# REALISTIC ALTERNATIVES TO RADIATA PINE IN NEW ZEALAND – A CRITICAL REVIEW

**J.P. Maclaren**
**Piers Maclaren & Associates Ltd**

**Report No. 90** **May 2004**

**FOREST AND FARM PLANTATION MANAGEMENT COOPERATIVE**

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## EXECUTIVE SUMMARY

### REALISTIC ALTERNATIVES TO RADIATA PINE IN NEW ZEALAND – A CRITICAL REVIEW

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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. The following species are the only ones that, given our current knowledge, can be planted at a profit in New Zealand on any substantial scale:

**Radiata pine:** Well-researched. Unusual species, in that it performs well on average-to-poor sites, and can be successfully "blanket planted" across vast areas. 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:** Well researched, but currently no growers' manual or publicly available price-list for logs. Is superior to radiata pine in nearly all profitability factors except for early growth rates and rotation age. Limited to some cooler parts of New Zealand.

**The Cypresses:** Above-average sites only. 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 resource could be impaired by future shortage of labour to prune trees.

**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. For example, there is only one *fastigata* PSP grown on a sawlog regime! 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 no published model provides 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:** Good volume growth on the right sites, but 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:** Ability to plant as wands, stakes or poles is a distinct advantage, especially where stock graze. Cheap establishment and pruning costs, and possibly 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. 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.

**Others:** 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.

## 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 report: volume productivity; stumpage 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, the following table summarises the seven indicators against radiata pine. Refer to individual chapters for details.

**Table 1.1: Summary of profitability criteria by species**

| Species | Vol. | Price | Costs | Timing | Risk | IRR% | LEV @6% | LEV @9% | LEV @13% |
|---|---|---|---|---|---|---|---|---|---|
| **P.rad – top** | 25.6 | 111 | 2000 | 25 | Low | 9.0 | 4528 | 21 | -2360 |
| **P.rad – av.** | 17.8 | 85 | 4765 | 27 | Low | 7.6 | 1386 | -727 | -1701 |
| **D-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 ($m^3$/ha/yr) 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^3$), as averaged across all recoverable volume.
- *Costs* refer to all growing costs until harvest ($/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.
- ? indicates that the data are suspect, or not available.
- IRR is internal rate of return.
- *LEV* refers to Land Expectation Value, which is the same as Net Present Value (NPV) but for a perpetual series of rotations.
- *For redwoods, the risk is High unless clones are screened for natural durability prior to a planting programme, in which case it is Low.

## SCOPE

The New Zealand Forest & Farm Plantation Management Research Cooperative commissioned this report. It does not attempt to go into detail about individual species: their description, their provenance, their cultivation, or their wood properties. At the end of each section there is "Further Reading" where this sort of information can be found.

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 in the NZ Journal of Forestry Science[1], and the Ministry of Forestry Zone studies (now out of print)[2]. The Ministry of Forestry also produced a "Small Forest Management" series in 1995[3], 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 publication 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[4], 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 (eg 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.

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[1] Cavana, R.Y. and B.P. Glass, 1985. Economic analysis of selected special-purpose species regimes. NZ JForSci 15(2): 180-94.

[2] Ministry of Forestry, 1995. Zone studies for Northland, Coastal Bay of Plenty, East Coast, Hawke's Bay, Taranaki & King Country, Manawatu & Wanganui, Wairarapa & Wellington, Nelson, Marlborough, Canterbury Inland Hill Country, West Coast , North East Otago, Otago & Southland Uplands, Otago & Southland Downlands,

[3] Ministry of Forestry, 1995. Small Forest Management. Vol 1 Special Purpose Timbers; Vol 2 Forestry Joint Ventures; Vol 3 The Resource Management Act; Vol 4 Planning a Small Forest; Vol 5 Establishing a Small Forest; Vol 6 Managing a Small Forest for Timber; vol 7 Harvesting a Small Forest; vol 8 Marketing a Small Forest.

[4] Royal Commission on Forestry, 1913. AHJR 1913, C-13.

There are many good reasons for planting trees. Provided that the species selection is biologically rational – ie 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 report 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 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 will be used as a benchmark, because it is relatively well researched. Other species will be compared to radiata pine for each of the elements of productivity – 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" – ie 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)[5].

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.

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 report, as it would require considerable extra time and resources.

In some cases, Species A is superior to Species B in all five elements, 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 (eg 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.

[5] LEV is preferred to the better-known Net Present Value (NPV), because it takes into account a perpetual series of rotations. The NZIF Professional Handbook definition, page E2-3, is "The "price" that can be attributed to land so that all the positive and negative "cashflows" (including the price imputed to the land) associated with the forestry "enterprise" when discounted at the required rate % indicate a zero "enterprise" capital value. In common language, the maximum that can be paid for land to achieve a given rate of project return." $LEV=NPV*(1+i)^n /((1+i)^n -1)$, where NPV is the Net Present Value for a single crop rotation and is the discount rate expressed as a decimal.

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[6].

Volume – expressed either as individual trees or as whole stands – is calculated from tree height and basal area, but the relationships are not straightforward and functions may have substantial error. Where none other is available, the simple Beekhuis stand volume equation[7] is crude but can be used for all species. Moreover, not all stemwood volume is *merchantable*[8]. 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 we will assume a uniform $40/m$^3$ 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 $40/m$^3$ may be worth leaving behind in the forest[9].

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$^3$ 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.

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[6] West, G.G. and M.O. Kimberley, Forest Research. Currently unpublished.

[7] Volume (m$^3$/ha) = Basal Area x (0.9 +0.3*Height). Note that this differs slightly from the formula for the volume of a cone (V= (Area x Height)/3), but Basal Area is measured at 1.4 m from the base, and is taken over bark whereas volume is expressed as under bark.

[8] "Merchantable" is used synonymously with 'recoverable' in this report. 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.

[9] Strictly, some harvesting costs are *fixed* (eg roading) and are the same regardless of the harvest volume, while others (eg 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, ie substantially below the assumed average cost of $40 per m$^3$.

The preference in this report is to use domestic markets, because this avoids the problematic conversion to JAS $m^3$ 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 – eg pruned sawlogs, unpruned sawlogs and pulp

**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[10]. 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/yr 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.

[10] 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%)[11].

**Risk and Uncertainty**
There are many risks in forestry than 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"[12] 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 involves questions of consumer behaviour. In this category, the past may be no guide to the future. Will the (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, eg 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.

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[11] NZIF Forest Valuation Standards, and also Manley, B. 2001. Discount rates used for forest valuation. NZ J.For, Nov. 2001. Page 14-15.

[12] "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*50000) + (0.3*2000) which equates to $35600.

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.

## 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[13]. 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. Individuals who have been particularly helpful are listed under Acknowledgements.

Table 1.2 provides, for the major species considered in this report, a summary of the knowledge that is critical to or important for evaluating their investment potential.

**Table 1.2: What we know about the major species**

| Species | Manual? | Total volume? | Rec Vol by log grade | Mill-door Price | Costs | Timing | Risk |
|---|---|---|---|---|---|---|---|
| P. radiata | √ | √ | √ | √ | √ | √ | √ |
| D-fir | × | √ | √ | √ | √ | √ | √ |
| C. macrocarpa | √ | √ | × | √? | √ | √ | √ |
| C. lusitanica | √ | √ | × | √? | √ | √ | √ |
| E. fastigata | × | √ | √ | ? | √ | √ | √ |
| Stringybarks | × | √ | √ | ? | √ | √ | √ |
| Blackwood | √ | √ | √? | √? | √ | √ | √ |
| Redwood | √ | × | × | ? | × | ? | √ |
| Poplar/willow | × | √ | √ | × | × | √ | √ |
| Others | ×* | × | × | × | × | × | × |

[13] 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.

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.
- *Risks* 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.

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[14].

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

One key result of this study, as illustrated in Table 1.2, is the alarming scarcity of hard data for species other than radiata pine and Douglas-fir.

[14] Although Ian Nicholas points out that there are good trials, and a large number of plots, in Ash-group eucalypts closely related to *fastigata*.

# RADIATA PINE
***Pinus radiata* (D. Don)**

Radiata pine[15] needs no introduction to anyone familiar with forestry in New Zealand, or – for that matter – the Southern Hemisphere. From humble beginnings, it now comprises 90% of the current resource. It is the preferred choice in commercial new-land planting, and in second-rotation stands it has supplanted many other species that were shown to be less profitable or more trouble to grow and sell.

It is not only the most common New Zealand exotic tree in terms of areal extent, it is remarkable in its spatial distribution, being present in every nook and cranny of the country as large forest blocks, small woodlots, shelterbelts, hedges or isolated trees. As one of the most salt-tolerant species, it can prosper within 30 cm of the high tide level. Being one of the most drought-resistant, it grows in arid parts of Central Otago where other trees are conspicuous by their absence. It endures shallow soils of low fertility, but will respond well to highly fertile sites. It survives out-of-season frosts – a major limitation in New Zealand – and is not especially prone to possum damage. Its range encompasses the full latitude of New Zealand, and it can withstand the ferocious winds of places like Pitt Island. Almost the only situation it will not tolerate is waterlogged soils.

A massive processing and marketing infrastructure has been built up around this species. The wood now permeates the New Zealand economy, from our fence posts and farm gates, to our house framing and furnishings, to our panel-boards and paper. Half of our harvest is exported. There are dozens of importing countries, but Australia, Japan, Korea and the USA dominate.

Radiata pine is the touchstone for profitability – the standard by which other species are evaluated. Failure to compete with radiata pine in key categories need not necessarily be interpreted as a reason not to grow other species, but merely that factors other than profitability – as narrowly defined here – must be sufficiently important to counteract the opportunity costs of doing so.

## PRODUCTIVITY

### Height Growth

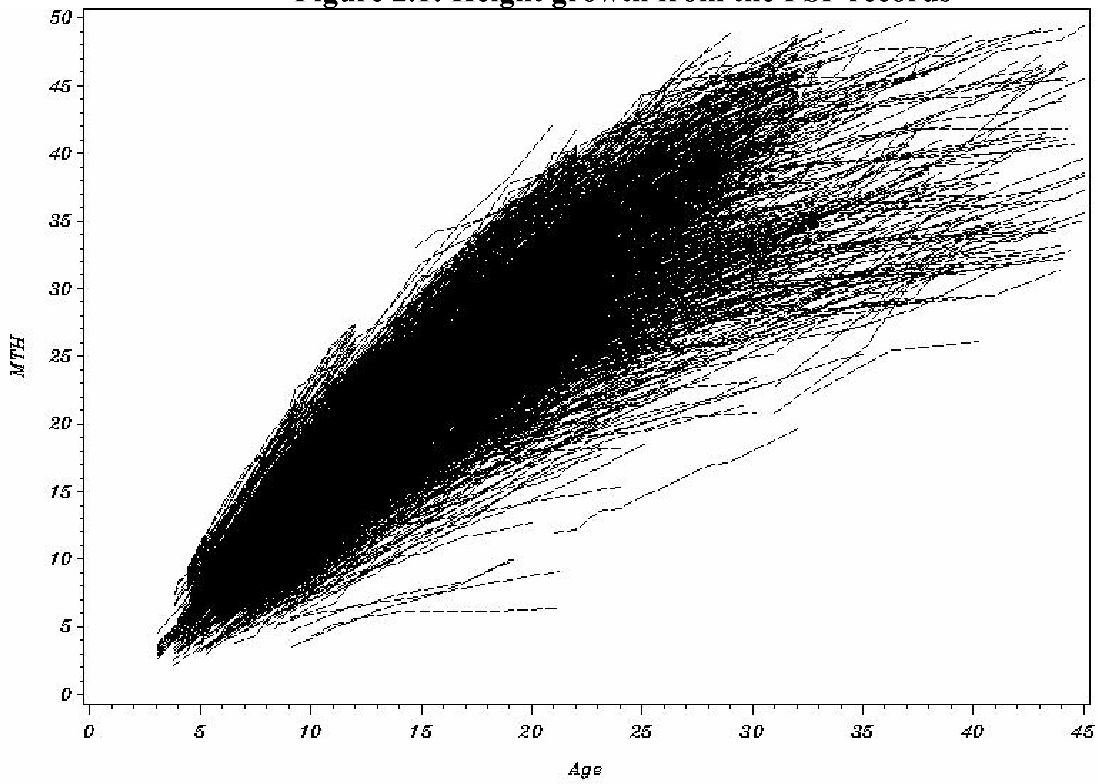
Site productivity has traditionally been expressed in terms of height growth, even though this is not of great interest in itself. Height growth in a stand is commonly expressed as Site Index[16]. Site Indices for radiata pine in New Zealand have been noted ranging from 8.9 m to 43.4 m[17], but

[15] For American readers, this is also called Monterey Pine. Its old botanical name was *Pinus insignis* or "remarkable pine".
[16] For radiata pine, site index is the Mean Top Height (in metres) of a stand at age 20. Mean Top Height is the height of the 100 largest-diameter trees per hectare, usually as obtained from a Petterson equation.
[17] Van der Colff, M. and Kimberley, M. 2003. Modelling a national height/age function for P. radiata in NZ. Unpublished paper presented at meeting of Forest & Farm Plantation Management Coop, Rotorua, July 2003. The data for this report were obtained from general PSP records.

there undoubtedly stands outside these extremes that have not been recorded. Note that the latter figure greatly exceeds the 37 m reported by Hunter and Gibson in 1984[18], but we would expect a higher figure from better sites and new breeds. There is also strong evidence[19] that site index increases by 3 m in second rotation stands. The data in Figure 2.1, however, indicate that site indices of 15-36 m are realistic and believable. Some degree of scepticism is advised in accepting figures greater than 36 m.

Obviously, radiata pine continues to grow long after age twenty – the age that relates to site index. The tallest radiata pine documented is 64.2 m tall[20].

**Figure 2.1: Height growth from the PSP records**




## Basal Area Growth

Individual tree diameter varies with stocking, and therefore is not a very useful measure. Nevertheless, out of interest, the largest diameter recorded in New Zealand is 255cm at breast height of the 132-year old "Grey" pine at Geraldine[21].

[18] Hunter, I.R. and A.R. Gibson 1984. Predicting Pinus radiata site index from environmental variables. New Zealand Journal of Forestry Science 14(1): 53-64.
[19] Woollons, R.C. 2000. Comparison of growth of Pinus radiata over two rotations in the Central North Island of New Zealand. International Forestry Review 2(2) 2000: 84-89.
[20] Burstall, S.W. and E.V. Sale 1984. Great trees of New Zealand. A.H. and A.W. Reed Ltd, Wgtn. 288 pages. Page 84.
[21] Burdon and Miller 1992. See refs.

Basal area incorporates both diameter and stocking, and is therefore a more useful descriptor. Model runs by G. West[22] have shown basal area levels of 55-73 $m^2$/ha at age 30 depending on which growth model was used. The Southland Growth Model (SGM3) assumes the highest level of BA growth and the Pumice Plateau Model (PPM88) the lowest. From FRI PSP data, Shula (1989)[23] stated that "basal areas of about 100 $m^2$/ha …can be approached by stand age 20 years" if stocking is sufficiently high.

**Volume for Top Sites**

Volume is the attribute of greatest interest to the commercial grower – height and basal area are merely contributing factors. Total volume is defined as the wood inside the bark from ground level to the tip of the tree. It does not include branches unless they are deemed "merchantable". For radiata pine, the proportion of wood that is *recoverable*[24] is normally assumed to average about 85% of the total, but this figure can be as low as 70% or as high as 95%[25].

In his analysis of the FRI PSP system, Shula[23] records the single greatest MAI for radiata pine as 52 $m^3$/ha/yr at age 25. The greatest standing volume was 1743 $m^3$/ha at age 47.5. These figures are for highly stocked stands.

Given that there appears to be a trend towards intensively tended regimes without production thinning[26], and to an increasing proportion of the estate planted on ex-farmland, what is the productivity of the new resource? The now-felled Tikitere trials near Rotorua may provide some indication. At age 27 (the year of harvest) the high stocking plots – nominally 400 stems/ha – had a standing volume of 1038 $m^3$/ha, giving a MAI of 38.4 $m^3$/ha/yr. The Current Annual Increment (CAI) at time of felling was 49.9 $m^3$/ha/yr, implying that – if the trial had been allowed to continue – the maximum MAI would have been somewhere between these two figures[27].

In order to standardise measures of site productivity, a technique has recently been developed by Graham West and Mark Kimberley, of Forest Research, called the *Productivity300 Index*. This expresses the MAI at age 30 of all radiata pine stands on a standard scale: where they have been pruned and thinned to a stocking of 300 stems/ha at an early age. Using Productivity300 Index, and the Radiata Pine Calculator[28] – as calibrated by the data from the Tikitere 400 stems/ha treatment – the volume at age 27 at Tikitere at 300 stems/ha[29] would have been 814 $m^3$/ha of which 692 $m^3$/ha would have been recoverable. In terms of total volume, the MAI at age 27 for 300 stems/ha would have been 30.1 $m^3$/ha/yr, and in terms of recoverable volume, it would have been 25.6 $m^3$/ha/yr.

[22] West, G.G. 1994. The comparative performance of the NZ1 growth model. Unpublished report. NZFRI Project Record no 4093.
[23] Shula, R.G. 1989. The upper limits of radiata pine stem-volume production in NZ. NZ Forestry August 1989: 19-22.
[24] Or merchantable. For definitions of total, merchantable, extractable and recoverable volume see Maclaren, J.P. 2000. How much wood has your woodlot got? Forest Research Bulletin 217.
[25] Goulding, C.J. 1995. Measurement of trees. Page 106 in NZIF Handbook 1995.
[26] Maclaren, J.P. and R.L. Knowles, 1995. Silvicultural regimes – radiata pine. P 83-86 in NZIF Handbook 1995.
[27] MAI continues to increase until the CAI declines to meet it. In practice, there is wide inter-annual variation in CAI due to climatic effects, and therefore a large dataset is necessary to determine the shape of the CAI curve. Similarly, estimates of maximum MAI are complicated by mortality, which fluctuates greatly from year to year.
[28] Green Solutions Software. Authors: Leith Knowles and Mark Kimberley of Forest Research. Forest and Farm Plantation Management Cooperative, June 2003.
[29] There was no 300 stems/ha treatment at Tikitere, so this figure must be estimated from the other treatments, which included 200 stems/ha and 400 stems/ha.

Of the recoverable volume, 234 $m^3$/ha (33.8%) would have been pruned, 405 $m^3$/ha (58.5%) were sawlogs, and 53 $m^3$/ha (7.7%) were pulplogs. A more detailed breakdown is provided in Table 1.1.

**Table 2.1: Recoverable Volume by Log Grade at Age 27 for a top quality site**

| **Log Grade** | **Volume ($m^3$/ha)** |
|---|---|
| Pruned P1 (PLI=6.4) | 234 |
| S1 | 38 |
| S2 | 158 |
| L1 and L2 | 84 |
| S3 and L3 | 125 |
| Pulp | 53 |
| **Total** | **692** |

Source: Radiata pine calculator, as calibrated by Tikitere data

### Volume for "Typical" Sites

For most species other than radiata pine, only the best examples of growth and quality are used in this report for comparison. The average as well as "best practice" is provided for radiata pine because it is the benchmark. In other species, the "average" is greatly influenced by poor performing sites, provenances or regimes. It is sometimes more a description of foresters' mistakes than a fair judgement of the species.

The *average* MAI of recoverable volume for radiata pine in New Zealand is 17.8 $m^3$/ha, according to the MAF statistics for the year ending April 1st 2001.[30] This equates to a total-clearfell standing volume MAI of 20.98 $m^3$/ha/yr or a total-volume (ie includes production thinnings) MAI of 21.78 $m^3$/ha/yr.

The weighted average yield of radiata pine from the 1995 MAF yield tables, at age 27, is 496 $m^3$/ha, broken down into pruned logs (83 $m^3$/ha), unpruned logs (302 $m^3$/ha), and pulplogs (111 $m^3$/ha).

### Summary of Volume Growth

**Table 2.2: Summary of radiata pine volume growth**

| **Max MAI ($m^3$/ha/yr)** | **MAI - top ($m^3$/ha/yr)** | **MAI – av. ($m^3$/ha/yr)** | **% recov.** | **% sawlogs** |
|---|---|---|---|---|
| 52.0 | 25.6 | 17.8 | 85 | 92.3 |

Notes:

- *Max MAI* is the highest mean annual increment (total volume) ever recorded in New Zealand.
- *MAI-top* is for recoverable volume using a direct clearwood regime on a farm site with a final crop stocking of 300 stems/ha and a harvest age of 27 years. It uses the Radiata Pine Calculator as calibrated by data from Tikitere Trials.
- *MAI –average* is the MAI for recoverable volume, including production thinnings, reported from the existing resource, using official statistics (NEFD).
- *Percentage recoverable*. This is the generally accepted percentage of recoverable volume to total volume.
- *Percentage sawlogs*. This is the percentage of recoverable volume that is suitable for uses other than pulp, as estimated by the Radiata Pine Calculator using a direct clearwood regime.

[30] http://www.maf.govt.nz/statistics/primaryindustries/forestry/forest-resources/national-exotic-forest-2001/nefd-2001-planting-and-harvesting-est.htm#Harvesting%20Data. The figure of 17.8$m^3$/ha was derived by calculating the recoverable volume per hectare of wood at clearfell (481.6$m^3$/ha, from 18.3 million $m^3$ on 38000 ha) and dividing by the average harvest age (27.0).

## PRICE PER UNIT VOLUME

The most authoritative source of log price information for radiata pine is the MAF website[31]. The preference here is to choose the most recent 12-quarter average for domestic sales (Table 2). Originally expressed in \$NZ per tonne, the prices have also been divided by 0.959 to convert to cubic metres[32]. Arguably, longer-term price information may be a better comparison for investments that span decades, but prices must then be adjusted for inflation. There is also dispute over whether long-term trends should be considered, and – if so – what should be the starting and finishing points of the trend analysis. Here, the minimum and maximum monthly prices for each grade are given to define the likely boundaries of values.

**Table 2.3: Domestic log prices – \$NZ per tonne delivered at mill (\$NZ per cubic metre)**

| Log grade | Price | Min (1992-2003) | Max (1992-2003) |
|---|---|---|---|
| P1 | 171 (178) | 120 | 340 |
| P2 | 131 (137) | 75 | 200 |
| S1 | 96 (100) | 67 | 125 |
| S2 | 88 (92) | 51 | 110 |
| L1 and L2 | 69 (72) | 50 | 105 |
| S3 and L3 | 65 (68) | 43 | 90 |
| Pulp | 43 (45) | 27 | 65 |

Source: MAF website, 12-Quarter prices up to March 2003

The mill-door price of radiata pine per cubic metre depends on the proportion of each log grade. On a top quality site at 300 stems/ha, all pruned logs could be assumed to achieve P1 specifications and therefore be worth about \$178/m$^3$. Put another way, the Pruned Log Index for a well-pruned regime harvested at age 27 would be about 6.4 and be valued approximately the same. Combining tables 1.1 and 1.2, we deduce an average mill-door price for a good site of \$76 921/ha or \$111/m$^3$.

Depending mainly on terrain and transport distance, costs of between \$15 and \$55 per tonne must be deducted from this to obtain stumpage values. An average of \$40 per m$^3$ is assumed. This results in a stumpage price of \$49 241/ha or \$71/m$^3$.

Using a more normal breakdown of volume, as described earlier, and assuming that pruned logs from 27-year old stands are typically worth about \$170/m$^3$, unpruned logs average \$77 and pulplogs \$45[33], we get a combined total of \$42 359 (about \$85/m$^3$) at mill or \$22 519 (\$45/m$^3$) on stump.

### Summary of Prices

**Table 2.4: Summary of radiata pine wood prices (\$NZ/m$^3$ at mill-door)**

| | Top price | High average price | Typical average price |
|---|---|---|---|
| **Price** | 340 | 111 | 85 |

[31] http://www.maf.govt.nz/forestry/statistics/logprices/index.html

[32] Maclaren, J.P. 2000. Bulletin 217, p.53.

[33] With no detailed data on the exact log grade composition of the average harvest, these figures were calculated by assuming that pruned logs comprise 80% P1 and 20% P2 (as per Agrifax), from prices in Table 1.2, and a ratio of unpruned log volumes in the Radiata Pine Calculator comprising S1 at 2.9%, S2 at 26.9%, L1/L2 at 29.2% and S3/L3 at 41.0%.

Notes:
- *Top price* is the best mill-door price for P1 logs recorded in the MAF website between 1992 and 2003.
- *High Average Price* is the estimated current mill-door price per metre of recoverable wood of all grades, for a well-grown stand on a top quality site.
- *Typical Average Price* is the current mill-door price per metre of recoverable wood of all grades, from typical stands being currently harvested.

