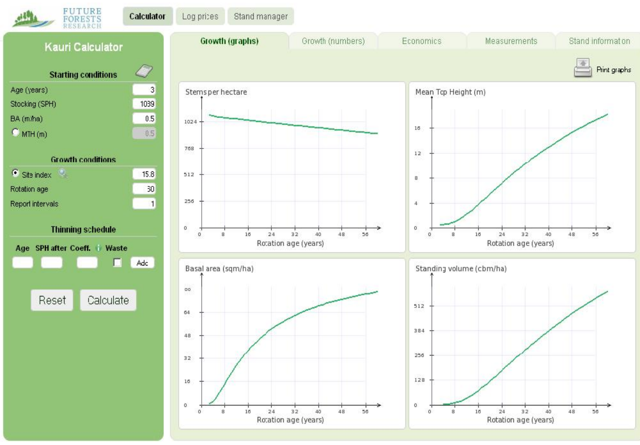

Figure 3. Example of the graphed output of Stocking (stems/ha), Mean Top Height, Basal Area, and Standing Volume development from the kauri calculator. The stand parameters on which the graphs are based are included in the left hand side of the image.

Some Results

To demonstrate the potential of the calculator six scenarios over rotations of 50, 60 and 100 years were tested. These scenarios incorporated different thinning and non-thinning regimes. For each rotation, scenarios with and without a land value were also included. The output for each scenario is summarised in Table 1. Each scenario was assumed to begin at 1089 stems/ha (3 × 3 m spacing) and followed the mortality function built in to the calculator.

For the 50 year old rotation only two scenarios were tested, one with an assigned land value ($3,000/ha) and one without an assigned land value. The scenarios without a land value have been included to replicate situations such as multiply owned Maori land.

For the 60 year old rotation one single quite severe thinning was included that reduced stand density at age 40 to 400 stems/ha (from 858 stems/ha), and then complete harvesting at age 60.

The 100 year old rotation included two thinning operations; the first at age 40 years to 400 stems/ha, and then a second at age 75 to 200 stems/ha.

The value of the land is shown to have a substantial influence on returns to growers as do thinning regimes and rotation lengths. However, regimes with less drastic yet more regular thinning once individual trees reach merchantable size may prove more profitable (e.g. every 10 to 20 years). Not only because income will occur sooner and more regularly, but also because the forest owner could carefully select both thinned trees as well as final crop trees. This in turn could also lead to some sort of continuous-cover forestry, e.g. plenter-wald or coup systems.

Obtaining early revenues from production thinning, where all other values remained the same significantly improved the economic return (typically an absolute increase in IRR of 2.6-5.5%). This is a logical consequence of the

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longer rotation of kauri, i.e. because of the time-preference (discount rate) early revenues weigh more than later ones. The significance of early revenues may, however, be slightly exaggerated due to over-estimation of the market value of the thinned wood. That is, the prices for thinned (very young) kauri wood may be significantly less than for more mature wood.

The inclusion or removal of an assigned land value to the calculation, where all other values remained the same, resulted in an increase in IRR of 1.2-1.5%.

Another important effect of thinning is its beneficial effect on the dimension (DBH) of the final crop. First of all, the study used a thinning from below, which leaves the fattest trees behind. Furthermore, many studies have observed that kauri also responds well to silviculture (i.e. thinning and pruning) - hence, the average DBH of the final crop will also benefit from the extra resources available after thinning.

The effect of transport costs has not been included in these scenarios. No attempt has been made to include these non-timber benefits in this current version of the calculator. The effect on log prices in the presence of an increased supply has not been thoroughly tested, however all scenario's were repeated with log prices being halved. This resulted in positive returns in all but one regime.

Conclusions

This basic economic model study showed with some confidence, that the economics of plantation-grown kauri is likely to be quite a lot better than previously thought. Planted on suitable land the forecasted economic return for kauri is 5-11%.

Kauri plantations are likely to be more stable and ecologically viable forests, with the added benefit of product diversification. Finally, kauri forest is the natural habitat for many native plant and animal species, and therefore can provide a wide range of (non-market) amenity and cultural values, while still producing highly sought after wood.

The kauri calculator is currently available on the members page of the FFR Diversified Species website, and will be publicly available on the FFR and Tane's Tree Trust websites in the near future. The calculator was presented to FFR at the members meeting in Gisborne 2012 and at a seminar to the 2nd year forestry trainees at the School of Forestry, Waiariki Institute of Technology.

Table 1. Estimated returns from a kauri plantation obtained from the kauri calculator under different rotation lengths, with and without thinning, and with and without land value. All scenarios were calculated at 8% Discount Rate.

Rotation length (yrs)	NPV ($/ha)	IRR (%)	Land Value ($/ha)	Thinning
50	$8,430	9.6	$3,000	Nil
	$11,601	10.8	$0	
60	$12,024	10.21	$3,000	At age 40
	$15,232	11.67	$0	
	$3,500	9.03	$0	Nil
100	$6,666	9.62	$3,000	1st thinning at age 40
	$9,905	11.08	$0	2nd thinning at age 75
	-$4,215	5.62	$0	Nil

Notes:

- Thinning costs at $28/tonne, harvest costs at $24/tonne.
- NPV and IRR include establishment and maintenance costs (5 releasing operations)
- Land value was either $3,000/ha for normal commercial forestry establishment, or $0/ha which may reflect multiply owned Maori land.
- Productivity was based on the best kauri plantation data. This assumes that with breeding, selection and improved forest silviculture that more stands would approach these productivity figures.
- Assumed that sawn kauri timber would achieve $1400 per cubic metre
- Each scenario returns a positive (but reduced) NPV and IRR at $700 per cubic metre, except for the 100 year rotation with $3,000 land value.