

A PERSPECTIVE OF THE EUCALYPT FORESTS: THEIR CHARACTERISTICS AND ROLE IN WOOD PRODUCTION

R. G. FLORENCE*

ABSTRACT

Despite the low yields obtained from them, the eucalypt forests have contributed substantially to Australia's development. During the post-war decades of rapid economic growth, sawlog availability has been run down in order to service the high level of wood demand, with the anticipation that the softwood plantation programme would progressively take over the major wood supply role. As this happens it will be possible to formulate long-term policies and strategies for the eucalypt forests.

It is argued in this paper that there will be advantages in maintaining a strong and stable forest products industry based on the eucalypt forests. This will require, in turn, a more acceptable balance between wood production and conservation of natural environments than has been possible in the past. It will also be essential to take account of the biological nature of the eucalypt, and to develop forest use strategies and practices which will maintain the stability of the eucalypt forest ecosystem.

INTRODUCTION

This paper aims to present a perspective of the future of the eucalypt forest as a wood resource. That perspective will be greatly enhanced where the reader also has some appreciation of the biological nature of the eucalypt forest and any constraints this may place on wood production. Admittedly, it is impossible to deal adequately with such diverse topics in the one paper. Nevertheless, some attempt to do so may help an audience at an international congress gain some "feel" for the nature of the eucalypt, the reasons for its widespread distribution, and silvicultural and biological attributes of the forest influencing its role in wood production. Against this background it should be possible to appreciate better some of the questions to be resolved in formulating policies for the eucalypt forests. Thus this paper

*Reader, Department of Forestry, Australian National University, Canberra, Australia.

is presented in three sections, the biological nature of the eucalypt, the eucalypt forest as a wood resource, and the continuing role of the forests in wood production.

THE BIOLOGICAL NATURE OF THE EUCALYPT FOREST

Continental Drift and the Australian Environment

An appreciation of the nature of the eucalypt forest should start with consideration of events some 60 million (m) years ago when the Australian continent separated from Gondwanaland (see relevant chapters in Keast, 1981). At this time, the Australian continent was largely covered by cool temperate rainforest dominated by Gymnosperms, notably the conifers *Podocarpus*, *Dacrydium* and *Araucaria*. The climate was probably humid and cool. Many other species are present in the pollen record, including members of the Myrtaceae, but not *Eucalyptus*. *Nothofagus* was not common at this stage.

During the early stages of continental drift there was a progressive change in climate; temperatures increased and rainfall became more seasonal. Nevertheless, the change was probably sufficient to create widespread vegetational and landform instability. Massive erosion reduced the continent to a vast plain, and when this was nearly complete, processes of soil laterisation developed over much of the continent. By 20 m years ago deeply weathered landscapes and soils were widespread through the continent.

Around this time there was a more fundamental change in climate; continental ice started to form in Antarctica, cooling the seas and leading to increasing drying of the continent. Nevertheless, rainforest seems to have retained a wide distribution for many millions of years, suggesting seasonal rainfall or only periodic aridity. During this period cool temperate rainforest with *Nothofagus* had a wide distribution, including central Australia, though now interspersed with increasingly extensive open forests and woodlands. *Eucalyptus* now becomes more common in the pollen record, together with cypress pine (*Callitris*), *Casuarina* and *Acacia*.

The Kosciusko uplift and extensive basaltic flows along the eastern seaboard some 10-15 m years ago would have reversed the general trend of decline in soils and vegetation within this region. There would have been a wide range of new environments (fertile basaltic soils, newly exposed parent materials,