## GROWING COSTS

Good forestry land in the Hawkes Bay Region is currently selling for about $2500/ha[34]. Forests in this region yield the highest Net Present Value[35] and therefore are a good guide as a "base case". Cheaper land elsewhere is likely to grow a less profitable crop, but more expensive land is unlikely to yield substantially higher benefits.

At the time of writing, New Zealand is undergoing rapid price rises for rural land, so it is difficult to conduct a comparative economic analysis in a situation where land is an important component of costs, and varies in price depending on the intended crop.

Initial stockings vary in current practice, as does the quality of planting stock. With the lowest common initial stocking (600 stems/ha) but the highest price per tree (50c each, for GF26+ aged field cuttings), the cost of tree stocks is $300/ha. With a higher initial stocking (1200 stems/ha) and a good/average planting stock (25c each, for GF19), the cost of tree stocks is also $300/ha.

Assuming that the previous land cover is pasture, cost of planting and releasing is taken to be $400/ha. Four pruning lifts are assumed, at a cost of $500, $330, $270 and $270/ha each[36]. Thinning costs are $145/ha, for a single thinning to waste.

Annual or periodic costs include general forest management, rates, fire insurance, fence and track maintenance, animal control, and *Dothistroma* spray. Only the latter is unique to radiata pine, and costs $25/ha twice during the rotation. The other costs are taken to be similar for all species, and are $50/ha/yr for every year of the rotation.

Costs associated with harvesting, including internal roading, are assumed to be the same for all species and are set at $40/m$^3$.

### Summary of Costs

**Table 2.5: Cost of growing radiata pine ($NZ/ha)**

| Nature of Cost | Typical cost | High cost | Low cost |
|---|---|---|---|
| Land | 2500 | 5000 | 500 |
| Tree Stocks | 300 | 400 | 200 |
| Establishment | 400 | 700 | 300 |
| Pruning & thinning | 1515 | 2000 | 1000 |
| Dothi spray* | 25 x 2 | 35 x 5 | 0 |
| **Overall** | **4765** | **8275** | **2000** |

* Although *Dothistroma* spray is not normally required in Hawke's Bay, it is standard practice over much of the Central North Island.

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[34] Author's own observations.
[35] Results of a confidential commercial contract, in which crown forest licences throughout New Zealand were analysed.
[36] From a confidential commercial contract.

## ROTATION AGE

The average rotation age in radiata pine is currently 27.0 years[37]. At 9% discount rate (pre-tax), the maximum LEV of most forests occurs well before this age, and in only two of the least profitable forests examined in a confidential study the peak occurred after age 30[38]. In some cases maximum LEV occurred even before age 20, but it is likely that inferior wood quality from such young stands would lead to a backlash from processors, and eventually penalties would force the age upwards. Here we assume that 25 is the minimum harvest age that would be marketable over the long term. We also assume that if site conditions are so inferior that optimum rotation ages are longer than 33, then radiata pine forestry is probably not the best investment for that land or that capital.

## RISK

The attitude of forestry valuers and purchasers to risks is reflected in their choice of discount rate. In New Zealand, this ranges from 9-13%, pre-tax[39]. The figure includes both the risk-free interest rate and a factor for risk. The former can be represented by the arithmetic mean of inflation-adjusted long-term New Zealand government bonds and is 0.58%[40]. The latter has two components: general risk from any portfolio of equity investments, and risks unique to forestry. Forestry risks in New Zealand can be considered indicative of radiata pine, being 90% of New Zealand's resource.

### Climate-related Risk

Radiata pine is extremely resistant to drought and moderately resistant to frost, but can be easily damaged by strong winds or wet snow. Snow (and to a lesser extent frost) can be avoided by careful siting, whereas wind is problematic in most parts of New Zealand.

The fact that the species has been grown for several rotations throughout New Zealand, with minimum overall impact from climatic events, is testimony to the fact that – at least at a national scale – this risk can be categorised as LOW.

### Pests and Diseases

Pests and pathogens currently in New Zealand are either not of major economic importance or can be controlled easily (for example, by spraying with copper oxychloride for *Dothistroma* needle-blight). There are a number of threats present in other countries, but it is not known how these will react under New Zealand conditions. For example, Pine Pitch Canker could be devastating to the radiata pine resource, but may need a foreign vector to spread the disease.

There is a widespread view that the prevalence of radiata pine, and its existence in a so-called "monoculture", predisposes it to greater-than-average risks from introduced pests and diseases. This is debateable, and is not (at least, up to the present time) supported by empirical evidence. The contrary argument is that the full resources of the forestry sector can be focussed on any organism that has breached border quarantine.

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37 http://nzfoa.nzforestry.co.nz/facts_figures.asp#
38 From a confidential commercial contract.
39 Manley, B. 2001. Discount rates used for forest valuation. NZ Journal of Forestry Nov 2001, p. 14-15.
40 NZIF 1999. NZ Institute of Forestry Professional Handbook, page A4-15.

The current opinion of experts in this field[41] that radiata pine is a LOW-risk species as regards pests and diseases, but certainly not that such risk is non-existent.

**Market Risks**
Radiata pine has a wide range of market uses. It is satisfactory or excellent in products as diverse as plywood, framing timber, barn-poles, reconstituted boards, newsprint, mouldings and furniture. It is a major commercial species in four continents and has considerable market recognition throughout the world. For some purposes, particularly external uses, it is not durable and requires chemical preservative, but is easy to treat if is socially acceptable to do so. Its light-coloured wood is currently an advantage - light woods can be stained darker, but not vice versa.

The versatility of the species implies that market risk is LOW. As long as there continues to be a worldwide demand for wood, relative to substitutes, we can be fairly confident that radiata pine can claim a considerable share of that market.

**Social Risks**
The negative attitude of many members of the public to large "monocultural" plantations of radiata pine is clearly apparent and does not need survey results to confirm it. While the prevailing legislation (RMA 1991) may purport to be neutral with regard to "activities" and to legislate only on "effects", the reality is that public attitudes soon express themselves in increased costs or administrative hurdles. Extra costs may occur with such activities as Forest Stewardship Council certification, either at the stage of land-use change, or at harvest. The social risks of continuing the current composition of the forest estate can be rated as MEDIUM.

**Summary of Risks**

**Table 2.6: Risks of growing radiata pine**

| Type of Risk | Risk Rating |
|---|---|
| Climate | Low |
| Pests & Disease | Low |
| Market | Low |
| Social | Med |
| **Overall** | **Low** |

## DCF ANALYSIS

A discounted cash flow analysis was performed both for a "top quality" site/regime and for a "typical" site/regime.

For the **top quality** site/regime, the Radiata Pine Calculator was used to estimate the volumes of each log grade for rotation ages ranging from 25 to 32 years, as calibrated with data from the Tikitere trials. Costs (establishment, silviculture, harvest) were as described above. Assumptions included: purchase of farmland at $2500/ha; pruning in four lifts; 12-quarter average prices.

[41] See references in Chapter 11 of Maclaren, J.P., 1996. Environmental effects of planted forests in New Zealand. FRI Bulletin No. 198.

The most profitable rotation age in terms of IRR or LEV at any discount rate from 6% to 13% was 25 years or less. Given the necessity to maintain wood quality, figures for age 25 were used. The IRR at this age was 9.0% and the LEV for each discount rate was as follows: $4528 (6%), $21 (9%) and -$2360 (13%).

For the **typical** site/regime, assumptions included: a 27-year rotation; land price of only $1000/ha; pruning in three lifts; national average volumes; 12-quarter average prices. The IRR was 7.6%, and LEV was $1386 (6%), -$727 (9%) and -$1701 (13%).

**Summary of DCF**

**Table 2.7: DCF Analysis**

| Profitability indicator | Top site | Typical Site |
|---|---|---|
| IRR% | 9.0% | 7.6% |
| LEV @ 6% | $4528/ha | $1386/ha |
| LEV @ 9% | $21/ha | -$727/ha |
| LEV @ 13% | -$2360/ha | -$1701/ha |

Notes:
- All figures for the "top quality site" are calculated for a 25-year rotation. Figures would be higher for even younger ages, but wood quality concerns (not currently included in log grade specifications) casts doubt on the long-term ability to achieve the same prices with younger trees.
- Figures for the typical site are for a 27-year rotation. Land is priced at $1000/ha, and pruning is later and cheaper than for a fertile farm site. Stumpage values are derived from average volumes for the 3 main log types (from MAF 1995 Yield Tables) and 12-quarter average prices.

## DISCUSSION

New Zealand forestry is often criticised as an inferior investment. Forestry in New Zealand is almost synonymous with radiata pine. But it is hard to understand how a rate of average return of 7.6%, over-and-above inflation, compounded over a 27-year timeframe, and relatively free of risk, can be considered inferior. Other enterprises may have demonstrated far higher returns over short periods, but these have nearly always been followed by high losses. A clever or lucky speculator may buy and sell at the right time so as to benefit from the high returns without suffering the losses, but if we consider the average return for any industry over a 27-year period, then radiata pine forestry ranks highly. It is hardly necessary to add, however, that past returns may be no indication of future investment opportunities.

## FURTHER READING FOR RADIATA PINE

Burdon, R.D. and J.T. Miller, 1992. Introduced forest trees in New Zealand: recognition, role and seed source. FRI Bulletin No. 124. No. 12. Radiata pine.

Clifton, N.C. 1990. New Zealand timbers, indigenous and exotic. The complete guide. GP Books. 170p.

Cown, D.J. 1999. New Zealand pine and Douglas-fir; Suitability for processing. FRI Bulletin 216.

Green Solutions Software. Radiata Pine Calculator. Forest Research, Rotorua. Available from the NZ Farm Forestry Association.

Kininmonth, J.A. and L.J. Whitehouse (eds) 1991. Properties and Uses of New Zealand Radiata Pine. Vol. 1, Wood properties. NZ FRI

Maclaren, J.P. 1993. Radiata pine growers' manual. FRI Bulletin 194.

Madwick, H.A.I. 1994. *Pinus radiata* – Biomass, Form and Growth. Published by H.A.I. Madwick, 36 Selwyn Road, Rotorua.

# DOUGLAS-FIR

**Pseudotsuga menziesii (Mirbel) Franco**
**Contributing author: Leith Knowles**

Douglas-fir[42] is New Zealand's second most important commercial plantation species. It comprises almost 6% of the standing resource[43] by area. It accounts for the highest volume of all the world's traded softwoods, and is well known internationally as a premium structural timber.

It was once planted more widely throughout New Zealand, but the advent of *Phaeocryptopus gaeumannii* needle blight (a.k.a. Swiss Needle Cast disease) restricted good growth rates to cooler areas. The basal area increment after infection is 20% less that before the arrival of the disease[44]. Careful site choice is important, because its growth rate seems to be directly proportional to rainfall and it is highly sensitive to out-of-season frosts.

Regarding wood properties, its main virtue seems to be its comparatively small branch size when compared with radiata pine under almost any regime. This makes it more suitable for structural uses. Reportedly – in comparison to radiata pine – it has lower moisture content, better stability, a higher strength-to-weight ratio, and is lighter and stiffer.

Unlike radiata pine the tree has no "defect core" of very low-density wood. It can therefore be sawn to lower small-end-diameters (100 mm for sawlogs, 50 mm for pulpwood). Good structural timber (No.1 framing) can even be obtained from production thinnings. It is resistant to attack by borer, and is naturally durable for out-of-ground contact. It is difficult to treat with preservatives currently authorised in New Zealand[45] and new regulations may prohibit construction of external walls with untreated wood, regardless of species.

## PRODUCTIVITY

### Height Growth

Height growth in windy New Zealand is not spectacular and does not compare well at young ages with radiata pine. For example, the best site index (in sample plots at Kaingaroa and Arrowtown) is recorded as around 40 m[46]. Given that site index in Douglas-fir is based on 40 year-old trees (as opposed to 20 years for radiata pine), this is equivalent to the best heights of radiata pine at half the age. Very old trees have similar heights to radiata pine, so it is clear that Douglas-fir can be considered a comparatively "late developer" in this regard.

[42] In New Zealand, the wood is known colloquially as "Oregon Pine" although it is not a pine, or even a fir.
[43] http://www.nzfoa.nzforestry.co.nz/facts_figures.asp#
[44] Manley, B.R. 1994. Growth loss of Douglas-fir associated with *Phaeocryptopus* in Kaingaroa Forest. Proceedings of Douglas-fir Cooperative, 15-16 February 1994, Nelson. Also, Knowles. R.L, Kimberley M. and Hood. I. 2001. Forest Health News, No. 114.
[45] "Douglas-fir sawn timber is suitable for use in buildings without preservative treatment…[it]is renowned as a refractory species because of the difficulty of getting chemicals into both the heartwood and dry sapwood". Quote from Cown, D.J.1999. See Further Reading..
[46] From the Douglas-fir calculator.

**Basal Area Growth**
Top basal area growth is reported by Mark Belton to be 4.5-6.0 $m^2$/ha/yr, for highly stocked stands. This is similar to the best figures for radiata pine (5 $m^2$/ha/yr). Douglas-fir is notable in that a well-stocked stand, even on high rainfall sites, has almost zero undergrowth – all the useful sunlight is fully captured by the canopy, possibly implying an impressive conversion efficiency. Moreover, the high rate of basal area growth continues until very high levels of standing biomass are reached. Highest basal area levels recorded in the Forest Research PSP were 160 $m^2$/ha at age 50, from plots near Lake Ohau, although most of the growth occurred before the arrival of *Phaeocryptopus* needle-blight. On the other hand, most of the historical data are based on Washington seed source, which we now know is substantially less productive than genotypes from Coastal Northern California.

A Douglas-fir calculator has been developed by Leith Knowles and Mark Kimberley, which in several ways in more advanced than the same technology for radiata pine. An essential component is the use of Site Basal Area Potential (SBAP), being the average BA increment for a fully stocked stand for the first 40 years. The Calculator generally uses models based on post-*Phaeocryptopus* growth rates.

**Volume Growth**
"**Top growth**" is 40$m^3$/ha/ha, from NZFRI PSP records[47]. This is substantially higher than figures for the Pacific Northwest, Britain and France – a fact Mark Belton ascribes to better summer moisture and longer growing seasons, among other reasons.

A *recoverable* yield of 1450 $m^3$/ha from a 46 year unthinned Douglas-fir stand has been reported by Ernslaw One Ltd, from its Conical Hill forest in South Otago[48]. While much higher harvest volumes have been recovered from older forests, this is for a relatively young stand. This equates to a *recoverable* MAI of 31.5$m^3$/ha/yr.

The national area-weighted MAI (from the 1995 NEFD Yield Tables) peaks at age 49-50, and is 20.3 and 17.5 $m^3$/ha/yr for total and recoverable volume, respectively. These figures include production thinnings and are very similar to the national average MAI for radiata pine (21.8 and 17.8 total and recoverable, respectively), although radiata pine is usually harvested well before it has reached its maximum MAI - after age 40, according to the same yield tables.

The ratio of recoverable volume to total volume in the NEFD is 85%, which is identical to radiata pine. It seems likely that – hard data being absent – the ratio was merely assumed by the compilers of NEFD to be the same. Leith Knowles has analysed "several hundred MARVL inventories provided by a major company" and derived the average figure of 88% - the default in the Calculator.

For the "best" site with an unpruned, production-thin regime,[49] the Calculator predicts a recoverable volume at 45-year clearfell of 1123 $m^3$/ha, being 88% of a total volume of 1275 $m^3$/ha. Of the recoverable volume, 96% were sawlogs other than arisings or pulpwood. Adding on the production thinnings, there is a recoverable MAI of 28.9 $m^3$/ha/yr.
The log-grade outturn as predicted by the Douglas-fir Calculator at age 45 is given in Table 3.1.

[47] Mark Belton and Nick Ledgard report this from a 50-year old untended stand at Lake Ohau in South Canterbury. The stand had a standing volume of 2059 $m^3$/ha and a Basal Area of 162 $m^2$/ha.
[48] Southern NZ D-fir News, Vol. 1 August 1999. Mark Belton & Associates
[49] Based on a Site Basal Area Potential of 2.4, and a site index of 40. These are at the top of the range permitted by the model, but are exceeded by plots in the database, although not simultaneously.

**Table 3.1: Log grade outturn ($m^3$/ha) for "best" site/regime at age 45**

| | S1 | M1a | M1b | S2 | L1 | L2a | L2b | Ari | Pulp | Total |
|---|---|---|---|---|---|---|---|---|---|---|
| Clearfell | 198 | 396 | 294 | 0 | 18 | 106 | 62 | 36 | 13 | 1,123 |
| Prod Thin | | | | | | 37 | 31 | 81 | 29 | 178 |

Source: Douglas-fir calculator, using SBAP of 2.4 and SI of 40

**Average and poor** growth can easily be predicted by adjusting Site Basal Area Potential and Site Index on the calculator. The national average of these parameters for seed of Coastal Northern Californian provenance is given in the calculator as SBAP 2.1 and SI 34, resulting in a 45-year clearfell yield of 800 $m^3$/ha from a total volume of 987 $m^3$/ha. The lowest end of the range in the Calculator has a Site Basal Area Potential of 1.0 and a site index of 24, resulting in a 45-year clearfell yield of 246 $m^3$/ha from a total volume of 374 $m^3$/ha.

***Summary of volume growth***

**Table 3.2: Summary of Douglas-fir volume growth**

| Max MAI ($m^3$/ha/yr) | MAI - top ($m^3$/ha/yr) | MAI – av. ($m^3$/ha/yr) | % recov. | % sawlogs |
|---|---|---|---|---|
| 39.6 | 28.9 | 17.5 | 88 | 96 |

Notes:

- *Max MAI* is the highest mean annual increment (total volume) ever recorded in New Zealand.
- *MAI-top* is for recoverable volume (clearfell + production thinnings) at age 45. It uses the Douglas-fir Calculator when top-of-the-range values are used for Site Basal Area Potential and Site Index.
- *MAI –average* is the MAI for recoverable volume, including production thinnings, reported from the existing resource, using official statistics (NEFD yield tables).
- *Percentage recoverable*. This is the generally accepted percentage of recoverable volume to total volume.
- *Percentage sawlogs*. This is the percentage of clearfell recoverable volume that is suitable for uses other than pulp, as estimated by the Douglas-fir Calculator.

## PRICE PER UNIT VOLUME

Although the Ministry of Forestry Zone Studies provide tables of growth rates, prices and costs for various species - including Douglas-fir – these are somewhat suspect, as no references are given. It is possible that some tables were merely "expert opinion" or informed guesswork[50].

More credibly, the Douglas-fir Calculator contains a set of default assumptions and prices. These were obtained from acknowledged Douglas-fir experts and from companies who are trading in this species[51], and were valid as at April 2003[52].

[50] Many of the tables contain a footnote: "*These "low" and "high" log prices are not based on market data*".
[51] Leith Knowles, pers. comm. July 2003.
[52] Prices have dropped by 10-20% since then (Leith Knowles pers. comm.).

The default prices used in the Calculator as follows:

**Table 3.3: Price for Douglas-fir log grades**

| | |
|---|---|
| Pruned Log PLI unit increase | 15 |
| Pruned (price for PLI = 4) | 160 |
| S1 | 225 |
| M1a | 200 |
| M1b | 200 |
| S2 | 160 |
| L1 | 140 |
| L2a | 83 |
| L2b | 83 |
| Ari | 60 |
| Pulp | 35 |

Note:
The Pruned Log price increases by $15 for every unit increase in Pruned Log Index above 4 (same price as unpruned S2)

Multiplying Table 3.1 by Table 3.3, we derive an average price of $179.50/m$^3$ of recoverable wood.

### Summary of Prices

**Table 3.4: Summary of Douglas-fir wood prices ($NZ/m$^3$ at mill-door)**

| Average price |
|---|
| 179.50 |

Note:
*Average Price* is the current mill-door price per metre of recoverable wood of all grades, derived from default prices in the Calculator, and for the ratio of log-grades in Table 2.1.

## GROWING COSTS

Land price for good Douglas-fir is comparative cheap, at $600-900/ha[53]. There is no correlation between its value for farming and its value for Douglas-fir, as the latter favours high altitude sites. Establishment costs, however, can be expensive as a result of high initial stockings (1500 s/ha or more[54]) and expensive 2/0 stock (42c each). Weed control can be more expensive than for radiata pine, because the species is less tolerant of many forestry herbicides. The end result is that establishment can be twice as expensive as radiata pine.

One considerable cost advantage is that pruning is not usually employed, as the main market is for structural timber where small knots (particularly if intergrown) do not detract from the price. Except for one waste-thinning to 600-800 sph at around 14m MTH, thinning can be delayed until trees are large enough for extraction, thus at least covering costs.

[53] Southern NZ D-fir News, Vol. 2, 2000 (?). Mark Belton & Associates. Also, Belton, M. 2000. The current NZ Douglas-fir new planting and investment scene. Douglas-fir Coop proceedings, 22 & 23 February, 2000, Darfield. Note: land prices have risen since this analysis and may have reached as much as $1500/ha for good Douglas-fir land.

[54] On sheltered sites, there may have been a trend to reduce stockings to 1250 sph.

**Summary of Costs**

**Table 3.5: Cost of growing Douglas-fir ($NZ/ha)**

| Nature of Cost | Typical cost |
|---|---|
| Land | 900 |
| Tree Stocks | 693 |
| Establishment | 495 |
| Pruning | 0 |
| Waste thinning | 150 |
| **Overall** | **2238** |

## ROTATION AGE

There is debate among experts as to an appropriate or typical rotation age for Douglas-fir but 45 years is a common assumption for a good site, with up to two production thinnings in the interim. A range of 35 to 55 years is evaluated here.

Being relatively wind-resistant, and with the capacity to produce marketable sawlogs from small trees, Douglas-fir is highly suitable for production thinning. Therefore rotation age is not necessarily a good indicator of the timing delay between costs and returns. There is often at least one production thinning, and multiple thinnings are not uncommon. "Thinning from above" has not been thoroughly tested in New Zealand, but it may be possible to extend rotations significantly by extracting only the largest trees. This process could eventually lead to "continuous cover forestry" whereby recruitment from below continuously replaces the harvest of larger trees. In this situation, harvest occurs whenever market conditions are suitable – the concept of rotation age is not so meaningful.

One problem with very old rotations is that piece-size is likely to reach unacceptable levels. There have been very high prices (NZ$1100/$m^3$) obtained from large "old-growth" trees in the Pacific NorthWest, but there also appears to be no price premium for size above about 400 mm sed[55] and – indeed – there are few mills that can handle very large trees.

## RISKS

**Climate-related Risks**

Although Douglas-fir has been devastated by wind in other countries (eg Europe's 1999 storm), the New Zealand experience is that it is substantially more wind-stable than radiata pine[56]. The same applies to snow. Young trees and newly flushed foliage can be killed by out-of-season frosts, but selection of sites with good air drainage can usually avoid this problem. Drought is probably the most serious climatic threat facing the species. Severe droughts in drier parts of Canterbury have periodically killed large trees, and Douglas-fir was identified by Frew[57] as being at greatest risk of drought damage out of four major species. Indeed, 60% of trees in the study aged 0-2 years were killed in the 1997/98 drought.

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[55] Notes taken during Coop tour of the Pacific NorthWest, October 2002.

[56] Brown, P.C. and S. Jones, 1989. Wind risks in the Bay of Plenty. In Somerville A. and S.J. Wakelin 1989. Wind damage in New Zealand exotic forests. FRI Bulletin 146.

[57] Frew, C. 1999. The 1997/98 drought survey. NZ Tree Grower, p. 31-34.

Altogether, climate-related risks could be rated as LOWER than for radiata pine, at least after the difficult establishment phase.

**Pests and Diseases**

Swiss Needle Cast disease *(Phaeocryptosus gaeumannii)* is estimated to reduce volume growth by 30% and log value per hectare by 26%, under typical regimes and prices[58]. It may be too early to gauge its ultimate impact throughout New Zealand. One possibility is that there may be more virulent strains of this needle-cast fungus in existence, which have yet to reach our shores[59]. Alternatively, the epidemics observed in the natural native range of the Pacific NorthWest may be the result of unfortunate combinations of climate, siting and management regimes. Appropriate genetic material, careful siting and lower-stockings may reduce the future severity of infection in New Zealand.

Possums can devastate Douglas-fir stands if their numbers are allowed to reach epidemic proportions. Possum control may be more difficult in the future, with restrictions on leg-hold traps and use of 1080 poison. Feratox (cyanide in capsules) is proving effective, but an eventual increase in bait-shyness is almost inevitable.

The risk of pests and diseases could be rated EQUAL to radiata pine, (ie Low).

