

# Realistic alternatives to radiata pine in New Zealand - a critical review<sup>1</sup>

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## Summary

Radiata pine comprises 90% of the 1.81 million hectares of plantation resource in New Zealand. There are a number of reasons for unease at this dominance of a single species. To alleviate this concern, several hundred thousand hectares of one or more alternatives must be established. Although there may be thousands of candidate species on the planet, the choice is severely restricted by practical considerations including lack of knowledge and perceived profitability. A profitable species must be cheap to grow, must yield large quantities of valuable wood in a short time, and must be low risk, where risk is a composite of biological, climatic and socio-economic considerations.

There are only two proven choices that, given our current knowledge, can be planted at a profit in New Zealand on any substantial scale: radiata pine and Douglas-fir. In addition there are a number of likely contenders: certain cypresses, certain eucalypts and redwoods.

Despite enthusiastic supporters, there is insufficient hard evidence for any other species (including natives) to suggest that they are capable of substituting for radiata pine on a large scale, and/or achieving the same levels of profitability.

## Scope

This review was commissioned by the New Zealand Forest & Farm Plantation Management Research Cooperative. The purpose is to compare and contrast potential commercial tree species in New Zealand grown for profit from the sale of wood. There have been at least two previous attempts to do this: a paper by Cavana and Glass<sup>3</sup>, and the Ministry of Forestry Zone studies (now out of print). The Ministry of Forestry also produced a "Small Forest Management" series in 1995, including a volume on Special Purpose timber species.

Since the above were published, new data have been collected for some species, and new models developed. Whereas the Zone studies addressed the question: "if I have a property in region X of New Zealand, which species should I grow?" this review takes a national perspective: "if I want to invest in New Zealand forestry – the exact location being immaterial – which species should I grow?"

## Introduction

Are there realistic alternatives to radiata pine or Douglas-fir? How do "alternative" species rate in terms of profitability, and if they cannot compete, how great is the margin?

Plantation forestry in New Zealand is frequently criticised because of its reliance on a single species. Radiata pine (*Pinus radiata* D. Don) now comprises 90% of the planted area, but this was not always the case. The 1913 Royal Commission<sup>3</sup>, for example, reported that it constituted less than half a percent of state plantings. The recent dominance of radiata pine may be attributable to its profitability, but a number of other factors, including wide site-tolerance, dependability, research back-up and market infrastructure, must also have contributed.

There are several reasons for the unease about the preponderance of radiata pine. These may include: the fear of some introduced pest or disease, and the perceived security provided by a range of alternative species; the belief that a "monoculture" will somehow exacerbate the incidence and severity of such an event; the concern about over-specialisation in one market product (e.g. a softwood, whereas future demand may be for hardwoods); the lack of product choice for domestic consumers; the aesthetic values of current forestry practices, given that people tend to prefer variety in their landscape; and the biodiversity implications of using a single canopy species. Public attitudes may also be more favourable towards: indigenous trees; classical European species; those with light green or deciduous foliage, or attractive flowers; those with naturally durable or colourful and interesting wood; or those that have a wider range of possible benefits in addition to timber production.

There are many good reasons for planting trees. Provided that the species selection is biologically rational – i.e. the trees actually survive and thrive – there may be no need to justify or even explain the choice to outsiders. If, however, the purpose is to make a profit from the sale of wood, then the rules are far more restrictive. Some species may well achieve this goal, while others are highly unlikely to do so. Whatever criterion of profitability is used, there needs to be some sort of ranking, albeit one that is imprecise.

This review does not attempt to duplicate numerous previous studies on individual species by detailing their traditional uses or performance under various climatic or siting requirements. Instead, the objective is to compare and contrast selected major commercial tree species under ideal conditions – where the goal is single-mindedly to profit from timber production. If there are additional reasons for favouring another species, or mix of species, then this is a separate exercise not considered here.

Discussion of profitability in forestry has often been trivialised by concentrating on one component in isolation. For example, if furniture of Species A can be retailed at twice the price of Species B, does this necessarily mean that

<sup>1</sup> This paper is a summary of the report produced for the Forest & Farm Plantation Management Research Cooperative. Readers who seek more complete detail on individual species, including wider references, should consult the original report. Contact Christine Dodunski (Christine.Dodunski@forestresearch.co.nz).

