Fast-growing eucalypts boost plantation prospects

Compared with Brazil, South Africa, Portugal, Spain, and quite a few other countries, Australia has only a paltry area of eucalypt plantations.

We can boast about 60 000 hectares; overseas they can vaunt seven million. What are the prospects for extending the area of plantations here? Recent research shows that these are a lot better than previously thought, but be prepared for some heated discussion in the months ahead!

Although some forest scientists have been promoting eucalypt plantations for more than 15 years, the Australian Conservation Foundation (ACF) has led the charge in recent public debate about the pros and cons of hardwood plantations. Last year, in its forest industry strategy, the Foundation called for the establishment of large areas of eucalypt plantations. The ACF suggested that if Australians put effort into developing these plantations with the enthusiasm we displayed establishing our softwood resource in the 1960s and '70s, then — except perhaps for very small volumes of high-value speciality timbers destined for things like furniture — we could phase out logging from native forests over the next 15–30 years.

The Australian Forestry and Forest Products Industry Council (FAFPIC), on the other hand, argues that substituting plantations for logging in native forests is unnecessary because non-wood values of native forests can be protected by careful harvesting. However, FAFPIC does support increased investigation of the prospects of hardwood plantations for both pulpwood and sawn timber. It envisages an expanded hardwood resource supporting new industries and supplementing the supply of timber from native forests.

So, whether or not the sound of mechanised harvesters in plantations would be a death knell for logging in Australia's native forests, enthusiasm for hardwood plantations seems to be broadly spread. While the debate continues among conservationists, economists, and politicians about what is financially, socially, and environmentally sensible — 'substitution' or 'supplementation' — it is worth taking a look at what forest and wood scientists say is biologically and technically possible.

B[illegible]ning with the trees

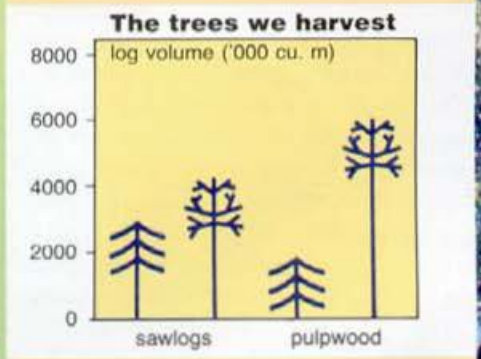
De[illegible]ite an Australian pioneering ethos that treated the eucalypt forests of the [illegible]00s in much the same way as the inhabitants of England must have viewed the oak forests of 2000 BC — impediments to agriculture — we still have about 40 million hectares of native forests. Since the turn of the century, Australia's foresters have built up a vast knowledge about their management. The continuing challenge has been to provide a steady supply of timber while keeping intact the broader benefits of forests — catchment protection, wildlife habitat, and their aesthetic and recreational value.

Rightly or wrongly, the perception of a land well endowed with eucalypt forests pushed the development of large-scale eucalypt plantations down the list of priorities. Foresters, however, have gained expertise in the establishment and management of plantations of a different sort, largely with exotic species planted to give us a home-grown supply of the softwood timber our continent lacked. These have comprised mainly radiata pine (*Pinus radiata*) in Australia's temperate climates and the southern pines (*P. elliottii* and *P. caribaea*) in the subtropics.

By the end of the 1960s, the spread of pines across southern Australia was drawing vocal criticism from those concerned that the plantations — some of them established at the expense of native eucalypts — were replacing an original forest containing a rich and diverse flora and fauna with monocultures that were not much more than biological deserts. Others argued that we'd be better off importing pine from New Zealand, where it could be grown more economically.

The heady days of softwood-plantation establishment are over, leaving a legacy of

The largest shining gum in Dr Beadle's 5-year-old trials in southern Tasmania. Note the dense shade cast by the tree's large canopy.



More than one-third of all the wood we harvest comes from coniferous forests, most of which are plantations of exotic pines.

Mr Dean Tompkins and Dr Ray Leuning (with hat) measure CO_2 assimilation rate in a fertilised, irrigated plot of 9-month-old flooded gum in southern Queensland. The scientists are using a 'Bingham apparatus' that lets them observe the tree's response as they change the environmental conditions around the leaves.