**Market-related Risks**

Some two-thirds of the world's existing resource of this species in the USA and Canada is publicly owned[60]. Lobbying by "environmentalists" is adding to the cost of producing wood from these countries. This presents an opportunity for growers in other countries, as it may result in price rises. There are substantial plantations of pines throughout the world – and one pine can often substitute for another – but plantations of Douglas-fir are less common. Given that Douglas-fir represents a large proportion of the world's traded softwood – especially in the Pacific Rim – it indicates that the species sinks or swims with the fate of softwood in general.

Although Douglas-fir is occasionally used for visual appearance, the main market is undoubtedly for structural uses. This constitutes a distinct market risk, as the demand for structural wood appears to be static or declining, while the market for appearance grades (at least for radiata pine) is expanding[61]. There is widespread concern about wood substitutes in general, but the threat must be stronger for structural purposes, given that multi-storey buildings are becoming more commonplace and that it is hard for an engineer to design structures using a biological (thus variable) material, even if standardised with the use of stress-grading. Efficient assembly of building components requires parts that are identical and precise in their measurements – ie no distortion.

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[58] Knowles, R.L; Kimberley, M.O.; and Hood, I. 2001. Swiss Needle Cast Disease of Douglas-Fir – impact on Growth. Forest Health News, No. 114, December 2001.

[59] Oregon Dept of Forestry, Forest Health Note March 1998. In Proceedings of Douglas-fir Cooperative, 22 & 23 February 2000, Darfield.

[60] 68.9% of the forest ownership in the Western United States is publicly owned. From US Department of Agriculture 2001, U.S. Forest Facts and Historical Trends.

[61] Bosman, R. and F. Burger 2001. Wood property requirements and product performance. In Wood Quality Workshop – summary including presentation slides and captured dialogue. NZ Radiata Pine Tree Breeding Cooperative, Report No 118.

The perception that natural durability is safer and more environmentally friendly than artificial methods of preservation may or may not be justified. It may or may not hold increasing sway in some of our key markets. Being resistant to damage by the common house-borer[62], it could be argued that timber treatment is not necessary for inside uses (provided that wood is kept dry). Even the heartwood of Douglas-fir, however, will rot within 5-15 years in ground contact[63], and – like the heartwood of radiata pine – is classified at the lower end of durability Class 3[64]. Recent moves to counteract the “leaky building syndrome” in New Zealand may result in legislation to ensure that all species are preservative treated for certain at-risk uses, regardless of natural durability. Both Douglas-fir sapwood and heartwood are very resistant to moisture uptake relative to radiata pine, and it would take a considerable period of exposure to reach the threshold necessary for decay[65].

An obligation to treat Douglas-fir framing with boron would add to the cost of this material relative to substitutes (wood or non-wood) and reduce the demand for the product and hence stumpage prices.

The market-related risks are uncertain but in view of its larger global market could be rated LOWER than for radiata pine.

**Social Risks**

There may be restrictions placed on the area of forest that can be clear-felled simultaneously. These restrictions may result from local legislation or from Forest Stewardship Council regulations. In either case, the result would impact favourably on Douglas-fir, which – being relatively shade-tolerant - is a species more suitable for smaller clearfell coupes. Continuous cover forestry is a possibility.

The downside of shade-tolerance is that Douglas-fir has the potential to seed itself into and eventually dominate large areas of indigenous forest, particularly in situations where the canopy is not naturally continuous or has been disturbed. Although careful siting and perimeter control can negate this threat, public perception and legal obligations do not necessary follow the scientific arguments.

The social risks are rated LOWER than for radiata pine.

**Summary of Risks**

**Table 3.6: Risks of growing Douglas-fir**

| **Type of Risk** | **Risk Rating** |
|---|---|
| Climate | V.Low |
| Pests & Disease | Low |
| Market | V.Low |
| Socio-economic | Low |
| **Overall** | **V.Low** |

Note:
Risks have been described subjectively. It is not possible to quantify most of the risks.

[62] Hosking, G.P. 1978. Forest and timber insects in New Zealand, No. 32. *Anobium punctatum*.
[63] FRI 1997. What’s New in Forest Research, no. 245.
[64] On a four-class scale, where Class 4 is not durable.
[65] Hedley, M.; Durbin, G.: Wichmann-Hansen, L.; Knowles, L. 2004. Comparative moisture uptake of New Zealand grown Douglas-fir and radiata pine structural timber when exposed to rain-wetting. Report No. 36 in Proceedings of Douglas-fir Cooperative, Nelson, 17-18 Feb 2004.

## DCF ANALYSIS

The Douglas-fir Calculator was run using top-of-the-range figures for Site Basal Area Potential (2.4 $m^2$/ha/yr) and Site Index (40 m at age 40). Assumptions included: land costs at $900/ha; establishment costs 72c/tree; no pruning; half trees culled at waste thinning (12 m) and production thinning at 24 m to a final crop stocking of 400 stems/ha. Rotation lengths for 35 to 55 years were examined.

The highest IRR was at the shortest rotation age – 35 years. It was 9.72%, which compares favourably to the best values for radiata pine. At 45 years, it had slipped to 9.14% and at 55 years it was 8.25%. The highest LEV was not necessarily at the shortest rotation age, if a low discount rate was used. (A 40-year rotation was best at 6% discount rate). Assuming a 45-year rotation, values were $9313/ha at 6%, $197/ha at 9% and -$2466/ha at 13%.

Figures for top, average and poor sites are given in Table 3.7

**Table 3.7: DCF Analysis**

| Profitability indicator | Top site | Av. Site | Poor site |
|---|---|---|---|
| IRR% | 9.1% | 7.9% | 3.4% |
| LEV @ 6% | 9313 | 4200 | -2851 |
| LEV @ 9% | 197 | -1241 | -3302 |
| LEV @ 13% | -2515 | -2835 | -3273 |

Notes:
The Douglas-fir calculator was used to estimate IRR and NPV, with top-of-the-range values for Site Basal Area Potential and Site Index, and default values for costs and prices. Figures are for age 45, in an unpruned regime with one production thinning. For the average site, figures were SBAP & SI were the national average for Coastal Northern Californian seed (2.1 and 34 respectively). For the poor site, bottom-of-the-range values for SBAP (1.0) and SI (24) were used, with a rotation of 60 years.

## DISCUSSION

Profitability on the best Douglas-fir sites is equal or superior to that on the best radiata sites for all criteria considered, except for rotation age. Although a late starter, Douglas-fir eventually produces similar volumes. Average mill-door price per cubic metre of recoverable volume is almost twice that of radiata pine. It is cheaper to grow, partly because of lower land values for suitable South Island sites, and partly because pruning is not necessary to receive good prices. Rotation age is longer – the typical age being 45 years – but rotations shorter than this are sometimes possible. Risks are generally lower, whether they be from climate, diseases, market fluctuations or adverse public attitudes. Internal Rate of Return and Land Expectation Value are at least as high.

There is one important caveat to the previous paragraph: unlike radiata pine, Douglas-fir is responsive to micro-topography and cannot to the same extent be successfully “blanket-planted” over large areas. Choice locations often consist of small, scattered sites. Although land prices are currently set by demand from pastoral farmers, it is conceivable that the best Douglas-fir sites will soon command premium prices in response to continuing interest in this species. This may not have a major effect on IRR or LEV but it may create the illusion that Douglas-fir is profitable anywhere it can be grown. A poor stand of Douglas-fir is likely to be a far worse proposition than a poor stand of radiata pine.

## FURTHER READING FOR DOUGLAS-FIR


Belton, M. various. Southern NZ D-fir News. Mark Belton & Associates.

Belton, M. 1998. Fir-sighted forestry. NZ Forest Industries Magazine, July 1998.

Belton, M. 2000a. Douglas fir a farm forestry species? NZ Tree Grower, May 2000. P.39-41.

Belton, M. 2000b. Commercial Douglas fir forestry in NZ. NZ Tree Grower, August 2000. P.35-37.

Clifton, N.C. 1990. New Zealand timbers – exotic and indigenous. The complete guide. Government Printing Office. 170 p.

Cown, D.J. 1999. New Zealand pine and Douglas-fir – suitability for processing. FRI Bulletin 216.

Hood, I.A. 1983. Swiss needle-cast of Douglas fir. Forest pathology in New Zealand. No. 2 1983.

Knowles, L., Kimberley, M. and Hansen, L. 2003. A user's guide to the Douglas-fir calculator. Version 1.0, April 2003. Available through the NZ Douglas-fir Research Cooperative.

Knowles, L. and N. Ledgard 2004. A great future for Douglas fir? NZ Tree Grower, Feb 2004, p. 15-16.

Ledgard, N. various. Newsletter of the Douglas-fir research Cooperative.

Miller, J.T. and F.B. Knowles 1994. Introduced forest trees in New Zealand – recognition, role and seed source. 14. Douglas-fir. FRI Bulletin 124.

Ministry of Forestry, 1996. Zone Studies – Otago and Southland Downlands, Otago and Southland Uplands, Canterbury Inland Hill Country.

# EUCALYPTS

***Eucalyptus* spp**

**Contributing authors: Errol Hay, Pascal Berrill**

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Of the approximately 600 recognised species of Eucalyptus present in Australia, only 160 have been grown in New Zealand and only a few dozen have been seriously considered for plantations. Fashions for certain Eucalypts or groups of Eucalypts have ebbed and flowed with changing information on growth rates, processing difficulties, new diseases or market acceptance. Current focus, for the warmer parts of New Zealand, is on the stringybarks and related species, with *E. fastigata* for cooler sites[66]. All other species have apparently insurmountable problems or at least very weak links in the chain that stretches from seed supply to saleable product.

The ash group were once popular, as these could be grown throughout New Zealand. *E. fastigata,* despite its coarser branching, is the only one of the group now being actively promoted. Tony Haslett and John Roper say that *fastigata* is "the only [ash eucalypt] currently being utilised as sawn timber, and even this is on a very limited scale"[67]. Haslett says "*E. fastigata* is at least as stable as radiata pine, both in the short and long term"[68]. Peter Davies-Colley identified this as the "species that may hold the most promise for farm foresters New Zealand-wide"[69].

There was considerable interest in the spectacular volume growth of *E. nitens* once its major defoliator (*Paropsis charybdis*) had been overcome by a biological control agent (*Enoggera nassaui*). Large areas of *nitens* were planted for pulpwood, and there was also interest in sawlog regimes. Dudley Franklin's house, near Rangiora, is a testament to the intrinsic merits of solid wood from this species, given sufficient labour-intensive care in drying. Recently, however, a hyper-parasite has reduced the effectiveness of the control agent, and *nitens* no longer seems so promising. This species is not discussed further.

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[66] Common names for eucalypts can cause considerable confusion. The species mentioned in this chapter are often called:

| | |
|---|---|
| *E. botryoides* | southern mahogany |
| *E. delegatensis* | alpine ash |
| *E. fastigata* | brown barrel |
| *E. fraxinoides* | white mountain ash |
| *E. globoidea* | white stringybark |
| *E. laevopinea* | silvertop stringybark |
| *E. maculata (*new name: *Corymbia maculata)* | spotted gum |
| *E. microcorys* | tallow wood |
| *E. nitens* | shining gum |
| *E. pilularis* | blackbutt |
| *E. regnans* | mountain ash |
| *E. saligna* | Sydney blue gum |

[67] Miller *et al.,* 2000. See Further Reading.

[68] Haslett 1988. See Further Reading.

[69] Davies-Colley, P. 1995. See Further Reading.

The market appears to favour red timbers, as demonstrated in the eastern blue gums (*E. saligna* and *botryoides*), but these have a wide range of pests and diseases[70] and severe growth stresses[71]. This is a pity, because these have been widely planted and for a time looked like a welcome addition to a forest or farm's portfolio of species. Patrick Walsh reports that a new introduction of a eucalyptus gall wasp *Ophelimus* currently "makes it unprofitable to replant" these species[72].

On warmer sites, *E. microcorys* and *C. maculata* merit some attention, but so far interest is restricted to a small group of enthusiasts. *C. maculata* ("spotted gum") has an attractively figured, oak-coloured timber. *Microcorys* ("tallow-wood") has high natural durability, and very few of either the insect or the processing problems that so bedevil other eucalypts. According to Wade Cornell[73], quality remains high right through to the pith and *microcorys* is the highest value eucalypt for sale in Australia. Unfortunately, plantations and wood supplies are both severely limited, so there is limited hard evidence to support claims.

The current consensus of researchers in the Eucalypt Action Group[74] appears to favour the stringybark group, which include *Eucalyptus muelleriana* and *globoidea*, with *E. laevopinea* and *youmanii* for colder sites. *E. pilularis* is closely related to this group. In contrast to the other eucalypts, which – due to longitudinal growth stresses – tend to have problems in end-splitting, sawing, and distortion of sawn timber, the stringybarks are relatively free of these concerns. The wood is hard, strong and stiff with good natural heartwood durability in ground contact. They are therefore highly suitable for decking and for engineering uses. The stringybarks have marginally slower height growth when compared to *E. nitens* or *E. fastigata*, but are equal to the ash group for diameter growth. One drawback appears to be their natural colour – blond to brown – rather than the red that is currently preferred by the market. Denis Hocking and Richard Davies-Colley declare that *E. muelleriana* is the current "first choice among stringybarks"[75].

## PRODUCTIVITY

### Height Growth

Height productivity of pre-paropsis *E. nitens* exceeds that of *E. fastigata* which is superior to the stringybarks[76], but all these species show height growth at least as good as (and usually better than) radiata pine on similar sites. The NZ-average site index (age 20) for *E. fastigata* is estimated to be 31.2 m, with a range of 23.7-37.3 m. For the stringybarks, 30.6 m is the average site index for good Northland sites, with 23.5 for medium Coromandel or Bay of Plenty sites[77].

In terms of maximum possible height, Burstall records a *E. pilularis* near Kerikeri with a height of 46.2 m. He notes *E. regnans* as New Zealand's tallest tree and the world's tallest hardwood, at 69.1 m, and "up to" 122 m respectively.

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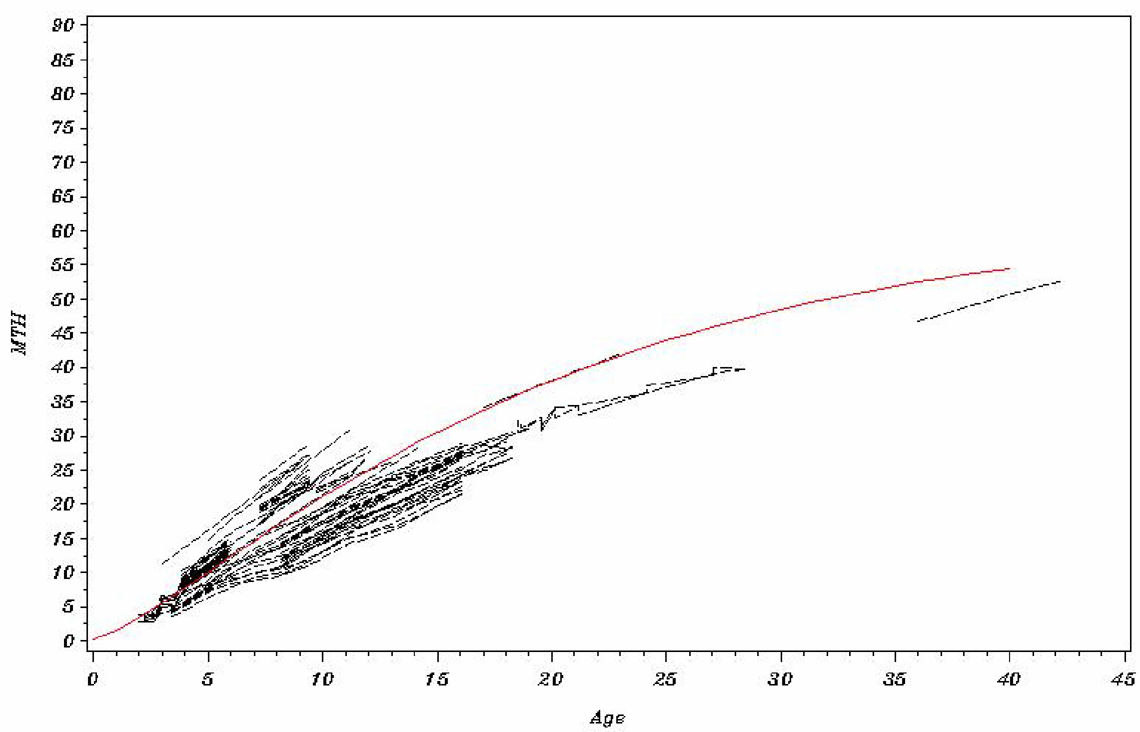
[70] McKenzie & Hay 1996. See Further Reading.
[71] Haslett 1990. See Further Reading.
[72] Walsh, P.J. 1999. Eucalypts – more insect introductions. Is it too late for *Ophelimus* control? NZ Tree Grower, Feb 1999. P. 25.
[73] Verbal communication at Eucalypt Action Group, Hanmer, April 2004.
[74] The NZ Farm Forestry Association has "action groups" specialising on eucalypts, cypresses, indigenous forests, blackwoods and redwoods. The Eucalypt Action Group has 105 members at time of writing and has had three annual meetings.
[75] Discussion at the Eucalypt Action Group AGM, April 2004.
[76] Shelbourne *et al*., 2003. See Further Reading.
[77] Berrill, J-P and A.E. Hay, 2001. Yield models for New Zealand grown *Eucalyptus fastigata, muelleriana, globoidea and pilularis*. Unpublished report

**Figure 4.1: Height growth of E. fastigata from the PSP records**




Note: the central line is a crude average and does not coincide with the height model developed by Berrill et al. The latter is more credible.

## Basal Area Growth

Height growth can be a poor method of evaluating tree productivity – volume is more closely related to diameter, and value even more so. Height growth is used mainly because it is somewhat independent of stocking, whereas basal area growth is closely related to management regime, especially if the stands are not fully stocked.

The eucalypts often outperform radiata pine in both height and basal area for a given stocking. The PSP data shows some spectacular basal area at high stockings. For example, one Rotoehu plot[78] of *E. fastigata* has a BA of 107 $m^2$/ha at age 23 (1500 stems/ha) and even higher figures have been recorded although these are somewhat suspect. On the other hand, eucalypts may well be grown on very low stocked regimes in order to maximise individual tree diameter (for ease of sawing). One theory[79] is that eucalypts don't perform well in highly stocked stands: they are said to be "crown shy", because the foliage and small branches are damaged by branch-thrashing between neighbouring trees

## Volume Growth

Miller *et al* (2000) provide matched comparisons of various ash eucalypts against radiata pine and some species compare favourably to the latter. MAI for volume is typically in the 20-30 $m^3$/ha/yr range. The best growth recorded by John Miller is 50-54 $m^3$/ha/yr for *E. regnans* in Kinleith Forest.

[78] RO 2085/4 15/0.

[79] Often propounded by the late Harry Bunn

Volumes for *E. fastigata* were examined from PSP records. The Rotoehu plot noted previously had a volume MAI of 45.6 $m^3$/ha/yr at age 23 for a high-stocked stand, but at the low stockings needed to produce large diameters suitable for sawing, the MAI drops to (still respectable) 20.5 $m^3$/ha/yr. One highly-stocked stand of *E. globoidea* in the Waitotara Valley, Taranaki, had a volume MAI of 27.4 $m^3$/ha/yr at age 18.

Using the prototype *E. fastigata* yield model[80], and using figures for a nominal stocking of 200 stems/ha and age 35, top yield is 28.6 $m^3$/ha/yr and average yield is 18.0 $m^3$/ha/yr. The figures of MAI provided in the yield model average the CAI, rather than dividing the volume at harvest by the rotation age (as is done here). The former approach includes losses from mortality, whereas the latter assumes that such losses are an inevitable part of growing the species and should not really be included for comparative purposes unless they are commercially extracted.

**Table 4.1: Summary of *E. fastigata* and stringybark volume growth**

| Species | Max MAI ($m^3$/ha/yr) | MAI - top ($m^3$/ha/yr) | MAI – av. ($m^3$/ha/yr) |
|---|---|---|---|
| E. fastigata | 45.6 | 28.6 | 18.0 |
| Stringybarks | 27.4 | 21.0 | 9.1 |

Notes:

- *Max MAI* is the highest believable mean annual increment (total volume) ever recorded in New Zealand from PSP records.
- *MAI-top* is for recoverable volume (clearfell + production thinnings) at age 35 for a good regime (200 s/ha final stocking) on a top quality site from the *fastigata* and stringybark yield models, with site index = 37.3 and 30.6 respectively.
- *MAI –average* is the MAI for recoverable volume at age 45 for a good regime on an average site from the yield models, with site index = 30.8 for *fastigata* and site index = 23.5 for stringybarks.

### Log Grade Outturn

Care needs to be taken in interpreting the high volumes capable of being achieved by eucalypts. Sawlog recovery relative to total volume can be low. This is because growth stresses can be minimised by using only large diameter logs (>40 cm sed). For example, in a study of 60-year old *E. globoidea* trees on Matakana Island, Somerville and Gatenby[81] estimated a sawlog yield of 680 $m^3$/ha and a pulp yield of 369 $m^3$/ha. (ie only 65% of the wood was sawlogs). Using MARVL information for 16 stringybark plots[82], the proportion of sawlogs averaged 29% but with a range of 0-71%.

An attempt has been made to predict log grade outturn for the eucalypts (Table 4.2) but the yield models for *fastigata* and for stringybarks give contradictory results. The former indicates a high proportion of the high-value grades, whereas in the latter pulpwood dominates.

**Table 4.2: Log grade outturn for "best" *E. fastigata* and stringybark regime at age 35**

| Species | Site | Self-pruned | A grade | B + S + L grade | Pulp | Total Rec Vol | Total Vol |
|---|---|---|---|---|---|---|---|
| E. fastigata | Top | 197 | 375 | 69 | 296 | 986 | 1000 |
| E. fastigata | Average | 125 | 237 | 44 | 187 | 623 | 632 |
| Stringybarks | Top | 202 | 80 | | 405 | 723 | 733 |
| Stringybarks | Average | 87 | 34 | | 175 | 312 | 317 |

[80] Berrill, J-P and A.E. Hay, 2003. Unpublished.
[81] Forest & Farm Plantation Management Coop Report No. 36.
[82] Berrill, J-P and A.E. Hay, 2001. Unpublished.

Notes:

- *Volume* was derived from the prototype *fastigata* or stringybark yield models as in Table 4.1.
- *Log grade breakdown* was inferred from prototype yield tables by Berrill and Hay (2001 unpublished). Assuming a mean DBH of 65 cm at age 35, the breakdown for *E. fastigata* is Self-pruned 20%, A grade 38%, (B+S+L) Grade 7%, Pulp 30% and Waste 5%. For the stringybarks, it is Self-pruned 28%, Sawlog grades 11%, Pulp 56%, and Waste 5%.

The figures for top growth in Table 4.2 should be treated with considerable caution! Spectacular growth rates occurring at young ages may not persist, or net growth may not closely resemble gross growth – in other words, mortality may occur. Standing volumes of this magnitude are not unheard of (at least with radiata pine or Douglas-fir) but have not yet been demonstrated as realistic with the eucalypts, particularly for whole stands as opposed to small-scale experimental plots.

## PRICE PER UNIT VOLUME

There is no doubt that some species can yield very attractive flooring, stairs, or furniture based on the genus' hardness and colour. In some cases, natural durability opens up a range of exterior uses such as decking. The downside is that most eucalypts, depending on species, are notoriously difficult to saw and dry because of growth stresses, and few New Zealanders have the skill to process the wood into a reliable product.

Stumpage prices also need to be interpreted carefully. Extrapolation backwards from sawn products needs to include the low sawmill conversion rates compared to radiata pine or other species. For example, the rate of conversion to sawn timber for the Matakana study was a respectable 59.5% (commensurate with the symmetry and size of the study logs), but this reduced to 19.9% after removing boards containing compression heart, or distorted by crook or surface checking from open-air drying. Clear grades comprised only 12.6%, due to small intergrown knots. This study is particularly significant in that *globoidea* is one of the stringybarks, and is a focus of interest precisely because it has lower distortion on processing than other eucalypts.

Mike Molloy[83] reports on recent eucalypt mill-door prices from near Whangarei:

A grade – clearwood with a minimum sed of 65 cm, $135/tonne;
B grade – knots on 1 side only; min. sed 40 cm, $105/tonne;
B1 grade – knots 2 sides only; min. sed 65 cm. $85/tonne.

The MOF Small Forest Management series states (Vol 1, page 45) that "some sawmillers who specialise in selling eucalyptus timbers are predicting that the 1994 values for large pruned butt logs shown [in Table 4.5] could double by 1998". This quote illustrates the unreliability of some expert predictions!

[83] Malloy, M. 2003. How to farm hardwoods profitably. NZ Journal of Forestry, Aug 2003, p. 32-36.