<sup>2</sup> Cavana, R.Y.; Glass, B.P. 1985: Economic analysis of selected special-purpose species regimes. *NZ Journal of Forestry Science* 15(2): 180-94.

<sup>3</sup> Royal Commission on Forestry, 1913. *AHJR* 1913, C-13.

it is more profitable to grow? Although weight-for-weight diamonds vastly exceed the price of coal, does a diamond mine always return more money to the investors than a coalmine? Again, if Species C has a shorter rotation than Species D, is this critically important – are shorter-term bank deposits always the best option?

The rules for profitability in forestry are no different to the rules for other enterprises: gross revenue depends on the quantity of saleable product and the price per unit; net revenue is gross revenue less the cost of production and transport to the point of sale; the time between expenditure and return must be minimised; and lastly risks and uncertainties must be considered. If forestry is different, it is because the investment interval is longer than for almost any other investment. This places greater emphasis on the time-value of money, and on risk/uncertainty. Risks are where the probabilities are known, and uncertainties where they are not – uncertainties are common in forestry because only a brave or foolhardy investor would claim to accurately foresee the state of the world half a century hence. Probabilities based on historical data are often suspect.

## The approach used

Radiata pine is used as a benchmark, because it is relatively well researched. Other species are compared to radiata pine for each of the elements of profitability:

- quantity,
- price,
- cost,
- timing and
- risk.

Sometimes hard data are available, but in some situations a subjective estimate must suffice.

The five elements can be scrutinised separately, or they can be combined into a single comparable figure by the use of Discounted Cash Flow Analysis. In the author's judgement, this methodology is not well understood by many lay people, and can confuse even those who regularly use the technique. The basic principles are as follows:

Starting with "bare land" – i.e. land devoid of trees, but which may contain weeds of different types – a hypothetical table of cash flow is constructed for each species. All expenditures and revenues are included, together with the year in which they occur. These are merged into a single figure using one of two techniques: Internal Rate of Return (IRR) and Land Expectation Value (LEV)<sup>4</sup>.

IRR is the preferred option if there is no "lumpiness" arising from the investment: in other words, if an entrepreneur can invest any sum of money on a sliding scale and withdraw the proceeds at any time, then – provided that risk/uncertainty have been adequately addressed by adjusting cash-flows – the only consideration is the inflation-free return on capital. This is best provided by a comparison of IRR.

<sup>4</sup> LEV is the Net Present Value (NPV) of future cashflows from a perpetual series of rotations with the land currently bare of trees. In common language, the maximum that can be paid for land to achieve a given rate of project return.

On the other hand, if the prime concern is to secure the greatest profit on an investment of fixed scale – for example on a given area of land or in a certain time horizon – then the Present Value method is to be preferred. Regrettably, this technique requires a previously determined choice of discount rate. Discount rates vary greatly between countries, sectors, and individual investors, and are an ongoing source of contention. Typical rates in vogue may also change over periods of decades. The solution is to provide present values for a range of discount rates. This will often give a range of answers, which is not a satisfying result even though it is a realistic one.

A thorough analysis should include a *sensitivity analysis* of all inputs, including volumes and price by log grade. This would indicate both the robustness of a conclusion, and the inputs that require the greatest scrutiny or research. Unfortunately, such an analysis is beyond the scope of this review, as it would require considerable extra time and resources.

In some cases, Species A is superior to Species B in all five elements of profitability, in IRR and in LEV for the full range of discount rates, and for all likely ranges of other inputs. The conclusion is clear: Species B cannot be chosen on the basis of profitability alone, at least with the assumptions used. In other cases, the conclusions are not so clear-cut and subjective judgement must be used to compare the two species. The decision-maker (e.g. the investor) must decide which indicators of profitability are critical and which are of lesser consequence.

## Quantity of product

Wood is sold by volume or weight, which increases with stand age. Some species are sprinters – good early growth – while others are marathon runners and do not achieve best performance until an advanced age. It can therefore be misleading to compare volumes at a fixed but arbitrary age. One solution is to provide a single figure for the productivity of a crop that is independent of timing – such as the maximum Mean Annual Increment (MAI) of stemwood volume under bark. MAI reaches a peak at a certain age (depending on species, site and regime) and then declines. In an economic comparison, the trees will usually be sold before they reach their peak MAI; therefore it is also useful to produce a table or function of stand volumes covering the range of likely rotation lengths.

