A REVIEW OF FAST-GROWN PLANTATION PROGRAMS IN CHILE, URUGUAY, BRAZIL, SPAIN, PORTUGAL AND SOUTH AFRICA

RICHARD B McCARTHY

1992 GOTTSTEIN FELLOWSHIP REPORT

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The Joseph William Gottstein Memorial Trust Fund was established in 1971 as a national educational Trust for the benefit of Australia's forest products industries. The purpose of the fund is *"to create opportunities for selected persons to acquire knowledge which will promote the interests of Australian industries which use forest products for the production of sawn timber, plywood, composite wood, pulp and paper and similar derived products."*

Bill Gottstein was an outstanding forest products research scientist working with the Division of Forest Products of the Commonwealth Scientific Industrial Research Organization (CSIRO) when tragically he was killed in 1971 photographing a tree-felling operation in New Guinea. He was held in such high esteem by the industry that he had assisted for many years that substantial financial support to establish an Educational Trust Fund to perpetuate his name was promptly forthcoming.

The Trust's major forms of activity are,

1. Fellowships - each year applications are invited from eligible candidates to submit a study programme in an area considered to be of benefit to the Australian forestry and forest industries. Study tours undertaken by Fellows have usually been to overseas countries but several have been within Australia. Fellows are obliged to submit reports on completion of their programme. These are then distributed to industry if appropriate.

2. Seminars - the information gained by Fellows is often best disseminated by seminars as well as through the written reports.

3. Wood Science Courses - at approximately two yearly intervals the Trust organises a week-long intensive course in wood science for executives and consultants in the Australian forest industries.

4. Study Tours - industry group study tours are arranged periodically and have been well supported.

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IMPLICATIONS FOR THE AUSTRALIAN FOREST INDUSTRY IN TERMS OF PRODUCTIVITIES AND ECONOMICS

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June 1994

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Over seventeen years, Mr McCarthy was Operations Manager for APM Forests with responsibilities for all land management, harvesting and related tree growing activities over some 80,000 hectares of plantation lands. He was also involved in all aspects of farm forestry and landcare and is a foundation member of the Gippsland Regional Landcare Committee.

He began his career as a cadet forester in 1963 for the Department of Forests in PNG. Initially he was responsible for large scale resource investigations. Four years later he was appointed District Forester in the Bulolo-Wau area of PNG, responsible for their reforestation program.

In forest education, he was Senior Lecturer in Forest Management at the PNG Forestry College in Bulolo. He spent two years as a scientific education instructor with the Pacific Islands Regiment in Lae, PNG.

After completing his M.Sc. in Forestry Management at the Australian National University, Canberra, (thesis topic: "A review of Farm Forestry, Problems and Possibilities in Australia"), he undertook an Australian Government consultancy to plan and establish a teaching forest at the Forest Faculty at the University Pertainain in Malaysia before joining APM in 1977.

His work has been widely published and broad experience in forestry has been recognised as a member of two World Bank missions to Sri Lanka and the Solomon Islands to review their forest sectors in 1989; the awarding of a Gottstein Forest Industry fellowship in 1992 to review the economics of fast grown plantations in Chile, Uruguay, Brazil, Spain, Portugal and South Africa compared to Australia; and until recently chairmanship of the Victorian Division of the Institute of Foresters of Australia and as a member of the Australian National University's Professor Eric Bachelard's Faculty review committee on forestry education.

In his consulting capacity, Richard McCarthy undertakes assignments in all areas of forestry such as policy and strategic planning; natural resource management; plantation establishment and management; farm forestry; resource evaluation; land use studies; forest and grass fire protection; training and occupational health and safety studies as well as environmental audits and impact studies; land care advice; environment management; land rehabilitation and revegetation.

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I would like to thank the many people who so willingly gave of their hospitality and time during the tour.

R.B. McCarthy
February, 1993

PREFACE

The world's forests, separated by great distances, controlled by disparate political systems, and distinguished by different ecological characteristics, are increasingly linked through international trade and the global effects of environmental degradation. Australia is at the crossroads of forestry development, with the painful experience (economically and socially) of changing from natural wood resources to plantation-grown resources. The key elements of structural change in the forest industry are related to a variety of issues concerning demand, supply and international trade in forest products.

Plantations in many other countries are already becoming increasingly important as a source of both industrial wood and fuelwood. Australia has the land, the expertise, and the potential to become a dominant force in world international forestry as a grower, processor and exporter. The question must be, 'Are we prepared — financially, socially and physically — to become that dominant force?' The findings from this review, which concentrate on the silvicultural activities of private commercial tree-growing in terms of productivities, should help the Australian forestry sector to decide.

Under the auspice of the Gottstein Fellowship, the author was able to visit those countries which have the greatest concentrations of fast-grown plantations (those with an MAI exceeding 12–15m^3/hectare and grown on short rotations), especially eucalypt, to undertake a review of the economics of wood production in terms of cost and growth rates. To assist in carrying out the review, a survey format was designed to provide a standardised assessment of each organisation and help define the level of plantation management for each organisation.

The significance of historical development of trade was assessed, and the bearing it had on the development of the forest industries and the development of plantation zones in each country was determined.

Recommendations are made in relation to (1) Australia, (2) Victoria, and (3) individual organisations such as APM Forests, on what each should be doing to be internationally competitive in forestry and the directions they should be following to achieve or maintain that international competitiveness.

The outcome of this study was not simply a comparison of cost and growth rate data by countries and regions and individual organisations, but *how*, within their framework, they achieved their results.

R.B. McCarthy
February 1993

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THE CHANGING FACE OF FORESTRY

CHANGING RESOURCES

Australia occupies one of the driest and most treeless continents. It has one of the most politically stable land tenure systems, a land base least affected by human threats, and the physical attributes of a dry climate coupled with sufficient water for tree growth.

It has the capability to produce, in half the time of the northern hemisphere and the tropics, wood with acceptable properties (basically, wood density) suitable for all forms of value-adding processes. Australia therefore has the capability to become one of the leading resource and forest products producers in the world.

Australia for too long has had its forestry approaches blinkered by a perceived abundance of old-growth forests, which have never belonged to the forestry industry because they are owned by all Australians. The last decade has shown the effect on the industry's resources when the public decided they wished to use their forests for other things.

Florence described this dilemma of Australian forestry, yet few people understood his conclusions and fewer people reacted to them.[1] Today the industry has lost much of its old-growth forest; the public owners are now firmly convinced that old is beautiful, Australian hardwood sawmilling has declined, and little new forest has been created for the survival of industry. Florence described Australian silviculture as knowing much more about the dynamics and management of even-aged stands of introduced conifers than about native hardwood species.

The plea of the rational conservationist has been for good forestry practices. The last few years have certainly seen consistent community concern about certain forestry practices, which are similar from one country to another. They include:

- Clearing native vegetation to establish plantations.
- Killing native browsing animals which affect plantation growth using poisons such as 1080.
- Bad roading practices (causing damage to community roads by log truck traffic and affecting water quality from road runoff).
- Harvesting complete catchment areas and destroying drainage lines, which affects water quality.
- Overuse of chemicals and fertilisers.
- Burning practices such as slash removal and fuel reduction burning.

The change in public perceptions, whether self-generated or influenced by the media, has resulted in the pool of old-growth native forest being less accessible to industry. The future hardwood resource is now predominantly even-aged regrowth stands resulting from silvicultural clearfalling practices of the 1960s (and, perhaps,

1 Florence (1988)

hardwood plantations of the future). Australian forestry companies have been forced to become dependent on smaller diameter trees and regrowth forests. They are being forced to consider creating and owning their own forests rather than again being dependent on public forests for their resources. That is, they must become forest *owners* if they are to survive.

Why have we reached this position? Since European settlement we have been drawing on old-growth eucalypt-dominated forest for most of our wood supplies. In managing these forests we have been concerned primarily with regeneration techniques or with the careful husbandry of existing growing stock to maintain the supply of sawlogs to industry. There has been little motivation for foresters to develop sophisticated silvicultural regimes for regrowth forests when there has been little likelihood of a market for small piece sizes. There has, and continues to be, little real encouragement from local government to establish tree crops on private lands as an 'as of use right' similar to agricultural pursuits.

CHANGING LAND MANAGEMENT

It is not only commercial forestry that is at the crossroads in Australia. Throughout the countryside a quiet revolution is occurring through programs and acitivities such as Landcare. Groups of private landowners are cooperating to rectify some of our past mistakes in poor land management. This has lead to an upsurge in tree planting as Australians realise how vital to this country are its woodlands and forests. It is interesting to consider whether these plantings will be sufficient to create an industrial wood source.

Much of the cause of the dire environmental problems in Australia (and overseas) has been in the wholesale destruction of trees. Farmers only realise the effects when topsoils blow away and paddocks and hill slopes erode, when salt-bearing watertables rise and turn once fertile land into salt pans; when improved pastures turn sour; and when rivers flood and turn saline and town water supplies are threatened.

Foresters only realise the effects when industrial wood using plants close because of a failure in wood supplies; when newly trained foresters cannot find employment; when other materials erode the historical timber markets; and when consumers turn to other materials for traditional timber uses because of their desire to protect the environment.

CHANGING MARKETS

The major markets are now in reconstituted wood fibre products. This is predominantly wood pulp, which is traded internationally. Other countries having exhausted their supplies of old-growth and have turned to plantations to provide wood pulp and, not surprisingly, obtained a better product in terms of quality, productivity and cost.

In relation to sawmilling, the Australian sawn timber market already has had a significant proportion (30%) of eucalypt wood replaced by *Pinus radiata* from Australian plantations. This is hardly surprising, as one of the reasons Commonwealth funds were sought by the State Forests Services was for funding an enormous long-fibre plantation program in the 1960s and 1970s for wood pulp and to replace or reduce the dependence for sawn timber on the native eucalypt resource and sawn timber imports. What will Australia do with its regrowth forests, which have always been managed on a sawlog regime, if there is a serious decline in the Australian hardwood sawmilling industry?

In 200 years, Australia has moved from a nation which believed it had sufficient natural forest forest resources to one which realised it has little. Ewing, in reviewing trends in the international forest industries sector, reported that we have seen demand for all forest products increase over the last 30 years but the pattern of growth has differed from product to product.[2] Sawn wood is becoming of decreasing importance in the world economy while panels increased in importance in the 1950s and 1960s even though demand for panels is now close to overall world economic growth. The development of alternative materials to sawn wood (panels) and slower population growth has resulted in this reduced sawn wood demand.

The challenge for the Australian forest industry, if it wishes to survive, is to establish its own plantations and to grow wood for a range of markets rather than for a single product, removing the uncertainties of the single-product markets. A bigger challenge for the industry is that, if it is to create new forest resources to compete in world markets, it must become competitive; even meeting domestic demand may not be economic in comparison to purchasing wood or wood products from other efficient producers. (Australia already imports one third of its annual wood supply. A large proportion of its forest industry is now involved in marketing imported forest produce.)

These changes in turn require a greater focus on management regimes for even-aged stands and plantations of native eucalypt species. But while there are growth plots and thinning studies for most of the commercial species, they do not provide a good data base for definitive studies on stand dynamics and thinning responses. There are limitations relating to experimental design, inadequate growth records,variable measurement intervals at critical periods and so on.

Little work has been done on the effect of silvicultural practices on wood quality — essential data for producing saleable plantation or even-aged stand wood. It is possible to develop a preliminary perspective of the silvicultural attributes of eucalypt forest stands, but only from overseas experiments.

