native species need to be large if new local processing initiatives are to survive. The current "cottage industry" scale means that prices paid are insufficient to encourage any expansion of the resource.

There was once real potential for the development of a continuous, sustainable, high value export industry from our indigenous forests. Now we can only regret the unenlightened policy decisions in the distant past, when the Crown negotiated very long-term contracts providing unsustainable timber volumes at an extremely low price to exclusive domestic customers, that robbed us of these opportunities. Some have said that the passing of the Forest Amendment Act 1993 is a policy decision made in a similarly unenlightened vein (see H.P. Heath comment, NZ Forestry, November 1992). It remains to be seen whether 'planted' native timber can compete as an option alongside more promising exotic alternatives, particularly with neither access to an export market price nor the continuity that management of a significant existing native resource might have provided.

Payback Period

There are other key issues. Most alternatives involve longer rotation lengths, more demanding silviculture, the build up of expertise (as distinct from 'information', which is available as pointed out in the commentary by Mike Wilcox (page 9)), considerable commitment, and the courage necessary for daring to be different in a conservative industry.

The payback periods are the major hurdle. New entrants into the forest industry must either buy their way into an existing cashflow with debt capital, or develop a resource from scratch and service the investment requirements from other income sources. Either way, capital is limiting and decision criteria such as IRR become more relevant (though many forest economists discourage the use of IRR in any set of circumstances). Under these circumstances, radiata pine is a highly preferable species, particularly because of its short rotation and established silvicultural expertise and markets. The 'gamble' of alternative species is really the preserve of those without the major cashflow constraints of first rotation foresters. Only when a forest comes on-stream and produces large positive cashflows can a forester afford to extend his planning horizon out to the truly 'strategic'.

Another prerequisite is a more sophisticated approach to decision making. The Resource Management Act and other issues point to the growing relevance of biological decision criteria to modify those answers derived from financial criteria. There is also a need to reappraise the application of appropriate discount rates to suit the total **economics** of a forest estate as distinct from the narrower **financial** aspects of a single crop or compartment.

Is It Attainable?

It is perhaps worth reflecting on the experience of radiata pine and Douglas fir when they were initially established by the State Forest Service early this century. At the same time, they faced much the same dilemma. The risk that the State took in establishing the plantations resulted in private industry having the confidence to follow suit. The whole gamble confirmed its promise when the timber came on-stream in the 1950s. This was largely the reason the combined State and private industries had the confidence for the second wave of expansion in the 1960s. An industry had been born. It is not at all fashionable to suggest that a Government strategic initiative might have come up trumps once in a while, but this is one such example.

The 1981 Special Purpose Species policy, requiring the NZ Forest Service to plant ten per cent of its establishment programme in a selected group of species outside Douglas fir and radiata pine, followed in this strategic tradition. The potential of this policy can only be speculated upon, but it is not impossible for a similar initiative to yet be taken up by a group of forest growers in a region. Dunedin City Council owned City Forest Ltd have implemented just such an initiative with their practice (in place since the late 1970s) of establishing between 30 and 40 hectares of macrocarpa (*Cupressus macrocarpa*) every second year. There is a commitment to tend and the hope that other private growers can gain confidence by the existence of such a new resource 'backbone' to take the plunge themselves.

My personal belief is that, in the absence of any hope of a Government initiative, it is the foreign owners who could provide the key.

They have the market contacts, the resources and, in some cases, the innovative attitude. Given time, the rapidly expanding farm forestry estate should reinforce any commitment by the major growers.

There is already evidence that the overseas companies are making their mark. Eucalypt and Douglas fir plantings in Otago and Southland are testimony to that. Long may it continue.

Chris Perley

Coastal redwoods in their natural habitat at Praire Creek State Park in Northern California. (Photo: D.J. Mead)

Redwood – an addition to exotic forestry?

W.J. Libby[1]

Reasons for additional species

First, let me be clear that *Pinus radiata* is a successful and proven species on a remarkable range of sites in New Zealand. In fact, radiata pine is my reason for being in New Zealand this year. Its great biological success, and now its spectacular commercial success, have been major factors in first creating and now intensifying commitment to plantation forestry here. This heightened commitment has led to plans for planting even more radiata pines, and to some concern about doing so.

The first and perhaps main reason for considering other species is the concern about having too many eggs in one basket. Burdon (1982) summarised and discussed the arguments for and against a monoculture of radiata pine, and concluded that there is cause for vigilance, but hardly for panic.

A second reason is that, as well as radiata pine grows here, there are some climates and some soils in which and on which it does not do well in New Zealand. Other species might grow better in such locations (Burdon 1975).