**Table 4.3: Yield and indicative 1994 prices**

| Log grade | Possible yield ($m^3$/ha) | Indicative 1994 prices (NZ$/$m^3$) |
|---|---|---|
| Pruned butt logs | 200-220 | 150-220 |
| Small branched logs | 70-85 | 80-110 |
| Large branched logs | 100-130 | 60-95 |
| Chip and firewood logs | 40-70 | 30-65 |
| Waste | 40 | - |

Source: MOF, 1995. Vol 1.

Multiplying the log grade outturn for a top *fastigata* site (Table 4.2) by Malloy's prices and allowing \$45/$m^3$ for pulpwood, we obtain total mill-door revenue of \$85 155/ha or \$91/$m^3$. Repeating the process for an average *fastigata* site yields only \$53 211/ha. For stringybarks, the harvest revenue for top and average sites is \$52 295 and \$22 510/ha.

**Table 4.4: Summary of Eucalypt log prices (\$NZ/$m^3$ at mill-door)**

| Species | Average price |
|---|---|
| *E. fastigata* | 91 |
| Stringybarks | 76 |

## GROWING COSTS

To grow eucalypts well requires good soil. On a scale where land for radiata pine is worth \$2500/ha, one would expect to pay \$3000/ha for land suitable for eucalypts.

Miller *et al.* (2000) suggest an initial stocking of 1100 stems/ha, which at \$0.65/seedling equates to \$715/ha in planting stock alone. This is considerably higher than radiata pine. Sensitivity to both weed competition and to herbicide also results in relatively high establishment costs. Early growth is considerably enhanced by soil cultivation and fertilisation. Pre-plant weed control is assumed to cost \$126/ha, cultivation \$42/ha, and planting \$254/ha[84]. Fertiliser is applied twice (at ages 1 and 3) and costs \$91 and \$129/ha respectively[85].

Once planted, however, the genus may be fairly cheap to grow through to maturity. Thinning and pruning costs may be low. Although eucalypts do not totally self-prune, they do shed most of the smaller branches leaving only a few larger ones to persist and grow. Having said this, the Zone Studies do not suggest that silviculture is particularly cheap, with a form pruning (\$100) at age 3, followed by two-hit pruning at ages 8 and 12 (\$500 and \$375/ha)[86].
Nicholas and Brown[87] report that cost of growing *fastigata* (excluding land) is \$1924/ha, which is lower than the costs in Table 4.5 and is fairly similar to the radiata pine.

[84] Figures from confidential contract.
[85] Ian Nicholas considers that the second fertilisation is often unnecessary.
[86] Northland Zone Studies. Ministry of Forestry 1994, p. 24.
[87] Nicholas, I. and I. Brown 2002. Blackwood – a handbook for growers and end users. Forest Research Bulletin No. 225. 93 p.

**Table 4.5: Cost of growing Eucalypts ($NZ/ha)**

| Nature of Cost | Typical cost |
|---|---|
| Land | 3000 |
| Tree Stocks | 715 |
| Other Establishment | 642 |
| Pruning | 975 |
| Waste thinning | 200 |
| **Overall** | **5532** |

Notes:
Some costs taken from confidential contracts, others from Northland Zone studies or other published material

## ROTATION AGE

The MOF Small Forest Management booklets suggest a rotation of 35-40 years (Vol 1) and 30-40 years (Vol 6). For this study, a 35-year rotation for sawlogs has been assumed. Although high volumes can be achieved at a younger age, and pulp rotations as low as 15 years have been advocated, it is necessary to ensure large diameters in sawlogs in order to reduce growth stresses. This necessitates a combination of low final stockings and fairly long rotations.

It might be possible to attain acceptable sawlog diameters despite higher stockings but only at the expense of increased rotation age. Conversely, it may not be possible to reduce rotation age, even with very low stockings, because of the implications of lower wood quality.

## RISKS

### Climate-related Risks

Frost is a major threat to most species under consideration. Shelbourne *et al* provide a table for stringybarks giving the mean minimum temperature of the coldest month in their natural range, and in no case do temperatures normally occur below -3°C. On the other hand, the ash group (including *E. fastigata*) will tolerate frosts of -10°C and perform well at elevations up to 500m.[88]

Eucalypts are not very susceptible to wind damage, with the ash group standing up better than others, and more resistant than radiata pine[89].

In a survey of species that died in the 1997/98 Canterbury drought, Frew[90] observed that the only eucalypt recorded as “unaffected or only slightly affected” was *globoidea*. The susceptibility of eucalypts to drought is always surprising in view of the perceived aridity of much of Australia, but the New Zealand plantation species are characteristically from the “wet sclerophyll” forests on the deeper, loamy soils of the higher rainfall areas.

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[88] Miller *et al.,* 2000. See Further Reading.
[89] Discussion on page 19 and 61 of FRI Bulletin 146, Wind damage in New Zealand exotic forests.
[90] Frew, C. 1999. The 1997/98 drought survey. NZ Tree Grower, p. 31-34.

Eucalypts may be especially prone to fire, as their oil-rich foliage and combustible litter ignites easily. Some species are well adapted to fire and can survive low-temperature burns, but charring may impair wood quality. Others are killed by fire, but their seeds have evolved to germinate prolifically in the warm ash. In either case, fire is highly undesirable in a New Zealand plantation situation.

Frost, wind, and drought can be minimised with careful siting, but cannot be totally avoided, so the climate-related risks are rated as MEDIUM.

**Pests and Diseases**
Eucalypts in general are at great risk from pests and diseases. This may be attributable to our proximity to Australia – often the pest is introduced without its natural predator. The latest introduction is gum-leaf skeletoniser (*Uruba lugens*), while the biological control agent for tortoise beetle (*Paropsis charybdis*) has been compromised by a new hyper-parasite. Fortunately the stringybark group seems to be fairly resistant to insects and pests. In the ash group, *E. fastigata* is "one of the healthiest eucalypts planted in New Zealand…. it is less susceptible to serious leaf fungal disease and insect damage"[91]. Denis Hocking argues[92] that it may be no coincidence that both the ash and the stringybark groups are more resistant to insect – or to possum – attack that the others. They both belong to the monocalypt sub-genus. On the other hand, Hocking said that they might be at greater risk from soil-borne fungal pathogens.

Despite Hocking's careful distinctions between the various sub-genera, black-butt leaf miner is recently causing problems in young stringybarks, and the poor track record of the eucalyptus genus in New Zealand would suggest a risk classification for pests and diseases of HIGH.

**Market-related Risks**
Domestic processors and users of eucalypts continue to have problems with the genus. It is certainly not foolproof, and – even if reliable combinations of species, drying, sawing and utilisation actually exist – it will take a while to educate the entire value chain. It is instructive that eucalypt plantations in Australia and elsewhere appear to be grown mainly for pulpwood rather than higher value sawlogs. It seems likely that the demand for such pulpwood will continue, but prospects of world trade in high-value plantation-grown eucalypt sawn timber appear doubtful. Having said this, the genus is a popular choice on all 5 inhabited continents, and we can anticipate some degree of "supplier push" as well as "consumer pull". The market risk is rated as MEDIUM.

**Social Risks**
Eucalypts are fast-growing evergreen hardwoods with (to some people) attractive foliage and stems and with a pleasant odour. The downside is that they may be seen as alien interlopers, similar to pines. A substantial international anti-eucalypt movement has evolved which appears to be based on (ill-conceived?) notions as to the peculiar habits of the genus in regard to water-use and allelopathic interactions with other plants. Any public opposition to pines would probably not be lessened by a major diversification into eucalypts. Despite this, social risks are rated LOW.

[91] Miller *et al.,* 2000. See Further Reading.
[92] Hocking D., 2003. Bugs chewing gums. NZ Tree Grower Feb 2003, p. 35-36.

**Table 4.6: Summary of Risks**

| Type of Risk | Risk Rating |
|---|---|
| Climate | Med |
| Pests & Disease | High |
| Market | Med |
| Socio-economic | Low |
| **Overall** | **High** |

Notes:
Risks have been described subjectively. It is not possible to quantify most of the risks.

## DCF ANALYSIS

Figures for top and average sites are given in Table 4.7. The longer rotation age (35 years as opposed to 25-27 years) is main reason for the lower figures relative to radiata pine.

**Table 4.7: DCF Analysis**

| Profitability indicator | Top site | Av. Site |
|---|---|---|
| IRR% | 6.1 | 4.6 |
| LEV @ 6% | 250 | -1958 |
| LEV @ 9% | -2940 | -3748 |
| LEV @ 13% | -4036 | -4257 |

## DISCUSSION

The spectacular volume growth that can be achieved with this genus, together with its worldwide adoption for plantations, signify that interest (and research) in eucalypts will continue for the foreseeable future. Eucalypts remain, in the words of Richard Davies-Colley[93], the "best genus for growing hardwoods in New Zealand".

Current favourites include the stringybarks and *E. fastigata*, but the database is often inadequate to develop reliable growth models. For example, there is only one plot of *fastigata* grown at low stockings. The dataset for the stringybarks covers three species on seven sites within three regions in a total of only 35 plots. Large-scale deployment of any of these species is risky until sufficient background research has been achieved.

With the exception of *laevopinea* and *youmanii*, the stringybarks are not a true "alternative" to radiata pine – they are limited (mainly by risk of frost) to Auckland, Northland and coastal strips in the North Island. *Fastigata* is suitable for more widespread planting. Other species, given our current knowledge, are too risky in terms of pests and pathogens to contemplate at this stage. Many of those eucalypts that have a good track record of survival are handicapped by the difficulties of processing their wood.

While acknowledging that the genus is capable of growing wood with valuable properties not shared by radiata pine – including greater strength, hardness, natural durability and colour range – more research attention in processing and genetics is needed to improve timber stability.

[93] Spoken at the AGM of the Eucalypt Action Group, April 2004.

## FURTHER READING FOR EUCALYPTS


Barr, N. 1996. Growing eucalypt trees for milling on New Zealand farms. NZ Farm Forestry Assoc. 140 p.

Clifton, N.C. 1990. New Zealand timbers, indigenous and exotic. The complete guide. GP Books. 170p.

Davies-Colley, P. 1995. *Eucalyptus fastigata*. New Zealand Tree Grower, Nov 1995. P. 10-11.

Haslett, A.N. 1988. Properties and utilisation of exotic speciality timbers grown in New Zealand. FRI Bulletin No. 119. Part V: Ash eucalypts and *Eucalyptus nitens*.

Haslett, A.N. 1990. Properties and utilisation of exotic speciality timbers grown in New Zealand. FRI Bulletin No. 119. Part VI: Eastern blue gums and stringy barks.

Maclaren, P. 1989. *Ophelimus eucalypti*: a recently introduced gall-making insect on eucalypts. NZ Tree Grower, May 1989, p. 26-27.

McKenzie, H. and E. Hay, 1996. Performance of *Eucalyptus saligna* in New Zealand. FRI Bulletin No. 195.

Miller, J.T., Cannon, P.G. and Eckroyd, C.E. 1992. Introduced forest trees in New Zealand: recognition, role and seed source. Vol 11 *Eucalyptus nitens*, FRI Bulletin No. 124.

Miller, J.T., Hay, A.E. and Eckroyd, C.E. 2000. Introduced forest trees in New Zealand: recognition, role and seed source. Vol 18 Ash Eucalypts, FRI Bulletin No. 124.

Ministry of Forestry 1995. Small Forest Management series, Vol. 1: Special purpose timber species. Eucalyptus, pages 31-46. Vol 6: Managing a small forest for timber.

Mortimer, J. 2003. A selection of alternative timbers. Taitua Books. Chapter 7. *Eucalyptus*. 72 p.

Shelbourne, C.J.A.; Nicholas, I.D.; Hay A.E. and McConnochie, R.M. 2003. Stringybark eucalypts for a future hardwood industry in New Zealand. NZ Tree Grower, August 2003, p.34-35.

Williams, B. 2001. The development of a Eucalyptus solid-wood industry in New Zealand. New Zealand Tree Grower, Nov 2001, p. 30-31.

# CYPRESSES

## *Cupressus* spp

**Contributing authors: Pascal Berrill, Patrick Milne**

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There are a number of cypress species and cultivars that appear to hold commercial potential. The best known are *C. macrocarpa*, *C. lusitanica* and the leylands (X *Cupressocyparis leylandii*). There are also possibilities in *Chamaecyparis lawsoniana, X Cupressocyparis ovensii*[94]*,* and *Chamaecyparis obtusa* (Hinoki).

Macrocarpa is found throughout New Zealand, but usually as individual trees or shelterbelts. Grown this way, its awkwardly large diameter, severe fluting, and large branches do not impress foresters. Grown as a tight stand, however, the tree is capable of producing high volumes of excellent wood.

Regarding wood properties, cypress is easily worked, with a fine even texture and a lustrous golden colour similar to kauri. Small intergrown knots may add rather than detract from the appearance. It is highly suitable for furniture, joinery and panelling and is sought after by cabinet-makers and boat builders. It also has the more traditional uses of exterior joinery, weatherboards and farm utility timber. Both main species have better short and long-term dimensional stability than radiata pine but do not have the same surface hardness[95]. The heartwood is durable even in ground contact (10-15 years) and cannot be pressure treated. The sapwood can be boron-treated for non-leaching situations. For above-ground uses, several cypresses rate highly in terms of natural durability[96].

There are some critically important differences with respect to radiata pine. The first is that there is insignificant pith – good quality wood can be obtained from the centre of a tree. The second is that branches are more numerous (perhaps 3-5 times as numerous) but – depending on the silviculture – may be smaller in diameter. Conversely, if the trees are open grown branch size can exceed even that of the notoriously large-branched radiata pine.

The shade tolerance of cypresses implies that stockings can be higher than for radiata, without mortality or even severe growth loss. Shade tolerance also explains the lack of thinning response[97]. To obtain large individual tree diameters in a short rotation, low stockings are desirable, but extra large branches in upper logs are an unwelcome side-effect. Given that small-diameter logs can produce satisfactory sawlogs, there may be no need to produce piece-sizes

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[94] Common names for these species are:

*Cupressus macrocarpa* – macrocarpa or Monterey cypress;
*Cupressus lusitanica* – Mexican cypress;
*Chaemaecyparis lawsoniana* – Lawson's cypress;
*Chamaecyparis obtusa* - Hinoki
X *Cypressocyparis leylandii* – Leyland cypress, also known by the name of each clone or cultivar; they are an infertile hybrid between *C.macrocarpa* and *Chamaecyparis nootkatensis*.
X *Cupressocyparis ovensii* – Leyland cypress, a hybrid between *C.lusitanica* and *Chamaecyparis nootkatensis*.

[95] Haslett 1986. See Further Reading.

[96] What's New In Forest Research, No. 245. 1997. New Zealand Forest Research Institute.

[97] Franklin, D. Review of research on cypresses in New Zealand – a summary. NZ Tree Grower, Nov 1997. P. 30-33.

equivalent to radiata pine (eg 60 cm dbh), and there may therefore no need to thin to low stockings (200-400 stems/ha) or endure long rotations (30-40 years). In addition, production thinnings are a distinct possibility. In other words, a comparison of cypresses using a regime similar to a direct clearwood radiata pine may be unfair: cypresses can be grown at higher stockings, possibly with shorter rotations, and (if the risk of windthrow is low) with production thinnings.

There is considerable domestic demand for this timber, and export consignments have been intermittent and variable in quality. It is likely that it has considerable export potential, given its similarity to related Asian species such as Hinoki (*Ch. obtusa*). The occasional overseas shipment has brought good prices, but an export industry has not yet been established because of the lack of continuous supply, particularly with wood of uniform good quality.

Cypress canker is the main drawback to widespread adoption of macrocarpa throughout New Zealand. The canker affects branch tips but – more importantly – destroys stem cambium and encourages fluting. It may even cause tree death. Although it may not have been of great economic consequence in the past, widespread planting of macrocarpa would probably create an epidemic of this disease with severe results[98]. Macrocarpa is particularly susceptible until it is about 10 years old, after which it becomes increasingly resistant[99]. Until non-canker resistant breeds and clones become available, macrocarpa is suited only for cold sites, and is canker-free only in the south of the South Island or at high altitudes. Lusitanica is more resistant to canker, and therefore is preferred in warmer areas. Note, however, that even lusitanica or (most of) the leylands are not totally immune to the effects of canker.

In the Cypress Growers Handbook, Stephen Brailsford[100] says "the major advantage that the current clonal selections offer is an apparent absence in the incidence of canker and dramatic reduction in number and size of branches". This may be a valid opinion, but this author cannot confirm the statement. Clonal trials have been widely established, but there appears to be no funding or intention to assess them. In any case, the presence of fewer and smaller branches may imply a lower leaf area and therefore a lower growth rate.

Of the Leyland cypresses, the most promising cultivars currently available are reportedly 'Ferndown' and 'Stapehill'[101]. They are primarily used for shelterbelts, but there appears to be no reason why they should not be planted as woodlots. Their wood quality would probably be similar to other cypresses. Patrick Milne says "in most situations they are a better alternative to macrocarpa, more site tolerant, much easier to manage and less susceptible to cypress canker"[102]. In particular, *Ch. ovensii* seems almost immune to the disease[103]. While it may be true that selected clones may be cheaper to prune (perhaps ⅔ the cost), they are also more expensive to purchase ($1.20-$2.00 versus $0.525 each).

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[98] The fungi responsible are *Seiridium cardinale* and *S.unicornis*. The former is the main problem with macrocarpa. Miller & Knowles (see Further Reading) say: "At present, the disease, though locally obvious, does not create a general threat to productivity or timber quality. However, the situation could change if planting rates increase, and especially if *C. macrocarpa* and *C. lusitanica* are planted on sites where stress and slow growth rates predispose trees to attack."
[99] Van der Werff, see Further Reading.
[100] See Further Reading.
[101] Strictly, these should be known as Stapehill clone 20 ('Stapehill') and Stapehill Clone 21 ('Ferndown').
[102] Milne P. 2002. Leylands – more than just shelter. NZ Tree Grower August 2002, p. 42.
[103] Hood *et al*, see Further Reading.

Lawson's cypress[104] appears to have gone out of fashion (ie most existing stands are old) but the wood is considerably stronger and stiffer than the other cypresses, and there may be a ready market in the United States. John Mortimer says "I believe we have sadly neglected the potential of this quite outstanding tree". It benefits from deep, well-drained soils but plenty of rain (>1000mm). It can withstand severe cold. Ian Nicholas comments[105] that it has lower productivity and poorer health.

## PRODUCTIVITY

### Height Growth

The tallest open-grown macrocarpa recorded by Burstall (1984) as 47.7 m high at age 92. Miller & Knowles say "typical mean top height values for macrocarpa on good sites for ages 10, 20 and 30 years would be 10.5 m, 20 m, and 26.5 m respectively". Such height growth would correspond to a radiata pine site index of 20 metres – poor by radiata standards.

Site index from Pascal Berrill's model[106] is 23.7 metres (age 20), although the actual data suggests that 15 m is more common. Pascal Berrill says the main reason is for the poor performance is poor siting: height in the cypresses is highly variable and very sensitive to site and climate.

### Basal Area Growth

Measurements of diameter with a tape assume a circular section and predictable bark width, but the cypresses – and in particular macrocarpa – tend to develop fluting in the stems. This can lead to gross over-prediction of basal area.

Basal area growth is estimated to reach 100m$^2$/ha at ages 22-23 by Berrill's model, although it is not clear what stocking this relates (but presumably in excess of 1000 s/ha). Putting this in perspective, this is similar to that achievable by radiata pine.

### Volume Growth

Estimates of volume productivity of cypresses differ between authors. It is hard to compare estimates directly, because of different assumptions regarding rotation age, stocking and inclusion of production thinnings.

**Table 5.1: Estimates of Cypress productivity**

| Author | Rotation age | Stocking (s/ha at harvest) | Harvest volume (m$^3$/ha) | MAI (Total Recoverable Volume/yr) |
|---|---|---|---|---|
| Brailsford | 20-25 | 600-800 | 738[107] | 23.1-29.5 |
| Jamieson | 35 | 200 | 570 | 16.3 |
| Berrill | 30 | 250 | 530 | 17.7 |

[104] Also called "Port Orford cedar"
[105] Pers. comm.
[106] Berrill, J.P. 2002. "Cypress 2002". Cypress growth model version 3. Unpublished.
[107] 605 tonnes/ha equates to 738 m$^3$/ha, given a green density of 820 kg/m$^3$.

These figures appear to be contradictory, with the Brailsford estimate being far more optimistic. The greater stocking of the Brailsford regime cannot compensate for the much shorter rotation age. Greatest reliance can be placed on Berrill's estimates, which are derived from hard data from the Forest Research PSP system, combined with sophisticated mathematical modelling.

Work by Pascal Berrill[108] of Forest Research shows that "data from older *C. lusitanica* stands…. appear to be artificially low [and was] probably caused by past selection of low-quality sites." His models indicate that a total volume of about 530 $m^3$/ha at age 30 is probably achievable for a 250 s/ha regime, and 300 $m^3$/ha at age 15 is achievable for 1100 stems/ha. This equates to MAI of 17.7 and 20 $m^3$/ha/yr respectively, which is similar to the average for radiata pine. The *maximum* MAI noted by Miller & Knowles was 21.3 $m^3$/ha/yr for Lawson's cypress – again similar to the *average* for radiata pine – but most growth was substantially inferior to this (5.3-9.9 $m^3$/ha/yr)

Recoverable volume can be considerably less than total volume because of fluting in the butt-log and forking in upper logs. Over longer rotations fluting may become pronounced in some seedlots. On the other hand, wood can be sawn to a small-end diameter of 10 cm. There needs to be an assessment of stands old enough to contain merchantable stems, perhaps using MARVL techniques, to clarify the ratio of total volume to recoverable volume and to provide hard data on the proportion of various log grades and how this changes with age.

## PRICE PER UNIT VOLUME

Brailsford reports prices of "$250-$400 per cubic metre of pruned logs and up to $3,500 for clear veneer flitches", and "knotty log prices of around $100 per tonne" but does not provide price points or references. In his economic analysis, he uses three log types: pruned peeler @ $250/tonne milldoor, knotty peeler @ $150, and sawlog at $90. Denis Hocking[109] reported a recent sale that supports these figures, but notes that the domestic market for veneers of knotty wood is far weaker than for clearwood. Regarding sawn timber, Hocking reports sawn lumber prices of $1100/$m^3$ for green "clear heart" of larger dimensions, and $1700/$m^3$ for the same product air-dried. For many end users a mixture of sap and heartwood is quite acceptable.

It is difficult to derive an average mill-door price for cypress wood, because the Berrill model merely gives total volume and does not (yet) break this down into log grades. Assuming the proportions provided by Jamieson[110] and milldoor prices of $350/$m^3$ for pruned logs, $200/$m^3$ for small-branched logs and $100/$m^3$ for large-branched logs, we derive Table 5.2. Given the uncertainty of the proportions and prices, this table should be treated with considerable caution.

**Table 5.2: Summary of Cypress wood prices ($NZ/$m^3$ at mill-door)**

| Average price |
|---|
| 129 |

[108] Berrill, J-P, C.J.A. Shelbourne, and R.B. McKinley, unpublished. Comparison of alternative species volume yields and stem dry matter production in New Zealand.
[109] Denis Hocking, pers. comm. of 11 August 2003, sold macrocarpa recently at "$350/$m^3$ on truck for top pruned logs, and $200/$m^3$ for the rest". The market was Gunn's Veneers in Christchurch. Also see Hocking, D. 2003. Cypresses – a nice little earner. NZ Forest Industries, Sept 2003, page 44.
[110] Page 18 of the MOF Species Purpose Timber Species book.

Notes
*Average Price* is the current mill-door price per metre of recoverable wood of all grades, assuming 29.8% of recoverable volume is pruned peelers, 12.2% is large-branched sawlogs and 58.0% is small-branched sawlogs. Pulpwood is considered unmerchantable.

## GROWING COSTS

Although the cypresses are found throughout New Zealand, they prefer more fertile, lowland, sheltered sites with sustained moisture supply especially during summer. Ross Jamieson[111] says: "cypresses need fertile soils for good growth and should not be planted on less fertile sites, which may be better suited to radiata pine". Patrick Milne endorses this view, and justifies it with data for both macrocarpa and lusitanica[112]. Therefore land costs would be at least as high as for good radiata pine sites, and the land price of $1550/ha given by Brailsford in his economic analysis is probably a gross underestimate. Here we assume $4000/ha.

High initial stockings (1000-2000 stems/ha) are preferred to promote rapid canopy closure, suppress weeds, reduce branch size and provide for good selection. At a cost of 52.5 cents each, this is a substantial outlay ($525-$1050/ha), with the higher stocking being favoured by many commentators. Being more sensitive to herbicides than radiata pine, and benefiting from deep cultivation, establishment costs can be greater.