Maximum volume production usually occurs in stands with high stockings and where severe thinning or pruning has been avoided. But thinning increases the diameter of individual trees, and pruning improves the quality of wood. Therefore, a refinement on the "Max MAI" approach to comparisons of productivity is to compare growth only in intensively managed stands. In radiata pine, this philosophy has been developed into the Radiata Pine Productivity 300 Index<sup>5</sup>.

Volume – expressed either as individual trees or as whole stands – is calculated from tree height and basal area, but

<sup>5</sup> West, G.G.; Kimberly, M.O. *Forest Research*. Currently unpublished.





*Photo 1: Douglas-fir is, besides radiata pine, the only proven choice that can be planted at a profit in New Zealand on any substantial scale. Hanmer provenance trial, age 39.*

the relationships are not straightforward and functions may have substantial error. Where none other is available, the simple Beekhuis stand volume equation<sup>6</sup> is crude but can be used for all species. Moreover, not all stemwood volume is *merchantable*<sup>7</sup>. A comparison of two species using crude volumes may be grossly misleading. A refinement is to add a column giving the ratio of merchantable to total volume by age, or – better – to compare volumes of similar log grades.

There is no point in comparing tree performance under less-than-ideal or even average conditions, because any given species of tree will fail to prosper if the conditions are sufficiently adverse. The comparison is then one of historical siting or management practice rather than species potential. The key determinant of productivity must be the best single, reliably quantified example of good growth in New Zealand. It is a separate exercise to discover how widely

this example can be applied in practice.

### Price per unit

The grower of trees is usually interested in stumpage price but data is often available only for prices at the mill-door or wharf gate. Logging, loading, internal roading, transport and post-harvest costs vary greatly but a uniform \$40/m<sup>3</sup> is assumed for the combined total of these, unless there are good reasons why a given species should have a greater or lower value.

Where no mill-door prices are available, it may be necessary to work backwards from the retail price of sawn timber by deducting the costs of processing. This approach is to be avoided, because it introduces additional uncertainties – including the conversion rate of roundwood to sawn timber.

It is essential – wherever possible – to subdivide wood into log grades, because price varies greatly according to log size, age and quality. Grades that are worth less than the \$40/m<sup>3</sup> may be worth leaving behind in the forest<sup>8</sup>.

Unfortunately, there are no standard specifications for log grades. For example, there may be hundreds of grades currently employed for radiata pine. Units of measurement vary (for example, export logs in JAS m<sup>3</sup> but domestic logs in tonnes); different currencies are employed (\$US or \$NZ); and there is no standard convention as to how best to average prices in a fickle market.

The preference in this review is to use domestic markets, because this avoids the problematic conversion to JAS m<sup>3</sup> and between exchange rates. The mean of the most recent 12-quarter average prices is preferred. Grades must sometimes be amalgamated into a few simple categories –

<sup>6</sup> Volume (m<sup>3</sup>/ha) = Basal Area x (0.9 + 0.3\*Height).

<sup>7</sup> “Merchantable” is used synonymously with ‘recoverable’ in this review. It is defined here as the wood that is of sufficient quality, size or age to have an existing market, other than firewood. The presence of merchantable wood is no guarantee that it will be profitable in practice to extract and transport it to the market.

<sup>8</sup> Strictly, some harvesting costs are fixed (e.g. roading) and are the same regardless of the harvest volume, while others (e.g. loading, cartage) are variable, and depend on the quantity of wood handled. Thus it may pay to extract and sell log-grades up to the level of the variable costs, i.e. substantially below the assumed average cost of \$40/m<sup>3</sup>.



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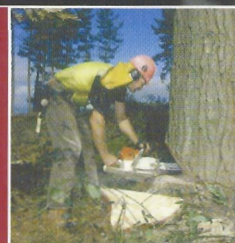
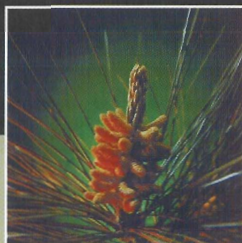
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## Growing costs

The cost of growing trees from establishment to harvest can be subdivided into:

### Land price

We cannot assume that all species require the same quality of land. At the one extreme, species such as black walnut require high-value horticultural soils and shelter to be grown successfully in New Zealand. At the other, Douglas-fir or Corsican pine grow best on relatively cheap South Island high country. This is an important consideration and cannot be omitted.