A third reason is that, even on some good radiata pine sites, there may be other species that are economically, biologically or aesthetically better. I now suggest that coast redwood (*Sequoia sempervirens*) is such a candidate. I do so with full knowledge that a substantial majority of New Zealand foresters hold the opinion that redwood has been tried, and that it has failed as a plantation species here.

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The history of coast redwood in New Zealand

Redwood is a magic tree. As such, it was one of the most planted of introduced trees by formal gardeners and acclimatisation enthusiasts throughout the world. Some of these early New Zealand plantings of redwood were sufficiently successful so that, during the major tree planting decades of the 1920s and 1940s here, large-scale forest plantings of redwood were attempted by both public and private organisations. One group of companies in the 1920s was even called the Redwood Forests Group (Healy 1982).

The great majority of these large-scale redwood plantations failed. These failures took several forms.

In some cases, all of the planted redwood died. The problem may have been inappropriate site, or inadequate site preparation, or bad weather conditions following planting, or inadequate post-planting tending, or planting stock that was physiologically in poor condition and doomed to die even in the best of other circumstances.

In some cases, at least some of the planted redwoods lived and grew well for a time. But then diameter growth slowed and height growth essentially stopped. Trees in this category may be seen near Matamata in central North Island (Figure 1), and in Wellington and Christchurch. In the latter two locations, frequent strong winds injure the tops of the redwoods, and their height is limited to that of nearby shelter.

Figure 1: A large redwood in central North Island near Matamata. Early good growth has been followed by signs of distress (dieback of top and branch tips), and is characteristic of isolated redwoods in this region. Explanations range from wind exposure to animal urine to soggy soils to who knows? (1993 photo I.C. Libby)

In some cases, the planted redwoods survived, but grew very slowly. Sometimes, other species were interplanted or later overplanted on these sites. In some of these cases, for example in the Rotorua Long Mile Grove, intermixed European larch (*Larix decidua*) allowed or caused many of the redwoods to begin rapid height growth after about ten years, and these redwoods soon overtopped the interplanted larch trees. In other of these cases, for example in Golden Downs Forest inland from Nelson, many planted redwoods persisted for decades in the understorey of overplanted Douglas fir (*Pseudotsuga menziesii*). These redwoods then grew vigorously from sprouts after the overplanted trees were harvested, currently surpassing the next crop of Douglas fir planted and volunteering on the site following harvest.

In some cases, the original planted redwoods attained large, even spectacular sizes. They may be encountered as scattered trees and groves throughout much of North Island, and in the Nelson-Motueka area of South Island. The tallest of them approach or even exceed 60 metres today, and many of these show no signs of ceasing height growth. Diameters are large, and stem form is often excellent.

If redwood is to again be planted on a substantial scale in New Zealand, it will be important to better understand where and why some redwoods have failed, grown poorly, or grown well (Elwood-Smith 1991).

Economics of redwood

New Zealand-grown redwood wood has a poor reputation in New Zealand, and probably deservedly so. It has often been cut from open-grown trees and milled by sawyers used to pine and using saws meant for pine. Furthermore, it is not used for the same end uses as pine or Douglas fir. This latter point is important, as it diversifies rather than duplicates market options. Thus, it wouldn't be prerequisite for radiata pine or Douglas fir to fail in New Zealand for redwood to become valuable here.

In California in the 1940s and 1950s, many foresters strongly and repeatedly predicted that young-growth redwood would find no ready market, and might even be useless. Wood from young-growth redwood has indeed proven to be less valuable and less valued than clear heartwood form old-growth redwood. But wood from second-growth redwood that was grown in stand conditions has sold well for over two decades in North America. This reality of the marketplace has surprised the experts and doomsayers. It seems likely that silviculture could create such appropriate stand conditions in New Zealand, and that wood from such plantations would differ little from wood from second-growth redwoods in California. There, young-growth redwood is generally harvested in the age range 60 to 80 years.

I have checked late 1992 prices in two retail lumber years in the San Francisco East Bay in California. In the "construction" grades, redwood prices averaged 77 per cent higher than those for Douglas fir (range 121-244 per cent of Douglas fir prices for various lumber dimensions in the two retail yards). For the more expensive "clear" grades redwood prices averaged 20 per cent higher than Douglas fir's (79-181 per cent of Douglas fir prices for various dimensions). In spite of the high retail prices being paid for Douglas fir in late 1992, redwood commanded higher prices in almost all sizes and grades.