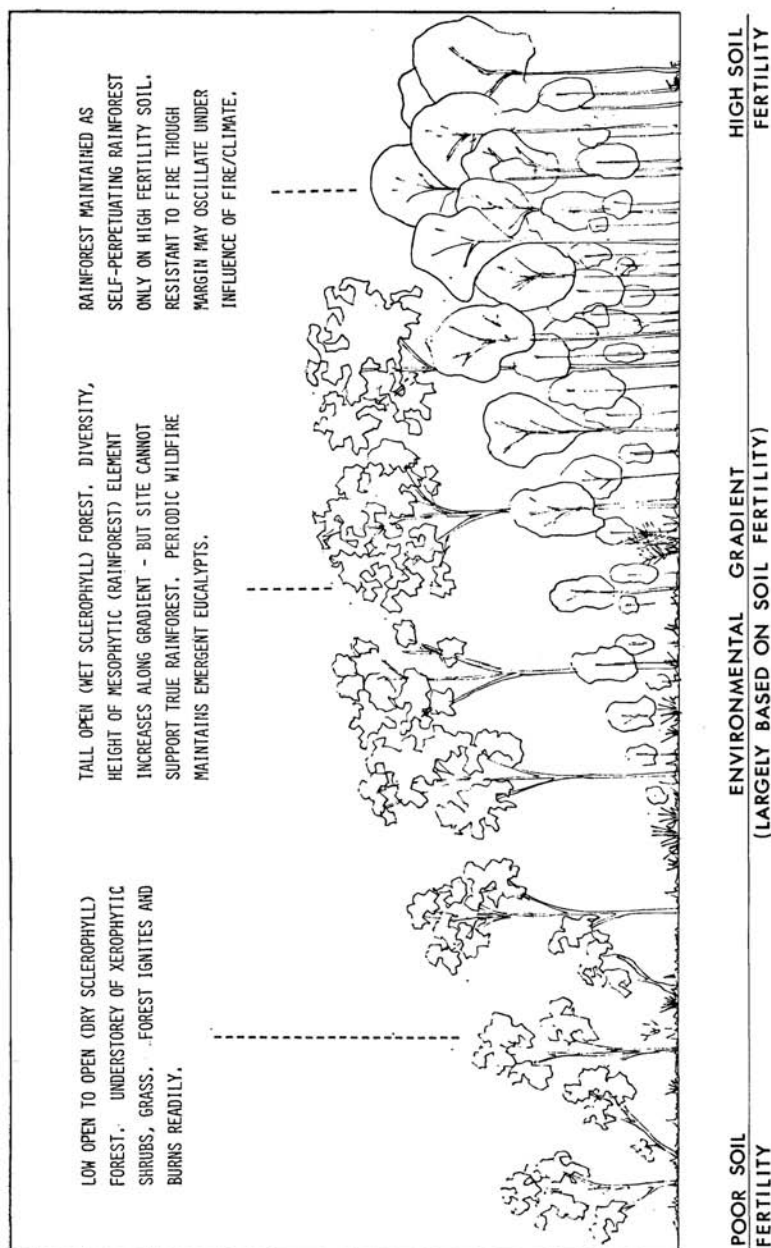


FIG. 1: Diagrammatic illustration of the influence of soil fertility on vegetation in east coast forests. The flammability of the forest and the role of fire (or other disturbances) in maintaining the wet sclerophyll forest is also shown.

higher rainfalls), and opportunities for vegetational expansion rather than retraction. This undoubtedly contributed to the conservation of some elements of the Australian flora, notably the subtropical rainforests, and the evolutionary expansion of others.

Despite these events, the gradual deterioration in climate continued over much of the continent, with the replacement of *Nothofagus*-Gymnosperm forest by sclerophyll forests, woodlands, and desert apparently being largely completed a million years ago. Moreover, there has been no specific endpoint to climatic change, that is, the Australian climate has been far from stable in the last 100 000 years. A series of glacial and interglacial phases has caused continuing and widespread instability in the vegetation, soils and landscapes.

Adaptation of the Eucalypt to Low Nutrient Soils

Against this background, it is possible to conceive the progenitor(s) of *Eucalytus* having outstanding evolutionary capacity to keep pace with environmental change. Thus *Eucalyptus* may have been a response *primarily* to declining soil fertility associated with erosion, weathering and laterisation of soils, and *secondarily* to a drying climate. Beadle (1966) argues that the Australian sclerophyll flora represents an adaptation to low nutrients rather than to a dry climate, and that rainforest genera are more effectively excluded from an area by low nutrients than by a dry climate.

Characteristics of the eucalypt which reflect adaptation to low nutrient soils have been suggested by Florence (1981). It is important to appreciate, however, that not all eucalypt species occur on soils of very low nutrient status. Because eucalypt species differ in their tolerance of, and competitive ability on low nutrient soils, the vegetational gradient from low or low open (dry sclerophyll) forest through tall open (wet sclerophyll forest) to rainforest is now seen to be largely associated with a gradient in soil fertility status (Fig. 1).

Adaptation of the Eucalypt to a Drying Climate

As the climate began to deteriorate more dramatically in the mid- to late Tertiary, the eucalypt would have been subject to a powerful new selection pressure, increasing drought. Today, eucalypt species are associated with a very wide range of environments, from those with a narrow environmental tolerance, occurring only under the most favourable of environmental con-

ditions, to those extending to the shrublands and desert formations of the interior. Limited physiological evidence is beginning to point to what may be a very significant characteristic of the eucalypt, that is, no eucalypt can be regarded as a true "drought evader" — *i.e.*, closing stomata early and reducing transpiration and metabolism to a minimum to evade leaf water stress. Rather, the eucalypt might be generally characterised as a "drought-tolerant mesophyte" (Florence, 1981), that is, maintaining transpiration and cell metabolism under drought conditions and tolerating low leaf water potentials.

During the mid- to late Tertiary we might think of the eucalypt evolving a range of characteristics progressively enhancing its tolerance of dry environments. At one end of the spectrum there are species which may reflect the eucalypt's origins in a moist environment, that is, species with high rates of water use restricted to near optimum habitats; a good example of one such species is mountain ash (*E. regnans*). As environmental factors change in the direction of increasing drought, a series of replacement species reflect increasing tolerance of dry environments.

There may be many physiological attributes contributing to drought tolerance in eucalypts, but undoubtedly one of the most important is their capacity to develop an extensive root system, both laterally and to depth, to maximise access to water supply. Moreover, the lignotuber habit may be critical in permitting the seedling to survive for long periods while the root system is developing to that point where dynamic growth is possible through sapling and pole stages. This drought-tolerance of the dry region eucalypt is well expressed in a study in Western Australia (Shea *et al.*, 1979) which showed that in a region with an average annual rainfall of 218 mm, and after a rain-free period of 18 months, two eucalypt species were able to effect a short period of transpiration each morning, and to restore water balance after stomatal closure and at night. In this case the development of an extensive vertical root system, probably during a prolonged lignotuberous seedling phase, could be the cardinal feature allowing stomatal activity, transpiration, and growth to persist under extreme drought conditions.