Cypresses have prolific branching, and if pruning is contemplated, costs of branch removal can be very high (15-25 m of pruned stem/hour in traditional regimes, or 4-60 m of pruned stem/hour in secateurs pruning regimes). Brailsford estimates a pruning cost of $2520/ha on 800 stems, to achieve 6 m pruned logs.

**Table 5.3: Cost of growing Cypresses ($NZ/ha)**

| Nature of Cost | Typical cost |
|---|---|
| Land | $4000 |
| Tree STOCKS | $1050 |
| Establishment | $1550 |
| Pruning | $2520 |
| Waste thinning | $150 |
| **Overall** | **$9270** |

Notes:
Some costs taken from Brailsford (undated)

## ROTATION AGE

Brailsford describes a regime with a final stocking of 800 stems/ha, and assesses rotation ages of 20, 22 and 25 years. In contrast to this, another acknowledged cypress expert – Patrick Milne – says, "Rotations are a little longer than required for radiata pine"[113]. Dudley Franklin suggests clearfelling at 35 years in a regime with production thinning, or 40 years in a direct regime[97]. Bruce Glass[114] recommends 30 years for both regimes. The Zone Studies consistently advocate longer rotations (35-45 years depending on the region). The Ministry of Forestry booklets Vols 1 and Vols 6 suggest 35-45 years, and 30-40 years respectively.

111 In MOF 1985. See Further Reading.
112 Milne, P. 2002. The importance of a good site for cypress. NZ Tree Grower.
113 Patrick Milne, August 1998, unpublished lecture notes.
114 What's New No 127.

Until the Brailsford regime is supported with hard empirical evidence, we should assume that the majority view (35-45 years) is correct.

## RISKS

### Climate-related Risks

Assuming that lusitanica is planted only in warmer areas, macrocarpa in very cold areas and drier/cooler/infertile areas are used for Leylands, much of the climate risk is removed. Although the cypresses prefer good sites, they are remarkably hardy. Macrocarpa will withstand very low rainfall (500 mm/yr), 10°C of ground frost, wetter ground than radiata pine, wind and salt-blasting. Lusitanica is less tolerant of wind (severe toppling has been observed), low rainfall (1000 mm/yr), frost (5°C) and salt.

Given that cypresses are as ubiquitous as radiata, with shelterbelts and solitary trees found on farms throughout the country, we can assume that – again on a national scale – that climatic risks are LOW except for *lusitanica* where they are MEDIUM (wind, frost).

### Pests and Diseases

Brailsford says that "cypresses, stock and wild animals do not go well together. The soft bark is eagerly sought by both sheep and cattle, with quite devastating effects. Hares and rabbits cherish Leylands and possums will travel quite long distances to cause havoc amongst lusitanica."

Brailsford argues that correct management and siting will minimise risks of cypress canker, but this is debatable. In any case, it is not clear that managers can identify less susceptible sites in advance of establishment. For example, unpredictable droughts may cause sufficient stress to trigger an outbreak. The best long-term hope lies in canker-resistant clones, for which there is an active research programme[115]. The current situation is that canker is almost inevitable on warmer sites, and the progressive loss of trees (sometimes up to 90% of the total) is arguably worse than total mortality, because the owner is often reluctant to switch to an alternative land use at an early stage.

The Leyland clone *Ch. ovensii* is being hailed by some as being almost free of canker, together with other benefits (form, branching). But, in this author's opinion, it would be extreme folly to base a large-scale planting programme on a single clone. Although opponents of plantations often use the term "monoculture" with this concept in mind, the huge genetic diversity that occurs in species such as radiata pine offers a remarkable degree of protection. This protection is absent in clonal plantations – such as most poplar plantings in New Zealand. A pathogen must merely overcome a single genotype to trigger an epidemic. Note, for example, that *Ch. ovensii* appears to very prone to possum damage[116].

The only time this author has encountered large planted stands of totally dead trees was with *C. lusitanica* in Malawi, 1990. Trees had been pruned to 6 m, and carefully thinned to about 200 stems/ha. They had excellent form and were old and large enough to harvest, but had recently been killed. The attributed cause was cypress aphid: *Cinara cupressi*.

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[115] Aimers-Halliday, J.; Dibley, M.; Faulds, T.: Low, C. 2002. Forest Research develops superior macrocarpa and lusitanica. NZ Tree Grower, May 2002. P.25-27.

[116] Observation of Dugald Rutherford in Conference Proceedings of Farm Forestry Association Conference, Hanmer April 2004.

The risk from pests and diseases could be rated HIGH for macrocarpa and the Leylands, and LOW for lusitanica.

**Market-related Risks**
There appears to be an unsatisfied domestic demand for this wood. A certain proportion of the population want wood in their homes or boats but their instructions to architects and builders and furniture-makers is often “anything but radiata”. Cypresses are hassle-free to process and use, look and smell different to pine, and have a great attraction to those who oppose chemical preservation. When the domestic market is eventually saturated, there is a large and untapped market in Japan (as a substitute for cheaper grades of Hinoki) or the United States (substituting for cheaper grades of Port Orford Cedar).

The market seems not to discriminate greatly between the various types of cypress – every species is desirable. Market risks are probably a lot LOWER than radiata pine.

**Social Risks**
Cypresses have a sombre appearance, “whose dark foliage is sometimes associated with mourning”[117]. Therefore, where landscape considerations are of paramount concern we cannot expect cypresses to be welcomed as a substitute for pines. There may also be peripheral issues relating to the perceived effect of conifers on soil values, or abortion in cattle from eating the foliage.

The main social risk, in this author’s opinion, relates to the huge labour requirements of cypress pruning. Large-scale cypress plantations would soon run into labour problems – there would be insufficient people prepared to engage in such tedious work. Shortage of workers would soon result in pruning costs rising to unrealistic levels, or else a switch to regimes that do not require pruning. Given the numbers of branches in cypresses, and the degrade that results from dead knots, it is hard to devise a profitable regime without pruning.

Social risks could be described as MEDIUM.

**Table 5.4: Risks of growing Cypresses**

| **Type of Risk** | ***C.macrocarpa*** | ***C.lusitanica*** | ***Leylands*** |
|---|---|---|---|
| Climate | Low | Med | Low |
| Pests & Disease | High | Low | High |
| Market | V.Low | V.Low | V.Low |
| Socio-economic | Med | Med | Med |
| **Overall** | **High** | **Med** | **High** |

Notes:
Risks have been described subjectively. It is not possible to quantify most of the risks.

## DCF ANALYSIS

There are insufficient data on volumes by log grade for a range of ages to undertake a meaningful discounted cashflow analysis of cypresses. The MOF Zone Studies bravely provide IRRs and NPVs at 7% discount rate for a range of species, but (wisely!) do not give supporting references for their log breakdown or their price assumptions. The IRR for cypresses varies between less than 6% and more than 10%, depending on region.

[117] Concise Oxford Dictionary, tenth edition.

## DISCUSSION

Like Douglas-fir, cypresses represent a useful possibility in a portfolio of alternatives to the radiata "monoculture". They are practical proposition, because we have several rotations' experience in growing, processing and marketing them. We know that the wood can fetch high prices and that there is an unsatisfied demand for it. Cypress canker is the one weak link in the chain – particularly as regards macrocarpa – but this may soon be overcome with careful tree breeding and clonal options, and anyway is less of a problem with *lusitanica*.

Cypress forestry involves high costs. Though the genus can be grown in most places, good growth requires good sites, which may be expensive. A valuable product implies clearwood, or at least small, intergrown knots. This implies very costly pruning regimes and/or high stockings together with judicious thinning. It may be unwise to assume that workers may be available in the future to prune large areas of cypress plantations.

The major weakness in the support available for this genus is in growth modelling – particularly prediction of volumes. At time of writing, there are models that provide estimates of total volume, but no breakdown into recoverable volumes by log grade. This is a major impediment to large-scale investment in cypresses.

There have been interesting developments in secateur-pruning (ie pruning very small trees), and proposals for clonal options and continuous-cover forestry, but these have yet to be thoroughly evaluated. There is a possibility of reduced rotation ages, given that small piece sizes can potentially fetch reasonable prices, but this is uncharted territory and it may be unwise to venture far down this route without a reliable map.

The Leylands are natural hybrids, and are remarkable in that they have occurred between individuals of different genera. Now that their usefulness has been established, there is a strong case for creating new hybrids, but this time from selected superior individuals. A mixture of clones (say 10-30 clones) in a stand would have genetic variation as great as a typical plantation of seedlings. The problem of course is that some members of the public may see this as another form of unacceptable genetic tinkering, even if recombinant DNA techniques are not actually used.

## FURTHER READING FOR CYPRESSES

Aimers-Halliday, J.; Dibley, M.; Faulds, T.; Low, C.; 2002. Forest Research develops superior macrocarpa and lusitanica. New Zealand Tree Grower, May 2002, pp. 25-27.

Barton, I. 2000. North Waikato Leyland Cypress Trial. NZ Tree Grower, February 2000. P.12-13.

Brailsford, S. undated but probably 1998. The cypress growers handbook – options for growing quality timber. Published by Brailsfords Forest Management Ltd.

Clifton, N.C. 1990. New Zealand timbers, indigenous and exotic. The complete guide. GP Books. 170p.

Glass, B. 1984. What's New in Forest Research, No. 127. Growing cypresses.

Edwards, V. 1991. Macrocarpa and lusitanica. Will cypresses rival radiata monoculture? NZ Forest Industries, July 1991. P. 36-39.

Haslett, A.N. 1986. Properties and utilisation of exotic speciality timbers grown in New Zealand. Part iii: Cypresses. FRI Bulletin no. 119.

Hood, I.A.; Gardner, J.F.: Kimberley, M.O.; Gatenby, S.J.; and J.C. Cox 2001. A survey of cypress canker disease. NZ Tree Crower, Feb 2001, p. 38-41.

Miller, J.T. and F.B. Knowles 1992. Introduced forest trees in New Zealand: recognition, role, and seed source. Vol 19. The cypresses (revised edition). FRI Bulletin No. 124.

Ministry of Forestry 1995. Small Forest Management series, Vol. 1: Special purpose timber species. Cypress, pages 11-20. Vol 6: Managing a small forest for timber.

Mortimer, J. 1991. From the shores of Monterey. Growing Today, Sept 1991, p. 31-33.

Mortimer, J. 2003. A selection of alternative timbers. Taitua Books. Chapter 6: *Cupressus macrocarpa*. Chapter 4. *Chamaecyparis lawsoniana*.

Self, M. 2000 Cypress canker. NZ Tree Grower, May 2000. P. 31-32.

Van der Werff, H. 1984. Forest pathology in New Zealand. Cypress Canker. No. 8, 1984.

# BLACKWOODS

***Acacia melanoxylon***

**Contributing authors: Ian Nicholas, Pascal Berrill**

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Several *Acacia* species are of potential commercial interest to growers in New Zealand. The most widely known and most commonly planted is *Acacia melanoxylon* or Australian Blackwood[118]. As an evergreen hardwood, it provides an aesthetically pleasing alternative to conifers, and can have impressive early height growth. The quality of the wood is outstanding: it exhibits a wide range of colours (including yellow, red-brown and black), has an even texture, machines and finishes well. This author can personally testify to its excellent woodworking properties.

The second most main *Acacia* species of note is *A. dealbata*, or silver wattle, which has spectacular volume growth rates - even rivalling eucalypts such as *E. nitens*[119]. One report gives a height of 20 m at year eight[120]. Pascal Berrill notes that there is an acute shortage of data for this species, especially for older ages, and that predictions of yield are highly speculative[121]. Its lack of popularity arises because of poor form, the presence of fire blight (in Tasmania), and the fact the species is remarkably short-lived. It dies, breaks open, or topples at a relatively young age. Possibly because the wood is not as dark in colour or as interesting as Blackwood, it has no established market[122]. It also has a greater potential for tree spread. On the plus side, it is reported to be drought tolerant, grow fast without developing growth stress, and to be stable during drying[123].

*Acacia mearnsii* seedlings are also in demand in New Zealand, probably for firewood plantations. Reportedly, the wood has a better colour than *dealbata* and the tree has even faster initial growth rates, although it slows down later. The species was once promoted as a source of bark for tanning, but chemical techniques have by-passed this technology. The species has been historically ravaged by gall fungus.

Blackwood has been planted in half a dozen countries, but poor site selection and poor choice of provenance may have led to somewhat unfair judgements. Although it can tolerate adverse sites, to be of commercial value it requires adequate rainfall, shelter, soils that are fertile and free-draining, and moderate temperatures. It cannot endure waterlogged (ie non-oxygenated) soils

Like radiata pine, cypresses or redwoods, the species is fortunate to have a handbook[124] dedicated to it. This incorporates much of the current knowledge and provides a wealth of further reading. Many of the statements in this chapter are transcribed almost directly from that handbook.

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[118] Also called Tasmanian blackwood, although it naturally occurs in five Australian states.

[119] A trial at Tapawera, Nelson, of *Eucalyptus nitens* used *A. dealbata* to mark the beginning and end of each *nitens* provenance. Although the 18-year old *nitens* had excellent growth, it was dominated by the *Acacia* markers both in terms of height and diameter.

[120] Don Bell, 2002. What are we – a garden club or market gardeners? New Zealand Tree Grower May 2002, p. 21-22.

[121] Berrill, J-P; Shelbourne C.J.A. and McKinley R.B., undated and unpublished report. Comparison of alternative species volume yields and stem dry matter production in New Zealand.

[122] John Mortimer, who trades in Blackwood, says that *dealbata* has "no commercial value". Page 98 in Trees for the NZ Countryside – a planter's guide.

[123] Cameron and McConnochie 1999. See Further Reading.

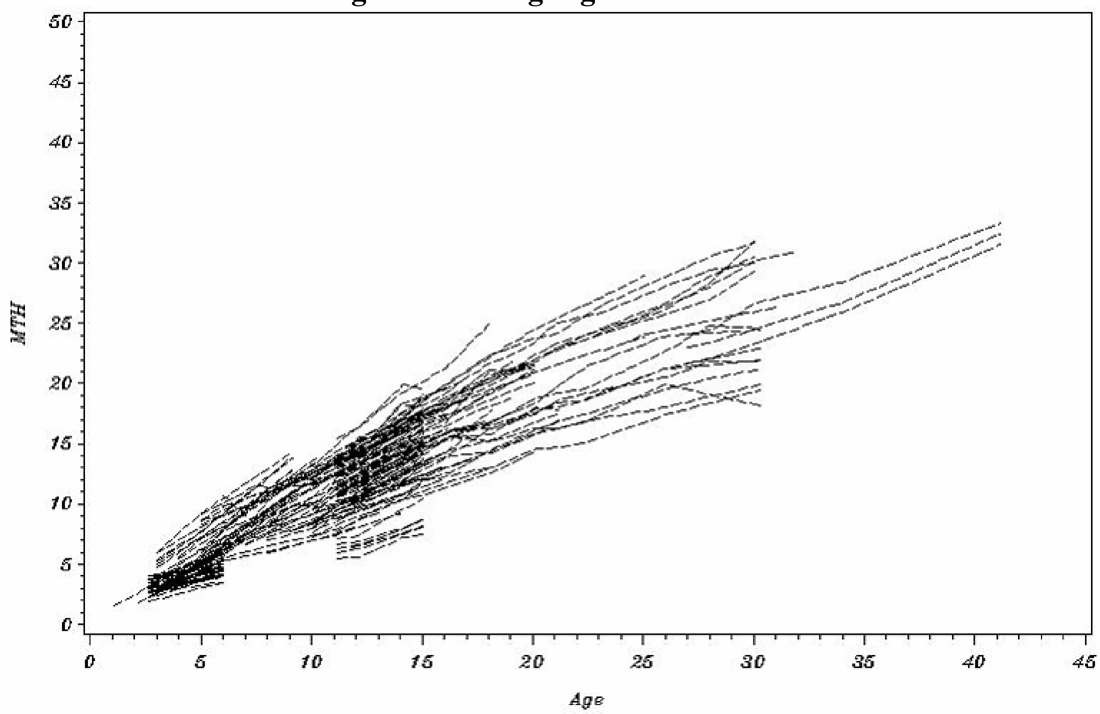
[124] Nicholas and Brown 2002, see Further Reading.

## PRODUCTIVITY

### Height Growth

Figure 6.1 was derived from the Forest Research PSP records. It can be seen that height growth is typically about 1m per year for the first 15 or so years, but slows down with age. The site index (Mean Top Height at age 30) is typically about 25 m with a range from 19-32 m. Forest managers who are new to this species are often very impressed with the initial height growth (the value of which, for outstripping woody weeds, should not be underrated) but sometimes fail to appreciate that this growth is not sustainable. The typical site index at age 30 is not as high as the typical radiata pine site index at age 20.

**Figure 6.1: Height growth from PSP records**




### Basal Area Growth

Forest Research models[125] using preliminary data (up to age 16) suggest that at age 34, dbh should reach 62 cm using a stocking of 160 stems/ha, or 57 cm at 200 stems/ha. If this stands the test of time, this is an encouraging result, both in terms of diameter growth and in terms of rotation age. One caution: these results were tested using a single site at Hunua (mean of 5 plots measured from age 5-17), which is claimed to have a site index of 35.1 (age 30). This is substantially higher than any height data indicated in Fig. 6.1.

### Volume Growth

Nicholas and Brown report that MAI for total volume ranges from 5-10 $m^3$/ha/yr, with a mean of 5.23 $m^3$/ha/yr. Maximum MAI is reported to be 21.09 $m^3$/ha/yr but this needs to put in perspective: it applies to stockings and ages that are not realistic commercial propositions. One problem with growing Blackwood as a timber tree, according to Nicholas and Brown, is that there is little sawlog material above the pruned butt, and most of the top logs (at a young age) are suitable only for firewood.

[125] Berrill J.P., Nicholas I.D. and Gifford, H.H. 2000. A growth model for New Zealand grown *Acacia melanoxylon*. Unpublished paper.

**Table 6.1: Volume by log grade (%)**

| Pruned | Sawlog (Branches <7 cm) | Sawlog (Branches >7 cm) | Pulp/firewood | Waste | Total |
|---|---|---|---|---|---|
| 58 | 13 | 2 | 26 | 1 | 100 |

Notes: proportions taken from Nicholas and Brown 2002, p. 71.

A similar breakdown of volume into log grades is given in Table 6.2:

**Table 6.2: Volume by log grade ($m^3$)**

| Pruned | Sawlog (Small Branches) | Sawlog (Large Branches) | Firewood | Total | Source |
|---|---|---|---|---|---|
| 70-85 | 20-30 | 45-55 | 40-70 | 175-240 | MOF (1996)[126] |
| 45.4 | 15.8 | 26.4 | 12.4 | 130 | Steward (1996)[127] |

**PRICE PER UNIT VOLUME**

Blackwood has been internationally accepted for 100 years as one of the world's great decorative timbers. It is highly suitable for furniture, cabinet-making, veneers, turnery and knobs, and can also be used for panelling, carving, flooring, boat-building and gunstocks.

Nicholas and Brown provide a table of sawn kiln-dried timber prices ex. Sydney, but it is problematic to calculate backwards to stumpage prices from such a list. They say that current New Zealand stumpage prices are $150-200/m$^3$ for sound trees, but do not indicate what proportion of total volume is recoverable, and is included in this stumpage figure. Inadequacy of supply has restricted the development of the New Zealand domestic market, but Nicholas and Brown anticipate that prices will rise substantially as more Blackwood becomes available around 2015-2020.

The absence of a strong domestic market has often been a source of disappointment. In a recent article, Mike Malloy reports[128] that "a mill south of Auckland offered about $58/m$^3$ for blackwood logs". Allowing for $40/m$^3$ in logging and transport, not to mention growing costs, this barely constitutes a profit at any discount rate! Malloy also reported a market survey of furniture and joinery manufacturers in the Auckland metropolitan region, which indicated that the 13% of respondents who use Blackwood account for only 3 m$^3$/year of wood. Malloy continues to say that the species has great potential, for example being one of only six species worldwide sought after for gun butts.

[126] Ministry of Forestry, 1996. Small Forest Management, Vol. 1: Special purpose timber species.
[127] Greg A. Steward, 1996. Marvl assessment of *Acacia melanoxylon* (blackwood). Unpublished FRI project record 4792. Figures are the mean of 21 plots from 12 sites throughout NZ, ranging from ages 8 to 32, with stockings from 150 to 1840 stems/ha. Due to the presence of some young ages, small-end diameters of 5 cm were used in the cutting strategy. Unless these data can be "grown on" to a reasonable rotation age (35-40), and adjusted for stocking, the results are – in this author's opinion – meaningless and should be omitted from consideration.
[128] Malloy, M. 2003. How to farm hardwoods profitably. NZ Journal of Forestry, August 2003, pp. 32-36.

## GROWING COSTS

With similar herbicide, cultivation and pest control requirements, establishment costs for Blackwood are equivalent to radiata pine. Fertiliser is often beneficial on P-deficient sites, at 150 g of superphosphate per tree. Seedlings (52.5 c each) are more expensive. The main extra – and optional – establishment cost relates to the use of "trainer" or nurse species. It is sometimes argued that without side competition from trainers (or else pre-existing vegetation), stem form is likely to be compromised and remedial pruning must be employed. Ian Nicholas argues, however, that a trainer is not needed if gauge pruning is employed[129]. This, he says, is simple and cheap.

Here we assume stockings of 714 stems/ha (7m x 2 m), with eucalypt trainers at $0.65/seedling, if used. We assume the same land price as for typical cypress forestry ($3000/ha), given that the site is sheltered, the soil is fertile and free draining, but could consist of riparian strips or erosion-prone slopes.

To ensure a single, straight stem, annual or biennial form pruning from age 2 to 5 years is necessary. Clear bole pruning can occur from age 4 to age 7. Thinning of all trainer trees, if used, is assumed to take place at age 6. Surplus crop stems are removed at age 7 and 10 (to a final stocking of 200 stems/ha).

Nicholas and Brown state that Blackwoods require about twice the labour (112.4 hours/ha) as radiata pine, because of greater pruning costs. They estimate that the cost of all plant materials, herbicide, full contract labour and supervision would amount to about $3,429/ha (on page 75 of their handbook) but provide a figure of $2892/ha (on page 77).

**Table 6.3: Cost of growing Blackwoods ($NZ/ha)**

| Nature of Cost | Typical cost |
|---|---|
| Land | 3000 |
| Tree Stocks | 375 |
| (Trainer stocks) | (465) |
| Establishment | 370 |
| Pruning | 1345 |
| Waste thinning | 350 |
| Overall | 5440 |
| If trainers used | 5905 |

Notes:
Some costs taken from Nicholas and Brown

129 *Gauge pruning* in blackwoods, as recommended by Nicholas and Brown, is the removal of all branches which exceed 30 mm in diameter. Pruning occurs annually from age three until a 6 m clearwood bole is obtained (ages 7-10).

## ROTATION AGE

Nicholas and Brown suggest a rotation of 35-40 years, with the lower figure being realistic on a top quality site. Although acceptable sawlog sizes may be achieved in that timeframe, it remains to be seen whether the wood quality will meets buyers' expectations. For example, the percentage of heartwood – which imparts the important attribute of colour – may be low in 35-year old trees. Having said this, a study of 21-year old trees at Hunua showed a respectable heartwood percentage of 61%[130].

John Mortimer has grown, harvested, milled and traded in Blackwood logs over the years. He says that "logs under 300 mm diameter give very poor returns as they are sappy and seldom straight. The target tree should be at least 600 mm dbh"[131]. This can, he says, be achieved in 40 years or less. Rotation ages of 30-40 years are noted in the MOF "small forest management" booklets[132].

## RISKS

### Climate-related Risks

Blackwood can withstand some drought but will not thrive in consistently dry locations. The species is sensitive to out-of-season frosts, but can withstand temperatures of –8 or -10°C in winter. Provenances can be selected to minimise risk of frost. Blackwood is quite stable, despite a shallow root system, but wind has a major negative effect on stem form[133].

Climate risk could be considered MEDIUM.

### Pests and Diseases

Psyllid[134] damage will occur on dry, exposed sites. This impairs the vigour of trees (loss of up to 40% in growth[135]), discourages single leaders and straight stems, and substantially increases pruning costs, although such damage appears to be a non-issue on sheltered sites. Tortoise beetle[136] is another Australian pest capable of defoliating trees. It was first discovered in Auckland in 1996 and has the potential to spread throughout the country.

The biological risk may be similar to that of Eucalypts: pests can immigrate relatively easily from the natural range of the species, but not necessarily together with their predators. On the other hand, unlike eucalypts there are not large numbers of pests and diseases already present in New Zealand. The risk from pests and diseases could therefore be rated MEDIUM.

### Market-related Risks

The high quality of the wood, combined with the increasing scarcity of equivalent wood from native sources or from tropical forests, augurs well for the future. There are existing markets in half a dozen countries and there is great potential to expand into new markets. Given these factors, market risks are probably a lot LOWER than radiata pine.

