right issues.

In terms of equity, it is important to note that no Government has ever committed to devolve Kyoto forest sink credits. Most Kyoto forests were planted before the Kyoto Protocol was even negotiated and certainly well before it came into force in February 2005. The argument by some existing forest owners that they have invested in trees on the basis that they had been promised such credits is not valid.

Devolving credits for trees already planted would therefore have created large, and we believe unjustified, windfall gains for a few forest owners, which would have resulted in large unjustified windfall losses to other parts of society.

Looking to the future, the options provide great opportunities for foresters. The government is looking at implementing one of the biggest replanting programmes New Zealand has seen since the war. New Zealand wood products are sustainable with low embodied energy. These characteristics should give wood a tremendous advantage over energy-intensive products like steel, concrete and aluminium - provided we have a comprehensive plan to exploit these business opportunities.

As I said earlier, over the next two months there will be widespread consultation on how best to work together to find long-term solutions. No decisions have yet been made on what the policy package will look like but there are some certainties: the rate of deforestation needs to be addressed, climate change is a reality, and doing nothing is not an option.

This applies to all sectors of the community. Everyone will have to play their part in reducing greenhouse gas emissions. The focus needs to be on making sure the solutions are enduring because, like government's all around the world, we're all going to be dealing with climate change issues for decades to come.

The discussion document is available online at www.maf.govt.nz/climatechange. For more general climate change information including the government's various policy consultations see www.climatechange.govt.nz

Clausewitz on forestry

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New Zealand foresters of the early 1970s had a collective vision of fast-grown pruned pine finding markets all over the world - and this unchanging flow of wood is destined to continue carrying our fortunes beyond 2050. Yet, it is doubtful that those foresters wanted, or expected, radiata pine to account for 90% of our plantations; and they might have been disconcerted to learn that only 50% of these forests have been thinned and pruned in a timely manner (NZFOA, 2006). This has become the ultimate expression of an indistinct concept, and for it to prove to be a success then one must look to the end account. In a sense we have progressed from the dreamtime (The Fatal Conceit) of the 1970s, through the sleepwalk (more of the same) of the 1980s and 1990s, and so to the current hangover (with limited practical vocation for overcoming difficulties and developing new opportunities) or, maybe, the awakening.

Consider a parallel history. The de Havilland Comet commercial jet first flew in 1952. Two years later it was grounded following catastrophic structural failures at altitude. The Cohen Enquiry attributed the failure to metal fatigue arising from stress concentrations in the corners of the square windows - a deliberate innovation to contrast with the portholes of a ship. With redesigned windows and a strengthened airframe the Comet continued to fly. However, others also learnt from the Comet disasters and Boeing came to dominate the commercial jet aircraft market with its introduction of a transatlantic service in 1958. The moral is that a single, foreseeable flaw can devalue an otherwise brilliant design. By analogy, the failure to acknowledge the indifferent intrinsic quality of radiata pine has effectively devalued our entire investment. Forestry will survive but…

…the internal (intrinsic) quality of radiata pine being planted today will be no better than that of the earliest mass plantings of the 1920s. At best, today's pines are straighter, more vigorous and with lighter branching. Having neglected to improve intrinsic quality of radiata, scientists are now playing up general virtues that can be attributed to any timber… "*wood has a whole bunch of other features that make it very attractive - its appearance and feel, and the fact that it's renewable. I think Kyoto-related issues and sustainability are going to provide another clear value outcome for forestry*" (Marilyn Head, 2006). If forestry was not prospering before it will hardly become so by strengthening a weak hand: the ground for further planting must be new ideas.

It should have been otherwise. In the 1960s Brian Meylan and Mervyn Probine (later to become State Services Commissioner) (1969) and Ian Cave (1968) at the old DSIR (now the CRI Industrial Research Ltd) explained the cellular basis for the mediocrity of young radiata. Sadly our "*trees [were] grown with a sole focus on quickness of growth [and] didn't take account of the underpinning qualities like stability*" (Marilyn Head, 2006). We were not alone. Professor Reg Preston FRS, of the Asbury Department of Biophysics at Leeds, tried to persuade British forestry to improve the intrinsic quality of Sitka spruce by the same means but industry wasn't interested, such that today, according to Macdonald and Hubert (2002) of Forest Research Scotland, two-thirds of production is absorbed in low-valued pallets, packaging and fencing. We both got the wood we deserved although it is not what we wanted.

Healthy, straight, vigorous trees are presumed; otherwise there would be no access to markets. It is the distinctive features of any species that allow it to make it on the world stage. These arise from its intrinsic properties and in this sense GF 2 and 30 are equally unimproved.