When eucalypts coppice (shoot from the cut stump) re-planting costs are saved. Unfortunately, not all species coppice and some do so only at certain times of the year.

Will our home-grown eucalypt plantations ever match the productivity of eucalypts overseas — like this 40-year-old flooded gum in southern Africa?

some 850 000 ha. Although they occupy only about 2% of our forested land, these plantations produce more than one-third of all the wood we harvest, supplying much of the timber we use for housing and low-cost furniture and the pulp for some of our daily newspapers.

The pines grow quickly in their alien environment, their health and productivity enhanced by the lack of predation from the pests found in their native countries. Transported to a land devoid of their natural enemies, the trees flourished in much the same way that eucalypts have flourished overseas (see *Ecos* 38 and 60). Drawing largely on that argument, conventional wisdom tells us that eucalypt plantations here couldn't reproduce the growth rates achieved in Brazil or southern Africa.

But recent studies indicate that it's worth taking another look at what happens to some of our gum trees when we nurture them in plantations, and pay more attention to their nutrition and to finding the best species and variety for a particular site.

Trapping the sun's energy

At the Tasmanian laboratory of CSIRO's Division of Forestry and Forest Products, researchers Dr Chris Beadle, Mr Charles Turnbull, Mr Trevor Bird, and Mr Derek McLeod, in collaboration with foresters from the State's Forestry Commission, have been examining the plantation potential of some fast-growing eucalypts planted in small trial plots in the Esperance Valley. One species in particular, shining gum (*Eucalyptus nitens*), is out-performing all its major competitors — Tasmanian blue gum (*E. globulus*), mountain ash (*E. regnans*), and alpine ash (*E. delegatensis*). (Shining gum grows naturally in the higher hills and mountains of the Australian Alps in Victoria and the coastal escarpments of the New South Wales Southern Tablelands.)

Although growth rates are likely to alter with time, after 5 years the trees are three times bigger than mountain ash of the same age growing in adjacent plantations.

Dr Beadle says that the attention given to the trial-plot trees in their early life made most of the difference. Unlike those in the adjacent plantation, trees in the trial plot were kept free of competing weeds and given regular applications of fertiliser. Also, for the first 4 years, applications of insecticide kept browsing insects at bay. Shining gum produced a stem volume of more than 45 cu. m per ha in its fifth year, a volume comparable with those in better eucalypt plantations overseas.

However, an ample nutrient supply — although it seemed to be a major determin-

Sawn timber and plantation eucalypts

Because most eucalypts overseas are grown to provide pulp, round construction timbers, or fuelwood, we can't look overseas for much guidance on the use of fast-grown eucalypts for sawn timber. However, we do know that the age of the tree is important. A widely held view in the sawmilling industry is that timber from eucalypts much younger than 50 or 60 years is prone to a number of sawing and seasoning problems. Sawmillers say that the young timber tends to 'spring' when sawn and, more importantly, 'collapses' while drying. But the severity of the problem appears to vary with the species.

In simulation studies and field trials on the sawmilling characteristics of young, naturally regenerated mountain ash — part of the Young Eucalypt Program research — Mr Gary Waugh and Mr Andrew Rozsa, of the Division of Forestry and Forest Products, and Mr Robert Mills of the Tasmanian Timber Promotion Board found that the range of material they examined was highly susceptible to drying degrade from the time the trees were felled. Drying the timber with the industry's current methods of seasoning produced little degrade-free material, due mainly to cell wall collapse leading to abnormal shrinkage.

However, earlier studies carried out on the timber of plantation-grown shining gum gave a somewhat different result. With the help of a local sawmiller, researchers Gary Waugh, Mr Richard Northway, also from the Division of Forestry and Forest Products, and Mr Bob McKimm of Victoria's Department of Conservation, Forests and Lands milled 48 logs of 20-year-old fast-grown shining gum, half into structural timber and half into 'appearance-grade' boards. (The log diameters were similar to those coming from 45-year-old unthinned mountain ash regrowth forest.)

After drying under four different schedules, they tested and graded the timber using current industry standards. They found that twist, spring, and bow were well within the permitted limits. And the wood, although not as dense as that of older trees, had comparable strength properties. But, because the young shining gum logs had large knotty cores, the appearance grades of the sawn boards were classified as low, highlighting a major problem ahead for plantation-grown trees.

