mercial crop, which ties up expensive capital. These forests are firstly a business's cash flow, part of an investment portfolio, or part of an individual's retirement plan. The 'quality' decision of a forest grower is not made in terms of physical quality per se, but rather in the way in which physical quality affects long-term profit maximisation. Forcing a grower to extend the rotation age simply penalises the grower by removing their profits and giving them to the processor, for whom life would become much simpler, allowing them to operate with less sophisticated technology and making their decisions less complicated. After many years of operating in markets which were stifled by State forest agencies and large corporates, forest growers can now make money growing trees. The last thing we need is to move back to some type of regulation to meet a 'quality' problem. A forest owner should quite rightly be able to make a decision to cut earlier and sell something of lower physical quality if it is more profitable.

In short, the quality problem is a communication and a market problem, not a grower problem. Everyone is in some way responsible for ensuring that quality concerns become part of the communication flow and thus part of the solution. The key is that we must ensure that the market keeps up with the information requirements that are necessary for 'quality' decisions. I have every confidence that the New Zealand forest industry is capable of adapting to this imperative without penalising forest growers by forcing some lengthened rotation.

Hugh Bigsby

Silviculture in New Zealand – A hundred years of change

Piers Maclaren and Leith Knowles

For perhaps 10,000 years, humans on five continents have practised agriculture. They have manipulated genetics, soil, water supply and weeds, to grow the most bountiful crops of the best quality. This contrasts with forestry, where in spite of historical, albeit localised, shortages of wood – with some exceptions people are only just progressing from the "hunter-gatherer" phase. Why is this?

For millennia, it has been known that the straightest trees grew at tight initial spacings. In these conditions, their tall, narrow, minimally tapered stems enabled them to reach the light before their competitors. Thinning by natural suppression of weaker trees also killed lower branches, which eventually decayed and allowed the formation of clearwood. The surviving, ancient trees often developed heartwood of great durability and outer growth rings of great strength. The reason that humans have not adapted their agricultural technology to forestry is one of economics: to duplicate this natural process using human effort required too great an investment up-front, and too long a delay to the payoff.

Some foresters are beginning to realise that, in order to meet economic criteria, wood must be grown in a way that is totally different from Nature's. Furthermore, in a world with a human population of six billion rising to 10 billion next century, natural forests will eventually not be able to supply enough wood. In the New Zealand context, far-sighted foresters reached these conclusions 84 years ago.

In New Zealand, the 1913 Royal Commission noted that exotic plantations would be required to replace the disappearing native forests. Which species should be planted, and how should they be grown? In a list of State plantings up to 1909, radiata pine ranked 18th, with only 110,000 trees planted. Nevertheless, its performance – in terms of both growth and wood utility – made it to the top of the list of Royal Commission recommendations. This was no doubt aided by a study published in 1914 of farm shelterbelts and plantations that had been utilised for house building in Canterbury (Cockayne, 1914), which concluded that radiata pine was "by far the most valuable and profitable timber tree that can be planted..."

Radiata pine was a fortunate discovery, but there were a few downsides. The species was not naturally durable, and it generated large branches, particularly if open grown. The clearwood was of excellent quality for many purposes, but the presence of knots – especially if they were large or bark-encased – downgraded the wood significantly.

High Stockings

High stockings could be used to control branch size. In order to suppress the lowest branches, however, very high initial stockings were required. In the first few years, trees are filling up the gaps, and branches do not become suppressed until they are underneath several metres of green crown. At 400 stems/ha, radiata pine branches do not die until they are 15-20 m below the tip of the tree. If branches 12 m from the ground are to be kept small, the spacings have to be tight until the stand is at least 20 m tall, and preferably taller. This has several negative implications.

First, it has been known since 1880s that the sapwood cross-sectional area at any point on a stem (i.e. the conducting tissue) is directly related to the branch basal area above that point (Jaccard, 1915). From this it may be concluded that you can't get smaller branches without a corresponding suppression of stem diameter growth. Tight stockings, therefore, involve sacrificing individual-tree volume for improved stem quality. To obtain trees of acceptable diameter at high stockings, it is necessary to have long rotations. And time is money.