Today there are three challenges

First, belatedly, the Wood Quality Initiative Ltd has the task of getting the best out of our unimproved pine. The

Table 1. Experimental grade recovery data by machine stress grading together with proposed changes (after Gaunt, 1998). Also shown (in brackets) are the newly amended grades and values in the current Standard (NZS3603:1993 Amendment 4, 2005).

	Machine grades	Bending stiffness GPa	Bending strength MPa	Compression strength MPa	Tension strength MPa	Grade recovery %
Grades applying in 1998	Reject					53
	F4	7.59	12.67	20.76	7.72	27
	F5	8.86	20.12	20.17	9.82	19
	F8					1
Proposed at that time, and as adopted	Reject					8
	MGP6	6.07 (6.0)	10.15 (10.0)	16.71 (16.0)	6.58 (4.0)	41
	MGP8	8.86 (8.0)	14.48 (14.0)	21.03 (18.0)	7.95 (6.)	49
	MGP10					2

focus is on identifying properties of stands, trees, logs, and boards so that each piece is exploited to its full potential. Such processes will be applicable to the next 30 years' wood supply as seedlings with unimproved intrinsic properties continue to be planted. De Havilland had an improved Comet in service within 2 years; sawmillers will have to wait at least 30 years before they see intrinsically improved pine. If the mediocrity of pine had been acknowledged earlier we could have begun culling the sub-mediocre - the truly awful - that much earlier. The current trend to lengthen rotations is only legitimate as a short-term tactic to mitigate the consequences of poor corewood, exacerbated by low stockings. More surprising than the consequences of low stocking, which are much reduced stiffness and increased warp-potential, is the fact that until 2004 foresters had not investigated such effects (Lasserre *et al*., 2004). Only recently has it become obvious that the strategies of the early 1970s that were designed to improve the economics of pine have conspired against achieving that objective.

An exaggeration? The fine imposed by the Commerce Commission for misgrading structural pine is a reflection of the difficulty in obtaining enough wood of adequate grade, even from regions noted for their supply of high-density logs. It must have been galling to find one's machine graded F5 competing with visually graded No 1 framing which in the new Standard has characteristic values that are the same as those for MGP6 (Table 1). The measured grade values for even F4 would have been superior to those found (but rarely measured) in visually graded No 1 framing coming from regions not noted for high density. The issue was that some wood was below grade; and not that it performed any worse than the equivalent No 1 framing.

Gaunt (1998) outlined the advantages of revising the structural grading rules. These machine stress grades apply to populations. Consequently MGP6 can include individual boards having values as low as 4.0 GPa. The new grades are magnificent for the manner in which low-grade, unimproved wood is upgraded (with reject grade falling from 53% to 8%, truly miraculous) - and the Standards Association of New Zealand has endorsed them - and this is the best that can be achieved with unimproved pine (Table 1). Again, the issue is not that these new grades will perform any worse than the previous grades; rather there is the risk that the need for lower grade values makes explicit the mediocrity of much unimproved pine.

In advocating a new grading system Gaunt (1998) observed, "*the reduction in strength is not as alarming as it appears, as in the majority of cases the design of a timber member is governed by stiffness. After stiffness the next most important issue is timber stability, then timber strength*". The important point is that machine grading measures stiffness directly whereas all other properties are estimated through statistical correlations. Hence there is no reason why MGP6, for example, should not be just that, i.e. all pieces of that grade having a measured stiffness of 6 GPa. If there is too much reject material then industry should switch to an alternative grade, say MGP5. Furthermore, although the consumer can buy lumber piece by piece at a retail yard, an individual board has no grade in the sense that "*the grade stress is assigned to populations of timber, not to individual pieces*" (NZS1748, 2006). Officially the industry is selling a package that will include some low grade, and is protected from standing behind the grade mark on a particular piece. If we continue such practices then imagine a marketing campaign that compares steel and timber grade-by-grade, and piece-by-piece. How stupid the industry would look? I know the excuse - load-sharing - but try that on Fair Go!

Currently, forestry faces little competitive pressure from steel in the housing market, e.g. in Australia. Steel prices are high because of the huge demand in Asia and proportionately limited supply, whereas lumber prices are stagnant. However as supply constraints are worked though and the current commodity boom subsides in the next 10 or so years, then expect large volumes of cheap, reliable, uniform steel framing to be marketed aggressively. Is this challenge best met with yet more unimproved pine? Our problem is unimproved pine.

Second, the Radiata Pine Tree Breeding Consortium has to develop superior breeds and clones. The task is made more difficult by under-resourcing. In anthropomorphic terms,

the issue is intergenerational theft. Forestry is preoccupied by the indifferent quality of the current crop - equivalent to spending on health care for senior citizens - while neglecting to spend up big on tree breeding - equivalent to pre-school and primary education. This is not helped by the fact that few are willing to pay a premium for intrinsically improved planting stock, so the production of unimproved pine will be drawn out beyond 2040. Yet in anthropomorphic terms the worst of today's young unimproved trees are not even toilet-trained.