Sensitivity of the Eucalypt to Micro-organisms and Leaf-eating Insects

While some of the eucalypts may have evolved in an environment very low in nutrients, and hence micro-organisms, there may have been little opportunity for those species to evolve

defence mechanisms against antagonistic or pathogenic soil organisms. Alternatively, there are other eucalypts which are much more resistant to such organisms. The past two decades in Australia have made us very aware of the eucalypt's sensitivity to micro-organisms. The introduction of *Phytophthora cinnamomi* to the jarrah (*E. marginata*) forest region in Western Australia has resulted in extensive dieback and death of this highly susceptible species. Jarrah also has a high rate of water use, maintaining transpiration under conditions of high summer temperature and low summer rainfall. It may be able to occupy harsh lateritic soils only through the development of a root system able to penetrate deeply through the laterite to moist layers beneath. But where the root system is affected by a disease organism, tree decline and death may follow quickly. Thus, while the attributes which confer drought tolerance on the eucalypt also confer a high capacity for wood production in dry environments, an inevitable disadvantage may be that the eucalypt becomes highly susceptible to any factors affecting continuity of water supply to the tree.

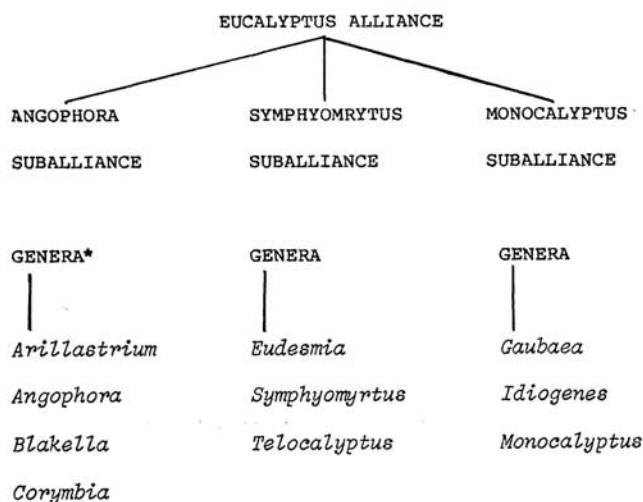
Insects which graze on eucalypt foliage co-evolved with the eucalypt — this is apparent in the way different groups of insects are associated with different groups of species having different phytochemical properties. Indeed, the relationship between host eucalypt and insect species can be used as a guide in classifying species in marginal cases. It has been suggested that differential insect grazing on regrowth in mixed species stands may affect the relative competitive ability of the species and eventually the composition of the dominant stratum — though this is not substantiated. Insect numbers in the eucalypt's natural environment fluctuate but are limited by ecological checks and balances. However, where ecosystems have been modified heavily by settlement, leaf-eating insects may reach epidemic proportions, causing severe damage to eucalypt forests and woodlands.

Species and Community Patterns in Eucalypt Forest

From the foregoing discussion, we might attribute the complexity of species patterns in many eucalypt forests to the competition for site occupancy by a large number of species differing from one another — often only slightly — in their tolerance of limiting site factors. Where site conditions are more or less uniform over a large area and highly favourable to a particular

species, then that species may achieve near total occupancy of that area — as in mountain ash, alpine ash (*E. delegatensis*) and some blackbutt (*E. pilularis*) and karri (*E. diversicolor*) forests. Elsewhere, a mosaic of species associations may reflect to a large degree the outcome of competition for site occupancy within an area varying in soil nutrient status, physical site characteristics and water status, and soil biological conditions.

The reasons for the large number of species within the one forest, and complex but predictable species association patterns, has become somewhat clearer in recent years. Perhaps one of the more important advances in our understanding of the eucalypt have been the concept that *Eucalyptus* is not a single entity, rather it consists of a number of taxa which are now seen to be sufficiently distinctive to be accorded generic status (Pryor and Johnson, 1981). While a classification based on 10 genera (Fig. 2) has not been formally proposed at this stage, these taxa are now widely referred to as subgenera following Pryor and Johnson (1971). Three of these subgenera comprise the forests of southern Australia, *Monocalyptus*, *Symphyomyrtus* and *Corymbia*. Each of these subgenera has its own set of broad



* These are referred to as subgenera in this paper.

FIG. 2: Taxonomic status of Eucalyptus as seen by Pryor and Johnson (1981), involving division into 10 genera.

ecological attributes; the summary of these attributes (Table 1) shows the way they differ in their tolerance of several environmental factors. This suggests that subgenera may have originated under rather different ecological conditions with, perhaps, subsequent ecological and morphological convergence; however, there is nothing in the pollen record which can shed light on this (Pryor, 1976).

An appreciation of *Eucalyptus* as a series of distinctive taxa provides a better perspective of pattern in eucalypt forests and woodlands than was hitherto possible (Florence, 1981). The two examples of pattern-environment relationships given in Fig. 3 suggest that along environmental gradients we might interpret pattern, first in terms of the distribution of subgenera in relation to environmental factors, and, superimposed on this, the more sensitive response of individual species within the one subgenus to quite small changes in environmental factors. Thus, where the environment varies in a complex way, a complex but predictable pattern of species associations is built up.

