



An Australian Government Initiative



Natural Durability of Five Eucalypt Species Suitable for Low Rainfall Areas

**Sugar gum, spotted gum, red ironbark,
yellow gum and swamp yate**

**A report for the RIRDC/Land & Water Australia/FWPRDC/MDBC
Joint Venture Agroforestry Program**

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Natural durability of five eucalypt species suitable for low rainfall areas: Sugar gum, spotted gum, red ironbark, yellow gum and swamp yate

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Foreword

Australian eucalypts are highly regarded for their durability, with the most durable species used for external applications such as posts, poles, general and heavy engineering construction, decking, and wharf and bridge piles. Farm foresters are growing eucalypt species to supply these and other markets for durable wood products.

There is a need for more accessible information on timber quality and product potential from species grown for farm forestry in lower rainfall areas – to assist growers, product marketing and buyer awareness. This Research Update presents the results of a literature review on uses, susceptibility to insects and natural durability of five species commonly planted for farm forestry in lower rainfall environments – sugar gum (*Eucalyptus cladocalyx*), spotted gum (*Corymbia maculata* and *C. variegata*), red ironbark (*E. sideroxylon*/*E. tricarpa*), yellow gum (*E. leucoxylon*) and swamp yate (*E. occidentalis*). Sugar gum and red ironbark appear to be the most naturally durable of these species. Service lives in excess of 25 years can be expected from these species. Spotted gum and yellow gum also provide adequate service lives, ranging from 15 to 25 years. No information on the natural durability of swamp yate is currently available.

Durability ratings reviewed in this report are largely based on analyses of old growth trees. Faster grown regrowth and plantation timbers are now entering the market, and there is some uncertainty as to whether the same durability ratings apply. Field tests and rapid laboratory assessment of plantation-grown and regrowth timbers are in progress and will be the subject of a future report. Early indications are that for many species, fast-grown wood has equivalent durability to slower-grown sources.

This project was funded by the Joint Venture Agroforestry Program (JVAP), which is supported by three R&D Corporations — Rural Industries Research and Development Corporation (RIRDC), Land & Water Australia, and Forest and Wood Products Research and Development Corporation (FWPRDC), together with the Murray-Darling Basin Commission (MDBC). The R&D Corporations are funded principally by the Australian Government. Both State and Australian Governments contribute funds to the MDBC.

This report was prepared in April 2006. It is an addition to RIRDC's diverse range of over 1800 research publications and forms part of our Agroforestry and Farm Forestry R&D program, which aims to integrate sustainable and productive agroforestry within Australian farming systems. The JVAP, under this program, is managed by RIRDC.

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Peter O'Brien

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Executive Summary

The durability of wood, or the natural resistance it offers to biodeterioration, is an extremely variable property. Durability is based upon the resistance of the outer heartwood of mature timbers, and classification in the Australian Standard 5604-2003 is based on laboratory trials and field experience. Most analyses are based on old-growth timber harvested from native forest. This report reviews the uses, susceptibility to insects, and previous durability tests for five eucalypt species important for low rainfall regions. The review aims to assist builders, architects, researchers and growers have confidence in, and better understand the species they are working with.

Timbers are divided into four natural durability classes. Sugar gum (*Eucalyptus cladocalyx*) has recently been re-classified and is now a class 1 timber for both in-ground and above-ground exposure. Spotted gum (*C. maculata*) is class 2 and red ironbark (*E. sideroxylon*) is class 1 for both decay and termite attack. Yellow gum (*E. leucoxylon*) is variable, ranging from class 1-3. Swamp yate is currently under testing regimes, not having previously been rated.

To date, species ratings for durability are largely based on old-growth native forest timbers. Current research as part of JVAP project CSF-61A is evaluating in-ground decay resistance, above-ground durability and termite resistance of plantation-grown and regrowth trees, to compare durability ratings for younger, faster-grown timbers of the target species. This will aid better management of plantations and better marketing of farm forestry timbers, especially from low rainfall regions. The analysis of plantation and regrowth timbers for the 5 species listed above will be the subject of a subsequent report.

