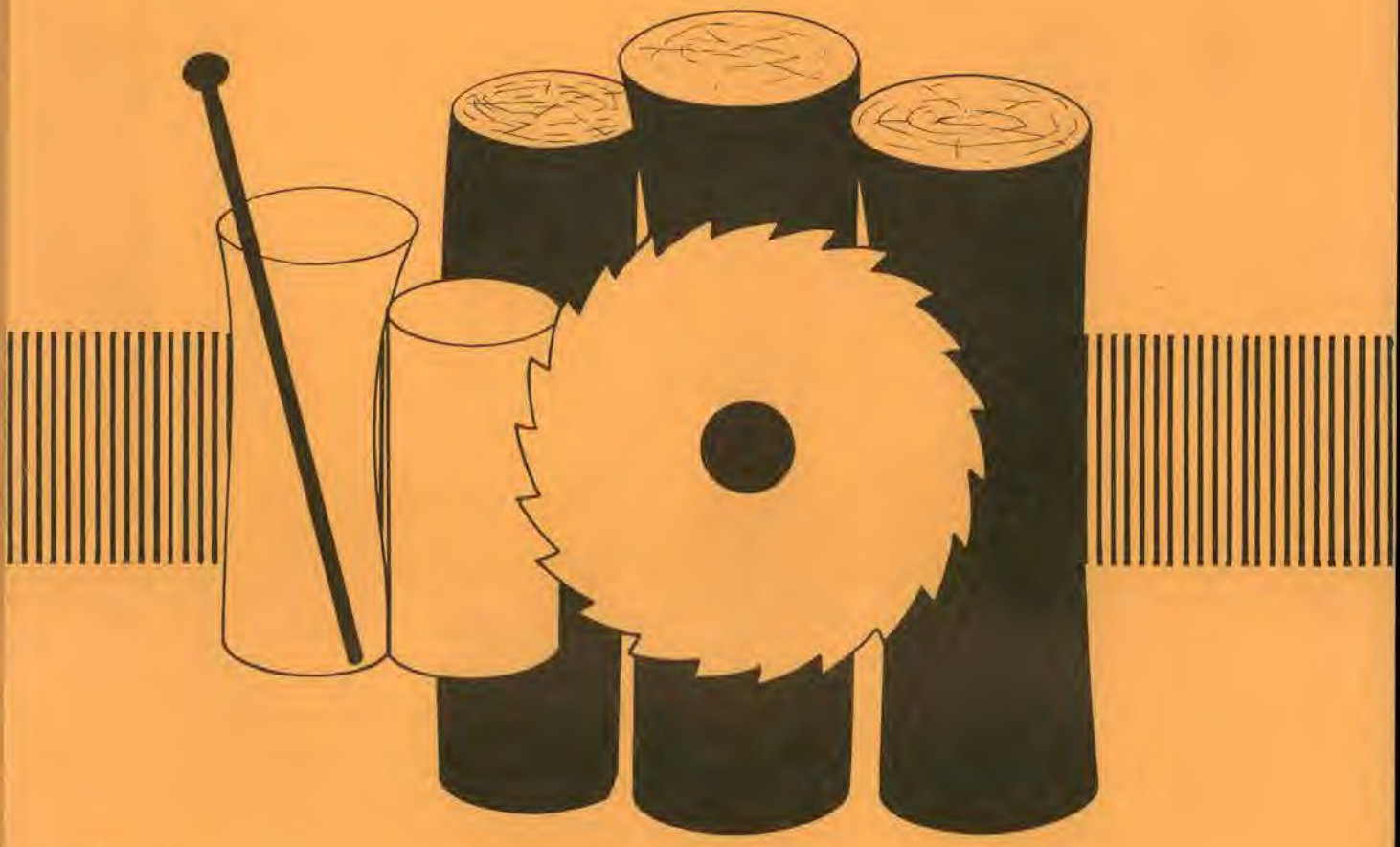
16TH FOREST PRODUCTS RESEARCH CONFERENCE

VOLUME 1



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1973

C.S.I.R.O.
Division of Building Research

C.S.I.R.O.
Division of Applied Chemistry

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Introductory Paper 1

THE NEW LOOK OF FOREST PRODUCTS RESEARCH

by Walter G. Kauman

Forest Products research in Australia entered a new era during the last two years with the reorganization of CSIRO and the new face of Wood Technology Division. At our last Forest Products Research Conference, held just after the transmutation of our old Division of Forest Products, we were too close to this event to have a clear view of the consequences. Today it is legitimate to ask - will the new look in CSIRO be a boon or a bane for Australia's timber industry?

I believe the answer to this question is contained in the facts that my message attempts to present.

What has happened during the last two years, and what is happening now? Let us look first of all at some figures. In May 1971, the Division of Forest Products employed 234 persons of whom 87 were professionals. Its budget was $1.8 million. Today, in the Divisions of Applied Chemistry and Building Research, approximately 230 persons, including 86 professionals, work directly with wood, and the two Divisions spend some $2.3 million on research on this material. In fact, wood is receiving considerably more attention than any other building material.

But figures tell only a partial story. What matters is what kind of problems we are tackling. Are they the problems of the present and future, or of the past?

What are the technical problems of the Australian forest products industry today? I would summarize them under a few major headings, each of which includes many facets that will be brought out during the discussions of this Conference:-

1. To make the most efficient use of our forest resource, remembering that it is a renewable resource.

2. To present to the consumer a high-quality engineered building material: TIMBER.

3. To improve the operations of the timber industry so that it can produce and market this engineered material successfully with an adequate profit margin.

4. To develop new or improved materials by using the potential and properties of the unique structure of wood, wood fibres and of the chemical constituents of wood, alone or in combination with other chemical substances, with special attention to the use of wood residues.

5. To explore and develop new or improved applications for wood and derived materials in order to maintain, expand and create markets that satisfy consumer demands.