What have Australian foresters been doing? According to Professor Henry Nix,[3]

'The largest eucalypt plantations in the world are in Brazil and South Africa — not in Australia. If we want to find out something about eucalypts, we have to go there. South Africa has very advanced technology for dealing with young eucalypts while Australia's is very antiquated. This is why our Forest Commissions won't look at young eucalypts as a proposition for plantations... Even with *Pinus radiata*, Australia has most to learn from Chile and South Africa.'

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2 Ewing (1988)

3 quoted inter alia in the *ANU Reporter*, 23 February 1990

Nix is correct in relation to eucalypts but not *Pinus radiata*. Australia can tell others much about *P. radiata* especially in dryland *Pinus* silviculture, and — while Australians might not like to admit it — New Zealanders also know about *P. radiata*. If anyone ever produces 100 or 200-year-old eucalypt plantations, we could advise them on how to maintain those plantations.

But the demand for wood fibre in the world is now greater than ever before. It forms an integral part of everyday life. Will Australia be able to capture some of that market demand?

WORLD WOOD DEMAND / SUPPLY

Australia imports one third of its forest products requirements. But it is not clear where it will get its future wood supplies, given that eventually public pressure could prevent any cutting of native stands.

In this review of plantations in selected areas around the world it was most apparent that there is little surplus wood. The majority of larger growers have ensured or are actively pursuing the strategy of becoming more self-sufficient in wood.

Since the world has yet to reach the finite market capacity for short fibre, where can Australian producers obtain additional long term supplies? The author examined Uruguay in some detail. Here, where climatic zones are similar to those in Australia and there are large tracts of flat land and encouraging government incentives, short-term seven-year rotation crops could be implemented. And with its small population, there would be little pressure on any forestry project. Major growers from Chile, which is now fully saturated with wood fibre development, are moving to Uruguay to grow their produce as well as capitalising on shipping routes east or west from Uruguay. Uruguay was the only area which offered potential for producers short of wood fibre to become self sufficient.

The potential exists right now for Australia to grow as many trees as possible. It is just as important to grow *Pinus radiata* as eucalypts, because the world will again arrive at a finite market capacity level for short fibre. The world is still desperate for structural material in the longer term. This is where Australia's *Pinus radiata* dry-forest regimes can make Australia a leading resource for the world market.

Australia has the potential to be a major producer in forest products. However, it will continue to lose its market share in commodity product markets where it is poorly supported by intensive plantation resources. These signs are in Australia now with the deteriorating woodchip export sales and the decline of our hardwood industry due to their dependence on public native forests rather than intensive plantations.

Table 1 details forest production from those selected countries who have become the major wood suppliers to the world. Each of the areas and industries are categorised by log type production and forest product type, production, and destination.

SILVICULTURAL REGIMES IN OTHER COUNTRIES

The data in Table 1 can be used to determine the level of management of the silvicultural regime — the purpose of thinning (if it is performed) and what the thinnings are used for. It is clear that, throughout the world, the most sophisticated silvicultural regimes are those where thinnings are involved. In all the areas visited, thinnings were only performed for the production of sawlogs. From the growing

Table 1 Forest production from selected countries.

	Plantation Clearfall Volume 10^6 m^3	Total Production Roundwood 10^6 m^3	Fuelwood 10^6 m^3	Market
CHILE				
CMPC	3.72			Pulp, paper, sawlog
Arauco	4.538			Kraft pulp;sawlog export
Shell	(Eucalypt establishment only)			
Forestal Valdivia	(*P. radiata* establishment only)			
National Total		16.4	6.2	
URUGUAY				
National Total		2.7	2.4	
BRAZIL				
Pisa–Florestal Newsprint Mill	1.0 (0.42 pulp)	1.0	0.5	
IKPC-Klabin	1.8			Pulp, paper, newsprint, sawn timber
Paper e Cellulose Catarinense (71% Klabin)	0.72	0.72	0.1	Kraft pulp, sawlog, fuelwood
Norcell	0.49	0.49	0.09	Export, pulplog
Aracruz	4.5	4.5		Eucalypt kraft pulp
National Total		238.0	172.0	
SPAIN				
Ceasa	0.54	0.54	0.54	Eucalypt kraft pulp
National Total		16.5	2.3	
PORTUGAL				
Sorpocel	1.3	1.3		Eucalypt kraft pulp, paper
Celbi	0.75	0.75		Eucalypt kraft pulp, paper
National Total		8.4	0.6	
SOUTH AFRICA				
Sappi	6.0	6.0 (+0.7 chips)	timber	Pulp, paper, sawn timber, mining
Mondi	3.4	3.4	timber	Pulp, paper, sawn timber, mining
HLH	1.6	1.6	sawn timber	Mining timber, hardwood chip,
Hans Merensky	0.85	0.85		Sawlog
USUTU	0.72	0.72		Unbleached kraft pulp
Satga CTC	0.55	0.55		Growers Association: chip export
National Total	15.6	15.6	0.24	
AUSTRALIA				
APM Forests	0.7	1.4		
National Total		11.47 (native euc.) 6.15 (softwood)	0.28	
NEW ZEALAND				
National Total		11.4 (softwood)		

viewpoint it is expensive to produce sawlogs. With *Pinus* species it is well accepted to have a 20 to 30-year regime.

The majority of eucalypt plantations visited operated on a 6 to 9-year-old regime, followed by one to two coppice crops where no thinning was practised for the production of pulpwood. It was only in South Africa that two organisations were thinning eucalypt plantations for the express purpose of producing sawlogs with a rotation length of 15 to 20 years.

MARKETS FOR FOREST PRODUCTS

Market location for plantation products has an important bearing on the present economics of the plantation enterprise, but there are very few instances where the plantation resource was actually *developed* for export markets. (An exception is Aracruz in Brazil.) This continually leads to a skewed economic comparison, because the exports are actually sales of produce surplus to domestic demand. In all cases, domestic consumption appears to be the most profitable niche.

Most of the plantations visited were developed for domestic purposes, for employment, to ensure that the country became self-sufficient in wood products, or because subsidies existed which encouraged private plantation development.

In relation to export markets, generally only clearfall wood suitable for conversion to sawn timber is exported in solid form. The shipping of pulpwood round logs is minimal because it is so expensive to ship.

The trends that are discernible in those countries that have become dependent on export earnings are as follows:

1 Individual companies work closely together under an industry association to develop:
   (a) trade and market information for customers;
   (b) self-regulation by insisting on strict standards; and
   (c) a very efficient marketing arm within the association.

2 The information available to the exporter or buyer vastly improves in standard and presentation.

3 As the plantation industry for each country develops and as the country becomes totally dependent on the plantation resource for domestic and export wood consumption, the range or multiplicity of log grades and markets develop.

4 As the plantation wood export industry grows, the forest industries have become one of the main catalysts in overhauling the stevedoring, port and shipping sector of individual countries. e.g.Chile and New Zealand.

5 World-wide, there is still much work to be done in the allocation of wood to specific markets from according to its position in the tree as well as rating those pieces of wood by density.

No one has yet developed an ideal system concerning where log sorting should be carried out to maximise each log's value. The New Zealand system of trained log makers on the landing is the best attempt yet to resolving this dilemma.

Coupled with the above, there is still the need for work to be done on the effect of silvicultural practice on wood quality.

WORLD-WIDE TRENDS

FUELWOOD

The greatest use of wood is for fuelwood for domestic and industrial energy. In the countries visited, much of the remaining natural forest stands are being destroyed, not by the pulp industries, but by fuelwood harvesting and by both subsistence and intensive agriculture.

No one really knows how much wood is used for fuel because so much pilfering occurs. Many industries visited employed 100 to 200 forest guards to protect their forests and keep squatters out. The squatters take over a forest area to practise their subsistence agricultural activities, for it only in the forest where there is sufficiently fertile soil for producing agricultural crops (e.g. government plantations in South Africa).

The challenge to the rulers of any country is to be able to harness the resources of the country sufficiently to re-establish trees on those areas denuded of tree cover, in order to replenish soil nutrient status depleted by subsistence agriculture and to provide fuelwood for the majority of the population. In the tropics and Africa the ameliorating effect of tree cover is most dramatic.

The world-wide trade in fuelwood trade could be in the order of US$7 billion (this may still only be half the trade), with perhaps 2 million people employed full-time in producing and marketing fuelwood.

In Brazil, with low fossil fuel reserves, so much fuelwood is used for industrial energy that the country is probably at the stage of being deficient in wood. It is not a surplus, as much as much of the world believes.

EFFECT ON WORLD'S POOR

With a wood shortage imminent in the world, it will not be the pulp industries that will suffer, but the poor people. They have no funds to purchase wood. Their nations' natural forests have been greatly reduced by clearing for agricultural activities such as cattle grazing, subsistence agricultural pursuits of clear and slash burn for food production; and timber products.

Many of the remaining national natural forests are now closed to the poor, because richer nations have provided funds to purchase those forests for their ecological and biodiversity attributes.

Although there is an enormous demand for fuelwood since there has been little money to purchase fuelwood, there has been no real private sector development of fuelwood plantations, i.e. they are not economically viable in international terms. Each individual government sector must give direction and assistance in this area.

However, there are markets waiting to be developed, including:

- The development of better stoves which use less fuel, are more efficient, and much less harmful to human health and hence the environment in general. (A saving per person per year of fuelwood if purchased of some US$25–100 per year is easily conceivable).
- The development of fuels from forest wastes such as sawdust mixed with coal, for example as a briquette. The binder could be the lignin that is extracted from pulpwood. However, energy is needed to dry sawdust and coal before they can be bound as a fuel.
- Low-cost agroforestry fuelwood markets.

There is tremendous potential for Australia to greatly expand its tree-growing activities to produce fuelwood for this world-wide fuelwood demand. Australia has an enormous number of fast-growing fuelwood species (proven from when they fuelled the mining batteries and steam trains and before electrification of the country) which we should be cultivating. With our vast land area and secure land tenure system, we could become a dominant force in the world fuelwood resource trade.

However, one problem will always be there. Will people have the ability to pay for the fuel produce?

MARKETS FOR PRODUCE

Around the world, the majority of sawnwood exports are to Japan, Korea and Taiwan. Pulp and paper products are traded throughout the world. Panel product trade is predominantly to Japan. Details of this trade are available if required.

POLICY ISSUES IN RELATION TO THE WOOD RESOURCE

SHIFT FROM PUBLIC TO PRIVATE OWNERSHIP

There is a major shift occurring in forest ownership from the public to the private sector. In every country, private industrial plantations had very definite and clear goals for plantation establishment and the management and marketing of forest products.

SUCCESS OF EUCALYPT PLANTATIONS OUTSIDE AUSTRALIA

The immense economic success of eucalypt plantations outside Australia has been due to the development of 'designer tree' plantations for specific sites and markets through a combination of techniques such as plant cloning, hybridisation, genetic improvement programs and cultural activities.

EFFECT OF FINANCIAL INCENTIVES

Direct financial incentives introduced specifically to encourage tree planting have worked (although critics will always find flaws); for example, Brazil now has 3 million hectares of industrial plantations.

The incentives in some countries have been small compared to the value of goods generated. e.g. in Chile since 1974, subsidies that cost US$50 million per year had by 1984 produced an industry generating US$400 million per year.

FOREST ACCOUNTING

Standard economic accounting for industrial forestry enterprises has not yet been devised anywhere in the world.