### Seedling costs

The price of seedlings obtainable from nurseries varies greatly with species. Sometimes this may be attributable to economies of scale, but other times it relates to properties of the species themselves. It is not possible to separate these components, but seedling costs have been obtained that are derived from three nurseries<sup>9</sup>. Initial stocking varies between species, and although there is often not a consensus on a preferred initial stocking, it is possible to make broad comparisons.

### Establishment costs

Some species require extra care in site preparation, including cultivation, fertiliser and weed control.

### Thinning and pruning costs

For the same stocking and stem diameter, thinning costs do not vary greatly between species, although production thinning may be a possibility in some cases but not in others. Pruning costs vary with branch size and number, and wood density, and some species do not require pruning.

### General management costs

These are assumed to be \$50/ha/year for all species, and include rates, insurance, fencing, weed and pest control and general supervision.

## Rotation age

"How long does it take for Species X to mature?" This common question has little objective meaning. Unlike many other crops, trees can be harvested at any marketable age. Generally, they improve in size and wood quality with age, but time-preference usually dictates that they are harvested long before maximum revenue or even maximum average volume increment per unit area is reached.

One difficulty is that rotation age interacts with silvicultural regime: optimum rotation age on a given site varies according to initial stocking, timing of thinning, final crop stocking, and pruning history. Rather than analysing all possible regimes, it is necessary to pick a likely best-case regime, and provide a range of rotation ages for examination.

<sup>9</sup> Forest Research, Edendale and Appletons. All 2003.

Another difficulty is that rotation age is very sensitive to discount rate. A high rate (or the use of IRR as a criterion) enhances the importance of early returns and thereby lowers the optimum rotation age. Advocates of alternative species commonly argue that the high discount rates currently in fashion inevitably favour relatively short-rotation species such as radiata pine. The solution is to analyse each species for a range of rotation ages and discount rates – including very low discount rates – and select ages that optimise profitability under a given criterion. Here a low discount rate (6%) is used and the extreme ranges of pre-tax rates currently employed by forestry valuers in New Zealand (9% and 13%)<sup>10</sup>.

## Risk and uncertainty

There are many risks in forestry that apply to all species. For example, fire and hurricane-force winds will destroy any forest. All trees are susceptible to certain pests and diseases. All wood is under threat from non-wood substitutes, such as concrete, steel, aluminium and plastics. Nevertheless, it is clear that particular risks are greater in some cases than others: for example, Douglas-fir is more wind-resistant than radiata pine, whereas the reverse is true for drought. Data can sometimes be obtained to quantify the probabilities.

The word "risk" is used loosely to describe both the likelihood of an event occurring and the extent of its impact should it occur. A low-impact, high-probability risk may have the same "expected value"<sup>11</sup> as a high-impact, low-probability risk and therefore may be treated identically in an analysis, but only the latter may attract public attention. For example, the probability of a disease eliminating all plantations of radiata pine may be extremely low, but if it were to occur the economic effects would be catastrophic. So a common view is that the predominance of radiata pine is "risky", even though a mix of species (possibly including such disease-prone genera as *Eucalyptus*) would certainly increase the annual incidence of damage in a typical year, if only because a wider range of hosts invites predation from a wider range of pests and pathogens.

Risk can be subdivided into the types of risk: *climate* risk involves tree death or damage from factors such as wind, frost, snow, or drought; *pest and disease* risk involves organisms that may not be present in New Zealand and may not even be known to science. Some indication of the likelihood of these types of risk can possibly be obtained from historical studies. More problematic are *market* risks, which involve questions of consumer behaviour. In this category, the past may be no guide to the future. Will the

<sup>10</sup> NZIF Forest Valuation Standards, and also Manley, B.R. 2003: Discount rates used for forest valuation - Results of 2003 survey. *New Zealand Journal of Forestry* 48(3): 29-31.

<sup>11</sup> "Expected value" is the technical term for the sum of all the effects of an event times the probability of that event occurring. Thus, if there is a 70% probability of a forest achieving \$50000/ha and a 30% probability of it achieving only \$2000, the expected value is  $(0.7 \times 50000) + (0.3 \times 2000)$  which equates to \$35600.