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Introduction

The durability of wood, or the natural resistance it offers to biodeterioration, is an extremely variable property. Given suitable environmental conditions, many organisms including bacteria, fungi, insects, and marine invertebrates can cause severe degradation of wood. Certain types of timber are noted for their marked resistance to biodeterioration and are commonly used as untreated material. In contrast, non-durable timbers generally require preservative treatment if they are to be used in exposed conditions, adding significantly to their cost. A number of factors influence the durability of a timber, including wood density, tree age, and growing location. Probably the most important factor is the extractives within the wood itself, which are formed after the sapwood is transformed into heartwood.

Box 1: Types of wood decay

Decay can occur in wood that becomes damp or is exposed to rain. There are three main types of fungi that can cause wood decay:

- White rotting fungi belong to a group of fungi called the Basidiomycetes, and degrade both cellulose and lignin. Because they remove the brown coloured lignin, and leave some cellulose fibres, decayed wood looks white, fibrous, and does not shrink.
- Brown rotting fungi are also Basidiomycetes, and degrade cellulose mainly. As lignin largely remains in decayed wood it looks brown, crumbly, and will shrink when the wood dries. This is common in softwoods. Brown rotting fungi includes the ‘dry rot’ fungus (*Serpula*) found around Melbourne, which does require moisture, but can transport that moisture over non-wood substrates.
- Soft rotting fungi belong to the ‘lower’ Ascomycetes and Fungi Imperfecti. They attack cellulose in the internal S2 layer of the secondary cell wall, bypassing some wood preservatives that coat the cell lumen. Decayed wood is often brown, so can be difficult to distinguish from brown rot. Soft rotting fungi favour wet conditions in soil, fresh water and cooling tower slats, and marine environments.

The natural durability of some Australian timbers under in-ground exposure conditions is listed in Australian Standard 5604-2003¹. These ratings or classes were first written in the 1950s and were based upon laboratory trials and the experience of foresters and those writing the standard². Durability is based upon the resistance of the outer heartwood of mature timbers (Figure 1). The sapwood of all species is considered non-durable, and for many timbers the inner heartwood and pith is also of lower natural durability than the outer heartwood. Timbers are divided among four natural durability classes. For in-ground natural durability the divisions are:

Box 2: In-ground durability classes

Class 1	timbers of the highest natural durability, which may be expected to have a service life of 25 years or more
Class 2	timbers of high durability, which may be expected to have a service life of 15 to 25 years
Class 3	timbers of moderate durability having a service life of 5 to 15 years
Class 4	timbers of low natural durability, which last up to 5 years

¹ Standards Australia. (2003) Timber-Natural durability ratings. AS 5604-2003. Standards Australia, Homebush, New South Wales.

² Tamblin, N. (1966). “Natural durability ratings”. CSIRO Forest Products Newsletter, no. 335, November, 1 pp.

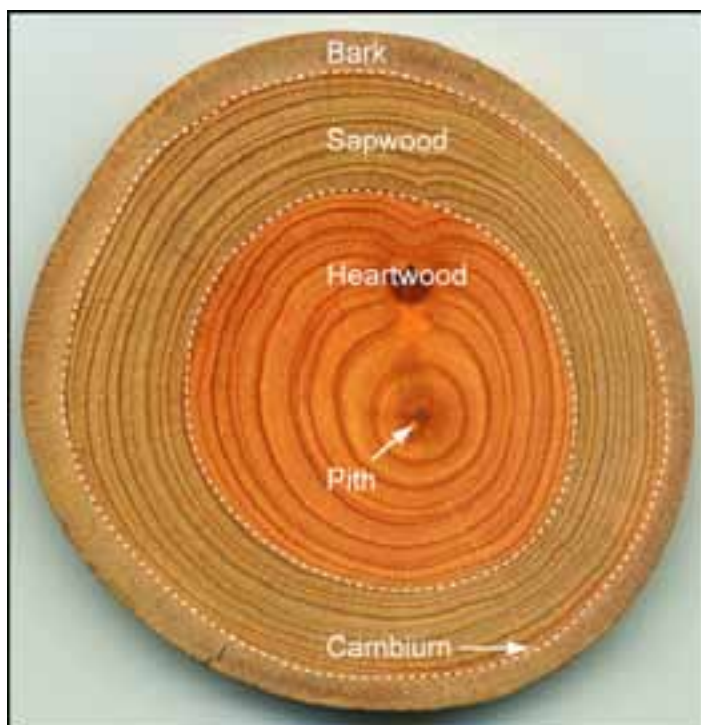


Figure 1. Cross section of hardwood stem, showing different wood components. Growth occurs in the cambium. Softwoods have similar stem structure, but different cellular structure (e.g. no vessels). Softwoods can have thicker sapwood bands, although some tropical hardwoods also have thick sapwood bands. Photo credit: Matthew Brookhouse, ANU PhD student in dendrochronology.