MANAGEMENT OBJECTIVES — NATURAL FORESTS

The management of the natural forests is moving to that of conservation and watershed protection. The problem is how to manage the local inhabitants who have

a legal right to collect especially fuelwood from those areas and to co-exist with subsistence agricultural practices.

INDUSTRY DEVELOPMENT ASSOCIATIONS

As a country's dependence on its forest plantation exports grows, there is an associated development of trade policies, growth of forest industry associations to help market the produce, and an overhaul of the shipping industry for the movement of forest produce.

Australian government agencies do little to assist the forest export industry: Austrade does not even understand the Australian industry. There is no one central organisation planning, leading, controlling or directing strategies for the development of a viable forest industry in Australia.

In the private sector, the National Association of Forest Industries has been more involved in resource security over natural forest than over developing new plantation forests.

SUPPLIES OF SHORT-FIBRE WOOD

Many in the industry consider that there may well become a glut of short wood fibre for the more economic products , because much short-fibre wood is being grown and marketed around the world. Coupled with the use of recycled fibre, there has been a dramatic drop in the price of short-fibre wood, which may well herald a maturing of that market.

If there was to be a breakthrough in new processes for the use of long-fibre wood (for example, a new use for tissue product or the withdrawal of short-fibre resources in rich nations for environmental reasons), then the next major wave of development in the plantation forest industry may well be in a resurgence of softwood plantation development.

Australian softwood sawmilling industry should not be embroiled in a savage price-cutting,resource-wasting sawn timber war. Around the world, there are no large trees available within plantations for sawn timber products other than the *Pinus radiata* resources of New Zealand, Australia, Chile and South Africa. Perhaps only Australia has the most uncommitted resource. To capture external markets, Australia has only to take advantage of the excellent market development that New Zealand has performed in the Pacific.

The domestic price war in Australia is being wrongly interpreted as a policy of no future plantings of *Pinus radiata* and an even lesser consideration for expanding these plantations. This raises the question as to how future markets for softwoods can be supplied.

PULPWOOD PRODUCTION FROM PLANTATIONS

In the utilisation of the eucalypt resource around the world , the dominant countries are growing and marketing only one product — pulpwood. Given that there is a finite level of production for any product, Australia should not grow plantations only for pulp, but continue its philosophy of silvicultural regimes that produce a range of products. Because of its dry climate, Australia can use regimes that produce small, high-quality products at an early age. To overcome any inherent difficulties in converting round logs into market products, the Australian industry should be researching building construction methods using round poles. The strength characteristics, longevity and other desirable features are easily met by this product, and it is cheaper than the alternatives. Methods of drying are already being developed to overcome end splitting.

CREATING PRODUCTS FOR GENERAL CONSUMPTION

The forest industry around the world needs to ensure that it is always creating a product which is affordable for general consumption. It needs to take heed of what has happened in the world energy and metal sectors; for example, the rise in prices of energy and metals in the 1970s encouraged efficiency gains and substitutions that ultimately reduced the growth in the demand of those materials.

The forest industry's real contribution to human welfare and to the environment is that its products are natural, renewable resources that are economic to produce and the scarcity can be overcome by harnessing other natural phenomena to create them. Scientifically, the industry is able to continually demonstrate natural resource and environmental accounting. But if the forest industry products become too exhorbitant in price, then people will change to other materials, such as steel framing for houses.

INDUSTRY ASSISTANCE FOR AGRICULTURAL INTENSIFICATION

If the forest industries were to assist in the development of processes for agricultural intensification, there would be a lessening of pressure on the forest (i.e. clearing for agricultural food production) and there would be more agricultural area available to plant trees.

The expansion of agriculture is one of the main reasons for deforestation in the temperate and tropical regions of the world. There needs to be an enormous scientific effort into areas as continuous crop rotation, legume-based pastures and agroforestry. In Gippsland alone, if APM Forests (a subsidiary of Australian Paper Manufacturers) was to do more work on pastures throughout the year — work on the palatability of native species as well as imported ones — there would be more farmland available to plant trees as a commercial crop.

Coupled with this work on pastures must also be work in the areas of integrated pest management and bioengineering of crop varieties. Natural resource growing industries must always be looking for alternatives to the need to use chemicals. Throughout the world , forest plantation development triggers alarm bells in people's

minds or in public forums where forestry practices are being discussed. There is a real need to do proper risk assessment.

There is a huge market opening up for natural herbicides, insecticides, fungicides etc. But currently researchers are working against outdated government regulations and often meagre returns on investment.

Intensifying the use of farmland to grow industrial tree crops can be a highly profitable venture but farmers must be given the right to own, cut and sell them at fair market prices.

PRIORITY FOR WOOD PRODUCTS

No country visited had any real priority for wood production as an objective of forest management. New Zealand and South Africa now practise this philosophy to some extent, although their plantations were not intended to meet such objectives.

Purey Cust (1992) highlighted the phenomenon which appears commonly spread throughout the European and American developed countries: supplier countries must conserve their forest resources, but it does not matter if the currently richer nations do not.

Purey Cust describes accurately how those supplier countries see this phenomenon. He uses the United Kingdom as an example. The UK spends £7 billion per year on wood imports (50 million cubic metres), mostly taken in unsustainable fashion to the detriment of other people's forests.

The justification given for this continued destruction is that it is uneconomic in terms of Treasury guidelines (based on the internal rates of return (IRR) to grow trees in the UK), that very little imported wood comes from the tropical rainforests (most from temperate forests), and that the forest 'need' of a developed country is for parks and habitat, not the satisfaction of its resource demands.

Yet the UK itself was once 90% forested and had the best forest climate and soils in Europe. It has reduced its forest cover to 5%, with another 5% in generally despised plantations, well below the EEC average of 25% and ahead only of Holland and Ireland. It now urgently seeks to cut back the agricultural binge of the post-war years and hesitantly includes hints that trees might have a place in the list of alternative options. Little is currently being done. A second example in the UK was the proposed scheme for the generation of power using tidal barrages. Again, local environmental objections and a failure to meet long-term Treasury guidelines stopped the project. Another example in the UK was the failure of wind-generated electricity production.

In all three cases, sustainable resource use was rejected outright without hesitation or apology. The assumption is that whatever is needed will continue to be supplied by other countries, and that it is there that the responsibility for sustainable resource use lies. An army of missionaries fans out through the third World bearing that message.

Not surprisingly this moralistic view causes increasing irritation in the developing world; if 5 % forest cover is enough for the UK, why, they argue is it not good

enough for Brazil, Indonesia, Malaysia? If the UK, consuming vast quantities of imported wood, sees no reason to either abate its demands or provide for the future and equates economic forestry with primitive behaviour, why should they not take the same view. After all, they all started out with a 90 % cover of natural forest. Table 2 provides an interesting comparison between the UK and Japan, two of the largest importers of wood products.

Table 2 A comparison between two of the largest wood importers.

Statistic	Japan	United Kingdom
Land area	37.8 million ha	4.5 million ha
Population	123.1 million	57.2 million
People/ha	3.3	2.3
% forest cover	67%	10%
Annual wood consumption	108.5 million m^3	54.5 million m^3
Annual per capita wood consumption	0.88 m^3	0.95 m^3
Source of wood supply		
Homegrown	30.5%	11.7%
Imported	69.5%	88.3%

Statistics such as these raise questions in people's minds: Will there be a reversal of wood supply zones in the future? Who is actually destroying the world's forests while protecting their affluent lifestyle? Will these countries start to utilise their own forests?

The current selfishness of the Western world could become extremely detrimental to those supplier countries if we were to see an resurgence in the use of Beech as a plantation species in Europe; or the development of a cold-tolerant eucalypt strain to grow in these areas. Apfelbeck (1985) reported that there could be an excess of 10–16 million hectares of farmland available in the EEC countries by 1990 available for tree cropping. (Due to planning scheme restrictions, these areas must be retained under rural pursuits.)

DEMAND FOR WOOD PRODUCTS IN THE WESTERN PACIFIC RIM

For Australia there is a real demand to be met for wood products in the Western Pacific Rim. There are 1.5 billion people living along side the Western Pacific Rim whose consumption has been artificially repressed. They are now looking for fibre supplies. These countries will show the highest growth rate and the weakest domestic position from a resource base to meet this growing demand.

Australia has the land base and the expertise to establish these plantations. The Federal Government National Plantation Advisory Committee (1991) reported that in Australia there were about 1 million hectares of land that are suitable for the establishment of plantations and marginal for intensive agricultural purposes.

EFFECT OF TRANSPORT COSTS ON COMPARATIVE ADVANTAGE

In time, unless shipping costs can be reduced (with the shipment of green wood, much water is being transported around the world), with rising labour costs in the developing countries and a fall in the labour costs in western countries; the comparative advantage to those current supply countries such as Chile and Brazil, could be removed. It may also be that there will be massive plantings of fast-growing species in Europe such as Beech or a cold-tolerant eucalypt.

Although Spain and Portugal have antiquated systems and high wood costs, they are so close to the European market that they are able to survive and make money because of the reduced transport costs to the main markets. If efficiencies could be obtained in terms of forest practices, land tenure and the success of designer trees such as *Eucalyptus globulus / camaldulensis* hybrid (for mass clonal production), Spain and Portugal could become the woodshed for the European market.

ADOPTION OF INDUSTRY STANDARDS

The advent of major international trading in wood products between countries has indirectly led to the adoption of similar industry standards within the major trading nations. eg. wood sales; product specification and standards; work practices; cultural techniques.

EFFECT OF POPULATION DYNAMICS

A review of the history of forest products trade reveals many interesting aspects of population dynamics . The wealthy have taken from the poor, but put little back in terms of replenishing natural resources. Plantation programs have only survived in sparsely populated areas and where there is little competition from agriculture.

Australia needs to determine where, within the country, there is a deficit of people and given suitable land and climatic attributes, implement plantation development in those areas.

RANGE OF PROFESSIONAL FORESTRY TRAINING

There is a range of professional forester training institutions within universities throughout the world. It is hard to understand why the teaching institutions have not come together to standardise forestry practices, reduce the output or attempt to combine scientific research on a world scale to examine mutual problems, such as nutrition of tree species or root morphology.

There appears to be a world-wide surplus of forestry professionals, and the technician area is basically uncatered for. This dilemma of Australian professional forestry could be readily rectified if all professional foresters around the world joined under one banner with one series of scientific publications. Electronic technology now exists to overcome the language barrier. Why can't we see the Society of American Foresters affiliating with the Institute of Foresters of Australia? Or through

the International Union of Forest Research Organisations (IUFRO)? The mechanism to achieve this has been accomplished already in the forest research area where world-wide forest research professionals come together through IUFRO. This would ensure the survival of the forester as a profession and encourage much greater professionalism throughout the world.

REVIEW OF HARVESTING SYSTEMS

INTRODUCTION

The sophistication and mechanisation of harvesting systems depends on the availability and cost of labour. As labour costs grow and domestic and export markets grow (depending on plantation resource size) and where the 'just in time' supply philosophy is practised; the mechanisation of the harvesting system increases. Similarly, transport becomes more sophisticated and cost-efficient.

Depending on the country's taxation laws, mechanisation is achieved through either importing the technology (e.g. Australia) or developing their own (e.g. South Africa, Brazil).

In all countries the chainsaw is used universally for felling, delimbing and cutting to length. The operation of chainsaws is as dangerous as ever, although it was apparent throughout the world that the Scandinavian methods of felling, delimbing and crosscutting were being followed.