Table 1  
What we know about the major species

SPECIES	Manual?	Total volume?	Rec Vol by log grade	Mill-do- or Price	Costs	Timing	Risk
Radiata pine	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Douglas-fir	No	Yes	Yes	Yes	Yes	Yes	Yes
<i>Cupressus macrocarpa</i>	Yes	Yes	No	Yes?	Yes	Yes	Yes
<i>Cupressus lusitanica</i>	Yes	Yes	No	Yes?	Yes	Yes	Yes
<i>Eucalyptus fastigata</i>	No	Yes	Yes	?	Yes	Yes	Yes
Stringybark eucalypts	No	Yes	Yes	?	Yes	Yes	Yes
Blackwood	Yes	Yes	Yes?	Yes?	Yes	Yes	Yes
Redwood	Yes	No	No	?	No	?	Yes
Poplar/willow	No	Yes	Yes	No	No	Yes	Yes
Others	No*	No	No	No	No	No	No

#### Notes:

*Manual* means that there is a manual published specifically for this species, containing practical and comprehensive information relevant to a potential grower. These manuals vary in their reliability.

\* Note: some good manuals on growing indigenous species have recently been produced.

*Total volume* means that credible estimates of total stem volume can be obtained, either from models or directly from relevant plot data.

*Vol by log grade* means that mature stands have been assessed to obtain a breakdown of total volume into four or more standardised log grades.

*Mill-door price* means that there are price data available (other than anecdotal information) of general long-term significance. One-off small consignments, particularly to ephemeral processors, may be anomalous.

*Costs and timing* imply that there are reasonable reliable estimates of growing costs and rotation age. Some degree of imprecision is allowable – at least in regard to costs – because the overall profitability of a species is unlikely to be sensitive to small changes.

*Risk* means that there is sufficient literature and/or anecdotal experience from small growers and consumers to derive subjective estimates of the various types of risk.

(U.S.) preference for light-coloured woods be reversed? Will plastic veneers become indistinguishable from genuine wood and will the market continue to differentiate between them? Lastly there are *social* risks, which involve changes in public attitudes, possibly resulting in prescriptive legislation. Will chemical timber treatments become unacceptable, at least in some markets? Will the fear of wilding tree spread prevent the development of an industry based on certain species? Will there be legal discrimination against growing certain species, e.g. exotic softwoods, in scenic areas? Will Forest Stewardship Council certification eventually lead to a higher proportion of alternative species? Evaluation of such probabilities must always be subjective.

Some types of risk can be positive as well as negative. Consumer demand for a given type of wood may fall, but it may also rise. Legislation may prohibit tree planting, but it also may compel it. Higher energy prices may make wood more costly to produce, but may impact more heavily on wood substitutes.

important for evaluating their investment potential.

The paucity of data is well illustrated by *Eucalyptus fastigata*. Of all the eucalypts researched in New Zealand, the focus has now been narrowed to this species and to several stringybarks. Given that many of the latter can be grown only on warmer areas, this places great emphasis on *E. fastigata* PSP data. Most plots have been grown for pulp regimes, so we raise the question: how many *E. fastigata* plots are available grown on sawlog regimes? The answer: only one! It is scarcely necessarily to underline the gamble an investment company would be taking when basing a major planting programme on this one plot<sup>13</sup>.

Note that no "growers' manual" has yet been written for New Zealand Douglas-fir or eucalypts. In other words, for

<sup>12</sup> Unfortunately the raw PSP data were not made available with all species, due to difficulties in obtaining permission from the myriad of land-owners involved.

<sup>13</sup> Although Ian Nicholas points out that there are good trials, and a large number of plots, in Ash-group eucalypts closely related to *fastigata*.

#### Data availability

Several main sources were useful in the course of this study. The Forest Research Permanent Sample Plot system was invaluable for providing hard data<sup>12</sup>. In some cases, these data have been distilled into user-friendly software as in the case of Leith Knowles' Calculators (radiata pine, Douglas-fir or poplars), or Pascal Berrill's models (eucalypts, blackwood, cypresses).