These problems are different from those I would have listed ten years ago, or even five years ago. and so they should be. It would be a poor research organization that continued researching the same problems forever. Problems are topical at one stage, and obsolete at the next.

What is the most logical way to tackle the job? You will note that the problems I have named all have one thing in common: they present a challenge of service to the community in a given area. A challenge to make the best use of a resource that belongs to the community, in order to serve the needs of a consumer market, now and in the future, ensuring at the same time that the industry that provides this service remains viable, and to extend the limits of knowledge so as to create from the resource new materials and new applications that contribute to higher quality living.

As I have said many times before, I believe the job must be tackled from the market end. We may occasionally have a seller's market, but post-war experience has shown that it does not help the industry, and certainly not the consumer, to take the attitude that timber will always be used because it has always been used. We must market it in competition with other products, and that means ever improving quality and service. In addition, we must face the fact that increasingly influential conservationist interests promote uses for the forest resource other than timber production.

How has CSIRO adapted to the new challenges over the last two years? I shall speak, of course, only for the Division of Building Research. Dr. Don Weiss will tell you about the work of the Division of Applied Chemistry.

First of all, we decided to start learning about the market. Lon Wymond, who is well known to you as the former Secretary of these Conferences, has begun a market study in depth to find out the reasons behind the figures that come out in statistical surveys. This includes some of the reasons why some customers are dissatisfied with timber - vital information if we want to improve the image of our material.

Our amalgamation with the old Division of Building Research gave us the chance to swing new knowledge and new talents into this area. Bruce Kennedy's group of Building Operations and Economics is having a cold, hard look at the realities of the costs of logging and dwelling construction and is planning to work towards a full assessment of the economics of timber supplies for building.

Next, we decided to build up our groups concerned with the means of production for satisfying the timber market. As some of my friends in industry have remarked recently, there is an increasing gap between the knowledge embodied in our research results and the knowledge actually applied to industry, particularly in the area of mechanical wood conversion.