Wherever eucalypts are grown for wood fibre , the removal of bark from the log is the major impediment to making eucalypt plantation cropping more competitive with agricultural fibre crops. No one has yet come up with an economic method of removing the bark. The latest Bell harvester viewed in South Africa demonstrates much promise.

In the areas visited, it was apparent that as markets grew and where the same export market was being supplied (due to economies of scale), harvesting and transport systems have been overhauled. For example, there is a change from short logs (one to two metres, which an individual can lift) to long lengths (four to five metres, which require mechanical means to lift them). This does not help the unemployed or conserve fossil fuels.

In the last decade little if any harvesting research has been undertaken in the world, even though harvesting forms the greatest component of the delivered wood cost to the mill door. This is where young professional foresters could be put to the greatest use, performing long-overdue basic research into harvesting systems, e.g. time and motion studies.

Similarly , no one is researching the transport of forest produce. Industry must address the issue of minimising the effect on the community of moving its produce, on the community locks up its roads as it has done with their native forests by more research and better practices in relatin to:

- custom designed log trucks (not just highway vehicles);
- reduced road damage;
- adeuate and equitable payment for use of roads.

CHILE

PINUS

In Chile, all trees are felled by chainsaw, delimbed on site or at the landing. Trees are extracted by forwarder; cable systems; skidder; oxen; and manually. Tree lengths are cut into desired log lengths at the landings. Log lengths are in 4.1 metre lengths to suit the export log and export sawn timber market. Because of small growers some 2.1 metre log lengths are still accepted although pulp companies hope to phase this out.

Costs quoted include US$34–39/$m^3$ for logs delivered to the mill. Costs quoted for log export were US$ 29/m^3 plus US$ 6/t for loading. Some export logs bring US$45/$m^3$.

Logs are sorted into domestic sawlog (sawn produce exported), domestic pulplog, export sawlog, veneer and export chips.

EUCALYPTUS

In Chile, there has been a renewed interest by small growers and or investors to grow eucalypts for wood chip export to replace the woodchip export of the native *Nothofagus* forest. Species include *E. regnans, E. globulus* and *E. nitens.*

Trees are felled using chainsaws, delimbed and then cut into 2.1 metre lengths.(so people can lift them). Depending on the market,logs are manually debarked in the forest or taken to the mill where the bark is used as fuel. Logs are extracted manually, by forwarder or skidder or oxen.

Prices quoted for export eucalypt wood chips were US$ 25/m^3 solid which they stated as being equivalent to US$ 62/dry metric tonne. (Arauco export much Eucalypt). Shell is purchasing wood domestically. This has caused a shortage of eucalypt pulpwood and a consequent rise in domestic pulpwood prices quoted of US$ 38 to US$ 45/m^3.

URUGUAY

Uruguay is short of wood, so there is little harvesting activity except for fuelwood harvesting. Fuelwood harvesting is from small one to two-hectare woodlots of *E. camaldulensis* scattered throughout the countryside.

BRAZIL

PINUS

In the operations visited, all felling was done by chainsaw (although if they used axes it was cheaper but more dangerous). At Klabin, for first thinning, every sixth row was being removed. Trees were being extracted in whole tree lengths with Valmet farm

tractors which had been adapted to skidder configuration. Trees were then cut into log lengths at the landing. Other methods include manual extraction,skidder or forwarder. Log lengths were from 2.1 to 4 metres.

Klabin quoted costs as US$ 16/m^3 delivered to the mill door. This consists of

Harvesting	US$ 4–5/m^3
Loading	US$ 1/m^3
Cartage	US$ 5–6/m^3
Company costs	US$ 4–5/m^3

Average haul distance is 90 km. Truck loads range from 15 tonnes to 45 tonnes. All trucks were new Volvo or Scandias produced locally. Brazil manufactures more of these trucks than Sweden.

All debarking is done at the mill. *Pinus* bark is used as fuel to produce steam.

EUCALYPTUS

Although there are immense plantations of Eucalypt in Brazil, all growers practise a similar silvicultural regime with trees being clearfalled at around 7 years; followed by one to two generations of coppice before the area is replanted.

In terms of world scale, Aracruz sets the standard. In 1992, Aracruz estimates it will produce 4.5 million m^3 of wood (to produce 1 million tonnes of pulp) from clearfalling 10,224 hectares of its own plantations. Aracruz uses two systems:

Manual (chainsaw felling):
- cut into 6 metre lengths,
- forwarder extraction,
- trucked with bark to mill,
- productivity one man with chainsaw gives 20 m^3/day.

Mechanical (locally developed harvester):
- forwarder (locally developed),
- productivity 25 m^3/ha but aiming to get to 40 m^3/ha,
- logs 6 metres long,
- trucked to mill with bark on.; cartage is by road train or B double which has a payload of 52 tonnes and a total weight of 72 tonnes,
- cartage is on a 24-hour basis ,
- harvesters work 16 hours per day,
- within 4 years 90 % of wood will be mechanically harvested.
- trucked with bark to mill where logs are debarked,
- bark is used for fuel.

Aracruz wood costs for wood harvested within 25 km of the mill is US$ 13.33/m^3 delivered. For wood harvested from a 170 km distant plantation area the cost is US$ 22.94/m^3 delivered. The average delivered cost is US$ 19.74 /m^3.

Aracruz is the pacesetter in eucalypt production in Brazil. Other organisations visited have similar or more antiquated methods of plantation harvesting.

Due to the tax laws of Brazil, it is cheaper for the large companies to develop and have their harvesting equipment manufactured locally rather than to import it. The harvester operating in Aracruz's plantations has been developed in association with local machinery manufacturers.

A similar exercise is being carried out at Aracruz in relation to forwarders. Here they have purchased two locally made brands, 12 in total (six of each brand) which are being evaluated for their field performance following the completion of their latest expansion.

In terms of transport, Aracruz operates a fleet of road trains or B doubles to its chipper 24 hours a day. Although it has effected savings in its transport costs ,it still has a bottle neck at the chipper unloading site. — a problem which would be world-wide in the history of any large plant.

At the mills, the plants have installed debarkers although every debarker viewed was stopped and having maintenance carried out or being deblocked.

SPAIN/PORTUGAL

In these countries the system is manual felling and cross cutting to 2.1 metre lengths with chainsaws. Logs are debarked in the plantation using axes although some plants use the bark for fuel. Wood is extracted from the plantations (many are small farmer woodlots) using agricultural tractor prime mover forwarders. There is also some mechanical harvesting carried out but this was not seen (Sorpocel).

SOUTH AFRICA

EUCALYPTUS

In South Africa the basic harvesting regime is:

- trees are felled with chainsaws,
- logs are cut into 2.1 metre lengths,
- logs are debarked by women using axes (the men normally use the chainsaw),
- wood is extracted using forwarders to depots,
- wood is stacked, then then reloaded onto road trucks to be transported to the processing site.

PINUS

Fell with chainsaw, delimb, cut into 4 to 5-metre lengths and transport to processing site where the logs are debarked and sawn or chipped dependant on end use.

There are some interesting developments in South Africa in the mechanical harvesting area. With the increase in wage rates, industry is looking at mechanising harvesting operations. The latest Bell harvester for eucalypts shows much promise. It fells, delimbs and cuts to specified length.

An interesting trial was being carried out on flat country with a comparison of conventional logging systems to cable logging systems to assess the effect of soil compaction. South African soil scientists have shown by many root studies that there is a marked effect on tree growth, depending on whether its tree roots are within the soil compaction zone.

With the reduction in demand from the mining industry for timber, the increase in wage rates and the change of the political system to one person, one vote, the South African Forest Industry has embarked aggressively on overseas acquisitions to assist in selling their forest produce. This is already causing companies to review their core activities, reduce labour forces and dependent on wage increases achieve greater mechanisation. Given the scientific base of the South African forestry professionals in terms of growth of plantation species; the same workforce is applying those scientific disciplines to evolving new improved forms of harvesting. The forest industry of South Africa wants to be the lowest cost producer of forest produce in the world.

WORLD FOREST RESOURCES

INTRODUCTION

Hagler refers to the FAO growing stock volume of the world's closed forests as approximately 300 billion cubic metres. Approximately 36% of this volume is found in conifer species, of which 85% is located in Russia, the USA and Canada. Hardwood or broadleaf timber is concentrated in Latin America (49%), Asia (19%), and Africa (13%).

The world's forest product industries rely upon less than half of total timber removals, or approximately 1.6 billion cubic metres, for the production of primary and secondary forest products. An additional 1.7 billion cubic metres per year are utilised for energy purposes. Jaakko Poyry arrived at similar estimates of world forest resources.

Jaakko Poyry detailed how few wood resources Australia has compared to the rest of the world given the size of its land mass and population.

The conditions of forests and the status of forest management differ markedly between industrialised and developing countries. The forest areas of many industrialised countries have stabilised and in some cases they have even increased during this century.

In contrast to the industrialised countries, forests in the developing countries have declined by nearly half this century. The World Bank and the United Nations Development Program (UNDP) estimate that more than 11 million hectares of forest are cleared for other uses every year (such as subsistence agriculture, fuelwood production, dams for irrigation waters, mining and major agricultural pursuits such as clearing for cattle raising).

PLANTATIONS

The problem is that no knows how much of the world's wood comes from plantations or how much plantation we need to supply the world's demands for wood fibre.

Fast growing plantations are not clearly defined and rarely segregated in production statistics. In addition, a considerable part of the plantations classified are in practice medium-growing or even slow growing. Part of the recorded plantations do not even exist. Especially in developing countries, planting areas are often exaggerated, the replanting not being deducted from total planting areas and failures not being taken into account. Consequently, the actual established, fully stocked areas in many countries are likely to be only 50 to 70% of those given in official statistics.

Though not segregated in production statistics, plantations in various countries are becoming increasingly important as a source of both industrial wood and fuelwood, as follows:

Brazil	*Eucalyptus* and *Pinus* species; industrial and fuelwood production
Chile	P*inus radiata*, and some *Eucalyptus* for industrial wood production
South Africa	*Pinus* and *Eucalyptus* species for industrial wood production
New Zealand	*Pinus radiata* for industrial wood production
Australia	*Pinus radiata* and *Eucalyptus* species, for industrial wood production

Other important areas are the southern USA; the Iberian Peninsula in Europe, Argentina,Venezuela and South Africa.

The following table from the Jaakko Poyry data bank and FAO shows there are in excess of 3 million hectares of fast-growing hardwood plantations and at least 12 million hectares of fast-growing softwood plantations. (A fast-growing plantation is one that has a mean annual increment exceeding 12–15 m^3/hectare per year, grown on short rotations.)

Major hardwood plantations are found in Brazil, the Iberian Peninsula and the Republic of South Africa. Fast-growing softwood plantations are found mainly in the southern USA, Brazil, Chile, Venezuela, New Zealand, Australia and South Africa.

Table 3 Areas of fast-grown plantations in various countries in1985 ('000 ha).

Country	Hardwood	Softwood	Total
Argentina	75	100	175
Brazil	[1] 1080	1475	2555
Chile	50	1050	1100
Venezuela	14	192	206
Mexico	23	62	85
Rest of Latin America	354	82	436
US southern	—	[2] 9000	9000
Portugal	450	[2] 512	962
Spain	395	25	420
Australia	43	774	817
New Zealand	23	1122	1145
Rest of Oceania	31	45	76
Indonesia	68	[3] 720	788
Malaysia	15	11	26
China	400	[3] 8611	9011
Rest of Asia	160	[3] 1602	1762
Angola	50	22	72
Congo	19	4	23
Kenya	7	158	165
South Africa	370	604	974
Zimbabwe	12	73	85
Rest of Africa	334	548	882

(1) excluding some 1,200,000 ha of Eucalyptus plantations for charcoal programs.
(2) mostly medium growing
(3) mostly slow growing

Table 4 Fast-Grown Plantation areas (estimates for 1987–88).