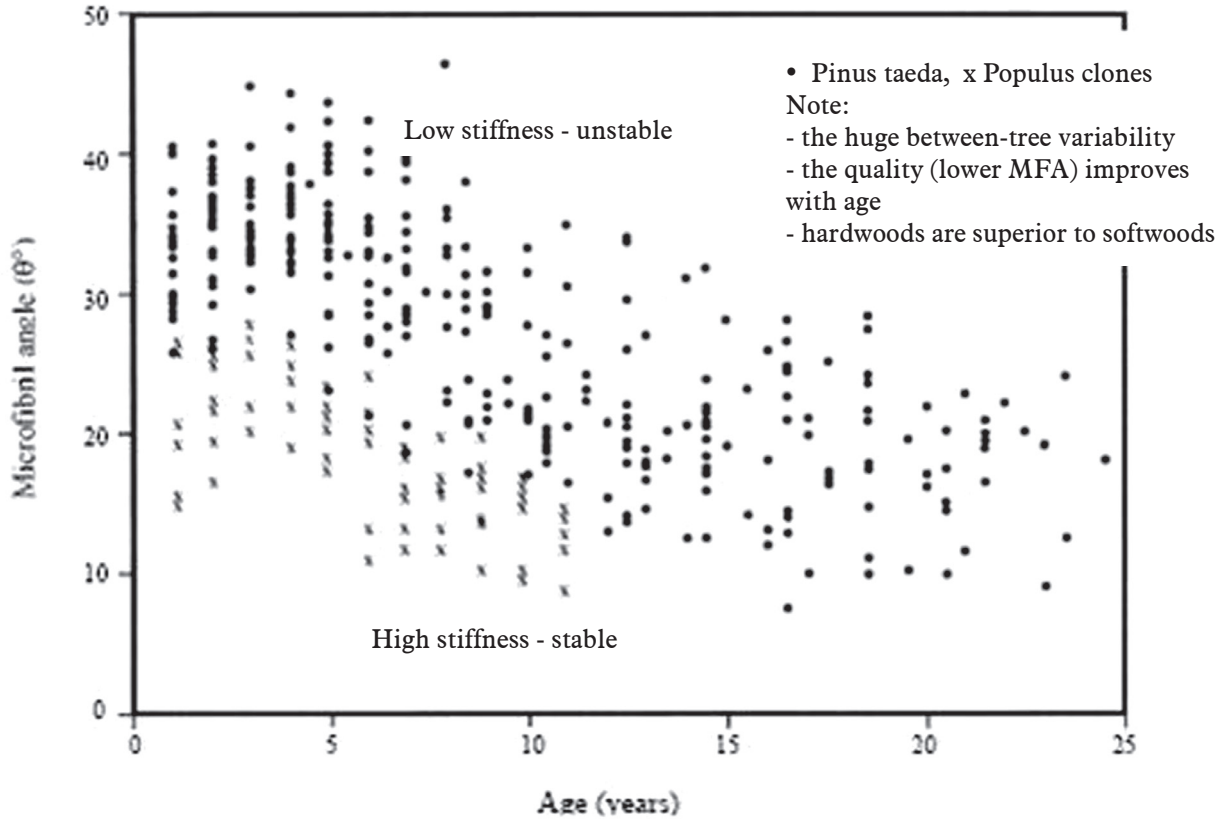
If one followed the logic of the old DSIR work then it was always going to be difficult to get quality wood from radiata pine on short rotations with low stockings. Practice would argue that this might be achievable with elite breeds of pine (Sorensson *et al*., 2004), which we long neglected to develop. However, theory hints that for young pine there is a "glass ceiling" which limits its potential. Ironically, the same threshold becomes a "firm floor" for young hardwoods, so for short-rotations these have more potential which we have hardly begun to explore (Figure 1). The cell-wall stiffness of the best, yet-to-be-improved young pines will be no better than that of the worst, unimproved young hardwoods. Certainly as the pines get older the intrinsic quality in the outerwood coalesces with that of hardwoods; but it is a long time to wait. One can debate the minimum, absolute, acceptable threshold for any timber. For pine the ideal ought to be at least 8 GPa, but even with improved pine, industry will have to tolerate some wood with 6 GPa for utilitarian uses (Table 1): ironically there are unimproved young hardwoods that could comfortably meet a threshold of 10 GPa.

Although one should not attribute the disappointment with pine exclusively to intrinsic quality, it has clearly co-operated with other reasons (exaggerated projected returns, indifferent silviculture, destitution of distinctive ideas for processing).