THE EUCALYPT FOREST AS A WOOD RESOURCE

There are some 40 m ha of native forest in Australia, and the area of eucalypt forest with the potential for commercial wood production is of the order of 28 m ha. The estimated availability of sawlogs from these forests for 1985 is approximately 4.0 million m³ (Australian Forestry Council, 1981). This is a very small yield for such a large area of forest, reflecting the fact that a large part of the forest now provides very little merchantable volume. Moreover, availability is expected to decline even further in the short and medium terms. Actual sawlog harvested in 1972-3 was close to 7 million m³, and it is anticipated this will decline progressively to around 3 million m³ by 2000. The reasons for this will be discussed later. On the other hand, pulpwood availability from native forests is expected to remain stable at around 6 million m³ between 1980 and 2000.

It is clear from such data that the eucalypt forest, as a whole, is a very low-yielding resource, and, despite the area involved, has fallen well short of meeting the demand for forest products in Australia. Alternatively, softwood plantations will play an increasing role in wood supply, with some 70% of total sawlog consumption anticipated to come from this source by 2000.

TABLE 1: DISTRIBUTION AND ECOLOGICAL CHARACTERISTICS OF THE SUBGENERA COMPRISING THE FORESTS AND WOODLANDS OF SOUTHERN AUSTRALIA

<i>Subgenus Monocalyptus</i>	<i>Subgenus Symphyomyrtus</i>	<i>Subgenus Corymbia</i>
RANGE		
Restricted to more coastal regions of south-east Australia, the south-west corner of Western Australia and Tasmania; occurs only where annual rainfall exceeds ca 600 mm; primarily a component of the forest formation — rarely a component of woodland.	Widespread distribution throughout continent — from forests of the high rainfall coastal regions to woodlands and low woodlands of the dry regions; occurs in suitable niches within shrubland and desert formations.	Monsoonal and dry-continental distribution in northern Australia, with extension along east coast, and an isolated occurrence in the SW of West Australia. Absent from temperate parts of Australia, Victoria and Tasmania.
TOLERANCE OF LOW NUTRIENT SOILS		
Occupies "poor" to "moderate" fertility soils; best adapted of subgenera to poor soils; may be the only component on such soils or in mixture with the bloodwood group of <i>Corymbia</i> . <i>Monocalyptus</i> species make up some of the most productive of Australia's commercial forests.	Does not normally occur on poorest forest soils but may be a component where other edaphic factors are limiting (e.g., aeration); tends to replace <i>Monocalyptus</i> as soil fertility improves; may be the only eucalypt component on higher fertility soils.	The bloodwood group of <i>Corymbia</i> may occupy low fertility soils in mixture with <i>Monocalyptus</i> ; bloodwoods may be replaced by the spotted gum group of <i>Corymbia</i> as soil fertility status improves.
TOLERANCE OF DRY CONDITIONS OR PHYSICALLY DIFFICULT SOILS		
Limited tolerance of dry environments; ranges from tall open forest (where some species may be restricted to near-optimum habitats) to low open forest on immature soils at low rainfall end of range.	Wide range in drought tolerance, occurring from coastal forest to dry interior; high rainfall species may have greater drought tolerance than <i>Monocalyptus</i> spp. with similar distributions; <i>Symphyomyrtus</i> spp. also show greater tolerance of poorly structured soils.	Could be seen as intermediate in tolerance of dry environments between <i>Monocalyptus</i> and <i>Symphyomyrtus</i> , though occupancy of monsoonal and dry continental areas means some species are highly tolerant of dry environments.
TOLERANCE OF UNFAVOURABLE SOIL ORGANISMS		
Little resistance to pathogenic and antagonistic soil micro-organisms.	Generally resistant to unfavourable soil organisms.	Highly resistant to unfavourable soil organisms.

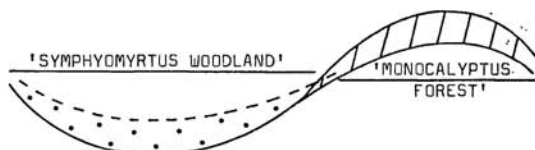
SOUTHERN TABLELANDS

Rainfall 600-750mm with summer stress period

HIGH	GRADIENT IN SOIL FERTILITY	LOW
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Soil formation influenced by mantle movement through many erosion phases

Immature soils

Symphyomyrtus Woodland:

E.bridgesiana, *E.melliodora*,
E.blakelyi

Deep soil but tree roots must cope with heavy textured poorly structured B horizon, marked seasonal variations in water status of A horizon and grass competition

Monocalyptus Forest:

E.macrorhyncha, *E.rossii*,
E.dives

Shallow soils, but light rain may penetrate to some depth through fissures in underlying rock and soil pockets through profile

EAST COAST

Rainfall 1000-1500mm well distributed with summer peak

HIGH	GRADIENT IN SOIL FERTILITY	LOW
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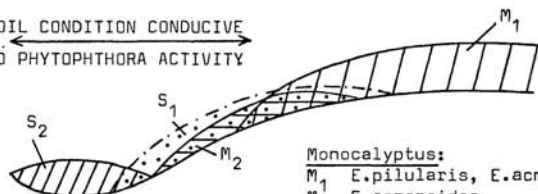
SOIL PHYSICAL CONDITIONS		
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Moderately impeded (silty) gully soil

Decreasing soil drainage/aeration

Moderate depth and drainage

SOIL CONDITION CONDUCTIVE
TO PHYTOPHTHORA ACTIVITY

Monocalyptus:

*M*₁ *E.pilularis*, *E.acmenoides*
*M*₂ *E.acmenoides*

Symphyomyrtus:

*S*₁ *E.microcorys*, *E.siderophloia*,
E.propinqua, *E.resinifera*
*S*₂ *E.grandis*, *E.robusta*
(plus *Tristania* sp.,
Syncarpia sp.)