The Bulletin 124 series (John Miller and Barbara Knowles) needs to be singled out for special mention, as do the various speciality "manuals" (radiata pine, cypresses, blackwood and redwood). The most useful reference journal was the NZ Tree Grower. Although many articles are anecdotal and lightweight, any insight of substance eventually appears there, and may not appear elsewhere. Lastly, there is a huge body of knowledge in the form of expert opinion, which may not meet the strictest criteria of scientific data, but must be better than an uninformed guess.

Table 1 provides, for the major species considered in this review, a summary of the knowledge that is critical to or



Photo 2: *Cypresses have good volume production on suitable sites. Economic evaluation is currently hindered by the lack of a model to predict log grade volume.*

these species each grower would need to undertake the effort of compiling practical information on such things as planting stock, siting, establishment techniques and regimes.

Cypresses are arguably New Zealand's third main genus after radiata pine and Douglas-fir. The discovery that there is not yet a reliable model available for predicting volume - at least in terms of log grades - for this genus, is startling. Farm foresters, enthusiasts and "lifestylers" may not need such information, but an investment company may need to convince the board of directors, lending agencies, and shareholders that a decision to invest in cypresses is rational and wise. This cannot be done if it is not possible to confidently predict the quantity of each type of product that will eventuate.

More fundamentally, as soon as we depart from the two main species, there is no standard set of log-grading rules: for example, how large are the branches in "small branched sawlogs", what is their minimum length and small-end diameter, and how straight do logs need to be?

One key result of this study, as illustrated in Table 1, is the alarming scarcity of hard data for species other than radiata pine and Douglas-fir.

### Profitability analysis

In large-scale New Zealand plantation forestry, perceived profitability is a major reason for choosing or rejecting a given tree species. Given that definitions of profitability vary, seven indicators are used in this review: volume productivity; price; growing costs; time delay between costs and returns; risks (climate, pests and diseases, market-related, and social); IRR; and LEV at 6%, 9% and 13%. Radiata pine is used as a benchmark for comparison.

The goal of this study is to assist decision-makers, not to supplant them! Any indicator may be emphasised, weighted or ignored as desired. For each species, Table 2 summarises the seven indicators against radiata pine.

### So how do the different species compare?

#### *Radiata pine:*

It is well-researched and an unusual species, in that it performs well on average-to-poor sites, and can be

successfully "blanket planted" across vast areas. It has good volume production, low costs, good prices, short rotation age, low risks. New Zealand has accumulated extensive operational experience in growing, processing and marketing radiata pine over more than three rotations.

#### *Douglas-fir:*

It is also well-researched, but there is currently no growers' manual or publicly available price-list for logs. Douglas-fir is superior to radiata pine in nearly all profitability factors except for early growth rates and rotation age. It is limited to cooler parts of New Zealand.

#### *The cypresses:*

Above-average sites only. It has good volume production, reasonable prices and medium rotation lengths, but high costs (land and pruning). A major problem is cypress canker, which restricts choice mainly to *lusitanica* and the Leylands. The potential of the latter is restricted by the small number of clones currently available. Despite good PSP records, no existing model provides volume by log grade, hindering economic evaluation. Expansion of the resource could be impaired by a future shortage of labour to prune trees.