The first major comparative trial aimed at objectively substantiating natural durability ratings was established in 1968-69 by CSIRO at five test sites³, Jolly's Lookout (Brisbane), Innisfail (North Queensland), Pennant Hills (Sydney), Walpeup (North-West Victoria) and Rowville (Melbourne), using timber sourced from mainly old growth native forest. Standard size stakes of the outer heartwood of various species were embedded in the

ground, exposed to weather, and their resistance to decay (fungal and bacterial attack) and termites evaluated over many years. The five sites were originally chosen because they were expected to provide both a high termite and decay hazard. However, after a number of years experience at the sites, the severity of decay and termite hazards were categorised within a range comprising very high, high, moderate, low and (for termites only) no hazard. On this basis, Jolly's Lookout has a very high decay hazard with low termite hazard; Innisfail, very high decay hazard with high termite hazard; Pennant Hills, high decay hazard with low termite hazard; Walpeup, low to moderate decay hazard with moderate termite hazard; and Rowville, moderate decay hazard and no termite hazard.

As well as in-ground natural durability, the performance of timbers above-ground is an important consideration. For example, according to the Building Code of Australia, structural members such as house framing must now be protected from termites, placing naturally resistant timbers at an advantage. However, there is even less information on the above-ground natural durability of various timbers. The in-ground ratings established by CSIRO are not necessarily indicative of the expected relative durability of timber used above-ground, although timber will generally last longer when placed above- rather than in-ground. A significant contribution on 39 timber species was provided by Myron Cause⁴. The latest understanding of above-ground performance for some species is provided in AS 5604-2003, but further research and testing is required for a range of species.

A general perception exists that young, fast grown trees will not produce heartwood as durable as old growth timber. However, researchers at CSIRO have compared the younger current resource of Queensland and Western Australia with the corresponding mature heartwood from old growth forest upon which experience is based. For 8 out of 10 species, plantation and regrowth timbers were found to have similar natural durability to mature timber⁵.

The following review on natural durability of the target species has been produced using information obtained from CSIRO's reference collection and the international literature. No literature on natural durability currently exists for swamp yate.

³ Thornton, J.D., Walters, N.E.M. and Saunders, I.W. (1983). "An in-ground natural durability field test of Australian and exotic timber reference species. Progress report after more than 10 years exposure". Material und Organismen, vol 18, no. 1, pp. 27-49.

⁴ Cause, M. (1993) Establishment and preliminary (5 yr) results of a major above-ground timber durability trial in eastern Australia. Proceedings 24th Forest Products Research Conference, Melbourne, 15-18 November 1993, Topic 2/13, 12 pp.

⁵ Johnson, G.C., Thornton, J.D. and Nguyen N.-K. (1993) "An accelerated field simulator study of the natural durability of heartwood from mature and regrowth trees". Proceedings 24th Forest Products Research Conference, Melbourne, 15-18 November 1993, Topic 2/21, 9 pp.

Durability of low rainfall species

Sugar gum

Sugar gum (*Eucalyptus cladocalyx*) is endemic to South Australia with naturally occurring populations in four areas (southern Flinders Ranges/Spencer Gulf, eastern Eyre Peninsula, Koppio Hills/Marble Range area and Kangaroo Island)⁶.

The timber is commonly used for poles, posts, bridge piles, heavy and general construction and railway sleepers⁷. The sapwood of sugar gum is pale and susceptible to lyctine borer attack¹. The heartwood is yellowish to brown, of fine uniform texture, grain commonly interlocked and the wood is hard, heavy and of moderate strength and highly durable⁸.