FIG. 3: Examples of pattern in eucalypt forest reflecting response of subgenera and species to gradients in soil properties. Examples are from the southern tablelands and east coast forests of New South Wales.

Characteristics of the Eucalypt Forest affecting Wood Supply

The reasons for the low wood yield may be found both in inherent characteristics of the eucalypt forest, and historical influences on them.

Characteristics affecting wood production include the sensitive relationship between site productivity and environmental factors, the inherently low yields obtained from old-growth forests, and a number of ecological and silvicultural factors restricting the yield from much of the forest that has been selectively logged or cutover without due regard to the requirement for regeneration.

Site production and environmental factors: Only a relatively small part of the eucalypt forest has good production potential; this is estimated to be 9.5% of the total forest area and includes the mountain ash and alpine ash forests of south-east Australia, the karri forest of Western Australia, and the higher quality wet sclerophyll forests of the east coast. Much of the eucalypt forest consists of a mosaic of forest types, reflecting the sensitive response of the forest to variations in environmental factors. Within this mosaic the more productive commercial forests occur under the more favourable environmental conditions. For example, mountain ash occurs only where a very narrow set of environmental conditions is met; alpine ash has a mosaic distribution associated with deeper soils and sheltered habitats within higher altitude forest; and the blackbutt forest has a highly discontinuous distribution along the east coast, occurring only where there is good potential for moisture storage and ready penetration of roots and moisture to depth.

The inherently low yield from old growth forests: The wood volume which can be harvested from the old-growth forest is low for a number of reasons.

- (1) While the eucalypt may be fast-growing through sapling and pole stages, rapid segregation into canopy classes will occur, with dominants and codominants able to maintain reasonable diameter increments only at wide spacing. Mortality within intermediate and suppressed classes will be high, or some of the stems may persist as a secondary stratum making very little diameter growth. In terms of the evolutionary concepts presented earlier, we may think of the outstanding success of the eucalypt reflecting, in part, the development of a particularly strong competitiveness

for site resources under conditions of environmental stress. This leads in time to the characteristic "woodland" appearance of undisturbed old-growth eucalypt forest, that is, large-boled wide-spaced trees dominating an open, largely grassy forest floor.

- (2) The potential wood volume obtained from the old-growth trees and forest may be substantially reduced by high levels of wood defect; many boles are too defective to harvest economically, and, for those that are, an average defect allowance of one-third of the gross volume is common. Sources of defect include poor bole form, severe fire damage at the base of the tree, decay in the central part of the tree attributable to fungi and termites, gum veins in wood developing as a result of drought and fire, and mechanical failure of the wood (e.g., opening up of a series of concentric rings when drying in the mill yard).
- (3) A considerable part of the wood biomass in mature and overmature trees may be contained in large spreading crowns, and this wood cannot be harvested economically. Where the break of crown occurs at a low bole height, a large proportion of the biomass will inevitably be wasted.

The effect of all these factors on the merchantable volume is reflected in typical yields from clearcut eucalypt forests. In combined sawlog-pulpwood operations, peak yields of 200-300 m³/ha may be harvested from high quality old-growth ash forest in Tasmania. On the other hand, typical old-growth forests, including blackbutt forest within the mountainous terrain of the east coast, would be expected to yield only 20 to 60 m³/ha of sawlog; such forests have been subject to many fires in the past, and defect levels are high. Integrated sawlog-pulpwood (woodchip) operations in typical forests of low to moderate quality yield a total wood volume of around 60 to 120 m³/ha, of which only one-third might be of sawlog standard. In contrast, a radiata pine plantation on a site of average quality would be expected to yield in excess of 600 m³/ha each 40 years; in this case almost all the wood biomass can be harvested and allocated to a wide range of products.

The condition of forest with a regrowth sawlog component: Forests with a relatively long history of exploitive utilisation and subsequent management and hence a regrowth component at or near sawlog size, are those which were more readily

accessible to early loggers. They include the forests at lower elevations, the foothills of the mountain ranges, and any higher elevation forests which were not so steep as to restrict logging before the advent of modern harvesting machines. Many of these forests were selectively logged up to a century or more ago and given silvicultural improvement treatments up to 60 or more years ago. Some of the most productive of the regrowth forests result from regeneration developing following wildfires which burned through cutover forest, and post-logging treatments which removed competing overwood trees.

Regrowth forests with a sawlog component may be either substantially even-aged or substantially uneven-aged. Examples of even-aged forest include ash forests in Victoria and Tasmania, and areas of blackbutt forest along the east coast. Such forests will be very valuable in maintaining sawlog supply from native forests; where fully stocked and markets exist, or can be developed, for a range of products, yields equivalent to a production of 8 to 20 m³/ha per annum can be anticipated. Alternatively, the uneven-aged forests tend to be variable in structure and growing stock condition, with a relatively low sustainable yield of sawlogs. This condition reflects a number of factors associated with selective cutting in eucalypt forests, including the intolerance of eucalypt regrowth to competition from overwood trees, the tendency to accumulate with time a component of weak crowned or poor-formed advance growth, and wide variation in the potential for obtaining natural regeneration without specific seed-bed treatments. The present sustainable yield of sawlogs from extensively managed irregular forest would be in the range of only 0.5 to 3 m³/ha per annum. However, given a wider range of markets for the products of the irregular forest, and more flexible and intensive silvicultural practice, these yields could well be raised to the range 2 to 6 m³/ha per annum.