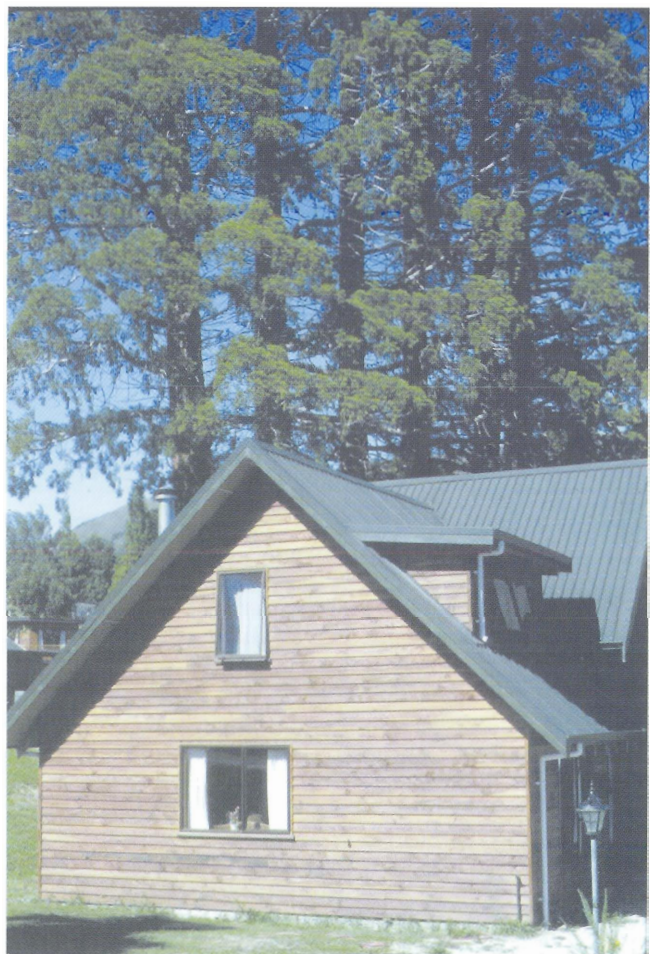


Photo 3: *Redwood house near Wanaka. An important attribute for redwood markets is durability. Clones need to be screened for durability before any major planting programme in New Zealand.*



Table 2  
Summary of profitability criteria by species

SPECIES	Vol.	Price	Costs	Timing	Risk	IRR%	LEV @6%	LEV @9%	LEV @13%
Radiata pine - top	25.6	111	2000	25	Low	9.0	4528	21	-2360
Radiata pine - ave.	17.8	85	4765	27	Low	7.6	1386	-727	-1701
Douglas-fir	28.9	180	2238	45	V.Low	9.1	9313	197	-2515
Cypresses (lusitanica)	17.7	129?	9270	35	Med	?	?	?	?
Eucalypts	28.6	91	5532	35	High	6.1 ?	250 ?	-2940 ?	-4036 ?
Blackwood	10 ?	~200	5440	35-40	Low	7.0 ?	?	?	?
Redwood	36.8	184	8147	30-70	Low-High*	10.5 ?	18533 ?	3609 ?	-3416 ?
Poplar	18.6	79?	5380?	12-25	High	?	?	?	?

**Notes:**

Figures are for the “best case” situation. In the case of radiata pine, national average data are also provided.

Volume refers to Mean Annual Increment of Recoverable Volume (m<sup>3</sup>/ha/year) at a typical rotation age, for a top quality site and for a good regime (that may include thinning and pruning).

Price refers to mill-door price (NZ\$/m<sup>3</sup>), as averaged across all recoverable volume.

Costs refer to all growing costs until harvest (\$/ha), including land costs, but excluding annual administration. For radiata pine, a low cost and a typical cost are provided.

Timing refers to typical rotation age, but there may be profitable production thinnings.

Risk is a subjective assessment of negative impacts from climate, pests and diseases, market fluctuations and/or socio-economic restrictions.

IRR is internal rate of return.

LEV refers to Land Expectation Value.

\* For redwoods, the risk is High unless clones are screened for natural durability prior to a planting programme, in which case it is Low.

? indicates that the data are suspect, or not available.

**The eucalypts:**

Certain species (*fastigata*, stringybarks) may break the poor record of this genus (disease, processing problems). There is insufficient academic research in the preferred species. In addition to the disease risk with this genus, the combination of medium-high costs, poor prices and medium-long rotations may lead to lacklustre internal rates of return.

**Australian blackwood:**

Currently there is no published model to provide volume by log grade. The main handicap is the poor volume production. The species is less well-suited for large forestry companies, or for blanket planting across complex landscapes. The best-case potential returns seem quite reasonable, but average returns are likely to be inferior to radiata pine, Douglas-fir or the cypresses. A good supplementary species, but not likely to be a realistic “alternative” species.

**The redwoods:**

They show good volume growth on the right sites, but are expensive to grow. One potential problem is that New Zealand-grown redwood may be non-durable, and the realisation of this could destroy the only current market (outdoor furniture in California). Clonal options could provide better quality assurance than seedlings. Perhaps emphasis should be on *Sequoiadendron* rather than *Sequoia*,

given the former’s wider site tolerance especially on cooler areas free of a canker fungus.