Sugar gum was given a tentative durability rating of class 2 in the 1950s⁹. However, CSIRO field testing at the five sites mentioned above has led to a reclassification of (mature) sugar gum to Class 1¹⁰. Thornton *et al.*¹¹ were able to show that the mean rating of the outer heartwood of sugar gum was among the most resistant hardwood species with respect to decay and termites at the 21 year inspection. Further inspection by Johnson *et al.*¹² showed that after 25 years exposure at the five Australian sites, sugar gum was in a group of the more durable species that had yet to become unserviceable at four of the five sites. At Innisfail, the most active of all the sites, all replicates had become unserviceable due to decay and termite attack. It appears to be performing as well as timbers of the highest durability, such as red ironbark, tallowwood and grey ironbark.

The Australian Standard, AS1604.1-2000¹³, listed sugar gum as durability class 2. However based on the research discussed above, it is now a class 1 timber for both in-ground and above-ground exposure in the standard recently published and devoted to natural durability¹.

Spotted gum

Spotted gum was once considered one species but has been reclassified to encompass a number of taxa. *Corymbia maculata* is found in coastal areas from Orbost in Victoria to south of Coffs Harbour in New South Wales^{14,15}. *Corymbia henryi* (spotted gum; large-leaved spotted gum) occurs from south of Grafton in New South Wales to the Brisbane area in Queensland. *Corymbia citriodora* subsp. *variegata* (spotted gum) occurs from Coffs Harbour in New South Wales to the Springsure-Maryborough region in central-eastern Queensland. *Corymbia citriodora* subsp. *citriodora* (spotted gum; lemon scented gum) extends northwards from the Springsure-Maryborough region (where it overlaps with *C. citriodora* subsp. *variegata*) to the Atherton Tableland in Queensland. Each of these *Corymbia* taxa share similar timber properties.

⁶ Doran J.C. (2000) "*Eucalyptus cladocalyx* F. Muell. Notes on taxonomy and nomenclature". CAB International Electronic Forestry Compendium full data sheet (Publ. CSIRO Forestry and Forest Products, Canberra).

⁷ Boas I.H. (1947) The Commercial Timbers of Australia, their properties and uses. CSIRO Australia.

⁸ Boland D.J., Brooker M.I., Chippendale G.M. Hall N., Hyland B.P.M., Johnston R.D., Kleinig and Turner J.D. (1984) Forest trees of Australia. Nelson-CSIRO.

⁹ Tamblyn, N. (1966) "Natural durability ratings". CSIRO Forest Products Newsletter, No.335 1 pp.

¹⁰ Thornton, J.D., Johnson, G.C. and Nguyen, N.-K. (1997). Revised CSIRO natural durability classification, in-ground durability rating for mature outer heartwood. CSIRO Forestry and Forest Products.

¹¹ Thornton, J.D., Johnson, G.C. and Nguyen N.-K. (1991) An in-ground natural durability field test of Australian timbers and exotic reference species. VI. Results after approximately 21 years exposure. Material u. Organismen 26 (2) 145-155.

¹² Johnson, G.C., Thornton, J.D. and Nguyen N.-K. (1996) An in-ground natural durability field test of Australian timbers and exotic reference species. XI. Results after more than 25 years' exposure. Material u. Organismen 30 (3) 219-230.

¹³ Standards Australia. (2000) Specifications for Preservative Treatment. Part 1 Sawn and round timber. AS 1604.1-2000. Standards Australia, Homebush, New South Wales.

¹⁴ Hill, K.D. and Johnson, L.A.S (1995). Systematic studies in the eucalypts. 7. A revision of the bloodwoods, genus *Corymbia* (Myrtaceae). Telopea 6: 185-504.

¹⁵ McDonald, M.W. and Bean, A.R. (2000). A new combination in *Corymbia* 'section Politaria': *C. citriodora* subsp. *variegata* (Myrtaceae). Austrobaileya 5 (4): 735-736.