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[130] Nicholas and Brown 2002, page 13.
[131] Mortimer, 2003. See Further Reading.
[132] See Further Reading.
[133] Nicholas, I. and S. Calderon. The influence of wind on the silviculture of special-purpose species. In FRI Bulletin 146.
[134] *Acizzia acaciae*, *A. uncatoides* and *A. albizziae*.
[135] Appleton and Walsh, see Further Reading.
[136] *Dicranosterna semipunctata*.

**Social Risks**
Blackwood has sometimes been criticised by environmental groups because it is difficult to eliminate from an ungrazed site and because it can persist (often unnoticed) in an understorey. The seeds retain their viability for long periods (>250 years), and cut stumps stay alive and coppice. It therefore has the potential to establish itself as a permanent fixture in native forest. Indigenous purists may oppose its use, even though it blends in well with the bush and does not spread. Without soil disturbance, it seems that it will not invade native forest.

On the positive side, Blackwood has superior erosion-controlling properties, due to its extensive root systems and its ability to sucker wherever a root is damaged (eg by soil slippage). It may be a preferred species for such sites.

A public that is bored with radiata pine would probably welcome the addition of large areas of Blackwood. The aesthetic merits of both the living tree and its wood should create a positive attitude towards the species. Social risks could be therefore described as LOW.

**Table 6.4: Risks of growing Blackwoods**

| Type of Risk | Risk Rating |
|---|---|
| Climate | Medium |
| Pests & Disease | Medium |
| Market | V. Low |
| Socio-economic | Low |
| **Overall** | **Low** |

Notes:
Risks have been described subjectively. It is not possible to quantify most of the risks.

## DCF ANALYSIS

Nicholas and Brown provide a "general guide" of cash flows on page 77 of their handbook. They calculate the IRR as between 9.3% and 11.0%, depending on whether management fees and overheads are included. The high figure is partly explained by the fact that they have omitted land costs: these should be added in at the start and deducted at the rotation's end. When a land price of $3000/ha is included, the IRR drops from 9.3% to 7.0%. This latter figure corresponds to previous estimates on page 75 of "5-8%", but barely supports the summary on page 85 of "7-10%".

The poor information on the breakdown of recoverable volume into log grades, combined with very poor price data – especially for milldoor log prices for large-scale shipments – makes this author unwilling to undertake Discounted Cash Flow Analysis on this species.

## DISCUSSION

Arguably, the full potential of Blackwood may not be realised under the current approach of using seedlings, rather that clones taken from a number of superior individuals. The species exhibits wide genetic variation, but can easily be reproduced vegetatively. Clones could be selected for stem form, branching characteristics, heartwood percentage and colour, wood density, disease resistance and growth rate. So far clonal trials have been disappointing, but this option cannot be ruled out as a long-term possibility.

Blackwood has already established itself in the normal portfolio of species used by farm foresters. Woodlots are certainly being grown successfully throughout the country, but their poor volume growth and stem-form often raise eyebrows among foresters familiar with other species. The markets have not yet been established at a level that would inspire confidence in risk-averse investors, and economic returns – using current prices – may be substantially inferior to radiata pine, Douglas-fir and cypresses.

Having said this, it is conceivable that prices could rise to levels that would allow this species to compete favourably as an investment alongside other species. The small-diameter sinuous stems should not be judged on the same traditional basis as for conifers – the sinuosity may add interest and value to the grain, and small diameters may be millable. Yet it is hard to escape the conclusions that total volume per hectare will be low; recoverable volume will be a low proportion of total volume; conversion from recoverable volume to sawn timber will be poor; and – because of low piece size – extraction costs per cubic metre will be high.

Even if a high stumpage price (per hectare) eventuates, and compensates for the shortcomings elsewhere, few enthusiasts would see Blackwoods being planted on the same scale as conifers. Sites need to be chosen carefully at the scale of about ten hectares, rather than a hundred or a thousand hectares. Pruning needs to be annual for a number of years, and involves the use of a branch gauge. It is a species for the farm forester, rather than for the large forestry company.

## FURTHER READING FOR BLACKWOODS


Appleton, C. and P. Walsh, 1997. Insect pest associated with Blackwood (Acacia melanoxylon) in New Zealand. New Zealand Tree Grower, Feb 1997, p. 38-39.

Appleton, C. and P. Walsh, 1999. Towards integrated management of insect pests in Acacia melanoxylon (Blackwood) plantations: a Farm Forestry perspective. New Zealand Tree Grower, Feb 1999, p. 26.

Brown, I. 1997a. Segmental growth and malformation in Australian Blackwoods. New Zealand Tree Grower, Feb 1997, p. 33-37.

Brown, I. 1997b. AMIGO field day – October 1997. New Zealand Tree Grower, Nov 1997, pp. 15-17.

Cameron, R. and McConnochie R. 1999. Acacias – looking beyond firewood use. NZ Tree Grower, November 1999, p.7-8.

Clifton, N.C. 1990. New Zealand timbers, indigenous and exotic. The complete guide. GP Books. 170p.

Haslett, A.N. 1986. Properties and utilisation of exotic speciality timbers grown in New Zealand. Part II: Australian blackwood. FRI Bulletin No. 119.

Ministry of Forestry 1995. Small Forest Management series, Vol. 1: Special purpose timber species. Blackwood, pages 21-30. Vol 6: Managing a small forest for timber.

Mortimer, J. 2003. A selection of alternative timbers. Taitua Books. Chapter 1. *Acacia melanoxylon*. 72 p.

NAWASA (National Water and Soil Conservation Authority) 1984. Wattles for soil conservation. Streamland 31.

Nicholas, I. and I. Brown 2002. Blackwood – a handbook for growers and end users. Forest Research Bulletin No. 225. 93 p.

# REDWOODS

***Sequoia sempervirens***

***Sequoiadendron giganteum***

**Contributing author: Wade Cornell**

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*Sequoia sempervirens*, or coast redwood, is the main focus of this chapter. *Sequoiadendron giganteum*, or giant sequoia[137], is also of merit but is less well researched in New Zealand. These are compared below.

***Sequoia sempervirens***

There has been a surge of recent interest in redwood, partly driven by a prohibition of logging over large areas of forest. Redwoods occurs naturally only in California and the southern tip of Oregon, so the wood supply from this species is greatly dependent on political forces at the State level in the U.S.A.. In view of the more relaxed attitude in New Zealand to commercial forestry (provided that the chosen species is an exotic, or at least a plantation that does not replace native forest), several companies from the United States have commenced reasonably large-scale plantings here. Investors may have also been encouraged by the observations of Professor Bill Libby, who is very familiar with forestry in both countries.

Of the two species, *Sequoia* is harder to grow in that it is more site-specific: it requires deep, permeable, fertile, moisture-retentive soils; warm temperatures; and year-round moisture. It can be killed by (severe) out-of-season frosts, and stunted by wind. Some 4500 ha have been planted in New Zealand, but there were widespread establishment failures[138]. Planting exceeded that for radiata pine prior to 1910, and there were massive plantings in 1913 and again in the 1940s. Mark Belton comments[139] that there remain only 100 ha of redwood with full canopy, but this is disputed by Wade Cornell who says that the former FCF and CHH estates contain several hundred hectares, mostly from the early plantings. In any case, it is to be hoped that we have now understood our past mistakes and have learned from them.

***Sequoiadendron***

A large number of individual trees exist throughout New Zealand, some over 50 m in height and four metres in diameter, but there are no reports of older plantations containing more than twenty trees[140]. There are no plots on the Forest Research PSP system that contain *Sequoiadendron*! The species is more site-tolerant than *Sequoia*, and therefore may have a wider role in New Zealand. Having said this, a canker fungus (*Botryosphaeria* sp.) is present in New Zealand and is causing concern in Europe, which may restrict successful plantations to cooler areas. *Sequoiadendron*'s ability to withstand cold conditions is evidenced by a successful trial on an exposed site at Ribbonwood Station, Omarama (altitude 650 m a.s.l.). The Californian market accepts the timber as equivalent to *Sequoia*, and it is marketed as such.

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[137] Also known as Wellingtonia, Big Tree, or Sierra redwood. Confusingly, in California only common names are used, and in that region *Sequoiadendron* is most often called giant Sequoia or just Sequoia. To avoid confusion in this chapter, the botanical names are used, but readers are alerted to the different nomenclature used in the place of origin and the main market. In this chapter, the word "redwood" is used to refer to both species.

[138] Edmonds, J. 1998. Radiata pine – are there alternatives? New Zealand Tree Grower, Feb 1998, p. 9.

[139] Presentation at "The Redwoods are Coming", 19 August 2002.

[140] Low 2002. See Further Reading.

**Both species**
Both species are well known to anyone interested in forestry around the world. An individual *Sequoia* is thought to be the tallest tree in the world – unless that honour is owed to *Eucalyptus regnans*. A famous example of a *Sequoiadendron* had a hole cut through the base, through which a road was constructed. Cars and buses were photographed passing through the trunk. When the tree collapsed in 1969, the growth rings were counted – it was 2300 years old!

Both species have an attractive red colour when freshly sawn, with a soft and straight-grained wood, which is easy to work. The vast majority of use is for landscaping – outdoor furniture, decking, fencing and weatherboards. The heartwood is moderately durable, although this attribute is highly variable. Even sapwood is reported to last 15-20 years. John Mortimer says[141] that NZ-grown material is moderately durable as decking (10-15 years) but not as durable as American-grown wood (15-25 years). "Graveyard" tests from Forest Research appear to cast doubt on the durability of NZ-grown wood at a realistic rotation age. All stakes in the first of such tests (1962) had failed at 48 months, and the second test and third tests (1998/99) are ongoing but so far seem to confirm the first[142]. Failure of small stakes in ground contact at four years old would indicate, as Mortimer says, a service life of only 10-15 years as decking[143].

One reason that *Sequoia* is often unsuitable for interior joinery is the abrupt transition between earlywood and latewood. When combined with the wide growth rings often achieved by New Zealand plantations, this creates a problem with finishing or with small cross-sectional material[144]. It has low hardness, stiffness and strength. On the other hand, it is fairly uniform from pith to bark. There is little shrinkage and once dry the timber is very stable[145].

Despite these apparent problems, there has now been a substantial amount of New Zealand *Sequoia* sold to California. They accept it quite readily and consider it to be very similar to their own second growth. Although *Sequoiadendron* has the (ill-deserved?) reputation of being more brittle than *Sequoia*, second-growth wood is similar in many mechanical properties to *Sequoia*. Little information is available on the wood properties of *Sequoiadendron* grown in New Zealand.

## PRODUCTIVITY

### Volume Growth
Libby reports very high MAIs from redwood in France[146], with the third rotation already harvested. Growth rates below 25 $m^3$/ha/yr are "rare", 30-40 are "common", and a maximum of 54 has been recorded. He says rates of 20-30 $m^3$/ha/yr are "common" in New Zealand. Rob Webster concurs[147], having estimated MAIs of up to 55.1 $m^3$/ha/yr in New Zealand.

An examination of the Forest Research PSP system shows only 9 plots listed as containing *Sequoia sempervirens*. Table 7.1 shows the volume growth for the five more mature plots.

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[141] Mortimer 1994. See Further Reading.
[142] Leith Knowles, undated. "Product Performance of Redwood (Sequoia sempervirence) in New Zealand. How does it perform, and can it be improved?" Unpublished report..
[143] Cornell queries the reliability of these tests, because of the variability in natural durability, but accepts that durability is a key issue.
[144] There is potential for genetic selection of higher density earlywood, thus smoothing out the texture.
[145] Edmonds, J. 1998. Op. cit.
[146] Libby 1999. See Further Reading.
[147] Presentation at "The Redwoods are Coming", 19 August 2002.

**Table 7.1: Volume growth of *Sequoia sempervirens***
**Listed on the Forest Research PSP system**

| Plot | Age | Volume | MAI |
|---|---|---|---|
| RO 2021/6 8/1 | 34 | 1250 | 36.8 |
| FR 92/5 1/0 | 80 | 2945 | 36.8 |
| RO230/0 1/0 | 95 | 2049 | 21.5 |
| SD 275/0 11/0 | 74 | 970 | 13.1 |
| FR 453/2 1/0 | 73 | 623 | 8.5 |

Note: Where several ages are recorded for the same plot, the age of maximum MAI is given.

The database in Table 7.1 is very poor, but the scanty evidence appears to support Libby's statements. The two high-performance sites are at the Brann's farm in the Bay of Plenty and in the Long Mile Grove near Rotorua. The poor sites are in Southland and Canterbury. Note the very high standing volumes, which could be of great interest from the point of view of (for example) carbon sequestration.

Seedlots from twenty provenances of *Sequoiadendron*, situated at Hanmer Forest, were measured at age 25 for diameter and height[148]. Using data from the "best" provenance (Atwell Mill), average diameter was 320 mm and height was 13.2 m at this age. Assuming that 333 stems/ha were planted and that mortality was zero, this equates to about 130 $m^3$/ha[149] or 5.2 $m^3$/ha/yr. This is a very low volume compared to radiata pine of the same age (typically, 520 $m^3$/ha or 20.8 $m^3$/ha/yr). It could be argued, however, that the site was unsuitable and the presence of a nurse crop – larch or birch at 1000 stems/ha – substantially slowed down the growth. Alternatively, *Sequoiadendron* may be just a slow starter: growth would be more comparable to radiata pine over longer periods. Libby comments that "up to 44 $m^3$/ha/yr" is possible with this species in Belgium[150].

Measurement of plots in the same series at Compartment 3 of Beaumont Forest produced more encouraging results (Table 7.2).

**Table 7.2: Volume of *Sequoiadendron giganteum* at Beaumont**

| | Stems/ ha | Mean DBH (mm) | BA ($m^2$/ha) | Vol ($m^3$/ha) | MAI Vol ($m^3$/ha/yr) |
|---|---|---|---|---|---|
| Seedlings (age 25) | 386 | 517 | 85.4 | 714 | 28.6 |
| Cuttings (age 24) | 400 | 549 | 97.6 | 733 | 30.5 |

Source: Proceedings of Douglas-fir Coop, 10 &11 Feb 2003, p. 144.

## PRICE PER UNIT VOLUME

Ignoring the price spike in 2001, which reached US$1400/MBM[151], prices are currently around US$750-850/MBM and rising steadily[152]. The main market is California, with the main outlet being the Home Depot.

[148] Low 2002. See Further Reading.
[149] Using the Beekhuis formula, see Chapter 1.
[150] Presentation at "The Redwoods are Coming", 19 August 2002.
[151] Conversion of MBM (thousand board measure) to $m^3$ is complicated, because details of length and small-end-diameter are required. Conversions range from 3.5 to 4.5 $m^3$/MBM, and here we assume a factor of 4. In other words, there are 4 $m^3$ in one MBM, and therefore a price of $800/MBM is equivalent to $200/$m^3$.

[152] Wade Cornell, e-mail of 8 November 2003.

Wade Cornell[153] has worked backwards from mill-door prices in California to derive a NZ stumpage price. He estimates NZD\$176/$m^3$ to convey redwood from stump to the Californian price-point. Using the exchange rate and price at time of writing this chapter, the Californian mill-door price would be NZD\$320/$m^3$, leaving a stumpage of \$144, or an "equivalent NZ mill-door price" of \$184/$m^3$. Cornell appears to make reasonable assumptions regarding recoverable volume[154], so some credence can be placed on his calculations.

The domestic market for redwoods is not yet developed, so it may be unfair to use existing local prices. Graeme Young, of Fletcher Challenge Forestry, reports[155] "Our current redwood sawlog price is around \$70-\$80 on truck. Can't see much future in that!" Loose, dead knots are a "real problem"[156] which could explain the low figures.

While lower logs can be pruned to remove branches before or soon after they die, and branches in very top logs will remain green, intermediate logs that are too high to prune but below the green crown may have dead knots. As with cypresses, it may be hard to devise a regime that entirely eliminates this situation. On the other hand, sequoia is remarkably shade-tolerant and Cornell considers that it may be possible through careful thinning to keep branches alive.

In summary, the potential stumpage value of redwood appears to be high, albeit with a volatility of both prices and exchange rates that would give wide confidence intervals.

**Table 7.3: Summary of Redwood wood prices (\$NZ/$m^3$ at mill-door)**

| Average price |
|---|
| 184 |

Notes:
*Average Price* is the current mill-door price per metre of recoverable wood of all grades, derived from figures provided by Wade Cornell in Nov 2003, and exchange rates in Jan 2003.

## GROWING COSTS

Given that land needs to be deep, moisture-retentive and sheltered, and that valley bottoms are ideal, it would seem that land prices must be similar to that for good cypress growth – we have assumed \$4000/ha. Cheaper suitable land may be available, but not if the costs of providing shelter must be included.

Unless nurse crops are used, Cornell recommends initial stockings of "at least 1200 stems/ha". The preference is to plant a mixture of up to 20 different clones, selected for heartwood durability, and perhaps branch size, heartwood colour, and wood density. The price of seedlings is currently \$1.21 each, but selected clones would presumably be considerably more expensive.

[153] See Further Reading.
[154] E-mail correspondence, 8 November 2003.
[155] E-mail of 20 October 2003.
[156] Janet Webb, from Big Creek Redwood Company, in a verbal presentation at "The Redwoods are Coming" August 19 2002.

Cornell says "Redwood establishment is far more difficult than for most other commonly planted exotic species". He suggests liming to adjust the pH to between 5.5 and 7.5 (ideal 6.5), and possibly adding fertiliser. The cost of applying 10 tonnes lime per hectare to raise the pH by one unit could be about $300/ha. Disc ploughing is preferred to aerate the soil, eliminate weeds, and allow easy expansion of roots.

Because redwoods are shallow rooted, selected herbicides should be used for the first two summers to discourage weed competition. Establishment costs are taken to be similar to that for cypresses ($1550/ha).

Redwoods are easy and practical to prune. Pruning costs of radiata pine on a fertile site were assumed to be $1370/ha, so a cost of $1000/ha for redwoods would be reasonable in view of their small, soft and infrequent branches. This cost assumes a pruned height of 6m, but in order to avoid dead knots (and possible infection of the New Zealand native termite), it may pay to ultra-high prune, in which case costs could be 2-3 times as much. With redwoods, the pruning would be primarily for the avoidance of dead knots rather than the production of clearwood – which is not plentiful enough in California to provide a good premium.

Waste thinning is assumed to be the same as for radiata, at $145/ha.

Overall costs are high, relative to radiata pine, (largely due to higher land prices) but cheaper than cypresses.

**Table 7.4: Cost of growing Redwoods ($NZ/ha)**

| **Nature of Cost** | **Typical cost** |
|---|---|
| Land | 4000 |
| Tree Stocks | 1452 |
| Establishment | 1550 |
| Pruning | 1000 |
| Waste thinning | 145 |
| **Overall** | **8147** |

## ROTATION AGE

Libby says, "final harvest age for redwood is surely greater than for radiata pine, but it is likely to be similar to that for Douglas-fir"[157]. He suggests production thinnings at 20-30 years and "the main value realised from the larger logs obtainable after 50-70 years". Given that there are very few mills left in California that can take logs with a large-end diameter greater than 60 cm, it is doubtful that rotation ages of this length will produce easily saleable wood. Furthermore, longer rotations aggravate the problem of dead knots (or alternatively, necessitate ultra-high pruning). In this analysis we accept Cornell's figure of nearly 60cm in 30 years as a realistic goal for Central North Island sites.

157 Libby, 1999. See Further Reading.

It is possible to achieve larger diameters in shorter rotations, but this may not be desirable. Cornell shows that basic density decreases with dbh for a given age, thus confirming for redwoods the common belief that "fast growth" leads to undesirable consequences. The data show a range of basic density between 390 and 290 kg/m$^3$ explainable entirely by diameter growth rate, ie by fertility and stocking. Fertile sites or low stockings encourages the growth of early wood relative to late wood and therefore decreases average basic wood density. To overcome this, selection is required for high-density clones. It is also possible to counteract the "problem" of fast growth by increasing stocking rates, but tight stockings have greater proportions of sapwood relative to heart. Sapwood is quite saleable, but not as valuable as heart.

## RISKS

### Climate-related Risks

Redwood seedlings can be damaged by severe out-of-season frosts. Reportedly, the famous Long Mile Grove was blanked with larch because the original redwood plantings had been (supposedly seriously) affected by frost – although as the name "sempervirens" (ever-living) suggests, the species is hard to actually kill. The presence of redwoods, even of the more frost-susceptible *Sequoia*, throughout New Zealand indicates that frost is not a major impediment.

Having no root hairs or tap root, redwood is badly affected by drought, especially if this occurs during summer. Drought can be caused by low rainfall, or else adequate rainfall in combination with non moisture-retentive soils. Some American investors say that New Zealand "droughts" are not as severe as those in parts of Redwood's home range, but the latter does provide a persistent supply of "fog-drip" to supplement the summer rainfall. The fog may also reduce evapotranspiration losses.

Wind is a major limiting factor on growth. New Zealand is windy throughout its length, and therefore microsites (gullies, lee slopes) need to be chosen to minimise this. The species' lack of tap-roots may predispose it to toppling by strong winds, although there is no empirical evidence for this as yet. *Sequoiadendron* was largely unaffected in the recent devastating storms of Western Europe[158].

Redwoods are famous for their tolerance of fire. Old trees have thick, fibrous fire-resistant bark that makes them almost impervious to fire-induced mortality. Nevertheless, young trees that have not yet developed thick bark can be easily destroyed and – even in old trees – fire scars reduce wood quality by allowing insects and disease to enter.

Because New Zealand is susceptible to El Niño-induced droughts, the climate-related risks – at least for *Sequoia* as opposed to *Sequoiadendron* – must be considered MEDIUM.

### Pests and Diseases

Redwoods have very few insects or pathogens, even compared to relatively healthy radiata pine. Bill Libby says, "disastrous epidemics of insects or pathogens on redwoods are unknown[159]". The New Zealand native termite, however, is considered a possible pest of significance. The native huhu beetle may also be important. Neither can penetrate live wood, but can enter the dead heart through dead knots. The occurrence of such knots can be minimised (although not totally eliminated) by a careful strategy of thinning and pruning.

[158] Brown, I. 2001. The Sequoia Group. New Zealand Tree Grower, August 2001, p. 30-31.
[159] Libby, 1999. See Further Reading.

Livestock, possums, and girdling of young seedlings by rabbits, hares or rats may threaten successful establishment, but are not more problematic than with other tree species.

The risk of pests and diseases can be rated as LOW.

**Market-related Risks**
Bill Libby reports that stumpage prices are typically higher and more stable than for Douglas-fir.[160] Since that statement, however, the price has shown considerably volatility – largely due to sudden restrictions in supply: a major company had a problem in obtaining approval for harvest plans. Price jumps of this magnitude are not thought to be of benefit to the industry in the long-term, because customers may seek alternatives, and may not return to their traditional habits when the price has settled. Substitutes include composite decking (plastic & wood-fibre), cedar and fibreglass.

There is a cultural demand for redwood timber in California that may be only loosely associated with the wood's intrinsic properties. The successful exports to date indicates suggest that the market show little resistance to the large ring-width or alien origins of New Zealand-grown trees, and commentators have suggested that the demand is so great that this is unlikely to be a problem in the future.

One important attribute is durability, especially of the heartwood. This is particular significant in that the main use is for outdoor furniture and decking, despite the little-known observation that some 15% of the wood sold is discovered to be non-durable[161] and that regular replacement of decayed wood appears to be accepted by consumers. If NZ-grown material (particularly of young trees) develops a reputation for particularly rapid decay, the discovery could almost destroy the main market. To avoid this possibility, clones need to be screened in the laboratory for durability before any major planting programme[162].

While it may be technically and perhaps commercially possible to artificially enhance the durability and wood density of redwood, such synthetic solutions beg the question as to why the natural product is preferred, and open the door for cheaper alternatives to flood into the market.

It may be risky to base an industry on a single market in one part of the world, even if that region is one of the wealthiest. It is conceivable that that could be a fashionable move away from the use of wood in California, perhaps driven by the perception that wood consumption is somehow antagonistic to conservation of precious indigenous ecosystems. One could imagine the use of redwood being compared to wearing of fur coats or consumption of whale meat. The Home Depot currently requires Forest Stewardship Council certification, indicating that some degree of environmental awareness is starting to enter the local marketplace.

If the Californian market disappeared or shrank, the species would have to be sold to other regions on its intrinsic merits: colour, dimensional stability and durability. Fortunately, its qualities in this regard are probably sufficient to maintain world demand.

Provided that clones are planted which are selected for durability and (preferably) wood density, market risk could be described as LOW. On the other hand, if unselected genetic material is used with no guarantee of durability, the market risk could be rated as HIGH.