Without early pruning, or perhaps some tree breeding, each plantation-grown log will produce more knotty timber than its older, naturally grown counterpart. And, given the current assessment criteria in the grading rules, the value of knotty 'appearance-grade' timber is low. Perhaps, in the future — as for radiata pine — the industry will promote 'knotty hardwood' as a desirable timber. No doubt consumer demand will influence the future product.

Utilisation potential of plantation-grown *Eucalyptus nitens*. R.J. McKimm, G. Waugh, and R.L. Northway. *Australian Forestry*, 1988, **51**, 63–71.

Sawn products from young eucalypts. G. Waugh, A. Rozsa, and R. Mills. *Prospects for Australian Plantations Conference, Australian National University, August 1989.*

ant of these high growth rates — didn't explain why this species is out-growing others in the trial, which were also supplied with abundant nutrients. Dr Beadle puts its greater productivity down to its ability to use the available nutrients to rapidly develop a large photosynthetic canopy that intercepts most of the available light.

With instruments (quantum sensors) installed on masts and on the ground, Chris Beadle has been comparing the amount of radiation above the canopies with that received on the forest floor. He has also been sampling and measuring the size and weight of leaves from the canopies to obtain a leaf area index (leaf area in square metres per square metre of ground) of the species in his trial. His measurements have shown that the species that grow the fastest trap the most light. The shining gum is particularly successful. At age three it was intercepting about 75% of the available radiation; by contrast, an adjacent stand of alpine ash of the same age intercepted less than 30%. The graph on page 9 shows how this is linked to growth.

It seems that the size of the photosynthetic canopy rather than its efficiency plays the major role in determining growth rates. Shining gum produces large leaves and lots of them. Getting the maximum light interception when the plantation is young is a valuable attribute that leads to higher growth rates sooner and thus the option of shorter crop rotations or earlier thinning yields. A dark forest floor is a good indication that, up above, there are plenty of leaves for photosynthesis. (Bushwalkers will be familiar with the dappled shade on the floor of older, natural eucalypt forests, where the canopies commonly intercept only about 25% of the available light.)

Another important factor in determining growth is the availability of nutrients and water. Temperature and humidity, too, play key roles as they largely determine rates of evapotranspiration and hence the available soil moisture. (Put simply, plantations further north need more rain than those in the south because more evaporates, but those in the warmer climes don't have to cope with Jack Frost nibbling at their leaves.)

Research on subtropical eucalypt species, particularly flooded gum, has been stimulated recently by funding from Shell Australia. This company is supporting a collaborative project between the Division of Forestry and Forest Products and the Queensland Department of Forestry to see how fast flooded gum can be grown in Queensland. According to Mr Robin Cromer, the leader of the CSIRO team, early indications point to growth rates that will certainly exceed those obtained with shining gum in Tasmania.

Obviously, when planning the locations of plantations, we would find it useful if we could use basic meteorological data to estimate their likely growth rates. Several scientists in the Division are working on this and the possibilities look promising. Dr Peter Sands — a colleague of Chris Beadle's in Tasmania — is developing models that will help predict how the local climatic conditions influence the height and diameter of young eucalypts. Dr Phil West is fine-tuning a model that simulates the growth of individual trees in a forest monoculture. And Dr Ross McMurtrie and colleagues are developing a more complex model that takes account of radiation energy and available water along with the processes of canopy photosynthesis, respiration, tissue production, and litter-fall.

Part of Robin Cromer's project — gathering information on the nutrition and physiology of flooded gum to determine what limits its growth in Australia — is also providing a valuable input to Dr McMurtrie's growth model. Data from field research simultaneously improve the models while providing a check on their reliability. Models that approximate reality well provide foresters with a technique that

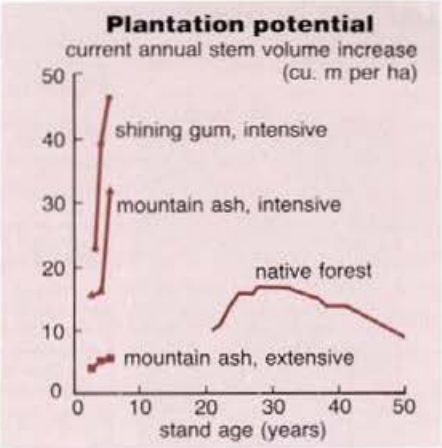
they can use to simulate and to compare eucalypt plantations growing in contrasting environments.