Second, tight stockings are expensive. They cost a lot to plant, and to thin. Early this century, spacings of 1.8 m by 1.8 m were common, which equates to over 3000 stems/ha.

Third, the long series of production thinnings that are common in Europe and Australia are not very practical in the New Zealand context. Our steep and broken topography, high wind risk, and scarcity of markets for thinnings do not favour this approach. Although some production thinning is still employed in New Zealand, it usually occurs only once in a rotation – when the thinnings have accumulated a satisfactory volume but before the stand has reached a height at risk from windthrow. Production thinning is declining in popularity, and is currently implemented on only a quarter of the national estate.

One possibility, as Australian Max Jacobs realised in 1938, was to control branches by pruning (Jacobs, 1938). Instead of using trees as a tool to control other trees, pruning shears or saws could be employed. This would solve the problem of large branches in the butt log, and avoid the necessity of very high initial stockings. Jacobs' work was significant in that together with that of the South

African, Craib, (Craib, 1939), it emphasised the malleable nature of radiata pine, compared to many other species.

Pruning introduced a whole new set of problems. First you have to start pruning a tree when it is small in order to minimise the knotty core. This means you have to select final crop trees at a very young age, or else prune more than you intend to keep. Second, you have to thin at the same time as pruning, or else – as was shown in a trial at Kaingaroa (Sutton and Crowe, 1975) – the unpruned trees will compete strongly against the pruned ones. Third, in order to capitalise on the high investment that you make in pruning, you must thin heavily. This is so trees can deposit a wide sheath of clearwood outside the defect core, and do this in an acceptable timeframe. But heavy thinning (i.e. low stockings) can result in large branches in the unpruned logs, and may have other wood-quality implications. Compared to Europe, New Zealand silviculture was going through an "unconstrained" period, where many options were becoming available. Ure pioneered the large-scaled application of pruning and thinning at Kaingaroa, and this period was ably described by Penistan (1960).

A milestone paper by Fenton and Sutton in 1968 summarised these concepts and described a regime that was "potentially more profitable" than one involving production thinning. This advocated a final crop stocking of 200 s/ha, pruning to 6 m, two-stage thinning at age nine and 12, with a clearfelling at age 25-26. Second log value would be ensured by selecting trees for clear-cutting potential. Their main contribution was to place silviculture within a financial framework, and to emphasise the advantages of growing radiata pine for appearance rather than structural grades. By and large, this type of regime has been adopted throughout the country, and now accounts for nearly half the resource. Common variations involve thinning even earlier, and in one hit, with final stockings up to 350 stems/ha, and clearfelling later.

A summary of the regimes practised in 1979 was provided by Nigel Williams in 1982. He divided the regimes into "Clearwood, structural, and other". The mid-range for initial stockings was 1540, 1670 and 2220 respectively. For final stockings, the mid-range was 300, 370 and 500. Rotation ages were typically 30 years (James, 1990).

Recent Initiatives

There have been several important recent initiatives. Much of the new land planting is taking place on farms, and it is now appreciated that basal area growth on these sites is far superior to traditional forest sites, albeit with a commensurate increase in branch size unless accompanied with an increase in stocking. Early thinning to low stockings (as low as 100 s/ha) on farm sites has been investigated in order to maximise understorey grazing, and to produce fat butt logs in a minimum time. Results of trials such as Tikitere support the current movement by farm foresters away from this extreme position, and to have somewhat higher than usual final crop stockings on such sites (Maclaren, 1993). At the same time, use of improved genetic material, particularly the widespread application of the 'growth and form' breeds, has led to increased vigour, improved stem form, lower initial stockings, and a reduction in internode lengths.

The large network of permanent sample plots, and replicated trials, continues to be extended to cover a wider range of silviculture, including second log pruning, followers, new genetic material, and to other species such as Douglas-fir. Analysis of these trials contributes towards improved knowledge which is being continually included in computer-based models of increasing reliability. It is no longer necessary to install trials to "demonstrate" this or that favourite regime. Within its limits, and when combined with local practical experience, the STANDPAK modelling system can be used to predict the consequences of a wide range of combinations of stocking, thinning, pruning and rotation age (Whiteside *et al.*). Current researchers would have difficulty with both the Fenton/Sutton and the Williams papers. The former unselfconsciously lobbied for a particular regime, whereas the motive of the latter was to "rationalise" the 70 regimes in existence at that time. It is worth noting that currently more than 30 regimes for radiata pine are used by industry.