[160] Libby 1999. See Further Reading.
[161] Wade Cornell, pers. comm. November 19 2003.
[162] The nature and concentration of extractives from plantlets are examined with a mass spectrometer.

**Social Risks**
The persistence of redwoods in the New Zealand environment (despite considerable attempts to remove it) may create some opposition. On the other hand, the species does not appear to pose a wilding threat, and the public is probably well-disposed to this type of forest – at least in moderation. The Redwood Grove at Rotorua, continues to be by far the most visited of all forests in New Zealand, native or exotic.

On the positive side, a redwood forest is capable of carrying higher standing volumes than almost any other type. If carbon sequestration comes to be highly valued, this attribute will stand it in good stead. The species is capable of reproducing itself with continuous-cover forestry, thus making it ideal for "permanent non-harvest forest sinks" and for erosion control. With a continuous-cover system, there is no period between crop rotations where the ground is unprotected by a canopy, and where the stumps and roots decay. Furthermore, redwood is capable of being buried by floods, up to a depth of 30-60 cm at a time, and remaining alive. This could be a useful characteristic in unstable landscapes or riparian strips.

The average citizen would probably welcome the emergence of redwood as a genuine alternative to pine "monoculture". Risks from social opposition in New Zealand could be classified as very LOW.

**Table 7.5: Risks of growing Redwoods**

| Type of Risk | Risk Rating |
|---|---|
| Climate | Low |
| Pests & Disease | V. Low |
| Market | Low-High |
| Socio-economic | Low |
| **Overall** | **Low-High** |

Notes:
Risks have been described subjectively. It is not possible to quantify most of the risks. The Low-High overall rating depends on whether genotypes are selected for selected for natural durability. If so, the rating is Low. If not, then High.

## DCF ANALYSIS

Figures for top, average and poor sites are given in Table 7.6

**Table 7.6: DCF Analysis**

| Profitability indicator | Top site |
|---|---|
| IRR% | 10.5 |
| LEV @ 6% | 18 533 |
| LEV @ 9% | 3 609 |
| LEV @ 13% | -3416 |

## DISCUSSION

There have been several "planting booms" of redwoods in New Zealand's short forestry history. Most of the plantings have failed and, although the few surviving stands are magnificent, this should act as a caution. Possible reasons for historic failure include: wrong provenances; inbreeding; poor siting; frost; inadequate care before, at and after planting; drought; lack of fertilisation; and inappropriate mycorrhizae. We may have learnt from past mistakes, but until we have accumulated sufficient operational experience over a number of sites and El Niño cycles, it would be unwise to expand the redwood estate too rapidly. Current planting rates are "several hundred" hectares[163], but orders from nurseries have "jumped".

A key to the success of redwoods is the procurement of suitable genetic stock. As this material needs have a guaranteed level of natural durability (and preferably wood density), the clonal option is probably the way to go. Establishment of trees chosen only for survival and growth risks creation of a resource that may be unmarketable.

Lastly, this author is surprised by the focus on *Sequoia* rather than *Sequoiadendron*. Assuming that the market does not distinguish between these species on the basis of wood properties, and that growth rates are comparable, it would seem logical to concentrate on the latter, because it is considerably more site-tolerant and fine specimens can be seen throughout New Zealand in many rural towns – particularly in the South Island. Drawbacks include the fact that growth data and operational experience are even more lacking than for *Sequoia*; the presence of a fungus disease that may restrict plantings to cooler regions; and slow initial growth and excessive taper may result in longer rotations.

## FURTHER READING FOR REDWOODS


Colbert, C.M. and D.L. McConchie 1983. Some physical properties of New Zealand-grown redwood. FRI Bulletin No. 26.

Cornell, W. 2002. NZ Redwood Growers Handbook. Diversified Forests Ltd, Henderson, NZ. 53 p.

Cornell, W. various. The Sequoia Group. Irregular newsletters.

Knowles, F.B. and J.T. Miller, 1993. Introduced forest trees in New Zealand: recognition, role, and seed source. Vol 13. The redwoods. FRI Bulletin No. 124.

Libby, W. 1999. Redwoods in Taranaki? New Zealand Tree Grower, May 1999, p.18-19.

Libby, W.J. 2002. Sources of coast redwood and giant sequoia planting stock. New Zealand Tree Grower, Feb 2002, p.30-32.

Low, C. 2002. Giant sequoia provenance trials in New Zealand. New Zealand Tree Grower, August 2002, p.32-33.

Mortimer, J. 1994. Woods of the World – the Coast Redwood. Growing Today, Sept 1994, p.24-27.

Tombleson, J. 2004. Redwood Memorial Grove reached 100 years. New Zealand Tree Grower February 2004, p. 35-36.


[163] Discussion at the second annual meeting of the 130-member Redwood Action Group, Hanmer, April 2004.

# POPLARS

***Populus spp***

**Contributing author: Allan Wilkinson**

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## INTRODUCTION

There are at least 30-40 recognised species of poplar plus countless subspecies, varieties, hybrids and cultivars. The most important poplars in New Zealand are the black and balsam poplars and their hybrids. These have been used effectively for soil conservation, windbreaks, and a few small woodlots, and have been utilised in small quantities as lightweight, pale coloured, general-purpose timbers[164].

The New Zealand breeding programme historically aimed to develop genetically diverse clones or cultivars conforming to three basic types:

1. A tree for wide-spaced plantings in silvo-pastoral systems;
2. A tree for single-row windbreak or stream-bank plantings;
3. A tree for block planting, either in conventional woodlots or in multiple-row riparian plantings.

For the purposes of this publication, we are interested only in the last mentioned. New Zealand breeding attempted to attain:

- High resistance to current diseases and insect pests;
- High rooting ability from unrooted stem cuttings;
- Rapid growth;
- Straight stem;
- Low palatability to possums;
- Basic wood density of at least 360 kg/m$^3$;
- Low incidence of pathological black heart caused by bacteria.

Poplar wood is a bland white colour, of fine texture, with indistinct growth rings. It has lower density than typical radiata pine, and with little change in properties from pith to bark. Its special properties include a lack of smell and resins, workability, softness, light weight, relatively high strength is proportion to its weight, and resistance to splintering. It has been used for general farm purposes (gates, stockyard rails, etc), for veneers and mouldings, and for furniture.

A wide survey of processors and users in 1986[165] indicated general dissatisfaction with the genus. The reported problems included difficulty in: sawing (tension wood); air drying (splitting and distortion); planing (a woolly or hairy finish); uneven uptake in pressure treatment; patchy uptake of primer and paint; shrinkage after installation as sarking; strength for such purposes as farm gates; the amount of wastage and inadequate strength when turned into such things as ice-cream sticks. In nearly all cases, radiata pine performed as well or better. The only major use was for medium density fibreboard, presumably because of the lighter colour that it imparted to the product.

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[164] Wilkinson 2000. See Further Reading.
[165] Williams *et al*. 1986. See Further Reading.

Some serious problems include tension wood and 'blackheart'. Tension wood is a common property of hardwoods with imbalanced crowns or leaning stems or grown on wind-prone sites. Blackheart – a bacterial infection possibly caused by branch dieback or stem injury – is not as pronounced in the newer clones. Poplar's high moisture content also leads to collapse in drying and/or longer drying times.

Despite these negative comments, it may be unfair to judge the performance of current or future clones and cultivars on the basis of historical data. Although, due to lack of funding, research into poplars has all but ceased in New Zealand, there is still widespread development in this highly variable genus occurring elsewhere.

Poplar has some notable advantages: first, it can grow in wetter areas than radiata pine, provided that the water is not stagnant. These sites include riparian strips, seepages and flood plains. Given the propensity of many of New Zealand's hillsides to slip during storms, erosion plantings are likely to continue and will eventually create a resource that could be utilised more fully. Second, poplar can be planted out of reach of livestock – in the form of poles – without the need to either fence the plantings or to forgo grazing for several years. Third, the foliage can provide valuable stock feed during droughts, but only at the considerable cost of pollarding, or by scheduling normal clearwood pruning to coincide with a feed shortage.

## PRODUCTIVITY

Most poplars are regarded as being "fast growing" in their natural habitats, for example reaching 13 m in height at age three. But height growth, particularly early height growth, is a not a useful index for the forester. Volume per hectare is far more significant. Wilkinson reports that unimproved clones of *Populus deltoides* planted at 2700 s/ha without irrigation have achieved 140 $m^3$/ha total volume at age four. At age 12, with a stocking of 500 s/ha, the volume of seven families of the same species at Brookfield Arboretum at Napier, ranged between 283 and 442 $m^3$/ha – equivalent to 20-37 $m^3$/ha/yr.[166]

This is very impressive, but it still falls far short of an index based on recoverable volume at a likely harvest age, especially in terms of preferred log grades.

### Volume Growth

In the year 2000 Forest Research produced a poplar yield model based on MARVL assessments of 39 mature stands. Using this model to achieve maximum growth rates (good site, no pruning, very high stocking) enables at productivity of about 53.5 $m^3$/ha/yr at age 15 – a figure close to the maximum theorized for radiata pine.

Assuming a more realistic sawlog-type regime[167] poplar yields an average MAI of 18.6 $m^3$/ha/yr, a figure somewhat inferior to radiata pine[168]. Wilkinson's statement that the species "…grow as fast or faster than radiata pine" may be incorrect, or at best misleading.

[166] Alan Wilkinson, e-mail of 29 March 2004. Note that the volume was overbark and measured down to 75cm diameter. Trees were transplanted as 2-year old seedlings and intercropped with maize for three years.
[167] Assuming a top quality site, poplar grown at 300 s/ha is estimated to yield a total volume of 558 $m^3$/ha at age 30.
[168] For example, the Canterbury average is given by the Radiata Pine Calculator as 24.23. Canterbury is inferior to all the other regions, while Waikato/Taupo tops the list at 35.21.

Chris Goulding[169], from Forest Research, says that poplar in Turkey averages 20 $m^3$/ha/yr and not uncommonly achieves rates of up to 45 $m^3$/ha/yr. One tireless advocate of this species, Allan Evans of Temuka, says that at 220 stems/ha would produce 438 $m^3$/ha at age 15[170]. This equates to a total volume MAI of 29.2 $m^3$/ha/yr, which is credible.

**Table 8.1: Volume growth of Poplars in New Zealand**
**(Grown at 200 stems/ha and pruned to 6 m, on a good site)**

*Source: Wilkinson 2000*

| Age | Total Recoverable Volume ($m^3$) | Log grade volume ($m^3$/ha) | | | |
|---|---|---|---|---|---|
| | | Pruned logs | Small branched sawlogs | Large branched sawlogs | Pulp |
| 10 | 150 | 50 | 43 | 7 | 50 |
| 15 | 274 | 130 | 74 | 13 | 57 |
| 20 | 370 | 163 | 120 | 21 | 67 |
| 25 | 433 | 179 | 153 | 26 | 75 |
| 30 | 471 | 189 | 173 | 30 | 80 |

Note: The total recoverable volume accords with the main author's evaluation of the Poplar Yield Model, but the breakdown by log grade does not. The above table is more conservative, ie it tends to categorise more of each log type as pulp.

## PRICE PER UNIT VOLUME

New Zealand sales of poplar are insufficient to determine potential mill-door prices. A well-publicised[171] sale at Waipawa in 1994 yielded $17000/ha net return to the grower. With an estimated yield of 438 $m^3$/ha and a logging/transport cost of $40/$m^3$, this equates to about $79/$m^3$ at mill-door. These figures were derived from popular articles and it is difficult to check them. Furthermore, the sale constituted only 2.04 hectares, so cannot be used as a reliable or consistent indicator of price.

It is possible to obtain figures from overseas transactions, although the exchange rates, price-points and log specifications are not always provided together with the price, making the data almost useless. More fundamentally, one could ask what the price of poplar would be in, say, Turkey or Italy if local radiata pine was available as an alternative.

**Table 8.3: Summary of poplar wood prices ($NZ/$m^3$ at mill-door)**

| Average price |
|---|
| 79? |

[169] Research into poplars for timber production, 28 September 1994. Unpublished internal report:

[170] "Poplars offer greater profitability than pines – specialist". News article dated July 16 1998, in Royal Society News.

[171] Cowperthwaite, see Further Reading. Also, various articles by Peter Wardrop, Allan Evans or Roland Clark, which appear to duplicate each other.

## GROWING COSTS

Poplars grow best on moist valley bottoms and lower hill slopes, with a PH of 5.0-6.5 and high calcium levels. This may put them in conflict with other land uses, especially if the intention is to plant in large tightly stocked woodlots. Land prices are assumed to be $4000/ha, similar to good land for cypresses and redwoods. On the other hand, if the species is restricted to erosion-prone gullies, it would be fair to value the land at zero, or even to use a negative figure! (The slips presumably devalue the adjacent land, by covering pasture, damaging tracks and fences, etc.). Even on more stable sites, the cost of land must be shared between the tree venture and the understorey grazing.

Planting rates are low – perhaps only 20% more than final crop stocking. Given a final stocking of 200 stems/ha, this equates to 240 s/ha planted. Here we assume that the preferred stock comprises 2 m unrooted poles, planted with a crowbar to a depth of 30 cm, and released with Roundup or Versatill. Costs of tree stocks are $3 each, with planting at $1 per pole, and releasing at 50c each. Appleton's nursery quotes poplar prices at $4.00 each, but these are for rooted cuttings 10-40 cm high. Presumably unrooted poles are far cheaper, but carry a higher risk of failure to establish.

Pruning is essential to produce clearwood. There are fewer branches to prune per metre than radiata pine, and the wood is softer. We assume $1.50 per tree for 200 pruned trees pruned to a height of 6 m. Note that pruning costs may vary greatly between hybrids, as some clones (eg crosses between *P. nigra* and other species) resprout prolifically from pruning wounds. Judicious stocking and timing of pruning can control the incidence of adventitious shoots.

**Table 8.5: Cost of growing Poplars ($NZ/ha)**

| Nature of Cost | Typical cost |
|---|---|
| Land | 4000 |
| Tree Stocks | 720 |
| Establishment | 360 |
| Pruning | 300 |
| Waste thinning | 0 |
| **Overall** | **5380** |

Notes: The high land price may be inappropriate. If the land is a problematic microsite, or if intensive grazing is maintained under the trees, the true figure could be substantially less.

## ROTATION AGE

Allan Evans has argued that 15-year poplar rotations are achievable in New Zealand, yielding a good return. Another forceful poplar advocate, Peter Wardrop, said[172] that poplars can achieve the size of a 30-year old radiata pine in only 12-14 years. Given that radial differences in wood density and other properties are minimal, such short rotation lengths are conceivable.

Poplar is generally regarded as a short-rotation species, so rotation lengths of greater than (say) 25 years would be unlikely. After this point there is a fairly rapid decline in volume increment without any compensatory premium for age. The range of harvest age can therefore be given as 12 to 25 years.

[172] Wardrop, P. 1994. Poplar markets itself. Farm Forestry Review, 20 July 1994, p.41.

## RISKS

### Climate-related Risks

Poplars are typically not drought-resistant and require at least 20 mm a week throughout the growing season, unless there is a high water table. In summer-dry areas, they should be confined to channels, tunnel gullies and seepage areas. In New Zealand's fickle climate, it is likely that poplars planted as woodlots over large heterogenous areas would be at considerable risk from drought. Having said this, it must be reiterated that poplars belong to a highly variable genus, which contain some species quite tolerant of dry hillsides.

In their deciduous state, all poplars can tolerate more than –30º ground frost, but some may suffer shoot damage if frosts occur in late spring or summer. There are cultivars which may be suitable for woodlots that suffer very little, if any, frost damage in New Zealand.

Poplars cannot tolerate much wind and may lose branches easily, making the tree susceptible to blackheart infection.

If clones are chosen carefully, and correctly sited, the climate risks in growing poplar can be rated MEDIUM.

### Pests and Diseases

Assuming that a grower has the good sense to plant only cultivars that are selected for possum and rust resistance, and to protect young stands from livestock, trees may survive to harvest without damage. On the other hand, there is a substantial risk that existing rusts[173] could mutate within the lifetime of a tree or a new disease could be accidentally introduced. The historical record with poplars is not good, perhaps because the species has been established with a very narrow (clonal) genetic base whereby a pathogen merely needs to overcome a single sequence of DNA to cause an epidemic. Secondly, any fungal disease that infests Australia is likely to be blown over to New Zealand within a few years.

With regard to the closely related willows, the introduction in 1997 of the willow sawfly *Nematus oligospilus* is currently defoliating trees over a wide area[174]. Again, a major contributing factor could be the clonal background of the plantings.

With the traditional approach of growing only clones (for ease of breeding) the risk of disease attack must be considered HIGH. There are alternatives to this approach, as mentioned later under Discussion.

### Market-related Risks

The current domestic market for poplar is not good. New Zealand processors can obtain a regular supply of radiata, which they mostly see at being superior to poplar in terms of quality, so the future for a vibrant domestic industry based on poplar wood does not look promising. Much radiata pine goes to waste on our hillsides, but could be recovered if demand was sufficient.

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[173] *Melampsora larici-populina* and *Marssonina brunnea*.

[174] Fung, L.E.; Charles, J.G. and D.D. Rowan. Willow what? NZ Tree Grower, Feb 2002, p. 15-17.

On the export front, China is a huge potential market that is quite familiar with poplar but has only recently becoming acquainted with radiata pine. It is not clear to what extent traditional attitudes hold sway over recent research results. The fact that China has recently accepted radiata pine in its building code may indicate the latter is gaining in importance. The lack of intrinsic wood properties that give poplar an edge over radiata pine suggests that market risks could be HIGH.

**Social Risks**
The attractive spring and autumn foliage of poplars is generally regarded with favour. Poplars, being a deciduous hardwood, are perceived as being a genuine alternative to sombre conifer plantations. The risk of tree spread is non-existent, with modern planting-stock being exclusively male. The risk of adverse social reaction to a widespread poplar programme must be classified as very LOW.

**Table 6: Risks of growing poplars**

| Type of Risk | Risk Rating |
|---|---|
| Climate | Med |
| Pests & Disease | High |
| Market | High |
| Socio-economic | Low |
| **Overall** | **High** |

Note: Risks have been described subjectively. It is not possible to quantify most of the risks.

## DCF ANALYSIS

Although there is now a good yield model for poplar, the absence of good price data, and the unreliability of good cost data, means that discounted cashflow analysis is not worthwhile for these species.

## DISCUSSION

For most wood uses, poplar is inferior to radiata pine. Processors have no reason to switch species should supplies become available at comparable prices. In certain types of pulping, however, it has distinct advantages including a naturally whiter colour. The light colour could also be in demand for some lines of furniture.

Although poplar is a useful addition to the New Zealand landscape, and thrives in locations not suitable for the main species, it is not a genuine alternative to radiata pine and Douglas-fir. In the words of Lindsay Fung[175] poplar is “more site-specific than radiata pine and should not be considered as a substitute for pine in terms of site-selection, management, end purpose, or wood characteristics; indeed poplar is complementary is all of these aspects”.

[175] Who took over from Allan Wilkinson at Aokautere Plant Materials Centre.

New Zealand will continue to have major erosion and flood problems, and willows/poplars provide one tool to control these. Research in these species needs to be resuscitated and revitalised. The enormous genetic variety in these genera suggests that there is scope for development of new varieties that can overcome past failings. The best approach may not be to use single clones – which has been the major cause of spectacular disease-induced failures in the past – but to use cloning techniques to replicate entire families. There are huge between-family differences (see the Brookfield Populetum data above) that could provide real benefit without unduly narrowing the genetic base.

## FURTHER READING FOR POPLARS


Cowperthwaite, V. A new lease of life. Growing Today, August 1994, p. 32-35.

Haslett, T.; Gilchrist, K.; and B. Britton. 1995. Poplar for timber and other uses? New Zealand Tree Grower, August 1995. P. 18-21.

Hocking, D. 1995. A more poplar choice. NZ Forest Industries, April 1995, p. 60/

Van Kraayenoord, C.W.S.; Slui, B.; and F.B. Knowles. 1995. FRI Bulletin No. 124, Introduced forest trees in New Zealand – recognition, role and seed source. Chapter 15, The willows (*Salix* spp).

Wilkinson, A. 1995. The poplar scene – New Zealand and overseas. The New Zealand Tree Grower February 1995, p. 28-30.

Wilkinson, A.G. 2000. FRI Bulletin No. 124, Introduced forest trees in New Zealand – recognition, role and seed source. Chapter 17, The poplars (*Populus* spp).

Williams, D.; Simpson, I.; and H. Bier, 1986. Properties of New Zealand-grown poplar. FRI Bulletin No. 112.

# OTHER SPECIES

The remarks in the introductory chapter must be reiterated: the objective of this publication is to identify any profitable tree species that can realistically alter the proportion of radiata pine in New Zealand's plantations from the current figure of 90%, relying solely on the sale of timber to justify the investment. Tree lovers, wood turners, lifestyle-block owners and gardeners could and should continue to enjoy and expand the use of their chosen species, while acknowledging that – as an investment driven by the sale of timber – their preference may not have the potential to alter New Zealand's land-cover by a factor of tens of thousands of hectares.

## NATIVE SPECIES

There is widespread and continuing public interest in New Zealand plantation forestry based on indigenous species, especially if the activity involves the establishment of indigenous forests on modified land rather than exploitation of an existing natural forest. Reasons for this interest include the fact that these species have a proven record of being suitable for the location (!), have historically yielded valuable wood, and are often the most popular landscape choice. A cynic could also argue that there is an element of patriotism/nationalism in the promotion of home-grown species and the rejection of exotics, and that this attitude is not consistent when applied to other rural but non-timber industries. Nobody, for example, would suggest that our pastures should be returned to indigenous grass species.

One unusual risk with growing natives in New Zealand as a timber crop is the possibility that the crop may be nationalised without compensation. This in effect has already happened to owners of natural indigenous forest, who have had their management options severely restricted by the Forests Act (1993 amendment), and who have lost some of the use of their asset relative to land-owners that converted to pasture prior to this date. Mills are currently prohibited from sawing indigenous timber unless authorised to do so. It is possible that, by the time that an indigenous crop has reached harvest, the public may have come to regard indigenous trees as being so sacrosanct that all commercial exploitation is effectively prevented.

A common, but fallacious, argument is that rotation age is not important in a situation where there is continuous cover forestry – or else continuous extraction from small coups in a mixed-age forest. This ignores the opportunity cost of tying up large amounts of capital (land, trees) for so long. Very long rotation ages make economic sense only if the capital cost is artificially reduced, for example by legal prohibition against conversion of the forest to another, more profitable land-use, and by restrictions on over-cutting. This ensures that the opportunity cost of the forest is almost zero (in effect, the owners' asset value has been expropriated by government decree) so that return on capital is unimportant. Where long rotations are the norm, for example in many European countries, such a situation may well prevail. The new criterion then becomes the maximum sustainable net revenue regardless of tree age.

The exponential effects of interest rate militate against long rotations, and become a critical factor in rotations exceeding (say) 60 years. It is worth reminding the reader of this important consideration (Table 10.1).

**Table 10.1: Effect of an establishment cost of $1.00 compounded at only 6% p.a. for a given rotation length**

| Rotation length (years) | Compounded costs ($) |
|---|---|
| 1 | 1.06 |
| 10 | 1.79 |
| 20 | 3.21 |
| 30 | 5.74 |
| 40 | 10.28 |
| 60 | 32.99 |
| 80 | 105.80 |
| 100 | 339.30 |
| 200 | 115 125.90 |

The lesson is that an individual, or a company, or a government, cannot usually afford to invest even a small amount of money, forgoing even a small rate of interest, for a very long time period. The opportunity cost is too great. But the converse of this phenomenon is often overlooked: a very small rate of return (such as the IRRs obtained by plantations of indigenous species) can be regarded as highly rewarding when compounded over very long rotations. As an investment, forestry has a planning horizon far in excess of any other human endeavour, and "hurdle" rates of return based on experiences with shorter investments may be inappropriate.

**NEW ZEALAND BEECH**
***Nothofagus spp***

<u>Main reference</u>: Wardle, 1984. See Further Reading.

Arguably, New Zealand beech holds the most promise for plantations of any native hardwood genus. Beech is capable of producing 5-10 $m^3$ of wood per hectare per year, depending on species and age of assessment. This is a respectable figure by international standards, but does not compare favourably with most of the others listed in Table 1.1.

The main argument against beech as a plantation crop is that it must be established in an existing beech forest. Seedlings are particular vulnerable to dry conditions, lack of appropriate mycorrhizae and weed competition, even from relatively non-aggressive native species. It would be technically quite difficult to establish a beech plantation on, for example, an ex-pasture site. Even if this was successful, snow and wind damage are common, and *Platypus* beetle attacks can devastate stands despite Careful pruning and thinning regimes. Risks of management failure can be described as HIGH.