Tree breeding opportunities

The fact that we may be near to creating a model that accurately simulates the growth of flooded gum is encouraging, particularly as it is one of Australia's major commercial timber species and widely planted in other parts of the world. Mr Peter Burgess, part of the CSIRO team working on the collaborative project in Queensland, estimates that two million hectares of flooded gum are growing overseas.

Countries that have pursued tree-improvement programs report better growth rates than we are used to here. Should we be looking at re-importing some of this material to take advantage of overseas breeding? Peter Burgess doesn't think so. One reason is the risk of introducing exotic pathogens that could infect our trees. He believes that we can improve the productivity of flooded gum, and other eucalypts, by going back to the gene pool of our natural forests.

Lately, overseas experience has given credence to his view. Despite an intensive breeding program in southern Africa, progeny of the program have not performed as well as trees grown from seed recently collected from Coffs Harbour. This finding supports the results of earlier trials carried out by Peter Burgess and Mr Peter Ades of the New South Wales Forestry Commission, when they compared progeny from a South African seed orchard with those selected from superior trees near Coffs Harbour. After 3 years, the local trees had



Compared with natural regrowth forest, intensively managed eucalypt plantations can grow very quickly. Shown here are the results of trials in southern Tasmania. Trials with other species in southern Queensland look even more promising.

43% greater average volume than the 'improved' African stock.

Peter Burgess thinks that this is because the original seed taken to South Africa came from one small area of the species' range. And it seems likely that other countries have inherited the same source. South Africa sent seed north from its plantations to establish flooded gum forests in other parts of the continent and, later, Zimbabwe exported large quantities to Brazil.

Over the last few years Mr Burgess has monitored the growth of flooded gum in other trial plots on three sites: one in northern New South Wales, one in southern Queensland, and a third near Mtao, Zimbabwe. This time he used seed taken from sites right across the species' natural geographic range. Surprisingly, in all three trials, the best form of flooded gum came not from one super provenance but from various locations ranging between the furthest north and the furthest south.

Mr Burgess believes that because flooded gum tends to grow naturally in relatively small areas in the forest — usually the moist gullies — it's likely that the gene pool at each location is fairly small and the species probably suffers from inbreeding. Mixing the genes from a wider range of locations (outcrossing) could lead to dramatic gains in productivity. He thinks that other eucalypt species prone to inbreeding may respond in a similar way.

Future eucalypt plantations could also benefit from other artificial breeding opportunities. Back in Tasmania, for example, CSIRO's Peter Volker is working with the local forest industry on a program that's attempting to hybridise shining gum and Tasmanian blue gum. Despite its prolific growth, shining gum has drawbacks. It has less-suitable fibres for pulping than the blue gum and doesn't shed its branches as readily. Moreover, unlike blue gum, it doesn't grow again (coppice) from the cut stump, so successive crops have to be replanted.

One problem with blue gum — as Dr Beadle demonstrated in his experiments — is its dislike of cold weather. Show it a frost and many of the leaves shrivel up, severely retarding its growth. Peter Volker hopes to produce a gum that will combine the branch-shedding, coppicing ability, and pulp yield of blue gum with the cold-hardiness of shining gum.

Scrimber®: big things from young trees

If we want to use more material from younger trees, then as consumers we'll have to accept new products in our local timber centre. One option for the industry, particularly for small-dimension timber products like skirting and architraves, is to cut out weak, low-quality sections in seasoned timber and glue the stronger pieces together with techniques such as 'finger-jointing'. This well-established technique in the softwood industry could be applied to timber sawn from young eucalypts to raise its value.

But there are other, newer ways to reconstitute wood. As this issue of *Ecos* goes to press, Scrimber International — jointly owned by the South Australian Insurance Company and the South Australian Timber Company — should have

The 'Scrimber' process — developed by CSIRO in collaboration with Repco Pty Ltd — can be used for softwood or hardwood. These Scrimber® products are made from jarrah (*E. marginata*).

rolled out the first of its Scrimber® products. Although at the moment the company uses only radiata pine, its technical manager, Mr Bruce Jordan, plans to carry out trials with a number of eucalypt timbers: he has already successfully used jarrah (*E. marginata*). In fact, the process was originally developed for eucalypts and was later adapted for radiata because of the large quantities of young pine available.