Country and Industry	Plantation Area ('000s of ha) Pinus	Eucalypt
Chile		
CMPC	225.9	19.06
Arauca	310.45	7.1
(part only)		
Shell Chile	Annual planting rate 9–10,000 ha	
	(estimate only: no statistics given)	
Forestal Valdivia	50.0	
Plant	10,000 ha *P. radiata* per annum	
National Total	1243.0	101.7
Uruguay		
Shell Uruguay	Annual planting rate 6000ha	
National Total	26.0	134.0
Brazil		
Pisa Forestal	68.4	3.6
IKPC-Klabin	71.2	33.3
Papel e Celulose Catarinense	30.0	2.8
Norcell		60.0
Aracruz		133.0
National Total	3500.0	1,475.0
Spain		
Ceasa		2.5
National Total	25.0	395.0
Portugal		
Sorpocel		47.0
Celbi		53.0
National Total	1230.0	530.0
South Africa		
Sappi	113.0	158.0
Mondi	110.0	200.0
	(estimate only: total of 340,000 ha plantations)	
HLH	30.0	110.0
Hans Merensky		5.2
USUTU	69.0	
National Total	671.6	538.5
Australia		
APMF	45.0	8.0
National Total	820.0	47.0
New Zealand		
National Total	1240.0	

Note: Plantation statistics are reported in detail in the report, if they were available.

COMPARISON OF FAST-GROWN PLANTATION PRODUCTIVITIES

There has been much conjecture about the tremendous growth rates overseas compared to Australia, especially of eucalypt species. However, Jenkin (1991) reported that overseas rates are similar to those obtained in Australia. The author came to a similar conclusion: that there is no difference at all in plantation growth (see Table 5, page 25).

Why the conjecture? Foresters overseas manage eucalypts on short rotations (7 to 9 years) for pulpwood and fuelwood which is at the end of the eucalypt's natural attribute cycle of rapid early growth. Many overseas organisations are taking the initial early growth and extrapolating that plantation growth over the plantation life for any time period. In Australia, this type of mensuration activity is not practised and plantations are run on much longer rotations only because of our blinkered 'sawlog' philosophy. In reality, if plantations are measured at similar times, there is no difference in growth rates.

Table 5 shows that there is no significant difference in growth rate of Australian eucalypts when compared with those in overseas countries. For example, the growth of E. globulus at 8.9 m^3/ha in Spain and Portugal is no different to the growth obtained in Gippsland. Anywhere in the world, growth rates depend on site, climatic and cultural aspects.

Aracruz's annual growth rate of 25 m^3 ob/ha (over bark) is far different from the often quoted growth rate of 60m^3 /ha/year for that company.

Table 5 Some projected growth rates from various sources (in m^3 solid under bark).

Country and species	Source	Growth rate (m^3 sub/ha/year)	Rotation (years)
Pinus radiata			
Chile	Jaakko Poyry/FAO	15–30	20–25
	McCarthy	20–21	20–30
South Africa	Jaakko Poyry/FAO	18–20	25
	McCarthy	11–15	15–23
New Zealand	Jaakko Poyry/FAO	15–30	25–35
Australia	Jaakko Poyry/FAO	15–17	20–35
	RAC	18	35
	APMF	22	28
Other *Pinus* species			
Brazil			
P. taeda, P. elliotti	Jaakko Poyry/FAO	20–30	20–25
P. caribaea, P. oocarpa	Jaakko Poyry/FAO	20–25	12–20
	McCarthy	20	20–25
***Eucalyptus* species**			
Chile			
E. globulus	McCarthy	8–17	12
E. regnans	McCarthy	15–25	12
E. globulus	Shell	22–26	12
E. nitens	Shell	22–26	12
Brazil (Aracruz)			
Hybrids of *E. grandis*	McCarthy	24	7
	Jaakko Poyry/FAO	16–60	7
Spain			
E. globulus	McCarthy	4–12	12–15
	Jaakko Poyry/FAO	4–20	8–20
Portugal			
E. globulus	McCarthy	8.9 (range 4–15)	12
	Jaakko Poyry/FAO	10–18	8–10
	Jenkin	10–22	10–12
South Africa (predominantly *E. grandis*)			
Eucalypt sawlog	McCarthy	26	23–25
Eucalypt pulplog		23	10–12
Eucalypt. mining		18	8–9
Eucalypt	Jaakko Poyry	20–22	11
	Jenkin (Sappi)	20–30	6–8
	Jenkin (Mondi)	17–18	8–12
Australia	McCarthy (APMF)	9–30	20–30
	Jenkin (Bunnings)	20–40	10–15
	Jenkin (CALM)	15–35	8–12
	RAC	14–34	10–45
	Jaakko Poyroy	15–20	10

EUCALYPT ATTRIBUTES USED IN OVERSEAS PLANTATIONS

FOLIAGE DENSITY

Eucalypts have thin crowns.

CROWN SHYNESS

Eucalypts do not have overlocking crowns.

HEIGHT GROWTH

Eucalypts have rapid early growth.

[*These first three factors have been used by overseas organisations to manage short rotation crops within the rapid growth cycle. (i.e. by 5–7 years eucalypts have slowed up in growth). We have already seen that this is where the illusion of faster growth rates overseas arises. This is when the measurements should be done, as it is when the forester can have most influence on the stand development.*]

CROWN SEGREGATION AND MORTALITY

Eucalypts segregate rapidly into dominance or crown classes, with a rapid reduction in stocking as suppressed trees die. Short rotations overcome this natural wood loss.

Because Australian foresters believed that eucalypts were only useful for sawmilling, and because not enough wood quality studies were performed, all Australian plantations have been managed on the natural strangulation philosophy. All that has really happened is that much growth and development of a eucalypt plantation industry has been lost.

SELF-PRUNING

The ability of eucalypts to shed branches naturally has to be the greatest attribute, coupled with tree breeding selection, to promote eucalypts as the most desired

hardwood sawlog resource. The South African sawmilling industry is a leader in producing sawn timber from young plantation eucalypts.

HYBRIDISATION

The ability of different eucalypt species to hybridise has enabled overseas growers to effectively design trees for specific sites, e.g. Aracruz in Brazil; Celbi in Portugal; and Sappi, Mondi and HL&H in South Africa.

MESOPHYTIC

The ability of eucalypts to seek available moisture has not been capitalised on anywhere in the world in terms of their ability to grow under irrigation regimes (especially in the recycling of waste water).

Florence (pers. comm.) considers that the availability of water for growth could be one of the major influences on the development of individual eucalypt species. Work in Victoria by Stewart, Dexter and Waugh (pers. comm.) has shown that you can vary the wood quality of eucalypt species by changing the availability of soil moisture over the rotation.

Industry needs to capitalise on this phenomenon, as it could enable the climatic range of various eucalypts to be extended. In Australia, work on growing eucalypts under irrigation regimes is still in its infancy.

POINTS OF SILVICULTURAL SIGNIFICANCE FROM OVERSEAS

PINUS SPECIES

CHILE

1.243 million hectares of *P. radiata*

Age class distribution	1 to 31 years
Planting rate	60,000 to 70,000 hectares/year
Average growth rate	20–21 m^3/ha/year (solid over bark)
Planting stock	seedlings (seed orchard seed only in late 1980s)
Initial stocking	1300–1600 stems/ha
Rotation length	20–30 years
Uses	Pulp,sawn timber, export sawlogs, fibreboard, veneers; e.g. Arauco produces 800,000 tonnes of kraft pulp/year.
Annual harvest	15 million cubic metres.
Silviculture	Nursery cost/1000 plants open rooted US$ 24/1000. Sequence of field operations. Clearing, burning, soil preparation as ripping, planting, seedlings, rabbit control, fertilising, weedicide. Average Cost US$ 250/ha. Maintenance including fire protection US$30/ha. Pruning cost US$70/ha.

BRAZIL

Pinus species are *P. taeda*, *P. elliotti*, *P. carribaea*, *P. oocarpa*.
The area of plantation is between 1.3 to 2 million hectares. (Industry estimate of commercially existing plantations which differs to National estimate of 3.5 million ha)

Annual harvest	6 million m^3 approximately	
Initial stocking	1300 stems/ha	
Rotation length	20–25 years	
Average MAI	20 m^3/ha/year	
Costs(US$)	Royalty	\$3–6/m^3
	Logging	\$4/m^3
	Transport	\$5–6/m^3
	Overhead	\$1.2/m^3
	Total	\$12–17/m^3

SOUTH AFRICA

Pinus species are *P. patula* (41%), *P. elliottii* (28%), *P. taeda* (10%), *P. radiata* (10%) and *P. pinaster* (6%).

The area of plantations is approximately 611,000 hectares. Annual harvest is approximately 9.7 million cubic metres. Uses, pulp, paper, sawn timber, particle board, poles, chips. Rotation length is 10–12 years for pulp and 20–25 years for sawlogs. Average MAI for P.radiata is 11–15m^3/ha/year.

Costs (Aus$)	Establishment	$10–15/ha
	Tending	$10–12/ha
	Protection	$12–40/ha
	Harvesting	$ 5–10/tonne
	Transport	$10–15/tonne

Average sale price less cost of harvesting & transport (Aus$)	$10–25/tonne
Rotation	23–25 years

AUSTRALIA

Pinus species are *Pinus radiata* (80%), *P. elliotti* (16%), *P. pinaster* (3%) and *P. carribea* (6%) (1988 figures).

Area	820,000 hectares (1988)
Production	5.7million m^3 (1988)
Regime	Average rotation length is 25–40 years for sawlog production with 2–3 thinnings for pulpwood commencing at age 14.
Log Length	4–6 metres
Initial Stocking	Seedling planting stock 1200s/ha Cutting planting stock 1000 s/ha
MAI	Average 20–22 m^3 ob/ha/year
Cost of Nursery	Seedling Stock Aus$80/1000 Clonal Cuttings Stock $A170/1000
Cost of Establishment	Aus$1200–1400/ha
Markets	Pulpwood, sawn timber, veneer, newsprint

EUCALYPT SPECIES

CHILE

Species	*E. globulus*; *E. nitens*; *E. delegatensis*, *E. regnans.*
Area planted per year	29–30,000ha
Area of plantations	101,000ha
Cost of containerised plants:	
E. globulus	US$34.31/1000
E. nitens	US$42.81/1000
E. delegatensis	US$38.97/1000

Cost of open rooted plants:	
E. globulus	US$25.93/1000
E. nitens	US$31.21/1000
Initial Stocking	1600 stems/ha
Rotation Length	12 years
Average MAI is confusing:	*E. globulus* 8–17m^3/ha/year (Shell is aiming to get 22 to 26m^3/ha/year with their new plantings of *E. globulus, E. nitens*).
Costs quoted	US$400/ha for establishment

BRAZIL

Most common species is *E. grandis*

- Hybrids of *E. grandis* and *E. urophylla*
- Hybrid clonal forestry; female is *E. grandis*, *E. saligna* and *E. urophylla*. The male shows characteristics of *E. camaldulensis*, *E. terticornis*, *E. urophylla*, *E. robusta* and *E. pellita*.
- Tropical areas use *E. urophylla*, *E. pellita*
- Cooler areas *E. saligna* better than *E. grandis*
- Colder areas *E. dunnei, E. citriodoria*, *E. cloeziana*, *E. viminalis.*

Area planted	1.475 million hectares of eucalypt plantations (1987).
Age class distribution	All plantations viewed in Brazil have a rotation period of 7 years approximately. The areas then produce up to two coppice rotations before being replanted.
Cost of containerised plants	Clonal forestry is practised extensively throughout Brazil. Aracruz quote US$59/1000 for cuttings and US$54/1000 for seedlings.
Initial Stocking	1111 stems/ha
Rotation Length	7 years
Average MAI	Aracruz quote an average MAI of 25m^3/ha/year solid wood over bark for their plantation average growth.