A continuing issue in the evaluation of silvicultural options is choosing between using log pricing scenarios which reflect market signals for both size and quality (market prices approach) or log grade definitions and prices which reflect the intrinsic residual value (residual value approach) calculated using detailed processing models. With increasing market size and industry experience in utilising the resource, it could be expected that these alternatives will merge over time.

The modern silvicultural researcher attempts to restrict his or her role to providing the knowledge and tools to aid evaluation, rather than advocacy. Forest owners are the customers, and the researcher's task is to provide decision-support rather than decision-making. Technical foresters in New Zealand are particularly well trained, and this definition of roles is seen as appropriate by both parties. Furthermore, it is now widely appreciated that "there are many ways to skin a cat", all of which have their good and bad points. A wide range of regimes can be justified, depending on the circumstances of the decision maker, including the choice of discount rate, species, site, genetic material, initial stocking, final stocking, production thinning, pruned height and rotation age. The researcher's role is to ensure that silvicultural impacts are predictable, so that decision-makers can act with the best information available, presented in the most useful form.

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Forest pests and diseases: a retrospective

Gordon Hosking*

This short article takes a brief look at the history of pest and disease impacts on New Zealand's forests, how forest protection has been tackled, and what the lessons might be for the future. It is not the intention to document even the major pest and disease events of the past, but rather to give a perspective of the themes and philosophies which have guided our response, and their relevance to future strategies.

In the Beginning

Little management of, or research into, pests and diseases of either exotic or indigenous forests of this country occurred until the middle of the 20th century. The late 19th and early 20th century was characterised by collectors and describers, such as botanists Hooker and Colenso and entomologists Hudson and Broun. In general, their work involved little evaluation of the relationships between flora and fauna, and very few observations on the status of pests and diseases relative to their impact on forest ecosystems.

The first real attention to pests and diseases came in the 1920s and 1930s through the Department of Agriculture, the Cawthron Institute, and later the Forest Service. While most initiatives at this time concentrated on surveys of insects and fungi, some individual organisms were singled out for comment including *Sirex noctilio, Diplodia pinea*, and *Phomopsis* spp. In the case of the former, biological control was attempted with the introduction of the parasite *Rhyssa persuasoria* (Miller and Clark 1937).

A greater focus on pests and diseases of forests resulted from the establishment of the Forest Research Institute in 1947, which included a small forest pathology section headed by Joe Rawlings. The early work of this group was mainly concerned with identifying and prioritising what problems existed in both plantation and indigenous forests, and determining what approaches might prove most fruitful in tackling them (Birch 1938).

Early Days

Two early initiatives of the small pathology group at the Forest Research Institute have provided lasting benefits to forest protection in New Zealand: the initiation of the insect collection and fungal herbarium, and the establishment of the Forest Biology Survey. The collections are now the most important in New Zealand for forest fungi and insects, and are essential diagnostic tools for both researchers and forest managers. The Forest Biology Survey, established on the recommendation of J. J. de Gryse (1955), was modelled on the Canadian system and formed the foundation of today's national forest surveillance system. It has for over 40 years been a central plank in the country's forest protection strategy.

Pest and disease management and research in the 20 years between 1960 and 1980 was largely preoccupied with three key issues: Dothistroma needle blight, Sirex wood wasp and Platypus pinhole borers. Lesser effort was directed to Armillaria root rot, Cyclaneusma needle-cast, Diplodia dieback, Phomopsis shoot dieback and the Arhopalus longhorn beetle. The forest health effort of this period can be characterised as reactive in its preoccupation with a number of new and existing problems. The balance of effort was often driven by changing forest policies such as the "on-again, off-again" beech management initiatives in which *Platypus* featured so strongly (Litchwark 1978).

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