The Aristotlean belief was that nature could be explained by self-evident principles, whereas Newton argued that fundamental concepts had to be founded, not on self-evident notions but on notions that would turn out, in their consequences, to match the experimental facts. The shortcomings of clearwood lay not with the idea - it was elegant in its simplicity - but with the execution and the disregard of the possibility that there might be underlying complex issues. Blame others for their failure to prune and thin 50% of the forest estate. Blame yourself for ignorance that low stiffness and spiral grain will distort the finest board, that compression wood will be distributed randomly in the straightest tree, that within-ring checking and resin pockets are not just a "Canterbury problem". The failure was not with the idea, it was the total lack of rigorous investigative scrutiny; the failure to test the idea for 20-30 years; the failure to seek out and welcome discordant opinion.

Thus the third challenge is to balance the forest portfolio, with say 30% of the resource in superior species. New Zealand has failed to progress any hardwoods - eucalypts (quality sawlogs in 12-15 years) or possibly even

Figure 1. For young trees there is a threshold microfibril angle at around 25-30o that for softwoods is a glass ceiling, while for hardwoods is a firm floor. The data relate to Pinus taeda (Yang et al., 1994) shown as large dots and various Populus clones (Shengzuo Fang et al., 2006) shown as small crosses.



the New Zealand red and silver beeches (denser, stiffer, stronger and more beautiful) - and has done little for the cypresses and redwoods (light, stable and durable), where the research has been too slow and miserly. Despite being blind to the limitations of pine - and all species have their limitations - we have too readily reeled off the problems associated with specific eucalypts or cypresses. After investing around $1 billion on research over the last 50 years we have crystallised the opportunities for pine, only to find that like an indulged only child, radiata has fulfilled its potential without fulfilling its parents' dreams (Table 1). Forestry held to pine because it could imagine nothing better. Yet a scheme that is admirably adapted to a half-million hectare estate may be utterly deceptive when the objective becomes one of filling a large empty space on the landscape. In comparison, our investment in alternative species has been tawdry.

The nature of this third challenge is uncertain. It could be simply a biomass-to-biofuel programme that seeks to utilise a polymer composite specifically created to resist biological and chemical degradation. Here hardwoods are preferred to softwoods, because they break down more rapidly in most biofuel or pulp digesters - hardwood lignin is less heavily polymerised. This is the opportunity that Genesis R&D Ltd is seizing in growing low-cost, hybrid willow on a 3-4 yr rotation around Lake Taupo (Snowdon *et al*., 2006): for New Zealand as a whole *Populus* might be a better choice because it has been selected as a model system by the US Department of Energy's Joint Genome Institute (DOE, 2006).

In the southern hemisphere a more logical genus would be eucalypt. Probably two distinct, parallel populations will be needed - one for biofuel and pulp, and the other for a 10-15 year rotation for consistent quantities of quality lumber with high-yield biofuel or pulp as the byproduct. With pine a single population is enough because what is good for one industry is largely good for the other. Not so with eucalypts, where distinct populations may be needed since characteristics optimal for biofuel and pulp appear to be the antithesis of those needed for solid wood and *vice-versa*.

Clausewitz observed of Borodino that Napoleon preferred to content himself with a half victory, not because the decision was in doubt, but because total victory would have cost him more than he was able to pay. Equally, our industry cannot afford another 2 million hectares of unimproved pine by 2025 (NZFOA, 2006). To insist on Kyoto credits or afforestation grants merely to plant an additional 100000 ha/year of unimproved pine is to succumb to a balmy idea - for forestry and for New Zealand. Just because something is a good idea, it does not necessarily follow that more of it is a better idea. For Clausewitz moral force (read: individual/ industry conscience, courage, esprit, resolve) is among the greatest of factors in deciding the outcome of any campaign, so when that is exhausted it is imperative to retreat until the balance of power is re-established. The new grounds for further plantings must be fresh ideas.

The Stern report on climate change has been criticised on two contrary grounds (*The Economist*, 2006). Stern argued that future generations are almost as important as the current, discounting their welfare by a mere 0.1% a year: higher rates, such as apply in forest economics, would be unethical. At the same time Stern gave too little weight to consumption by the poor, deeming a dollar to be worth only ten times more to someone whose income is ten times less. Strong necessity strives for the right balance; as we must for pine relative to other species.

Granted that other species require far more skill in site selection, whereas radiata is unusual in its ability to thrive almost anywhere. However in terms of outcomes, all industry wants is denser, stiffer and more stable lumber from shorter rotations - and much less variability. Logically these features are better found in young hardwoods, where a dollar spent ought to be worth more than a dollar spent on pine. An inclusive, realistic vision for forestry by 2025 would use some afforestation grants to fill empty spaces on the landscape with a new generation of short rotation hardwoods together with intrinsically improved pine. There are so many opportunities and so many things we should be doing now.

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