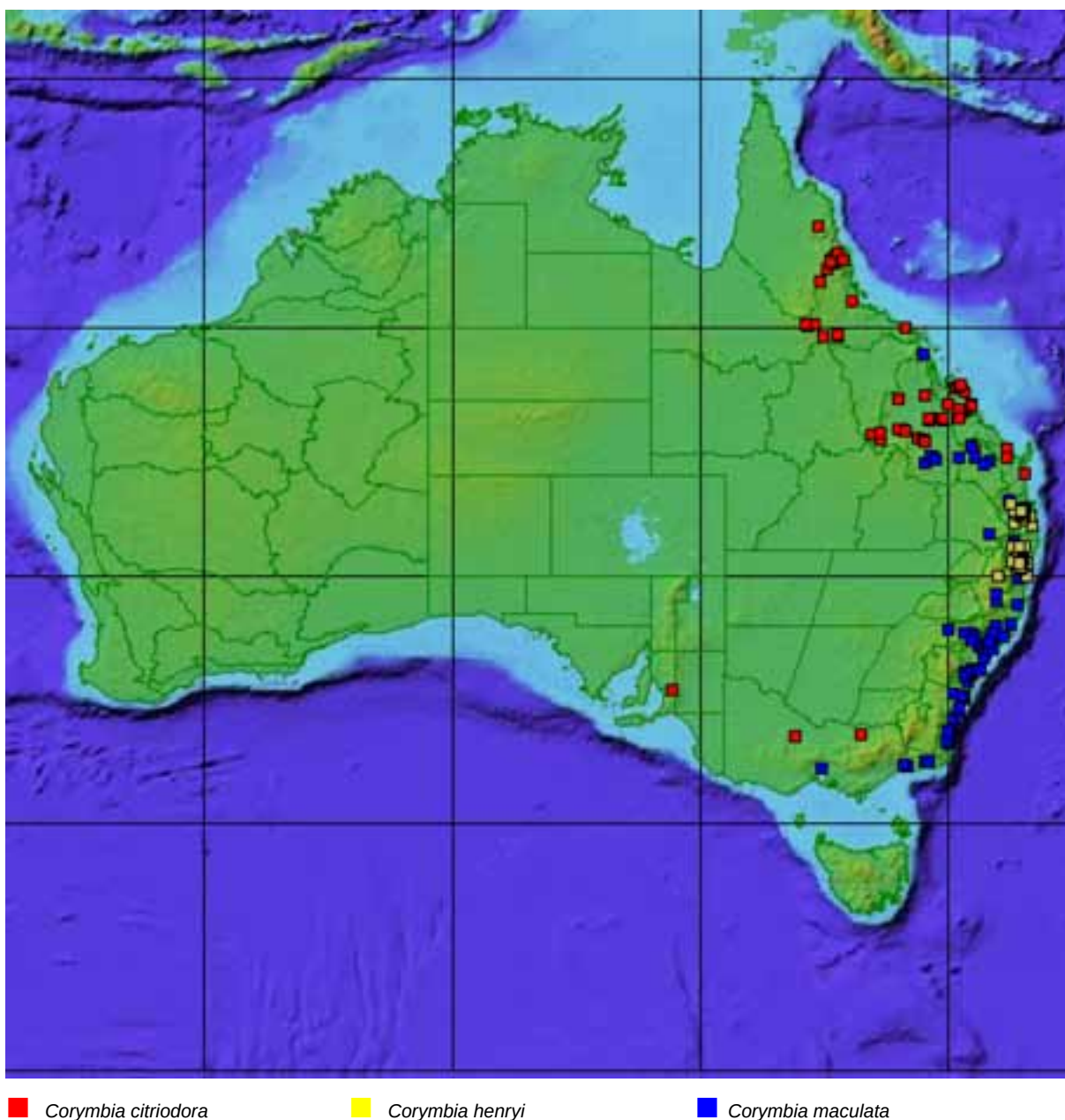


Figure 2. Distribution of spotted gum subspecies. The distribution marked for *Corymbia variegata* includes both subspecies *variegata* and *citriodora*. See text for explanation. (Map sourced from Australian Virtual Herbarium website: <http://www.cpbr.gov.au/cgi-bin/avh.cgi>).

Spotted gum's uses include heavy engineering construction, poles, piles, flooring and plywood¹⁶. It has been one of the major pole timbers for Australia's power and telecommunications networks, in particular throughout Queensland¹⁷. The sapwood is pale and is very susceptible to lyctine attack¹. The heartwood is light to dark brown, the grain often interlocked and moderately coarse textured with fiddle-back figure. The heartwood is hard, strong and highly durable¹⁰.