The creation of our Forest Conversion Engineering group was a step aimed at reducing this gap. Although the Group is by no means neglecting research to increase our knowledge about the behaviour of wood, as evidenced by their recent achievements in the field of softwood seasoning and by the appointment of a new research scientist to pursue investigations on the drying of hardwoods, the main efforts of Merv. Page and his colleagues are at present in production engineering to help industry make the best use of our results. A new consulting service, inaugurated recently, goes even further and offers assistance with detailed design and development problems to companies not equipped to handle these themselves. I want to emphasize that this service, for which we charge, is additional to our traditional technical assistance which is continuing at least at the same level as in the old Division of Forest Products. In addition to the Group's market research I should also mention progress with the development of a new sawmill residue burner that we hope will conform with the clean air legislation and also their recent studies on the economics of milling small logs.

Composite wood-based materials are the fastest expanding sector of the timber industry and warrant special consideration. This is the domain of Ken Plomley's Forest Conversion Science group - thus named because improvement of composite materials depends to a considerable extent on better scientific understanding of the wood surface, adhesives and wood-water relations. Recent successes in obtaining improved water resistance of particle boards are the result of several years research and should lead to new Australian standards for the applications of this material. Work on the wood surface is one of our areas of so-called "pure" research where we believe better scientific understanding is a necessary prior condition for progress. In the longer term, we hope the group will play an important role in finding new uses for wood residues.

This work, however, is only one link in the chain connecting the tree to the final consumer. Consumer preferences, market demand and national requirements are constantly evolving, and we must keep abreast of this evolution to know where timber and timber-based products can best make a contribution to the economy from one year to the next. Research on new or improved applications of timber is therefore essential, and it is in this area that Harry Kloot with our Engineering group is most active. Building is by far the major market for timber, and Timber in Construction is one of the topics of the Conference. I will content myself with just enumerating some headings of our programme: Structural use of plywood and particle board; improved design methods for light timber frame construction; trials of new ideas in house design are all receiving considerable attention. In addition, the recent reorganization has enabled us to increase research on general structural problems such as structural reliability, sharing in timber structures and wind resistance with special emphasis on cyclone conditions, so that timber may increasingly become accepted as one of the engineered building materials and be fully competitive with other contenders for the building market. Bob Leicester's Engineering Science team is contributing to the latter fields.

"Biodegradable" is a fashionable word today, but in timber this property is still a drawback. Research institutions and industry have developed many excellent preservative substances, but they are still far from perfect in many situations, and inability to guarantee long life causes losses in markets such as sleepers, poles and marine piles. Growing concern about the environment is casting a shadow over the continued use of many traditional preservatives based on chlorinated hydrocarbons and other wide-spectrum compounds. Norm Tamblyn's Preservation group is directing its work, on the one hand, towards improving the efficiency of existing preservatives by studying the resistance of some organisms to certain substances, by improving penetration, retention and fire resistance and methods of impregnation. On the other hand, in parallel with studies of the natural durability of wood, the microbiology and entomology teams are engaged in some quite basic research on the natural history and biochemistry of the attack on wood by insects, fungi and microorganisms, with the ultimate aim of developing new types of preservatives that will be active only towards the species concerned without affecting the general environment.

Finally, but by no means least, we have been moving even closer to the foresters, mainly through the work of Jim Nicholson in the Forest Conversion Engineering group. One of our major projects in this field concerns log quality, with the double aim of extracting the greatest possible utility from each tree that is felled, and of helping industry to meet the challenge of lower log quality and smaller log size in our natural forests as the original virgin growth is becoming exhausted. You will be hearing about

this highly important subject in the discussions on small log utilization and on whole tree - any tree utilization.

The changingnature of our forest resource, the greater emphasis on proper resource management and the changing nature of the market caused by improved methods in the application of competitive materials and by the increasingly expensive labour component, all require us to seek new ways of research to enable timber to remain a widely preferred building material, and if we can achieve this it will be a boon indeed to the forest industry. To work towards this goal, the new Division of Building Research is transforming the traditional research pattern of the Division of Forest Products by bringing in new ways better suited to the problems of the 70's and 80's. A lot remains to be done, but I believe the first two years of operation have shown that we are on the right way.