Policies and Practices affecting the Current Availability of Sawlogs

The eucalypt forest has been a declining commercial sawlog resource for many decades, both because of the characteristics outlined, and because of historical influences on the forest. One of the more basic problems has been the fact that forest services were not established in their modern form in most States until around the 1920s — when they were given for the first time a

positive brief to continue to build up the permanent forest estate, to regulate logging, to rehabilitate forest degraded by highly selective logging and fire, and, most importantly, to provide a mantle of fire protection for the forests.

The demand for wood during World War 2, and the decades of rapid economic growth since the war, placed great strains on the native forests. Nevertheless, governments committed themselves to meeting as much of the wood demand as possible from public land forests in order to maintain the impetus of development and keep prices as low as possible. The forests brought under management before the war were totally inadequate for this. However, advances in harvesting and milling technology meant it was now possible to extend logging to the escarpment and mountain forests and to the tall wet sclerophyll forests of southern Australia where effective management had hitherto been impossible. Moreover, the opportunity for export of woodchip to Japan from the late 1960s meant new sources of sawlog became available from integrated sawlog-pulpwood operations in forests which had been economically marginal for sawlog management alone. Much of the forest in these categories has been cut at a rate well in excess of the sustainable yields of sawlogs; the sawlog capital has been intentionally run down to service the high level of wood demand, with the anticipation that the softwood programme — which had been greatly expanded in the mid-1960s — would progressively take over the principal wood supply role.

The post-war period also saw changes in silvicultural practices. Until the late 1950s eucalypt forest silvicultural had been essentially conservative, but there now began a swing towards broad-acre clearcutting with widespread use of slash burning as a means of site preparation for seedling establishment. Many factors contributed to this swing, including the high level of demand for wood, the difficulty (if not impossibility) of applying selection techniques to less accessible or high quality wet sclerophyll forests, disappointment with the condition of many selectively logged and silviculturally treated forests, increasing costs and shortages of labour, and a greater emphasis on stand regeneration in forest management. The advent of the woodchip industry further strengthened this trend. However, there have been some exceptions; Queensland, for example, has a limited eucalypt forest resource, and has always maintained as a prime objective of management the husbanding of existing growing stock to sustain supply to industry; and a revised indigenous forest

policy for New South Wales in 1976 accepted much the same objective for its coastal region forests.

As the demand for wood increased and silviculture became increasingly intensive and systematised, forestry in Australia became increasingly vulnerable to the wave of environmentalism that developed, world wide, through and beyond the 1960s. Environmental conflict has been directed mainly at the clearing of native forest for softwood planting, the extent of clearcutting in native forest management, and the logging of the more environmentally sensitive forests such as rainforest and communities with tall sclerophyll emergents from a rainforest stratum. Largely as a result of this there has been a reduction in potential sawlog production through the transfer of forest to national parks and related reserves, and a greater emphasis on conservation objectives within forest committed to wood production.

THE FUTURE OF THE EUCALYPT FOREST

In 1982 a questionnaire returned by 5000 members of the Australian Conservation Foundation showed "native forests" to be top priority for action in a list of 18 topics that included such sensitive issues as "south-west Tasmania" and "The Great Barrier Reef". This points to a broadly based social concern for that which is uniquely yet ubiquitously Australian, and the need for comprehensive planning about the future of the eucalypt forests. It is no longer appropriate in forestry to rely upon *ad hoc* responses to events as they unfold!

There would be few countries where the role of native forests is not subject to public debate. Typically, this debate is about the extent of timber harvesting, conservation of plants and animals, wilderness values, soil conservation, yield and quality of water, landscapes and aesthetic diversity. This is certainly the case in Australia. For the Australian forests there are, in addition, a number of more basic biological questions raised in that debate, reflecting a growing appreciation of the biological nature of the eucalypt, the possible effects of forestry practices on the ecological stability of the forests, and the need for better integration of these factors in long-term resource planning. Thus, two topics are addressed in this section, the continuing role of eucalypt forests in wood production, and conservation and ecological factors in eucalypt forest planning.

The Continuing Role of the Eucalypt Forest in Wood Production

Sawlog production: The traditional approach to policy formulation in Australia has been to determine the total future demand for sawlogs, the availability of sawlogs from native forests — at or near its lowest point — and the area of softwood plantation needed to bridge the gap between the total wood demand and the supply from native forests. In this way “self-sufficiency” in wood production has been a primary aim of Australian forest policy. We can briefly examine each of these components of policy.

Self-sufficiency in wood production is no longer tenable as a basis for Australian forest policy. Australia has no tariff protection for unmanufactured timber and is vulnerable to imports of cheap timber. This situation is expected to continue. The structure of the Australian timber import industry (which includes some large transnational companies) and the continuing strong demand for imported timber make it highly unlikely that Australian-grown softwoods will succeed in replacing imports. Indeed, experience suggests that as more Australian softwood timber becomes available this may compete in the traditional Australian hardwood market rather than displace imports.