Costs, US$/ha (Aracruz)

	R1	R2	Coppice
Year 0	853	562	453
Year 7	1654	1362	911

Average costs quoted 1989 for establishment include an average cost of first year establishment including land of US$1500/ha and a maintenance cost of US$40–50/ha.

Wood Costs (1989, US$/m^3)	Stumpage	3.05
	Harvesting	6.05
	Transport & Handling	6.66
	Overheads	1.20
	TOTAL	16.96

Aracruz	Harvesting cost	US$ 6.53/m^3 (25 km from mill)
	Harvesting cost	US$11.24/m^3 (170 km from mill)
	Average cost	US$ 9.67/m^3

At Aracruz the most interesting development was the reduction in the amount of wood required per tonne of pulp from the advances of the clonal program.

1985 4.52m^3/tonne of pulp
1989 4.17m^3/tonne of pulp
1990 4.05m^3/tonne of pulp
1992 Average 4.2m^3/tonne of pulp

They aim with the full use of clones to get to 3.7 m^3/tonne of wood for 1 tonne of pulp produced.

SPAIN

Species	*E. globulus,* also some *E. camaldulensis*
Area	395,000 ha
Age Class Distribution	12–15 year rotation, clearfall copice rotation twice before replanting.
Stocking	1600 stems/ha
MAI	4–12 m^3/ha — very variable
Costs	Varied from US$2000 to 3000/ha (delivered wood)
Quoted delivered wood price	US$59/$m^3$

PORTUGAL

Species	*E. globulus*
Area	530,000 ha
Age Class Distribution	The rotation age is 12 years, then clearfall, 2 coppice rotations, then replant
Stocking	1000–1200 stems/ha (it was 1600 stems/ha)
Rotation length	12 years average
MAI Average	8.9 m3/ha (range 4–15)
Cost of Nursery Stock	Seedlings US$50/1000 Cuttings US$270/1000
Cost of Establishment	US$ 2000/ha
Delivered Wood Cost	Plantation US$16.8 m^3/ha Maintenance US$5.5 m^3/ha Harvesting US$19.6 m^3/ha Transport US$19.6 m^3/ha TOTALUS$61.5 m^3/ha

SOUTH AFRICA

Species	*E. grandis* predominant species with some *E. saligna.*
Area	538,485 ha, of which 394,000 ha is *E. grandis* (and *E. saligna*)
Production	6.5 million m^3 from plantations

Age Class Distribution	Age class	ha	%
	awaiting replanting	49,355	10
	0– 4 years	218,402	43
	4– 9 years	178,422	35
	9–14 years	14,727	8
	14–19 years	9,249	2
	19–24 years	7,139	1
	TOTAL	approx. 538,485	

Initial Stocking
1100 to 1200 stems/ha sawlog regime
1600 to 2000 stems/ha pulpwood

Rotation Length	Sawlog	23–25 years
	Poles	8–9 years
	Mining timber	9 years
	Pulp	10–12 years

MAI Sawlog & Veneer log:
greater than 20 cm 26.4 m^3/ha/year
(23–25 years) 8–20 cm 4.5 m^3/ha/year

Pulpwood	(10–2 yrs)	23.7 m^3ha/year	
	Poles	(8–9 yrs)	18 m^3/ha/year
	Mining (9 years)		18.3 m^3/ha/year

Cost
Aus$500 to 600/hectare new establishment.
Aus $300 to 500/hectare coppice rotation.

AUSTRALIA

Eucalypt Species
Temperate: *E. regnans*, *E. nitens*, *E. globulus*; subtropical: *E. grandis, E. saligna*

Area	47,000 hectares
Log Lengths	4–6 metres
Production	N/A
Regimes	Pulpwood 10–30 years
	Sawlogs estimated 30+ years
Initial Stocking	1000–1100 stems/ha
MAI	Dependent on species 9–30 m^3/ha/year
	e.g. *E. globulus* range 10–15 m^3/ha/year
	E. regnans range 20–30 m^3/ha/yr
Cost of Nursery Stock	(Seedlings) Aus$230/1000 (in containers)
Cost of Establishment	Aus$1300 to 1800/ha
Markets	Pulpwood
	Future sawlog supplies

COMPARISON OF AUSTRALIAN AND OVERSEAS SILVICULTURAL SYSTEMS

In all areas visited, industrial wood production by the private sector was sourced from intensively managed plantations. No industry, especially the pulp and paper industry was relying on native forest wood fibre supplies.

There is world-wide pressure on forest industries to withdraw from harvesting native forests. The withdrawal of old-growth stands from harvesting (on the pretext of it being Spotted Owl habitat) in the USA has forced wood buyers from the USA to search for future supplies in other countries. It is claimed that Chile has now effectively sold all its surplus wood resource.

These changes, caused by social pressures, have their greatest impact on the pulp and sawlog forest industries. However media and conservationist activity in relation to the continued management of native forest stands creates false impressions in people's minds of what is happening, especially in regrowth stands. No credit is given for the financial resources that the industry returns to forest areas for their continued regeneration and protection from dangers such as pests, diseases and fire.

In Australia, although there is a phasing out of harvesting in old-growth forests, there is no scientific or financial reason why regrowth stands cannot be managed, harvested and regrown in perpetuity. As in the USA, we might ask how the stands will be regenerated, maintained and protected economically in the longer term without a forest industry to provide economic resources.

One of the major reasons that the world's forest industries should invest in plantations is that the subsequent wood produced is of known quality, volume and age. It is these factors that determine the profitability of the added-value venture.

WHAT EFFECTS ARE SILVICULTURAL REGIMES HAVING?

All pulp manufacturing companies are increasing their levels of wood self-sufficiency. This is being done through the purchase and control of forest lands in close proximity to manufacturing operations. The control of local resources through long term leases or agreements or the ownership or control of wood fibre resources off shore (e.g. STORA in Chile and Portugal, and International Paper in NZ) and increased procurement of imported wood pulp or wood fibre.

Other countries are significantly increasing their silvicultural expenditures for genetic research, site preparation, fertilisation, and optimum harvesting, wood handling and transportation systems.

In the past, and even currently, as land prices increase, companies look to areas of cheap land for wood production. With the increase in forest land prices due to the massive investments in forest industries, the Chilean companies are starting to look at Uruguay for forestry investment. This is because the government there is actively encouraging plantation investment and because cheap, flat land is available.

However, as transport has such a market effect on the profitability of the forest products industry, forest owners must now concentrate on ensuring competitive wood crops are grown close to their processing plants. This is causing major reviews of companies resources and location to markets throughout the world. In time it could well be that Europe produces its own forests, to the detriment of many current plantation production zones in the Southern Hemisphere.

The movement of commodity product manufacture and new pulping capacity to intensively managed forest regions where cost structures (land, labour and growth rates) favour low-cost fibre availability continues.

The loss of market position in commodity product markets by those producers poorly supported by intensive plantation resource (due to a deteriorating wood cost and wood availability), relative to international competition, is occurring. For example, US producers are buying established forest industries in New Zealand and Chile, and in Spain, producers are trying to establish plantations to counter massive wood costs and loss of market position.

Australia is completely misreading the signs in terms of plantation development. The *Pinus radiata* resource should be expanded and the levels of management increased not decreased. Our eucalypt plantations should be vastly expanded; we should not be simply contemplating this action.

SILVICULTURAL SYSTEMS

Before commencing the fellowship, the author found it hard to comprehend that Australia could far behind in plantation expertise. In fact Australia is certainly not lagging in plantation management expertise: it has simply not bothered to establish plantations of hardwood species. This is what has caused the turmoil of reduced wood supplies currently in the industry.

This can be extended to the sawmilling industry. Australia has not carried out sufficient scientific research into the sawing of plantation eucalypt to create a new industry: other countries have achieved the breakthroughs. Australia needs to review those breakthroughs (in South Africa and Brazil). It may well be that the site factors (soil, climate, etc.) may completely influence the behaviour of the log. Australia could be planting its eucalypt forests in the wrong situations. It is imperative that detailed scientific studies on the effect of silvicultural practices on wood quality be undertaken.

PLANTATION PRODUCTIVITY INDICES

SEED

In terms of seed collection and processing, Australia is among the leaders in the world. In terms of our *Pinus radiata* resource, the effects of intensive tree breeding programs are reflected in the products now being produced from younger, smaller trees.

In terms of genetic seed material source programs, the plea of the tree breeder and provider of seed is that Australia has done far too little in creating seed orchards for all the eucalypts species. The effect of agricultural clearing, fire and the reservation of existing native eucalypt stands could see those species disappear altogether, which would be a terrible waste of genetic resources.

Of great concern to the author is that in Australia we continue to 'give away' our genetic eucalypt material. The only program coordinated by the Federal government (even to the extent of climatic modelling for species site selection) assists all our competitors. There has been no return to Australia. In fact, Australia may have lost more eminent scientists due to this program than any other.

VEGETATIVE MATERIAL

Countries such as Brazil and South Africa are much more advanced in this area than Australia in terms of eucalypts. Australia and New Zealand are more advanced in the *P. radiata* area. For the similar climatic zones in Australia, it is simply a transfer of technology for those species to adapt this to Australia.

For the temperate areas, the generic problems of those species is what prevents the establishment of new plantations by these means. However the pioneering work of Celbi in relation to the development of a cuttings program for *E. globulus* is an area that Australia should immediately adopt. To see the rapid early growth of *E. globulus* stands drop off and then the stands at 18 to 24 months start to display the unevenness in height due to genetic makeup will be overcome using vegetative propagation. The experience with *P. radiata* can be applied to temperate eucalypts.

Australia is lagging behind in the work of eucalypt hybridisation and subsequent vegetative propagation of the best material. To replace Australia's tree cover, the influence of hybridisation would overcome the many problems facing successful establishment of plantations. Hybridisation in nature in Australia is probably the way in which species were able to adapt naturally to new areas. The understanding of hybridisation and subsequent propagation of the material now allows the forester to design a tree for a specific site.

When the eucalypts overseas are compared with trials established of Australian seed sources, it is quickly apparent that the overseas stands are probably all hybrids. We are seeing the effects of probably one of the greatest hybridisation propagation programs of any plant ever, anywhere in the world. Australia needs to re-evaluate its tree breeding strategies to capitalise on this remarkable aspect of the eucalypt.

NURSERIES

Eucalyptus Nurseries

The South Africans are the world leaders in this field. Wherever you visit a major grower's plantation project, you view either exact replicates of the South African SAPPI nursery system or adaptations of their methodology.

The strategy of machine sowing, minimum watering, fertiliser and just-in-time regimes has helped enormously in developing most successful plantations.