ASPECTS OF WORK IN PROGRESS AND PROGRAM CHANGES IN THE DIVISION OF APPLIED CHEMISTRY

by

D E WEISS

As its name implies, the Division of Applied Chemistry is primarily concerned with the application of chemistry to national problems, particularly those of long range significance. Well before environmental research became fashionable it had begun major programs concerned with bush fire control, water conservation and purification, aspects of insect-plant-animal relationships of ecological significance, and biodegradable insecticides. Rather than concentrate on petrochemical research, it has preferred to explore the potential of Australian plants for medicinal purposes and to study some of the stock poisons they contain. Its synthetic polymer skills are also not along traditional lines. They have concentrated particularly on polymer-mineral filler interactions and specialty polymers for animal feeds and water and effluent treatment. Thus for many years the Division has had a strong bias towards natural product chemistry and has tended to avoid traditional areas of industrial chemical research.

The incorporation of part of the former Division of Forest Products into the Division of Applied Chemistry two years ago has complemented and strengthened these interests in important ways. It has brought in specialised knowledge concerning the fibre properties of plants - particularly trees - which complements our interests in other plant components. As you will hear later, we are extending these interests also to aspects of plant proteins so that we are now interested in total plant chemistry. It may be timely for us, in collaboration with the NSW Technological Museum, to look at the eucalyptus oil industry from the point of view of recent advances in chemical separation technology in view of the increasing interest which is developing concerning mechanical cropping of short rotation eucalypts. We are also relooking at vegetable oils as polymer precursors.

It has brought in skills in natural polymer production and processing which complements our other interests in synthetic polymers. I do not see synthetic polymers and cellulose as being competitors. Rather, I believe their different costs and properties enable them to be exploited best in combination with mutual advantages. Such wood fibre-plastic composites cost considerably less than the pure, or glass filled plastics but more than pure wood products. They should be looked upon therefore as competitors to other reinforced plastics rather than wood products. As a consequence we have expanded our earlier studies of mineral-polymer systems to include composites containing cellulose-based fibres and we hope to build up our technical facilities for such work substantially over the next year or two.

The amalgamation has brought in, too, the pressing environmental problems of the forest products industry and focused attention on the important need, throughout agriculture as well as forestry, for better plant or tree utilisation, non-polluting conversion technology and improved building materials, finishes, fire retardants and preservatives.

It has strengthened also our interests in plant biochemistry and bioenergetics. Although most of our work is chemical it is frequently conducted in collaboration with biological units in CSIRO and outside.

Physical separation of the two groups, and lack of space at Fishermen's Bend, has not yet enabled our programs to be integrated as closely as I would like, but we have nevertheless made a start in this direction. Dr Willis, a synthetic polymer chemist, has been transferred from the Water Group to the FPL program although he is remaining in Dr Solomon's Polymer Section. Dr Wallis is receiving valuable assistance from our organometallic chemists in his work on novel pulping and bleaching processes. This work is also relevant to the conversion of wood waste into fuel oil, a matter of considerable long-term significance. We are also forging new links with our Photochemical Group and have begun exploratory work on novel surface coatings for wood and paper products. We are continuing of course our close ties with the Division of Building Research in these laboratories and we expect closer ties to develop between our insect chemists and that Division's entomologists. As our work on composites develops we expect to become increasingly involved with the Division of Building Research in this area as well.

As a result of these interactions the concept of integrated photosynthetic process industries - IPPI for short - has evolved which, I believe, should become a national, as well as a Divisional goal. Its aim, which I will discuss later, is to exploit, for social and economic gain, Australia's major advantage - its photosynthetic potential By discarding less of the plants we grow, through converting their fibre and nutrient components into consumer goods as well as foodstuffs, it ought to be possible to make more land available for recreation, water conservation and wilderness, to use less pesticides and fertilisers, to create viable rural communities so as to relieve major city pressures and at the same time to develop greater national wealth from a major resource not possessed by our principal customer - Japan. It would also provide opportunity for marrying, with mutual profit, major aspects of our synthetic and natural polymer industries. This is no pipedream. The forest products industry has already shown that it can be done. What needs doing is but an extension and broadening of what has already begun. I see it as a practical approach to solar energy utilisation and to many of our environmental, social and economic problems as well.