The rotation age is debateable but figures of 45-60 years have been postulated. Trees in natural stands would achieve a dbh of less than 30 cm in this time, suggesting that typical rotations may be a lot longer.

There is no doubt that beech wood can be used for high-value end uses, such as furniture and flooring. It has an attractive finish (depending on species) and is quite hard and strong. Due to the exceptionally small size of the pits linking the cells, it is very difficult to dry and process, but it is possible to do so. Recovery rates from natural stands can be very low because of hollow logs and hidden defects, some of which are visible only when the logs are sawn. It is not yet clear to what extent careful pruning and thinning can improve recovery. For selected logs, mill door prices are reported to have risen from $75/m$^3$ to $200/m$^3$ between the mid-1990s and 2001[176].

It is interesting that the beech resource came under close scrutiny only when podocarps were becoming scarce. The lay public appear to believe that "hardwoods" are always hard, and this is invariably a desirable attribute, but the historical evidence from pioneer nations like New Zealand and the United States belies this view. It seems that softwoods were always cut out preferentially. Softwoods may possess compression-wood, but hardwoods have the more problematic tension-wood. Hardwoods may distort more in processing and be more difficult to use (eg to saw or to nail). Furthermore, it could be argued that most of the traditional structural uses of hardwoods have been replaced with increasingly cheap steel or preservative-treated timber, so that their value relative to softwoods may have even declined in the last century.

To summarise, beech is a genus that can be grown only in existing beech forests. Volume productivity is relatively low, risks of crop failure are high, rotation ages are relatively long, costs can be high, and prices per hectare unexceptional. On nearly all counts the genus is an "also ran".

## KAURI
***Agathis australis***

Main reference: Bergin and Steward, in press. (See Further Reading)

Kauri has a special place in the history of this country, and in the hearts of New Zealanders. Large trees are a popular sight for tourists, with the largest still living (Tane Mahuta) being 4.4 m in dbh and 52 m in total height.

The wood is internationally recognised as being a premier timber for a wide range of purposes. The heartwood has a good figure and is naturally durable. Having said this, it may not be greatly superior in properties (for, say, boat building) to some cypresses – which are cheaper to buy and considerably easier to grow.

A thriving market for bland non-durable sapwood kauri is unlikely, so it is probably essential to prolong rotations until substantial heartwood appears. Increment cores in over 530 planted and natural second-growth stems have ascertained that no heartwood is present in 30 cm stems but moderate amounts exist in stems 60 cm wide. Usable amounts may appear within 75 years[177]. On the other hand, a 120-year old ricker stand (ie smaller individual diameters) sawn by the Forest Service in the late 1970s showed that less than 1% of the boards were classified as heartwood.

One notable feature of kauri is its ability to self-prune. Branches that are cut back to leave a stub will abscise within about 6 weeks, leaving a trunk free of knots. Perhaps this characteristic can be used to reduce pruning costs (mechanical pruning?) in accessible plantations.

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[176] Allen, R. 2004. Sustainable indigenous research funding. NZ Tree Grower February 2004, p. 37-38.
[177] Klitscher, K. 2002. Update on research with native species at Forest Research. NZ Tree Grower May 2002, p. 33-34

The natural range of kauri is in the warmer parts of the country, but planted trees are thriving in colder areas, including in the south of the South Island. Bergin and Steward note that, although small seedlings cannot survive frosts in excess of -1°C, twigs are not killed above -7°C. Natural spread is limited by survival of seedlings, and also by inability to compete with cold-adapted species. An artificial situation with planted trees and weed-control would greatly extend the potential range. Growth rates of kauri can be reasonably high (up to 13 $m^3$/ha/yr) for highly stocked stands.

An economic study of kauri was conducted in 1996[178], and concluded that the IRR was 2.9% (60 year rotation) or 2.3% (80-year rotation) with conservative assumptions. This rose to 5.5% and 4.3% with optimistic assumptions – increased sawn timber price, and reduced land cost, processing costs and commission. The authors calculated that non-timber benefits would need to be substantial to generate a positive NPV (Table 10.2), using conservative assumptions.

**Table 10.2: Annual value of non-timber benefits required from growing a kauri plantation at New Plymouth in order to meet target rates of return under the base-case scenario.**

| Target real rate of return (%) | Annual value of non-timber benefits ($/ha/year) | |
|---|---|---|
| 4.0 | 20 | 177 |
| 6.0 | 420 | 510 |
| 8.0 | 688 | 734 |
| 10.0 | 901 | 922 |
| 12.0 | 1090 | 1100 |

*Source: Herbert et al. 1996.*

## TOTARA
***Podocarpus totara***

Main source: Bergin 2003, See Further Reading.

Totara is of great historical importance. It was the preferred species for building marae and waka or for use as fence-posts, floor piles or furniture. It is one of the most naturally durable of all native species and was considered superior to kauri for many end uses.

Unlike many native species, it regenerates readily in pasture, thus making it suitable for plantations on non-forested land. It is relatively unpalatable and can tolerate considerable grazing pressure. Volume growth is about 10 $m^3$/ha/yr.

The 1913 Royal Commission referred to the "utter absurdity of suggesting such a tree as the totara for afforestation purposes" in view of the 80 year rotation length deemed necessary to produce sawlogs containing heartwood. While accepting the wisdom of this statement, we can be grateful that not all of our ancestors shared this attitude. The modern tendency to emphasize the needs of the present and to devalue the needs of future generations would not have created the great European cathedrals – or the great European planted forests.

[178] Herbert, J.; Glass, B.; and Kimberley, M. 1996. A preliminary stand productivity and economic case study of plantation grown kauri. Proceedings of NZ Institute of Forestry, Apr 29th – 1st May 1996, Invercargill.

## OTHER NATIVE SPECIES

Tanekaha (*Phyllocladus trichomanoides*)
Rimu (*Dacrydium cupressinum*)
Kahikatea (*Dacrycarpus dacrydioides*)
Puriri (*Vitex lucens*)
Kohekohe (*Dysoxylum spectablile*)
Rewarewa (*Knightia excelsa*)
Kanuka (*Kunzea ericoides*)
Kawaka (*Libocedrus plumosa*)

David Bergin and other researchers at Forest Research, Rotorua, have investigated plantations of these species. Stands up to a century old exist and have been assessed for height and diameter growth, and curves fitted[179]. Generally, diameters of 60cm or more are not reached until the stand is 75 or more, thus ruling them out where profitability from timber is a prime consideration. The recent sharp rises in prices (eg rimu logs now fetch $\$400/m^3$) do not alter this judgement.

## CLASSICAL EUROPEAN SPECIES - Oak, Chestnut, Elm, Ash, European walnut

There is considerable public affection for the classical European species, mirroring the love New Zealanders hold for their indigenous forests. The English origin of many of the current human inhabitants may partly explain this attitude. The living trees are attractive (for example, the oaks in Hagley Park, Christchurch, are popular) and the wood is valued for furniture and other products.

Contrary to most public opinion, New Zealand-grown hardwoods are not intrinsically inferior to their European counterparts because of their "fast growth". In situations where growth is faster (ie wider growth rings at the same age), the ring-porous hardwoods – such as those in this section – will actually produce stronger and harder wood[180]. This common misapprehension probably arose from observing the inferior timber in wide growth rings, but not realising that the predominant reason for wide rings is that they come from young trees or from the centre of older trees, rather that necessarily being derived from particularly fast-growing individuals.

In any case it is not clear that New Zealand growth-rates are always greatly superior to the country of origin. Where these species have done particularly well, for example in Botanical Gardens in the major cities, the sites are exceptionally free-draining, fertile and sheltered.

Land costs on such superior sites would be many times that of normal forestry land. The cost of establishment of classical European species is also high (tree stocks, high initial stockings, prolonged weed control and tree shelters).

There is a false assumption that these species must yield a high return to the grower, by virtue of their scarcity and their high growing costs. Economies of scale in the timber sawing, re-manufacturing, furniture making and marketing industries are such that this is usually not the case. If there were a sufficient and continuous supply of (say) quality oaks, then an industry could grow around this resource and reasonable prices could be expected. The actual situation is somewhat different.

[179] Pardy, Bergin and Kimberley 1992, see Further Reading.
[180] See, for example, Haslett 1984 (in Further Reading).

At a recent Farm Forestry field-day[181] in Canterbury, a stand of 124-year old oaks was being selectively logged and quarter-sawn. The typical stumpage for large logs was only about $150/m$^3$ – about the same as butt-logs from pruned 28-year old radiata pine or unpruned 45-year old Douglas-fir. One critical difference is that, in the case of the oaks, the logs were carefully selected from the best trees (perhaps 10% of the total) whereas the prices for radiata pine and Douglas-fir are the average for almost all butt-logs in a stand.

Risks of growing these trees include those from climate (wind), disease (Dutch elm disease, chestnut blight), and animal damage (hares, possums, livestock).

In summary, the Classical European species will continue to play an important part in our landscape, but will probably remain a very small part of our wood-based industry. They are restricted to the most favourable sites, are costly to grow, are risky, have excessive rotation lengths and do not yield a high stumpage price on a per-hectare basis.

## NON-RADIATA PINE SPECIES
***Pinus nigra, Pinus ponderosa***

Burdon and Miller (see Further Reading) list seven pines as possible sub-economic alternatives, mainly as "contingency species" should some catastrophe strike radiata pine. They acknowledge, however, that some of these (eg *P. muricata*) are so similar that they have the same spectrum of diseases. Most of the pines are also indistinguishable to the lay public from radiata pine, so would not appease a population eager for genuine alternatives on the landscape.

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. If rainfall is adequate, but frost is still a problem, then there may be a case for Ponderosa pine – which is hardier than radiata but with sufficient rainfall will grow more volume than Corsican[182].

At high stockings, Corsican pine can yield a respectable 13-24 m$^3$/ha/yr depending on rainfall. The currently preferred regime is for roundwood, especially poles, for which it is superior to radiata pine. It has relatively good form (straightness, taper, nodal swelling) and light branching, and is very easy to dry and to treat with preservatives.

Outside the colder regions and the rain-shadow of the Southern Alps, the species does not do well because of *Dothistroma* needle blight.

Provided that suitable land remains sufficiently cheap (say, <$500/ha) and there continues to be a place in the market for poles, Corsican pine is a useful species but does not constitute a genuine alternative to radiata pine.

[181] Proceedings of NZFFA Annual Conference, Hanmer, April 2004. Page 30.
[182] Ledgard and Belton 1985. See Further Reading.

## BLACK WALNUT
***Juglans nigra***

Siting for black walnut is critically important. To prosper, the species requires deep and free-draining alluvial soils, with near-neutral pH and high organic matter[183]. The sites should be sheltered. In terms of cost of inputs and potential returns, it resembles a horticultural, rather than a typical forestry, crop.

Even if considerable care is taken in siting, the species has a high risk of failure – as many stands throughout the country will testify. Out-of-season frosts will kill fresh growth and young trees. Both wind and possums can distort the crown so that the recovery of long straight stems is compromised.

Despite these caveats, Nicholas (1997) provides a map showing a high proportion of New Zealand (mainly in the North Island) as being the "potential range" of the species. Undoubtedly, individual trees could survive and persist in such areas, contributing to the potential range in an ecological sense, but to achieve a profit (however defined) the effective range would surely be a tiny fraction of this area.

New Zealand prices for individual logs have been reported as fetching $1500-$2000 each[184]. The high price that can be obtained for Black Walnut can compensate to some extent for high costs, risks, and long rotations, but it is not clear what price can be obtained per hectare as opposed to the return from selected logs, derived from selected trees. Haslett (1986) describes New Zealand-grown wood as being similar in the critical properties of hardness and bending strength, although being somewhat lower in stiffness and compression parallel to the grain. There seems to be no reason why New Zealand wood cannot achieve the same high prices as those obtained in the United States, except for the additional transport costs to the market.

In summary, Black Walnut requires considerable effort and cost to grow well, but has the potential to achieve high returns on ideal microsites. It is debateable whether other horticultural crops would not be a better proposition for such sites. In any case, the species is clearly not a contender to substantially reduce the percentage of plantation forest in radiata pine.

## PAULOWNIA SPP.
***Common names: Chinese empress tree or princess tree***

There are nine recognised species of *Paulownia*, a genus closely related to *Catalpa*. Present in New Zealand are *P. catalpifolia, elongata, fargesii, fortunei, kawakamii* and *tomentosa.* The genus is best suited for warm summer temperatures (mean daily temperature 24-30ºC), which may be a major reason why growth rates in New Zealand have often been disappointing relative to China.

*Paulownia* is a good example of a rural investment opportunity that has been over-hyped. The species was originally promoted as having ultra-short rotations (10-22 years), excellent individual-tree growth rates, and high prices at harvest. A widespread promotional campaign around 1990 led to considerable interest. In the rush to join the bandwagon, many growers chose the wrong species or variety for their region, or planted trees on an unsuitable site.

[183] Nicholas *et al.* 1997. See Further Reading.
[184] Haslett 1986. See Further Reading.

Sites should be free-draining, well-watered and sheltered, but with deep and friable soils. Growing costs are high, with one promoter (Kevin Avery) recommending almost horticultural-type care at establishment (deep cultivation and bedding, fertilisation, watering every 2-4 days, and provision of shelter).

There are many risks involved. Many growers have failed to take sufficient care with establishment and siting. Livestock and possums can damage or ring-bark the young trees. Caterpillars, aphids or witches' broom (a microplasm) have also been reported. Some species can endure fairly hard frosts, but only during the winter when they have no leaves. Out-of-season frosts are a common problem in New Zealand and casual visitors from continental climates are often unaware of our different conditions. Droughts are also common, perhaps exacerbated by the ENSO cycle, and *Paulownia* is particularly susceptible to a moisture deficit. Wind can easily shred the large soft leaves, but these will regrow unless the wind is persistent. It is very rare for trees to actually be blown down.

They have been occasions where the trees have grown well in New Zealand. Diameters of 50 cm are obtainable in 15 years, but the wide growth rings (25-50 mm) would not meet specifications for highest grade logs (< 10 mm). To achieve top prices, rotation ages of 22 years or more are required. The high-value logs exported from the U.S. are from naturally regenerated stands (growth rings 3-5 mm) and have the preferred straw or silvery grey colour.

The wood is very low density[185], having properties intermediate between balsa and radiata pine. It is not hard or strong, but is easy to saw and has slightly better overall dimensional stability than that of radiata pine. It was originally said to be ground-durable, but Forest Research tests showed that it was no more durable than untreated radiata pine (<5 years in ground contact). It is highly resistant to conventional pressure treatment with CCA preservative.

Uses in Japan and China include furniture (including drawers and drawer linings), gift packaging, ornaments, woodcarvings, and musical instruments. Prices have been reported as NZ\$200/m$^3$ on skid site in China, or NZ\$430/m$^3$ landed in Japan[186]. This is impressive, but the prices were for selected logs and were probably not sustainable. The species has been planted "throughout China's farmland in a huge reafforestation programme"[187] and there have been increasing exports from the U.S.. There are also rumours of substantial plantings in Australia, South Africa and South America following the same wave of promotion that New Zealand experienced.

The authors of an economic study[188] of *Paulownia* in the U.S.A. showed that, even at the lower of two yields, the species could achieve NZ\$4611-6277/ha at 10% discount rate. Land price was not included, so this would be the maximum price that an investor could pay for land to achieve a 10% rate of return. They cautioned, however, that "expansion of supply beyond the natural growth of this market could rapidly drive paulownia prices that could make plantation production uneconomic".

[185] 285-300 kg/m$^3$ compared to 420 for radiata pine.
[186] Barton, I. 1990. Paulownia…growing fast. Growing Today, April 1990, p. 43-45.
[187] Professor Derrick Donald, Senior lecturer in silviculture at Stellenbosch University quoted in Australian Forest Grower, Autumn 1988, p. 8.
[188] Hardie, I.; Kundt J.: and Miyasaka, E. 1989. Economic feasibility of U.S. Paulownia plantations. Journal of Forestry, October 1989p. 19-24.

In this author's opinion, the main limitation of this species is not the high growing costs or risks, but the fact that the market is still extremely limited and can easily be saturated. Note that the total usage of Paulownia in Japan is around 100,000 $m^3$ per year. To put this in context, New Zealand cut 20.940 million $m^3$ of wood in total for the year 2001.

In the unlikely event that *Paulownia* forestry became a profitable and sustainable industry, it is inconceivable that it could provide a serious contribution to the 1.8 million hectares currently in plantation forestry.

## OTHER SPECIES OF INTEREST

The following list (not comprehensive) contains other species that have been advocated by at least one person for widespread use in New Zealand.

- *Abies grandis* and *religiosa*. (The true firs). Can tolerate cold conditions. Slow growing.
- *Acer pseudoplatanus (*Sycamore*).* Has bad potential for tree spread, surviving and propagating in extreme shade. The wood has a good figure.
- *Aurocaria heterophylla* (Norfolk Pine). Natural clearwood from uninodal habit. Fast growing in warmer and coastal areas. Main problem is the bland white softwood is not an obvious alternative to radiata pine.
- *Alnus spp,* including *A.acuminata* (Andean alder). Reasonable growth. Tolerates poorer sites. Nitrogen fixer.
- *Catalpa speciosa.* Too unreliable (poor form, wind damage). Resprouts from pruning.
- *Cryptomeria japonica* (Japanese cedar, Sugi). Excellent form, good market prospects, but very slow growth rates.
- *Cunninghamia lanceolata* (Chinese fir)
- *Gleditsia tricanthos.* (Honey locust). Pods are edible for livestock. Durable, high-quality wood. Has long thorns, poor form (multileaders), wind damage.
- *Larix* spp. Japanese larch (*L. kaempferi*) is the fastest growing, with an unimpressive MAI of 14.3 $m^3$/ha/yr and a dbh of 31.5 cm at age 32[189].
- *Liriodendron tulipifera.* Fast growing, but no market for the wood.
- *Liquidamber styraciflua*. Attractive autumn foliage.
- *Picea sitchensis* (Sitka spruce). Disappointing relative to their success in North America and Europe. Susceptible to attack from aphids and mites. Site sensitive. Very slow growth.
- *Prunus serotina* (Black cherry). Poor form, but good prices offered for veneer.

[189] West, G.G. 1991. Douglas fir, Japanese larch and European larch in pure and mixed stands. NZ J. For. Sci. 21(1): 3-9 (1991).

- *Robinia pseudoacacia* (Black locust). Otto Krijgsman, or Rangiora, makes a living selling *Robinia* cuttings. Despite his claims about the straightness of his Hungarian clones, New Zealand's windy conditions frequently result in misshapen trees. There is concern about the ability of trees to resprout after pruning, and doubt about the quantity of heartwood present even after long rotations. Long thorns are a problem in most clones, and in the absence of grazing suckering can create a weed problem. On the positive side, it is one of the only exotic species in the Forest Research category of very durable (>25 years in ground contact) that can survive the cooler conditions that prevail in most of New Zealand.

- *Syncarpia laurifolia*. Turpentine tree. Very durable (<25 in ground contact), resistant to teredo worm.

## RECOMMENDATIONS FROM WADE CORNELL (Warm Climates, North of Auckland)

*Elaeocarpus grandis*
*Toona ciliata*
*Grevillia robusta*
*Cinnamomum camphora*
*Melia azedarach (Australian var)*
*Flindersia schottiana*
*Tristania conferta*
*Agathis spp. (eg robusta)*
*Casuarina spp.*
*Eucalyptus pellita and tereticornis*
*Swietenia macrophylla*

## FURTHER READING FOR INDIGENOUS SPECIES

Bergin D. 2003. Totara: establishment, growth and management. New Zealand Indigenous Tree Bulletin No. 1. Forest Research, Rotorua.

Bergin, D. and G. Steward in press. Kauri: establishment, growth and management. New Zealand Indigenous Tree Bulletin No 2. Forest Research, Rotorua.

Herbert, J.; Bergin, D.; and Steward, G. 1997. Native trees for production forestry. What's New in Forest Research, No. 243.

Pardy, G.F.; Bergin, D.O.; and Kimberley, M.O. 1992. Survey of native tree plantations. FRI Bulletin No. 175.

Wardle, J. A. 1984. New Zealand beeches. Ecology, utilisation and management. NZ Forest Service. 447 pp.

## FURTHER READING FOR CLASSICAL EUROPEAN SPECIES

Haslett, A.N. 1984. Utilisation properties of New Zealand grown European oak (*Quercus robur*). Touch Wood, No. 4. November 1984, p. 20-21.

Knowles, R. 1993. New directions for the New Zealand chestnut industry to consider. A report prepared for the Martin New Memorial Trust, the NZ Chestnut Council and Waikato Chestnut Growers Association covering the International Congress on Chestnut, held at Spoleto, Italy, Oct 20-23, 1993.

Ledgard, N. and M. Giller, 1999. Form pruning deciduous hardwoods. NZ Tree Grower, August 1999, p. 36-38.

Mortimer, J. 1994. Woods of the World – the English elm. Growing Today, August 1994, p. 24-27.

Mortimer, J. 2003. A selection of alternative timbers. Taitua Books, 283b Duck Rd, RD 9, Hamilton.

## FURTHER READING FOR PINES

Burdon, R.D. and J.T. Miller, 1995. Alternative species revisited: categorisation and issues for strategy and research. NZ Forestry August 1995, p. 4-9.

Ledgard, N.J. and M.C. Belton, 1985. Exotic trees in the Canterbury High Country. NZ J. For. Sci 15(3): 298-323 (1985).

Miller, J.T. and F.B. Knowles, 1986. Introduced forest trees in New Zealand: recognition, role, and seed source. 1. *Pinus nigra* ARN. European black pine. FRI Bulletin 124.

Miller J.T. and F.B. Knowles, 1989. Introduced forest trees in New Zealand: recognition, role and seed source. 10. Ponderosa and Jeffrey pines. FRI Bulletin No. 124.

## FURTHER READING FOR BLACK WALNUT

Haslett, A.N. 1986. Properties and utilisation of exotic speciality timbers grown in New Zealand. Part IV: Black Walnut *Juglans nigra* L. FRI Bulletin No. 119.

Nicholas, I.D.; Gifford, H.H. and Kimberley, M.O. 1997. Siting Black Walnut. FRI Bulletin No. 188.

## FURTHER READING FOR PAULOWNIA


Barton, I. (ed). Paulownia news. Newsletter of the Paulownia Action Group. November 1990 - ?.

Barton, I. and Nicholas I. 1991. The potential of Paulownia as an agroforestry tree in New Zealand. Paper presented at the ANZIF Conference, Christchurch, Oct 1991.

Glass, B.P. 1992. Market trends for Paulownia timber in Japan. What's New in Forest Research, no. 226.

Haslett, A.N.; Young G.D.; Simpson, I.D.: Britton, R.A.J. 1992. Paulownia – the timber of the future? What's New in Forest Research, No. 225.


## FURTHER READING FOR OTHER SPECIES


Bullock, B.T. 1994. Hungarian strains of black locust (*Robinia pseudoacacia*) – really just a boutique species? NZ Tree Grower, August 1994, p. 14-15.

Edmonds, J. 1998. Radiata pine – are there alternatives? NZ Tree Grower, Feb 1998, p. 9.

Miller J.T. and F.B. Knowles, 1989. Introduced forest trees in New Zealand: recognition, role and seed source. 3. The larches – *Larix* spp. FRI Bulletin No. 124.

Miller J.T. and F.B. Knowles, 1989. Introduced forest trees in New Zealand: recognition, role and seed source. 6. The spruces – *Picea* spp. FRI Bulletin No. 124.

Miller J.T. and F.B. Knowles, 1989. Introduced forest trees in New Zealand: recognition, role and seed source. 7. The silver firs – *Abies* spp. FRI Bulletin No. 124.

Mortimer, J. 1995. Woods of the World – Robinia, the black locust. . Growing Today, April 1995, p. 26-29

Mortimer, J. 1995. Woods of the World – The Japanese cedar. Growing Today, May 1995, p. 26-29.

Mortimer, J. 2003. A selection of alternative timbers. Taitua Books, 283b Duck Road, RD 9, Hamilton.

(NAWASCA) National Water and Soil Conservation Authority, 1987. New Start for Black Locust? Streamland 55.

# CONCLUSION

**Proven choices:** radiata pine and Douglas-fir

**Likely contenders:** certain cypresses, certain eucalypts and redwoods

**Niche markets and restricted microsites:** blackwoods, poplars, black walnut and Corsican pine

**Non-starters:** All other species. 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 chapter, therefore, is written with some trepidation!

Why are we looking for alternatives to radiata pine? Burdon and Miller (see Further Reading) 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, eg 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. Cypresses, 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.

## FURTHER READING FOR CONCLUSIONS


Burdon, R.D. and Miller J.T. 1995. Alternative species revisited: categorisation and issues for strategy and research. NZ Forestry August 1995, p. 4-9.


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