**Poplar/willow:**

Their ability to plant as wands, stakes or poles is a distinct advantage, especially where stock graze. They have cheap establishment and pruning costs, and possibly the very short rotations (<15 years) may attract an investor, but the wood has little advantage over radiata pine and is likely to be worth much less, if it is saleable at all. They are not seen as a substitute for radiata pine or Douglas-fir, but as a complementary species, especially in terms of erosion control and flood mitigation.

**Conclusion**

So what are the species that, given our current knowledge, can be planted at a profit in New Zealand on any substantial scale?

There are only two proven choices: radiata pine and Douglas-fir. In addition there are a number of likely contenders: certain cypresses, certain eucalypts and redwoods.

Species that may have a place in niche markets and restricted microsites are blackwoods and poplars. Although not included in Table 2, black walnut and Corsican pine also fall into this category.

Black walnut requires considerable effort and cost to grow well, but has the potential to achieve high returns on

ideal microsites. However, it is debateable whether other horticultural crops would not be a better proposition for such sites.

Corsican pine (*Pinus nigra* var. *laricio*) is able to grow on sites that are too cold for radiata pine, including large areas in inland Canterbury and Otago. It can also (like radiata pine) tolerate very dry conditions. The currently preferred regime is for roundwood, especially poles, for which it is superior to radiata pine.

All other species are non-starters. Each fails either on one or more of the five factors of profitability (volume, price, costs, timing and risk), or else there is insufficient information to establish the level of some of the factors.

In the author's experience, advocates of any particular tree species can often become emotionally attached to their preference, and any criticism (however mild) can be met with outright hostility. This paper, therefore, is written with some trepidation!

Why are we looking for alternatives to radiata pine? Burdon and Miller<sup>14</sup> suggest that there are three distinct reasons for diversification: the need for species suitable for non-radiata sites, for wood qualities where radiata is not suitable, and for "contingency" species, should any serious problems be encountered. It could be argued that there is a fourth, and equally compelling reason: the basic human need for variety and diversity in their surroundings, regardless of economic imperatives.

It must be acknowledged that there are many thousands of potential timber species present in the world that could grow in parts of New Zealand, and that only a small fraction of these have been adequately researched. In the cases where species have been tested and have failed, there is always the nagging doubt: did the trial represent a full range of provenances or varieties? Was the establishment practice up to modern standards, e.g. were the correct mycorrhizae used? Was the siting inappropriate? Were the drying schedules realistic? Were all the processing and marketing options sufficiently well explored? And so on.

Resources will always be inadequate to systematically assess all possible combinations of species, siting, management, processing and marketing practice. A true alternative to radiata pine may await some new discovery or research. Until that time comes, however, we must make decisions based on the existing evidence.

There are good reasons why radiata pine, and – to a lesser extent Douglas-fir – continue to be the main plantation species in New Zealand. Cypressess, redwoods and eucalypts have the potential to greatly expand their planted area, but blackwoods, poplars, black walnuts and Corsican pine will probably remain restricted to niche markets and microsites. Sadly, there are no other species clamouring for attention.

It may be unrealistic to expect the private sector to

provide the long-term resources to pioneer research into a tree species that has no existing base in New Zealand or overseas, if for no other reason than the fact that, by definition, such an industry does not yet exist!

If, at any time in the future, the Government of New Zealand wishes to stimulate the growing of a diverse range of alternative species in New Zealand, it will first need to complete several years or decades of preparatory work. There must be a substantial research programme with continuity of funding and management structure to more fully investigate the growth and wood characteristics of each of a narrow range of species. There also needs to be an agency charged with collection and compilation of key data, including mill-door or wharf-gate prices.

The importance of research continuity in this context must be emphasised: for example, three-year funding (that enables suitable people to be employed and trained with no assurance of continued employment) will merely address peripheral issues and will not underpin a major shift in New Zealand's forest cover.

## Acknowledgements

The major contribution of "contributing authors" Leith Knowles, Errol Hay, Pascal Berrill, Patrick Milne, Ian Nicholas, Wade Cornell and Allan Wilkinson is acknowledged. These people are not responsible for any errors that may occur, and may indeed disagree with my conclusions.

<sup>14</sup> Burdon, R.D. and Miller J.T. 1995. *Alternative species revisited: categorisation and issues for strategy and research*. NZ Journal of Forestry 40(1): 4-9.