The process is appealing because it not only 'upgrades' the value of timber from young trees but utilises up to 80% of the log — about 30–40% more than traditional sawmilling.

You can obtain more information about Scrimber® products from Scrimber International, P.O. Box 663, Mount Gambier, S.A., 5290. Telephone (087) 24 2911.

Pulp and paper and plantation eucalypts

The wood from young, plantation-grown eucalypts differs from that produced by older trees growing in natural forests. At the risk of some over-simplification: younger trees are generally favoured for pulp, but are less desirable for sawlogs (see the box on page 6).

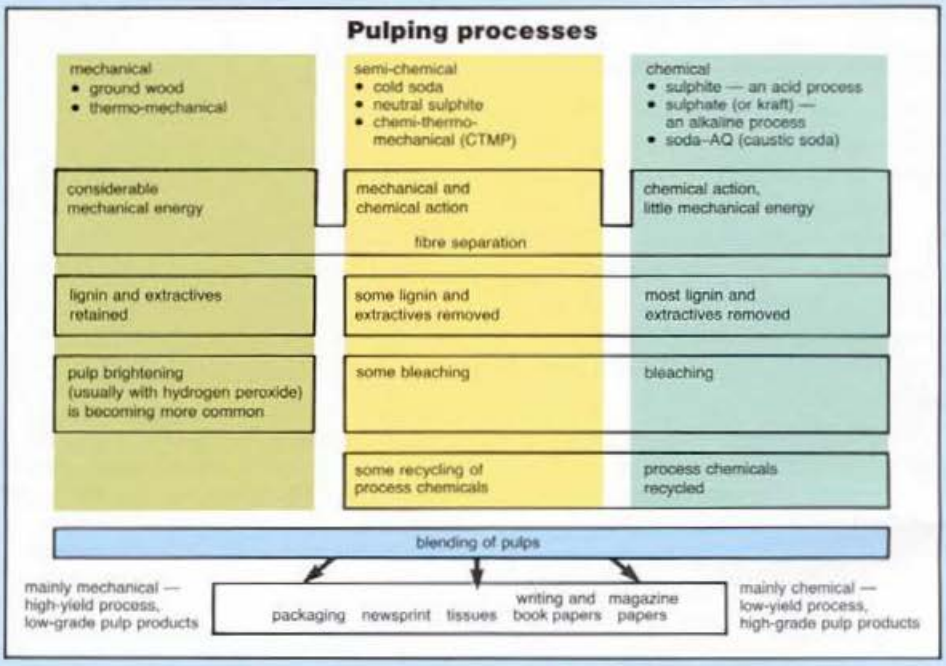
Annual crops, agricultural residues, cotton-rags, and cellulose fibres from almost any kind of plant can be made into paper; but the pulp and paper industry uses wood as its principal fibrous raw material. Underlying the sophisticated technology of modern paper manufacture is a relatively simple process: the plant's cellulose fibres are separated from each other, beaten, then reconstituted in flat sheets to form paper. The method used to separate the fibres is really what differentiates the different pulping processes (see the diagram). Each one produces a different-quality pulp and paper.

Unfortunately for the paper industry, trees aren't just made up of cellulose fibres. Eucalypt woods comprise about 40–62% cellulose, 12–22% hemicellulose, 15–22% lignins, and variable quantities of phenolic compounds, ellagic acid, gallic acid, and ellagitannins. The mechanical processes produce the lowest-grade papers because they retain most of the non-cellulose material. Chemical processes, as used in the kraft (German for strong) milling that produces most of the world's eucalypt pulp, make the best-quality paper because they remove unwanted compounds (extractives and lignins) from the pulp and the fibres themselves suffer relatively little damage.

Industry prefers younger eucalypts because the wood is less dense and requires less chemical to separate the fibres, resulting in a higher yield. And, because the percentage of extractives is smaller, less chemical is needed to remove these. The heartwood of older trees contains large quantities of undesirable compounds that tend to gum up the digester screens and to colour the pulp.