Johnson *et al.*¹² indicated that after 25 years exposure in the CSIRO trial, test stakes of spotted gum were serviceable at only one of the five sites, Rowville (considered the least active of the sites). After 21 years exposure, at least 75% of replicates had become unserviceable at Brisbane due to decay, Innisfail due to termite attack, Pennant Hills due to decay and Walpeup due to termites¹¹. *C. citriodora* had minor decay in an above-ground trial after five years at Beerburrum near Brisbane.⁴

Both the Australian Standard 1604.1¹³ and the revised CSIRO natural durability ratings¹⁰ assign spotted gum as durability class 2.

Red ironbark

Red ironbark (*E. sideroxylon*) occurs in northern Victoria near Wangaratta and extends through the western slopes of New South Wales up to southeastern Queensland⁸. The closely related *E. tricarpa* extends mostly around the central goldfields area of Victoria through to southeastern New South Wales¹⁸.

E. sideroxylon is used for heavy engineering construction, poles and sleepers¹⁶. After removal of the sapwood, it is used throughout Victoria and New South Wales as poles for electricity distribution¹⁷. The sapwood is yellowish and susceptible to lyctine attack¹³. The heartwood is dark red, has moderately fine texture and interlocked grain, is very hard, strong and of the highest durability⁸.

E. sideroxylon has been one of the top performers in the CSIRO in-ground natural durability field-test of Australian timbers. After 25 years exposure it is performing satisfactorily at Pennant Hills, Walpeup and Rowville. At Brisbane and Innisfail, a number of replicates have become unserviceable, as is the case for all but a couple of species¹².

An accelerated decay test of natural durability was performed in the Division's Accelerated Field Simulator¹⁹. The top 100 mm of the above-ground portion of selected specimens of outer heartwood was obtained from the ongoing field test at the Melbourne test site after 10 years exposure²⁰. The specimens were inspected every four weeks for the first two years and then at eight weekly intervals for the remaining three years. Red ironbark was one of only five naturally durable timbers that had serviceable replicates after five years exposure²¹.

The Australian Standard 1604.1¹³ has red ironbark as durability class 1 and the revised CSIRO natural durability ratings¹⁰ classify it as durability class 1 for both decay and termite attack.

To date, no information on natural durability can be found in the literature for the closely related species *E. tricarpa*.

¹⁶ Bootle K.R. (1985). Wood in Australia: Types, properties and uses, McGraw-Hill Book Company Australia Pty Ltd.

¹⁷ McCarthy, K. and Greaves, H. (1990) Decay detection and remedial treatments in wooden poles. 23rd Forest Products Research Conference, 19-22 November 1993, Topic 1/5 16 pp.

¹⁸ Brooker, M.I.H., Connors, J.R., Slee A.V. and Kemp L. (1997) EUCLID: Eucalypts of south-eastern Australia (CD-ROM identification key), CSIRO Australia.

¹⁹ Johnson, G.C., Thornton, J.D., Creffield, J.W. and Howick, C.D. (1983). Natural durability studies in an accelerated field simulator – a novel approach. The International Research Group on Wood Preservation. Document No. IRG/WP/2197.

²⁰ Thornton, J.D., Johnson, G.C. and Saunders, I.W. (1981) Accelerated "fungal cellar" testing of the natural durability of the heartwood of Australian timbers in ground contact. 20th Forest Products Research Conference, 16-20 November 1981, Topic 1/6 7 pp.

²¹ Thornton, J.D., Johnson, G.C. and Nguyen N.-K. (1995) Specimen life statistics of untreated heartwood of 35 timber species after five years' exposure in the accelerated field simulator. Material u. Organismen 29 (2) 81-92.

Yellow gum

Yellow gum (*E. leucoxydon*) occurs naturally in central western Victoria, southeastern South Australia, on Kangaroo Island, in the Mt Lofty and southern Flinders Ranges and on the Eyre Peninsula⁸.

Its uses include heavy structural engineering, fences, railway sleepers, building, framing and poles¹⁶. The sapwood is pale and is susceptible to lyctine attack¹³. The heartwood is pale brown, with yellow or pink tints, commonly with interlocked grain, hard, strong, very dense and of the highest durability⁸.