The softwood planting programme (currently around 0.5 million ha planted with an annual programme of around 30 000 ha) is now considered by some to be in excess of the self-sufficiency requirements and hence well in excess of what could be the future demand for Australian softwood products. In recent years each State forest service and a number of private owners have pursued planting policies relevant to their own organisations with no national consensus being reached on the need for, or the most advantageous distribution of plantation areas. Because the minimum capacity of modern wood-using industries required for profitable operation is increasing (particularly pulp and paper industries), plantation programmes in several regions have been expanded beyond the areas originally anticipated in order to attract and service those industries. In addition to this, we are seeing an increasing interest by private land-owners in softwood planting and the willingness of governments to support this. Thus it seems inevitable that some at least of the products of the Australian softwood industry will have to be marketed overseas.

Where does this leave the eucalypt forests? Because of the volume of softwood sawlog which will eventually be produced

and its presumed price advantage, there are those who see softwood replacing hardwood in all segments of the market other than those requiring particular strength or more distinctive or decorative wood features. If this were the case, then we would see progressive withdrawal of timber production from much of the eucalypt forest. Alternatively, there are those who argue that the specification of hardwood for a range of uses will remain sufficiently strong to maintain a viable hardwood industry through much of the forest. Australia clearly needs a much more positive approach to resolving such questions — preferably an approach that is nationally based. Formulation of a national eucalypt forest policy might take account of the following factors:

- (1) There will be a reversal in the decline in eucalypt sawlog availability as increasing quantities of regrowth reach commercial size. Mountain ash regrowth in Victoria and blackbutt regrowth in New South Wales will contribute substantially to sawlog production in the near future, and in Tasmania (ash forest) and Western Australia (karri forest) large areas of regrowth sawlog will be available from about 2020. These forests will be capable of sustaining multi-product industries, while regrowth in the more irregular forests can continue to provide a diversity of products to smaller industries.
- (2) Many of the eucalypt forests, particularly those with a longer history of management, are a valuable social resource, and are becoming increasingly so with greater recreational use of those close to major cities, the growth of provincial towns, and the trend to semi-rural living through the more coastal regions of southern Australia. While there will be, in future, a greater emphasis on the non-wood values of these forests, there may still be distinct advantages in continuing to base a strong forest products industry on them.
- (3) A continuing and widely distributed industry based on the eucalypt forest would provide a financial base for fire protection (essential in the Australian environment) and general resource management. If wood production were to be withdrawn from too much of the Australian forest, there could be a heavy and socially unacceptable cost in maintaining the 40 million ha of that forest. Continuing wood production would also provide wider opportunity for rural

employment, and through silvicultural treatment the opportunity to rehabilitate forest in poor condition. While there would be economists who might disagree, part of the cost of maintaining a strong hardwood industry might be met from returns from the softwood programme — much of the capital for which was drawn in the first place from the logging of native forests.

- (4) Increasing recognition of the fine qualities of many timbers and advances in product technology (e.g., conversion of small sizes, plywood and lamination) are widening the eucalypt's role in the more specialist markets. Indeed, there appears to be growing industry confidence in the long-term production role of the eucalypt forest — a role that can only be enhanced in both the domestic and export markets as the supply of tropical hardwood dwindles.

Based on evaluation of these and other factors, we might begin to see the eucalypt forests in a new production perspective and develop policies and strategies accordingly. We may be already beginning to see this — for example, through a widening recognition of the need to maintain sawlog production to as great an extent as possible for the short term. This is expressed in the trend away from total clearcutting programmes, with greater emphasis on conserving saplings, poles and even existing sawlog trees for continuing sawlog harvest.

Pulpwood production: The greater part of hardwood pulpwood production in Australia is presently committed to woodchip export (4.5 m m³ in 1981). The Australian pulp industries drawing on native forests utilise only about one-quarter of the total pulpwood cut from native forests. The continuing commitment of eucalypt forest resources to woodchip export raises some important questions. These programmes were largely conceived as integrated sawlog-pulpwood operations, with emphasis on the opportunity to supply sawlog in a deficit period, and to improve the productive condition of forest marginal in various ways for sawlog management; they are generally seen as supporting integrated sawlog-pulpwood production on a more or less permanent basis. However, unless we pursue a policy of building up hardwood markets for the long term, it is open to question whether there will be sufficient demand for the sawlog volume which will become available in time from some of the larger woodchip export programmes, notably those in Tasmania, and whether we

will see, increasingly, public forest land managed for pulpwood production alone.

Another question to be resolved is the future of the hardwood pulpwood industry itself. It was anticipated that a number of the woodchip export programmes would generate local pulp-paper industries, but this has not happened because of high capital costs, the limitations of the resource, or both. Thus, some hard national thinking is needed on a number of questions, including the long-term demand for short-fibre pulpwood both in Australia and overseas, the desirability of maintaining woodchip export programmes in the long term, the desirability of managing eucalypt forest for pulpwood alone, and the prospects for developing "high-yield" pulpwood resources to the stage where they can support profitable pulp or pulp and paper industries without overcommitting any regional resource to such an industry.