I also checked California State Tax Board values for second-growth logs of various species in the north and central coast of California, for July to December 1992. Redwood logs averaged 148 per cent of the value of Douglas fir logs of the same dimension (range 139-157 per cent). Averages (and ranges) of redwood log values compared to logs of other species from that region were: 230 per cent (212-261) of sugar and ponderosa pines (*P. lambertiana* and *P. ponderosa*); 242 per cent (229-257) of incense-cedar (*Calocedrus decurrens*); 383 per cent (333-430) of white and grand fir (*Abies concolor* and *A. grandis*); and 1148 per cent (833-1500) of radiata and shore pine (*P. contorta* var *contorta*).

One might expect the figures for radiata pine, above, to be reduced, as imports of radiata pine from New Zealand and Chile create familiarity and then demand. However, 1988 South African figures for South African plantation-grown redwoods and pines (species not broken down) report redwood prices to have been 1133 per cent those of pine (Sesink 1988). One final California figure: the value of redwood logs for split products was 750 per cent that of all other California species.

If New Zealanders haven't figured out how to use redwood by the time plantations are ready for harvest, it is likely that they can ship redwood logs to California where they know perfectly well how to mill and sell it. There, redwood serves an up-scale market (and as such suffers less from economic cycles than do pine and Douglas fir). Sawn redwood is used for interior decorative paneling, exterior cladding, lawn furniture and outdoor decks. Chips from sawmills, slabs and edges provide long fibre for two of Cali-

fornia's largest pulp and paper mills; and the bark and sawdust are used in garden mulch.

Biology of redwood

While many species of fungi and insects live in and on redwoods, there has never been an epidemic of either recorded. In short, it is a relatively safe, fast-growing, well-formed tree. On decent sites, growth rates of 20-to-30 m^3/ha/yr are common, and on excellent sites even higher rates may be expected (Sesink 1988). A third-rotation plantation in France has recorded harvests averaging just over 50 m^3/ha/yr in the first two rotations.

Redwood is difficult to establish. However, once established, later rotations may be coppiced from stump sprouts, as was the French plantation mentioned above.

According to Prof. Henry Hellmers (personal communication 13 Apr. 1993), among New Zealand's various temperature and rainfall zones, some seem ideal for the growth of redwood. This opinion is based on his long research with redwood seedlings (Hellmers & Pharis 1968 and earlier papers cited therein). In particular, he found that the best growth of redwood seedlings occurred with 19°C day and 15°C night temperatures, but that they grew well in other day-night temperature regimes as well.

Like most species, redwood does better on good sites (Figure 2) than on poor ones, doing well on nutrient-rich deep moist soils. It seems to be more site-demanding than radiata pine. However, it can probably handle wetter and heavier soils than can Douglas fir and radiata pine, and in both France and California it handles colder winter temperatures than does radiata pine and hotter summer temperatures than does Douglas fir.

Redwood can be cloned (Rydelius & Libby 1993). Thus, good clones could be selected and effectively propagated.