Australian Standard AS 1604.1¹³ classifies yellow gum as durability class 1 for the mature outer heartwood. However, results after more than 25 years exposure in-ground suggest it is not performing as well as sugar gum. All replicates had become unserviceable at Brisbane, Innisfail and Pennant Hills. At the less active sites, Walpeup and Rowville, some replicates remain serviceable¹². After 21 years exposure all replicates at Brisbane had become unserviceable due to decay, all replicates at Innisfail were unserviceable as a result of termite attack and all replicates at Pennant Hills were unserviceable due to decay. At least 75% of the replicates had become unserviceable at Walpeup while not enough replicates had become unserviceable at Rowville¹¹ to determine cause of failure.

The revised CSIRO natural durability ratings¹⁰ classify yellow gum as having a wide range of natural durability from 1-3 for decay and a range of 2-3 for termite attack. This range of durability classes for both hazards suggests variability in the trees collected for the trial, such as in age, forest location or genetic stock.

Swamp yate

Swamp yate (*E. occidentalis*) is naturally distributed in the southern part of Western Australia including the Stirling ranges. The principal occurrence is on lower country, usually alluvial flats subject to flooding, where the soil is often clayey. It can thrive near salt lakes and some provenances are notably salt-tolerant^{8,22}.

The heartwood is pale, hard, and somewhat straight-grained. There is high tannin content in the bark⁸. The wood has been used for posts and poles, and while it has been used in situations where heavy and strong wood is required, it is regarded as inferior to the related species, yate (*E. cornuta*) that is considered one of the hardest and strongest timbers in the world²³. There appears to be a potential for producing finer sawn products from swamp yate²⁴.

Swamp yate was not included in the CSIRO in-ground field test of Australian timbers and there appears to be no other natural durability information in the literature. The revised CSIRO natural durability classifications¹⁰ and the Australian Standard AS1604.1¹³ have the closely related yate as durability class 2.

²² Marcar, N. E. and Crawford, D. F. (2004) Trees for saline landscapes. RIRDC Publication No. 03/108, RIRDC, Canberra.

²³ Hall N., Boden R.W., Christian, C.S., Condon, R.W., Dale, F.A., Hart, A.J., Leigh J.H., Marshall, J.K., McArthur, A.G., Russell, V. and Turnbull, J.W. (1992) The use of trees and shrubs in the dry country of Australia. Aust. Govt. Publ. Service. 558 pp.

²⁴ Bird P.R. (2000) Farm forestry in southern Australia: a focus on clearwood production of specialty timbers. The State of Victoria, Department of Natural Resources and Environment. 265 pp.

Conclusions

CSIRO Forestry and Forest Products have carried out the majority of research into the in-ground natural durability of the outer heartwood of Australian timbers. Four of the five target species have been included in this research. Sugar gum and red ironbark appear to be the most naturally durable of these species. Service lives in excess of 25 years could be expected from these species. Spotted gum and yellow gum would also provide adequate service lives, ranging from 15 to 25 years. No information on the natural durability of swamp yate is currently available.

The natural durability results obtained to-date relate to old growth material. The resource available today is likely to comprise the faster grown and considerably younger plantation or regrowth material. There is an often quoted opinion that the faster grown timber is always going to be markedly less durable than old growth timber. This is by no means the rule as shown in accelerated testing where only two of ten timber species examined were significantly less durable than the mature resource⁵.

With the support of the Joint Venture Agroforestry Program (JVAP), the investigations described in this Research Update will be further developed for the same five species through the project called 'Natural durability of *Eucalyptus* trees for farm forestry in lower rainfall areas'. The project will determine in-ground decay resistance using CSIRO's Accelerated Field Simulator, above-ground durability using a flat panel test²⁵, and resistance to termite attack using the drum technique²⁵ (see figures 3, 4 and 5). The effect of tree age on natural durability of the five timber species will also be examined. The methodologies of assessing natural durability will provide valuable information on the suitability of the target species to enhance the economic and environmental benefits of farm forestry in lower rainfall areas.

²⁵ Australasian Wood Preservation Committee (1997) Protocols for assessment of wood preservatives. September 1997, 24 pp.



Figure 3. Assessment of above-ground durability using a flat panel test at Innisfail



Figure 4. CSIRO's Accelerated Field Simulator used to test in-ground decay resistance



Figure 5. Testing wood samples for resistance to termite attack