The advances in container science has led to much more understanding of root morphology. The hard-earned experience of the problems of insufficiently developed root systems with P. radiata cuttings, especially on infertile harsh sites, has led foresters to rethink or think about what is happening to the whole plant system. (Foresters in the past have been guilty of only looking at the tops of the trees, not the roots, and many plant failures are attributed to poor root development). This is now making people consider the exact specifications required from a seedling and what is required in the field in terms of the best rooting medium; for example, fertiliser is one of the aids for tree growth, but it is merely thrown on the ground and we hope the plant takes it up, but not really sure how. Is there a mycorrhizal mechanism to aid eucalypt nutrition?

The short rotation length of the major eucalypt plantations has led to much earlier confirmation of whether different nursery practices are successful. This effect on profitability of the total enterprise has led to revolutions in nursery practices.

However, in some large operations there is the continued need to control the total system from nursery to field establishment. Where this does not occur, there is unnecessary duplication and loss of overall quality control of every facet of the operation.

Much work has been done on containers in South Africa to manage root development, operating to a just-in-time planting philosophy.

Pinus Nurseries

In relation to the production of open-rooted seedlings of *Pinus* species, Australia and New Zealand lead the way . New Zealand has led the way in *P. radiata* plant production by the cutting method, and Australia has adapted this methodolgy.

The problem of infertile sites and the success rate of cuttings is extremely dependent on the development of good root structures. This problem has also been highlighted with large eucalypt programs where failures have occurred on poor soils or harsh soil types. Here the root system developed (lateral roots) has not been able to cope with the harsh environment. In fact Aracruz, in its extension programs with farmers, supplies them with seedlings rather than cuttings due to the harsh and often unprepared sites in which the trees are to be planted.

In relation to containerised *Pinus* seedlings, although the Australian and New Zealand system has been to get away from containers, the USUTU pulp company of Swaziland has made impressive efforts to produce *Pinus* seedlings in containers and develop excellent root systems with the ability to hold that plant until field conditions

are most optimal. Australian *P.radiata* growers have much to learn from this system. The matching of plant to site is not done as well in Australia, and there is a severe penalty in growth.

ESTABLISHMENT PRACTICES

Vegetation Manipulation

In this area the comparison of productivities between organisations with similar operations and terrain showed that there was no difference in the productivity of the operation. The differences are due to wage rates and labour productivity. Australians do not obtain the productive rates that overseas labour does, yet demand much higher payments.

1 Clearing

This practice of removing native vegetation by mechanical or physical means around the world has been phased out due to environmental pressure. Where productivity indices were available for similar sites, similar productivities were obtained. In fact the larger, more progressive companies, such as Aracruz and Klabin, make a big issue of the retention of areas of native vegetation within their forest holdings.

2 Preplanting Weed Control

There are several methods used. Where labour is plentiful and inexpensive, manual methods of cutting and grubbing are employed on the site prior to planting. The amount of energy expended is probably no different to that in using mechanical means as bulldozers, and often the sites and the type of vegetation do not lend themselves to mechanical means of slashing. The manual method is more environmentally desirable because there is less soil disturbance. Of course it is much slower and does not last as long as weedicide application.

The use of chemicals for broad-spectrum weed control such as Roundup is practised in some areas. However this practise has basically stopped due to bad environmental effects such as massive sheet erosion, the chemical moving off-site and contaminating water supplies, etc.

The most cost-efficient systems to date use a band or circle of weedicide to remove competition only within the vicinity of the planted seedling. Again, where labour is plentiful and inexpensive, manual methods are practised. As chemical costs and the necessary safety precautions necessary to maintain their use increase, major growers are evaluating the economics of these operations and are turning back to mechanical and/or manual methods in some situations, for weed control.

3 Burning

In some areas burning of vegetation, especially the slash, is still practised. However, the major growers are beginning to realise that this world-wide practice is most detrimental to the long-term productivity of the site.

4 Slash Maceration

No one is as advanced as APMF in terms of slash treatment and ensuring that soil productivity is maintained. This is where APMF probably leads the world in terms of techniques for establishing second and subsequent rotations. It is interesting to note that this concept was originally developed in the USA to remove low scrub for land clearing operations for agricultural development.

In all the areas visited, plantation development has been on new sites. Little effort has been put into second rotation site preparation. The only reason that they have been able to get away with poor practices to date is that the soils are sufficiently nutrient rich to carry a second crop. They do not know if they have or are suffering a second rotation decline. This is especially so in Chile and New Zealand, where the majority of plantations are first rotation.

Soil Manipulation

Through the efforts of APMF and the commercial skills of companies such as Savannah Equipment, Australia is the world leaders in forestry cultivation equipment. The matching of equipment to the site is best seen in Australia at APMF.

Although the South Africans have put a much greater sustained scientific effort into soils, there is confusion because probably the short rotations do not require such continued intensive cultivation (South African research showing no increase in growth at second planting after cropping for 7 years). But this does *not* relate to other horticultural crops, where continued cultivation enables continued mineralisation. The other pertinent factor is that the soils in those overseas plantation areas are much better.

All growers where possible rip the planting row prior to planting for maximum growth. Productivities are similar to Australian conditions. However, the science of ripping and the use of wings (angled plates attached to the ripper to shatter the subsoil but not overturn it) is not as developed as in Australia and New Zealand. More work on how much cultivation and root criteria to ensure wind firmness is still needed.

Planting

Here, Australia has much to learn. The system practised by Aracruz of intensive supervision, watering the planting hole prior to planting and after planting, close supervision of weedicide and fertiliser application and the additional growth obtained is something that Australia must implement.

There is no standard planting tool anywhere in the word: they do not know what is most suitable, nor even what should be the real depth for maximum plant development. The major industries could come together to implement scientific studies to find the best tool. The author agrees with people from Aracruz and Shell Chile that probably the best planting implement is the human hand.

Plant care and transport to the field still requires much development. The South African nursery container system lends itself to the development of the best method of handling and field storage of plants.

Seeding

No large organisation practises seeding as they cannot implement the genetic gains

they have captured in their tree breeding programs.

Natural and Enhanced Regeneration

It is well documented that the days of extensive forestry practices such as natural and enhanced regeneration techniques are unacceptable to forest ownerthroughout the world. When the public own the natural forest they desire other uses for their forests. With private forest ownership, these techniques are too slow and unreliable in terms of producing certain quantities of merchantable produce at specified time intervals.

Coppicing is practised extensively for those eucalypt plantations species which are capable of coppicing. Growers estimate that the second crop moves up one to two site classes compared to the original crop. The availability of inexpensive labour makes this practice possible.

However, coppicing in Australia needs to be extensively tested to determine its true potential, to capitalise on those established root stocks and to see why it cannot be practised with mechanical means. The pulp quality of this resource needs to be ascertained. Is it the same or different to seedling stock? As Australian industry enters the era of low wood availability, this resource could be an important stop-gap.

Fertilisation

All major growers visited use fertiliser as initial growth starter. It is the standard 100–200 grams of NPK fertiliser.

In relation to eucalypts, no one is any closer to knowing what the nutritional requirements of the tree are. This area is one where the whole industry need to fund the best scientific work possible to find what is needed to make eucalypts grow. No one can yet say if a different fertiliser is needed for different soil types and whether it would make the tree grow any faster.

The Australian work in relation to *P radiata* nutrition leads the world. The most interesting breakthroughs are yet to come, with the commercial assessment of later aged thinned stands.

Spacing

Forest scientists around the world need to continually review this area. No one has demonstrated conclusively that any one stocking strategy is better than another. The majority of growers are planting on a 3 3 3 m grid. to give 1100 stems/hectare. They have reduced this from around 1600 stems/hectare.

Protection

1 Animals

Wherever native trees are being establish in plantations they are browsed by their natural predators. e.g. wallabies in Australia, moose in USA and deer in UK.

The effect of human hunting and destruction of the natural habitat has saved many forest growers from massive animal browsing problems. e.g. elephants in South Africa. Where native animals are concerned, the same environmental emotional arguments apply and are expounded by the international conservationist groups.

Where introduced browsers such as rabbits are involved, people are less concerned, although a big campaign was waged against the use of 1080 in Chile for rabbit control. This presumably was because people were eating rabbits after poisoning.

The use of extremely hazardous chemicals and repeated applications to obtain successful establishment of tree crops, would be one of the most susceptible facets in overseas tree establishment. Methods such as fencing, hunting, etc. are practised and all with limited success.

2 Insects

Overseas, ants, especially termites, are the biggest browsers of plantation trees., apparently attacking only eucalypts.

There were some disturbing insects attacking *P. radiata* such as tip moth in Chile and a caterpillar in Brazil in *P. patula*. Little other insect attack was apparent.

3 Humans

At the establishment phase, the major human threat is from those assuming squatter rights over the land or grazing domestic stock on the areas or pilfering of wood. (Even in Australia, the use of 1080 stopped unscrupulous farmers from practising illegal grazing on plantation areas.)

All major growers visited employed extensive crews of armed guards (called forest guards) to protect their forest plantations to stop squatting and pilfering of the plantation resource as it matures.

4 Climate

Everyone suffers the effect of too much or too little rainfall. Problems due to hail were infrequent compared to some Australian plantation growers experiences. The occurence of windthrow is a major problem in some localities.

5 Weeds

The problem of blackberry infestation suffered in Australia and New Zealand was not a major problem in those countries visited. In Chile, as in New Zealand, there are enormous gorse infestations of fertile plantation country, which cannot be allowed to happen in Australia: but already along the roadside verges in Gippsland we are seeing the commencement of gorse infestation.

There are other weeds which, though not prevalent in Australia, cause similar problems to noxious weeds such as blackberry in Australia.

6 Fire

All growers suffer the effects of fire. Throughout the world, initial aerial suppression of suspected fires is being practised by the large growers. In Brazil and Portugal, helicopters are used under similar arrangements to Australia. In South Africa, fixed wing aircraft are used in a cooperative arrangement for patrolling all plantations. They use fire-retardant drops to suppress fires. The aircraft are replacing individual company surveillance systems, although ground fire fighters must still be employed to complement the air support.

Little research has been carried out in the world in relation to bushfire fighting especially aerial fire suppression; fire prevention methods and flammability of species. There is tremendous scope for individual organisations involved in growing the same species to cooperate on joint research programs.

Fire tower surveillance still involves human spotters. However, some different systems being attempted include the use of infrared cameras in towers, aerial fire towers, aeroplanes flying fixed predetermined flight paths, and different tower structures.

Ground equipment has not varied from fire trucks, bulldozers, knapsacks and ground clearance tools. The author's collection of photographs of various fire trucks continues, as every organisation has a different type of fire truck.

Post-planting Weed Control

A variety of methods are used to carry out post planting weed control. Where labour is plentiful and inexpensive, manual methods of hoeing may be used up to 4 to 5 times in the first year. All major growers utilise some form of weed control as they are all aware of the attributes of good growth by the removal of weed competition.

Aracruz employ people with gas pressured knapsacks and good operator protection to apply weedicide in a circle around each plant. Similar chemicals are employed to those in Australia.

In any plantation program, the taxation system treats the first year's operations as the establishment phase and capitalises this expenditure.

MAINTENANCE

With fast-growing tree crops as in Australia, follow-up maintenance regimes are essential to achieve the desired growth rates and the optimum return on the investment. Much effort goes into reducing costs in this area, for apart from the land servicing charges, there are several operations which affect the merchantability of each piece.

Operations in the second and subsequent year (although similar to year zero) may be of the same nature as in the establishment phase.