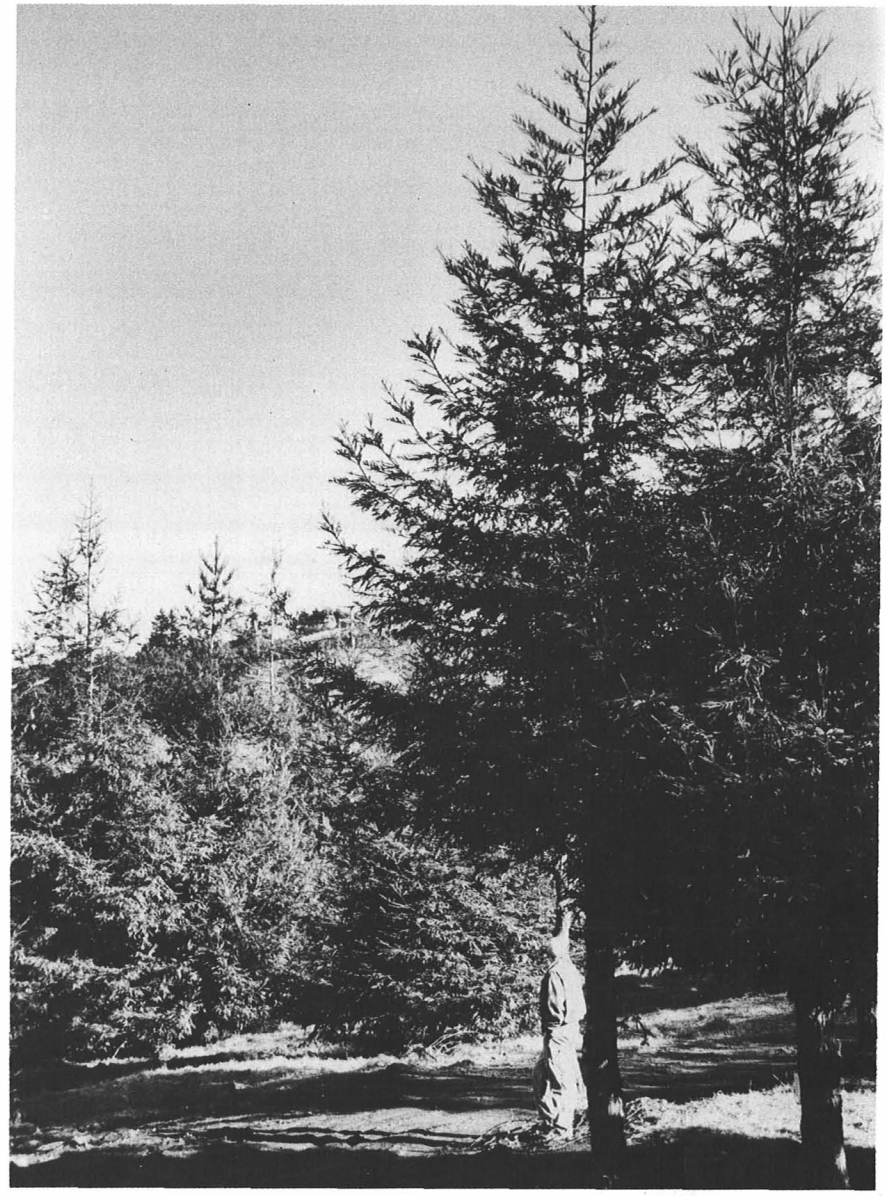

Figure 2: Amenity plantings of redwood near the Skyline recreational facility of Mt Ngongotaha in Rotorua, six years after planting. This site is fertile. Prior to planting, a general herbicide (in this case, Roundup) was applied and it killed all vegetation in a circle of about 1.2 metres diameter. A month later, a good-sized (about 20 cm tall) container-grown redwood was planted in a hole in the centre of this competition-free circle. In spite of subsequent grazing-associated mortality, survival has been about 80%, and the larger trees have grown more than a metre per year. (1993 photo I.C. Libby)

Aesthetics of redwood

How does one quantify the aesthetics of a tree species? A tour guide at Rotorua's Long Mile Redwood Grove claims that she has never heard a visitor judge that Grove to be ugly. In my opinion, the redwoods in the Long Mile Grove have combined with New Zealand native tree ferns to produce a forest that is among the most aesthetically pleasing of any on Earth (Figure 3).

Want to learn more about redwood?

FRI Bulletin 124, Introduced Forest Trees In New Zealand. Recognition, Role and Seed Source. 13. The Redwoods, by F.B. Knowles and J.T. Miller, provides detail on redwoods' early establishment and care, among other things. It will soon be available (order from Publications, New Zealand Forest Research Institute, PB 3020, Rotorua, likely price about $25/copy).

What's to be done?

A general rule-of-thumb is that foresters can accept only one new species per generation. New Zealand's first two generations of foresters have learned to grow radiata pine and Douglas fir. The third generation of foresters now seems to be coming on line. I hope that some modest attention will again be given to the establishment and early growth of redwoods on a variety of sites. I suggest that this be done carefully, avoiding overcommitment before reliable establishment practices are mastered and early growth data are in.

A worldwide 200-clone redwood experiment is now being conducted by Prof. John Kuser (Forestry & Wildlife, Cook College – Rutgers U., PO Box 231, New Brunswick, NJ, 08903, USA). A subset of Kuser's clones, drawn from throughout the redwood's natural range,

might be appropriate and useful in exploratory trials. If these clones were used in early trials, there would be little chance of surprises later due to use of an inappropriate seed source, and data could be pooled among users with respect to performance by clones and region of origin. Small plantings (less than 100 trees) could be established on a variety of promising sites, in easily-found locations where radiata pine or other species are being planted.

Such a subset of the Kuser clones has been successfully brought through quarantine and these are now being propagated in New Zealand. Contact Tasman Forestry's Centre for Advanced Forest Biotechnology (PO Box 149, Te Teko, Phone 07 322 8511) for information on their availability.

Site preparation and post-planting vegetation control should be better than that used for radiata pine plantations. For this reason, it seems that some farm foresters might be particularly helpful in developing the next phase. Such farm foresters have the cultivating equipment, skills, and proximity necessary for installing and closely observing such early trials.