The strength and finished quality of paper depend largely on the thickness of the fibre walls and the ratio of fibre length to diameter. Put simply, longer fibres bind together better and produce strong but rough papers commonly used for packaging. Shorter fibres bond less well and make weaker papers but produce a smoother surface. Eucalypt fibres are shorter than softwood fibres and so are desirable for top-quality writing and printing papers that need adequate — but not necessarily high — strength properties, high brightness and opacity, and a smooth, strong surface. The industry commonly blends hardwood and softwood fibres to obtain strong papers with an acceptable finish.

Of course, things are never quite that simple; complications include the fact that the fibre length of eucalypts varies with the species and age of the tree: younger trees tend to have shorter fibres — even shorter than the ideal for paper-making.



While modern 'chemical' pulp-mills recycle most of the chemicals used, it is not possible to recycle all the by-products formed during chlorine bleaching. Alternatives to the use of chlorine — removing more of the lignin at an earlier stage, bleaching with oxygen, and substituting other chemicals — are under investigation. Meanwhile, a reduced demand for bleached paper would reduce by-product output.

Mr Noel Clark and colleagues from industry and the Division of Forestry and Forest Products in Melbourne have recently examined the quality of the pulp and paper produced from samples of Tasmanian-grown mountain ash and messmate stringybark taken from naturally regenerated regrowth forests of various ages. (Their research is part of the Young Eucalypt Program mentioned in the main article.)

After analysing the samples for their chemical composition they pulped these using the kraft process and carried out paper-making tests. They found that trees younger than 10 years had the poorest pulping and paper-making properties, relative to older trees of the same species. Those in the 20- to 59-year age range performed best. Of course, as overseas experience with plantation-grown species has shown, the quality of pulp from other young eucalypts may be different.

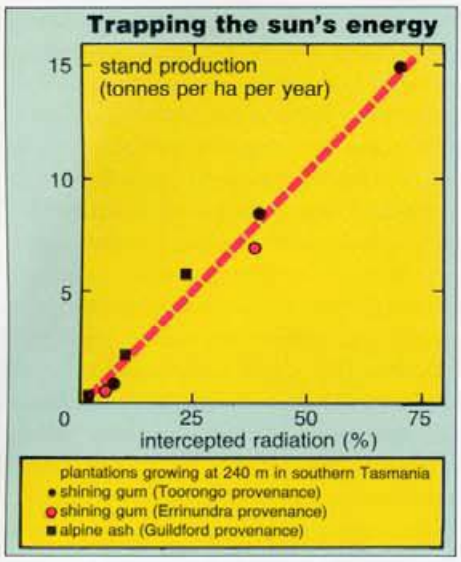
The effect of age on pulpwood quality. N.B. Clark, A.F. Logan, F.H. Phillips, and K.D. Hands. *Appita*, 1989, **42**, 25–32.

Pulpwood requirements for the pulp and paper industry. F.H. Phillips. *Australian Forestry*, 1988, **51**, 106–11.

The plantation potential

Eucalypt breeding appears to have enormous potential for raising growth rates and wood quality, but whether we can lift productivity generally to overseas levels remains to be seen. Other factors are important. Will sufficient land be available? Successful plantations will need high rainfall — at least 900 mm for plantations in the south, and perhaps more in the warmer areas in the north. Soils should be reasonably fertile and well drained and the terrain not too steep. And we will definitely have to spend time and money controlling weeds in the young plantations: eucalypts perform poorly when set the task of competing against them. Moreover, to get maximum growth we will almost certainly have to add fertiliser.

Mr Cromer found that fertiliser, applied on Victorian-grown blue gum within the first 2 years of planting, trebled its stemwood biomass after 10 years (see the chart opposite). Trials with flooded



All other things (water, nutrients, etc.) being equal, stand productivity can be directly related to intercepted radiation. The size of shining gum's photosynthetic canopy (it has large leaves and lots of them), rather than its efficiency, seems to play the major role in determining its superior growth rate.

gum in Queensland indicate that similar or greater responses are occurring there.