PROTECTION AGAINST ANIMALS

The problem of browsing by domestic stock is a world-wide problem, and methods from fencing to the employment of forest guards are employed to protect young plantations. In Australia and some other countries, especially where native species are being re-established, browsing by native animals continues throughout the first year. Methods of adequate protection are not available. Most other countries escape this browsing problem.

PROTECTION AGAINST INSECTS

Some plantations are effected by insects, although the majority of overseas plantations (if not under stress) escape insect attack. In Spain and Portugal, especially where eucalypts are under stress, there is insect attack and there are prevention research programs in place. Ants are the major problem. Continued repeat applications of chemical is necessary to kill ants.

PROTECTION AGAINST PATHOGENS

As for insects, few problems are experienced overseas unless plantings are in the wrong situation or plants are under stress.

PROTECTION AGAINST HUMANS

Compared to the absence of this problem in Australia, the major cost to the large growers overseas would be the effects of humans on the plantations. Massive numbers of forest guards are employed to protect organisations forest estates. 200 to 400 people is not uncommon per organisation.

Problems encountered include large-scale pilfering of fuel wood and saleable wood in Chile and Brazil, where wood is also taken by pirate charcoal operators; and South Africa where the influx of people into that country has lead to squatters taking over

areas of forest or plantation for subsistence agriculture (since the only areas with good soil nutrient status are within those forested areas.)

CLIMATE

The problems of hail were not considered important overseas. An interesting facet though was in comparing loss statistics in the years when Australia had much windthrow, Chile also suffered windthrow. It would too good to be true that long term weather trends from South Africa could assist Australian weather forecasters. South Africa is now into its fourth year of drought. Will Australia suffer the same fate?

WEEDS

All regions suffer this problem. The greatest overseas problem is the infestation of good country by gorse, as in Chile and New Zealand. Annual programs are carried out, but the continual search for better weedicides needs to be constantly evaluated. All growers felt that they were at the mercy of the large chemical companies.

FIRE

All organisations suffer from fire, and annual programs are essential to protect the estates. In South Africa where they burn the external breaks due in manyinstances to the presence of rock, much plantation is also lost due to these fires escaping. In Brazil it was observed that they break up large continuous tracks of Pinus with strip plantings of Eucalypt to act as fire breaks.

Some pruning of lower stems of Pinus plantations is carried out for fire protection purposes.

WEED CONTROL IN OLDER STANDS

A variety of methods are employed to control this weed growth, both mechanical and manual.

INFILLING

Large growers have found that improving nursery practices, watering-in plants and using good planting methods reduces infilling requirements; special attention is given to having fully stocked stands, and this is closely monitored and implemented if needed.

SPACING

In *Pinus* plantations in Chile, all growers practise the Sutton clearwood regime. Plantations are precommercially thinned at set ages as per devised management regimes.

In eucalypt plantations where coppicing is practised, spacing operations on the individual stem as well as spacing within the row is carried out at predetermined ages.

Precommercial thinning operations are carried out in seedling eucalypt plantations only if sawlog production is required.

FERTILISATION

Only in Australia is later-age fertilisation performed on a large scale. It is being considered for some eucalypt sawlog regimes overseas.

PRUNING

Pruning was performed in all *Pinus* plantations observed overseas, especially for clearwood production. This consists of initial low prunings followed by extensive high pruning of selected stems for the production of sawlogs. In all cases of plantation development, the author considers that the pulp production is subsidising the sawlog production.

It will be interesting to observe the effect of tree breeding programs on the Chilean resources of *P. radiata*. Much effort sems to be wasted in the growing phase due to little new research being done on sawing and marketing of unpruned logs. Does pruning produce a superior product? The New Zealanders are convinced that it does.

Only for sawlog production overseas is stem selection carried out,. Stems are removed for pulp at early thinnings, and then the remaining stems pruned for sawlog production. This applies to *Pinus* (and eucalypt sawlog stands in South Africa).

OTHER CONSIDERATIONS

MANAGEMENT REGIMES

Overseas companies are as advanced or more advanced than Australia in management regimes. In Chile, companies such as CMPC and ARAUCO are as advanced in their plantation management as Australia and New Zealand for P.radiata. However the influence of Sutton and his clearwood regime is most apparent in Chile. Dependent on the location and productivity of the stand, various regimes are practised. These range from an intensive regime of 3 thinnings and 4–6 prunings with clearfalling at 27 years to a no management regime of no thinning and no pruning and clearfalling at age 21 years.

In South Africa and Brazil (at Aracruz) eucalypt management regimes to specific end product uses are far superior to any Australian systems. However, the simplicity of short rotation fast growing Eucalypt plantations far outweighs the complexities of 80 to 150-year native eucalypt stand management regimes which Australian foresters have to deal with.

Many sophisticated computer programs are used, ranging from stand modelling to geographic information systems.

ROADING

This issue is world-wide in terms of the nature and the cost of the road. The biggest factor affecting plantation development is that manufacturers have not tailored transporters to suit wood fibre transport. The continued adaptation of highway trucks to forest situations means that the forest owners must continually increase the investment in roads to suit these trucks. The matching of trucks to terrain is probably best done by armies of the world. The problems of log extraction and effect on forest roads is the same world wide.

All growers are becoming more aware of the effects of forest roads on water quality and continued monitoring and maintenance operations have become essential.

SUMMARY

OBSERVATIONS

1 Worldwide, the greatest use of wood is for fuelwood for domestic and industrial energy. Much of the natural forest stands in the countries visited are being destroyed, not by the pulp industries but fuelwood harvesting and clearance for agricultural (both subsistence and intensive).

2 In Brazil, which has low fossil fuel reserves, so much fuelwood is used for industrial energy that the country is probably at the stage of being deficit in wood. It does not have a surplus, as much of the world believes.

3 With a world wood shortage imminent, it will not be the pulp industries that will suffer but the poor people, who cannot purchase wood.

4 The major world markets are in reconstituted wood fibre products. Wood panel usage is increasing at the expense of solid wood.

5 Throughout the world there is a major shift occurring in forest ownership from the public to the private sector.

6 The immense economic success of eucalypt plantations outside Australia has been due to the development of 'designer tree' plantations for specific sites and markets through a combination of techniques such as plant cloning hybridisation, genetic improvement programs and cultural activities.

7 Direct financial incentives introduced specifically to encourage tree planting have worked.

8 Standard economic accounting for industrial forestry enterprises has not yet been devised anywhere in the world.

9 The management of the natural forest is moving to that of conservation and watershed protection.

10 As a country's dependence on its forest plantation exports grows, there is an associated development of trade policies and a growth in forest industry associations to help market the produce and an overhaul of the shipping industry for the movement of forest produce.

11 Many in the industry consider that there may be an imminent glut of short fibre wood.

12 Plantation regimes of eucalypt are predominantly for one product only — pulpwood.

13 No country visited had any real priority for wood production as an objective of forest management.

14 The removal of bark from eucalypt logs is the major impediment world-wide to making eucalypt plantation cropping more competitive.

15 Little, if any, research on harvesting or on forest produce transportation is undertaken anywhere in the world.

16 Unless shipping costs can be reduced, with rising labour costs in the developing countries and a fall in the labour costs in western countries, the comparative advantage to those current supply countries such as Chile and Brazil could in time be removed.

17 The advent of major international trading in wood products between countries has led indirectly to the adoption of similar industry standards within the major trading nations.

18 Plantation programs have only survived in sparsely populated areas and where there is little competition from agricultural pursuits.

19 No one knows how much of the world's wood comes from plantations, what the total area of the plantations is, or how much plantation we need to supply the world's demands for wood fibre.

20 There is no difference in plantation growth rates overseas to those achieved in Australia.

21 There is world-wide pressure on forest industries to cease harvesting in native forests.

22 All pulp manufacturing companies are increasing their levels of wood self sufficiency.

RECOMMENDATIONS

1 Australia should initiate moves to have a world-wide set of standardised forestry practices promulgated.

2 Australia needs to devise standard economic accounting methods for industrial forestry enterprises.

3 Australian forest industries will need to progressively become forest owners.

4 Australian forest growers need to grow wood for a multiplicity of markets rather than a single product.

5 There needs to be much scientific work done in the allocation of wood to specific markets from within its position in the tree as well as rating those pieces of wood by density.

6 There is tremendous potential for Australia to vastly increase its tree-growing activities to produce fuelwood.

7 Australian forest industries need to assist in the development of processes for agricultural intensification which would lead to a lessening of pressure on the forest for agricultural pursuits as well as making more agricultural area available for growing trees.

8 Australia needs to meet the demands for wood products in the Western Pacific Rim.

9 Australia needs to examine where within its borders there is a deficit of people and, given suitable land and climatic attributes, implement plantation development.

10 Australia needs to instigate harvesting research and forest produce transportation using the pool of talented young professional foresters available within the country. World-wide, the industry must accept its obligation to the community in relation to log road transport.

11 Australia should be increasing its *Pinus radiata* plantation resource to capitalise on the markets created by New Zealand in the Pacific, as well as domestic markets. Similarly, our eucalypt plantations should be vastly expanded to meet domestic and export markets.

12 Detailed scientific studies need to be undertaken in Australia on the effect of silvicultural practices on wood quality.

13 Detailed scientific studies into the sawing of plantation eucalypt need to be undertaken.

14 Major industries around the world need to come together to implement scientific studies to find the best planting tool.

15 Australia should implement the Aracruz/Shell system of watering plants.

16 Coppicing of eucalypt in Australian plantations needs to be extensively tested to ascertain its true potential and capitalise on established root stocks.

17 Work needs to continue on the nutritional requirements of eucalypts.

CHALLENGES FOR THE FUTURE

1 Where will the wood for Australia come from in the future, let alone the World? Will Australia have the entrepeneural courage (willpower and desire) to become a dominant wood producer?

2 What is the quality of the wood being grown now?

3 Will we see a reversion to pole construction of buildings given the expansion of small sized uniform eucalypt plantations around the world?

4 Are the Australian forest plantation growers capable of practising nursery regimes of 'just in time'; watering in of individual plants in the field; detailing rigid Eucalypt plant specifications; carrying out detailed studies on root morphology; standardising planting practices and tools; carrying out detailed studies on the effects of silvicultural practices on wood quality?

5 Will the industry properly address the problem of heavy truck usage? Will there be a resurgence of rail transport for forest products?

6 How will industry address the effects on the biosystem in relation to the continued growth of short-fibre crops under monocultural systems?

7 Will the Australian forest industry be able to liaise with other similar bodies around the world, regardless of national boundaries, in the following areas?
- Industries; joint research work on mutual technical problems.
- Industries associations; do similar advertising campaigns, do similar timber marketing promotions; do similar industry standard programs. Talk and co-operate with each other.
- Universities. Standardise forest professional training around the world; work on joint basic function long term research programs co-operatively.
- Professional associations. Make one international forestry association for all foresters around the world.

CONCLUSION

Australia has the land, the expertise and the potential to become a dominant force in world forestry as a grower, processor and exporter. It is at the cross-roads of forestry development, with the painful experience (economically and socially) of changing from a natural wood resource to a plantation-grown resource. The quality of the wood from plantation-grown eucalypts is different to that from mature (old-growth) eucalypts, and is similar to that grown overseas. The author hopes that the findings of this review will help the Australian plantation forestry sector to become that dominant player.

The question must be: 'Is Australia prepared financially, socially and physically to become a major international plantation wood supplier and processor?'

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