Figure 3: The Long Mile Redwood Grove in Rotorua, planted in 1901. (1993 photo by I.C. Libby)

Figure 4: Redwood and narrow-leaf peppermint, *Eucalyptus pulchella*, behind the Forest Research Institute in Rotorua. Both are growing well in close mixture, with similar heights and diameters but strikingly different stem form. (1993 photo by author).

Mixed-species trials might also be done (Figure 4). In California, redwood occurs in natural mixtures with radiata pine and Douglas fir. Bluegum (*Eucalyptus globulus*), or radiata pine, or various hybrid poplars (*Populus* sp.) have been grown in two-species mixtures with redwood with some success. Such a mixture gives a stocked plantation if the redwood fails and, if both succeed, opens the possibility of harvesting the interplanted species early and growing the redwood on to age 60 or more.

Conclusion

Please do not interpret this comment as indicating that radiata pine should not be replanted on sites where it has done well. Surely that is appropriate, and in most cases it will be the option of choice. I am suggesting that some sites, particularly those with soils that are too wet for good radiata pine or Douglas fir growth, should be considered for redwood. And I am also suggesting that some outstandingly good sites, where radiata pine or Douglas fir would do or have done very well, could also be tried for redwood, for a variety of purposes and reasons.

Acknowledgements

Dennis Richardson suggested that a comment such as this might be useful. The California retail and stumpage prices were obtained by Sue Kloss, Graduate Forestry Programme, University of California, Berkeley. Plantation growth rates are mostly for French plantations, and were provided by Alain Bailly, AFOCEL, 26120 Malissard, France. John Miller and

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Robinia pseudoacacia for ground-durable posts?

N.J. Ledgard*

Introduction

Foresters, particularly researchers, are supposed to be adept at thinking at least 20-30 years ahead, because of the long time their tree crop takes to reach maturity. It is thanks to such visionaries as Sir Francis Dillon Bell and Dr 'Winkie' Sutton that the forestry industry is in the rosy position that it currently finds itself (today's visionaries are at a distinct disadvantage, for they have to do battle first with economists who have difficulty seeing past present-day costs and returns – but that's another issue). What do today's visionaries see as newcomers to the future forestry scene? I'd like to suggest that, in a world trying to cut costs and showing more and more resistance to insecticides, fungicides and toxic chemicals generally, there should be an increasing role in the future for naturally durable timbers. Down here in the colder parts of the South Island we have some good candidates for above-ground use, particularly in the likes of Douglas fir and macrocarpa. However, it is a different story below ground, for we are generally too cold for the ground-durable eucalypts such as *Eucalyptus pilularis* and even *E. muelleriana*. One species stands out as a good candidate and that is the black locust or *Robinia pseudoacacia*. But, as this article attempts to explain, growing ground-durable *Robinia* heartwood is not likely to be easy.

Robinia pseudoacacia or black locust is a native of eastern North America. Since about 1600, when it was possibly the first North American tree introduced to Europe (Keresztesi, 1988), it has been widely planted elsewhere. By 1986 over three million ha of *Robinia* plantations existed outside the USA, with China and South Korea each having planted over one million ha.

Robinia in New Zealand

Robinia has been planted in New Zealand for over 100 years. The species has not earned a good reputation because of poor form and a tendency to breakage in exposed sites. However, it retains its attraction to many tree growers because of its capability to produce durable heartwood early in life. The heartwood has been tested in New Zealand for ground durability and was initially classified as at least "durable" and probably "very durable". Of 33 hardwoods tested, *Robinia*, was one of only three species listed in the second category and was the only one that grows relatively readily in the colder parts of the South Island. However, more recent FRI assessments of *Robinia* after 26 years rate posts more likely to be "durable" (rather than "very durable") with an average service life of 20-25 years (D. Page, FRI – pers. comm.). Page also queries whether the heartwood from young trees will be as good quality as the older material used in the FRI tests.

Improved Hungarian clones

In 1985, Otto Krijgsman of the Forest Research Institute (Rangiora) visited Hungary and was impressed with the form and growth of some of these clones. Consequently, improved material in the form of seed and rooted plants from seven clones was imported in 1986. These were used to establish various trials in the Rangiora nursery in 1988.

Demonstration planting in FRI's Rangiora nursery

The main aim of these plantings was to demonstrate management options for growing roundwood. They included seven clones and one seedlot of Hungarian origin and one seedlot of New Zealand origin, each represented by 375 trees. These were planted at three spacings – 1000 s/ha

Inside the *Robinia* management plot (4000 s/ha) year three. Close spacing and thinning to one stem per stump has promoted reasonable form in this seedlot of NZ origin.

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