Insect attack on the young trees will definitely lower productivity, but would large-scale spraying be economically or environmentally desirable? Growing large areas of monoculture — even a native eucalypt — may increase its susceptibility to infection by a disease. For example, some overseas plantations suffer badly from cankers.

On the positive side, we know a lot about the genus *Eucalyptus* and its genetic variation, and we have access to the world's entire gene pool to draw on for breeding. Many eucalypts are prolific seed producers and are easy to grow from seed. Because the trees are native they have an intrinsic ecological value here. And we have an industry familiar with the raw material, supported by research based on trees growing in native eucalypt forests. Much of this technology and knowledge can be transferred to their plantation-grown cousins.

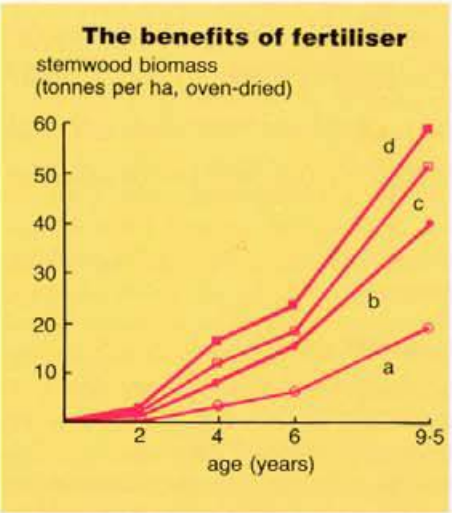
For example, it was Australian research that overcame some of the problems associated with the application of the kraft pulping process to eucalypts, now used throughout the world for pulping the genus (see the box). Various current CSIRO forestry research projects are also pertinent to questions about eucalypt plantations. Among them, the Young Eucalypt Program in which the Division of Forestry and Forest Products is a partner is designed largely to provide information about how we may intensively manage regrowth of our native forest. The project completed its initial phase at the end of last year and is yielding research results that are relevant to plantations.

In southern Queensland, the Division's STAG project (Soils, Trees And Grass) has been monitoring the growth of flooded gum and pasture to determine the interactions between the two at different stand densities and, in particular, the effect of competition for water, nutrients, and light. 'Agroforestry' projects should find results of this research most valuable: after nearly 4 years, trees planted at 300 stems per hectare have reached a form good enough for a timber crop, while the pasture production is similar to that on control plots where no trees are growing.

And there's more research ahead in Tasmania. Last planting season, with the financial support of the National Afforestation Program, Huon Forest Products, and the Forestry Commission of Tasmania, Dr Beadle established 100 ha of shining gum, which he'll grow under an intensive management strategy while monitoring the trees' nutritional requirements and growth. Australian and overseas foresters who have seen Dr Beadle's trial plots of shining gum are keenly interested in the potential of this species.

The likely outcome?

Will the 1990s herald a rapid expansion of eucalypt plantations across Australia? It seems likely. Australia's major forestry companies are already increasing the size of their plantation holdings — by 4500 ha per year in Tasmania and 1000 ha annually in both Victoria and Western Australia.



In Mr Cromer's trials, Victorian-grown Tasmanian blue gum responded dramatically to different quantities of fertiliser. (Treatments 'a to d' represent 'none to most'.)

Last year the Western Australian Department of Conservation and Land Management announced plans to establish 5000 ha of Tasmanian blue gum in the first stage of a project that proposes annual plantings of 10 000 ha on cleared land in selected water catchments in the south-west of the State during the next decade.

Obviously, economics will play a significant role in determining how many eucalypt plantations we'll see dotted across Australia by the turn of the century. Their location will be critical to their success. Because transport costs have such a large bearing on the viability of timber- and pulp-mills, the price of land close to existing or proposed processing plants will be crucial. And the sites must have adequate rainfall. Plantations on low-rainfall sites — unless they can be irrigated (by sewage effluent perhaps?) — will never be economic.

And environmental concerns are obviously going to play their part, too. Community opposition to logging in native forests and 'greenhouse-induced' demands to plant more trees will each add another dimension to the economic imperative.

One thing's fairly clear: on sites where there's plenty of water for the trees, the growth rates of our plantations won't be the limiting factor. With a change to more intensive management and some judicious tree breeding we can expect to see some rapid growth from the old gum tree.

David Brett

More about the topic

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