Conservation and Ecological Factors in Eucalypt Forest Planning

Development of the plantation softwood industry in Australia has begun to ease the demand on the eucalypt forest which has, since the mid-1960s, led to major conflicts with the conservation movement (e.g., over the alpine region forests in Victoria, the karri forests in Western Australia, and rainforest and wet sclerophyll forest logging in New South Wales and Queensland). At the same time, reduction in the demand for hardwood will create an environment where it will be possible to develop and implement policies for the native forests that are more consistent with the values society now ascribes to them. Unfortunately, it is Government, rather than the forest service which is taking the initiative in this — exemplified by recent changes in the administrative structure of land management agencies and forest planning procedures in Victoria and Western Australia, and discontinuation of rainforest logging in New South Wales. Thus it is all the more urgent to develop forest policies and strategies that give due regard to potential social advantages in maintaining a strong industry based on the eucalypt forests.

In formulating policy it will be necessary first of all to address the sorts of questions raised in this paper about the *long-term* role of the eucalypt forests. Depending on how these questions are resolved, we can then begin to allocate the resource in a way that will both meet the more legitimate demands of the conservation lobby, and support a forest products industry appropriate to the future needs of the country.

But this planning must go further than simply allocating forest land to different uses and combinations of uses. As an integral part of that planning we will need to take account of all constraints to production imposed by the need for forest conservation, the biological nature of the eucalypt, the maintenance of ecological diversity within all production forests, and any expressions of concern about the effects of forestry practices on the forest environment. It is only the last of these issues which will be addressed here.

Within the environmental debate about eucalypt forest management two major biological issues have been raised — the possibility of site nutrient depletion and the spread of disease organisms associated with clearcutting and slash burning practices. As will usually happen in a conflict situation, many expressions of biological concern have greatly exaggerated the threat to the eucalypt forest, for example, the fear that dieback disease would ultimately spread to all forest disturbed by logging. Nevertheless, an appreciation of the biological nature of the eucalypt highlights the need in forest management for continuing awareness of species-site relationships, and the possible effects of some forestry practices on the ecological stability of the forest.

It is because the eucalypt will make a commercial forest on poor soils that the extent of nutrient loss associated with logging, particularly clearcutting, has become an important environmental issue. The lower quality eucalypt forest could be drawing on a very small pool of (available) soil phosphorus (*e.g.*, Hingston *et al.*, 1980), and until we know more about the nutrient cycling within the eucalypt ecosystem, the eucalypt's access to nutrients in differing forms in the soil, and the rate of accession of nutrients to the soil, then concerns expressed about nutrient depletion cannot be fully resolved.

Another nutrient-related issue concerns the use of hot fire to reduce the sometimes massive accumulation of slash left after clearcutting, and to prepare a good seed-bed. It has been argued (Raison, 1980) that any immediate advantage from this will be outweighed in the long term by site nutrient losses which cannot be replaced through normal accession during a sawlog rotation. This conclusion has been disputed just as strongly by others (Turner and Lambert, 1980; Nielsen and Ellis, 1981). That the argument cannot be readily resolved reflects both the difficulties of research on nutrient budgets where slash fires are involved,

and limited inventory of the effects of different site preparation practices on growth patterns in regenerated forest.

Perhaps the most critical of the biological factors is the sensitivity of the eucalypt, notably the subgenus *Monocalyptus* to pathogens and plant-antagonistic micro-organisms. The devastating effect the root fungus *Phytophthora cinnamomi* has had on the jarrah forest is the best known example of this. In this case, an understanding of the relationship between the expression of the disease and site factors has reached the stage where it has been possible to resume logging in the forest, while hopefully containing the spread of disease. *Phytophthora*-induced dieback of eucalypt forest is also associated with certain site conditions in eastern Australia (e.g., infertile low-lying sites with poor drainage characteristics). Moreover, *Phytophthora* has a wide distribution in the forest soils of eastern Australia, and, where the fungus is present, we must appreciate those factors which may be restraining expression of the disease and develop management practices accordingly. This could involve encouraging mixtures of species varying in resistance to the disease, maintaining vigorous growing stock and preventing any undue increase in soil wetness by using some form of partial cutting.

Phytophthora cinnamomi is not the only organism causing concern. A species of *Armillaria* is constantly associated with the decline and mortality in mixed species forests in central Victoria, and in this case both *Monocalyptus* and *Symphyomyrtus* species are affected. These forests had been heavily cut last century, regrowth developed, and logging was resumed on a selection basis from 1947. The expression of the disease seems to be associated with selection cutting in pole or mature regrowth stands; past drought stress may also have influenced disease development in some areas (Edgar *et al.*, 1976). Another, and perhaps more serious example of ecological instability is found in Tasmania's southern regrowth forests. These forests had regenerated following fires, mostly (though not entirely) in forest logged over in the late 1800s and early 1900s, and for some decades have formed the basis of a sawlog and pulpwood industry. Decline and mortality in these forests is having a serious impact on forest growth, shows no signs of abating, and threatens the long-term security of the industry. While there have been a number of valuable hypotheses (reviewed by Podger *et al.*, 1980) the decline is still unexplained, although drought stress, again, may have been a factor predisposing stands to the disease.

If the origins of tree decline and mortality in both cases are related in some way to the history of logging, repeated burning, and the development of highly stocked even-aged stands, then important lessons can be drawn from the experience. While there is, of course, no certainty that any of these factors helped trigger the decline of regrowth stands, it could be prudent, until more is known of causal relationships and disease processes, to base both short- and long-term policies and strategies on such an hypothesis.

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