Under this general umbrella it is proving practical to attract to this area a greater effort than hitherto. A substantial grant has been received from the Reserve Bank of Australia for this purpose and we are establishing new ties with other Divisions - notably Animal Physiology, Chemical Engineering, Land Research, Soils and Protein Chemistry. Consequently our work of relevance to this meeting is expanding rather than receding.

As will be apparent later, while we are striking out into completely new areas we are continuing much work concerned with wood quality assessment, and environmental influences on wood quality, but with increasing emphasis being given to the complete utilisation of mechanically harvested young, rather than mature wood. Our work on the woodchip industry, which includes a collaborative study with the Division of Chemical Engineering on pipeline conveyance of chips, pulp and paper manufacture and paperboard conversion is also continuing. However greater emphasis is being given to process innovation and the application of modern chemical engineering techniques to enable wood or pulp to be processed under conditions not readily achieved in laboratory glassware. Only in this direction can we hope to find relatively unexplored areas for study. However it will take time to build

up the necessary chemical engineering staff and facilities, the importance of which I stress. A useful start in this direction has been made, in collaboration with the Division of Chemical Engineering, on pulping in liquid sulphur dioxide and equipment is being built to study in that Division explosion pulping procedures and, in this laboratory, pulp refining at temperatures above the fibre glass transition temperature (*ca.* 130-150°C). The recent appointment to this laboratory of Dr Gartside, a chemical engineer, represents an important step in building up our chemical engineering skills.

You will be hearing much of this work from others more qualified than I. However there are two aspects of our program which I will refer to briefly as they will not be discussed later.

The first relates to an important joint program with the Division of Soils and the South Australian Woods and Forests Department concerning nutritional aspects of second rotation *Pinus radiata*. We are finding that the suite of mycorrhiza associated with juvenile pine differs considerably from that associated with a mature tree. When a mature forest is clear-felled and replanted it takes some years for the new suite of organisms to establish. It may be that this phenomenon is a factor in the retarded growth observed at some sites in the early years of a second rotation pine crop.

The second development has emerged from joint work with the School of Biological Sciences, the Australian National University, and the Walter and Eliza Hall Institute concerned with fundamental aspects of energy transformation in biological membranes. This study, along with recent developments overseas, suggests that selenium is almost certainly an essential trace element for respiration in plants and animals. Since selenium will probably be lost through volatilisation in a forestry burn there may be situations where, as a result, the soil becomes depleted of selenium to critical levels. Unfortunately this possibility was not realised when our Bush Fire Research Section made recently an extensive study of the volatile components in forestry burns with air pollution in mind. However, we hope to look at selenium volatilisation in a fire soon. The Division of Soils is also studying selenium uptake by pines on our behalf; some fungi are quite remarkable scavengers of selenium.

I hope this gives you a broad indication of the direction our research is heading. I leave it to my colleagues to highlight some of the details and practical results.

Introductory Paper 1

SOME THOUGHTS ON FOREST PRODUCTS RESEARCH IN PAPUA NEW GUINEA

By S. J. COLWELL

On the occasion of this the last Forest Products Research Conference prior to a major change in government in Papua New Guinea it could be of interest to briefly touch on the highlights of achievement in Forest Products Research in P.N.G., point up the failures, or short comings in our research approach, and endeavour to forecast the future.

It could be difficult to "crystal ball" the future - it is almost as difficult to highlight the achievements of the past. I would however like to try.

Achievements

1. As an organisation we have on most occasions had an officer present at this Conference but always an expatriate and always on his own, today there are three of us, one of whom is a local P.N.G. officer. On the occasion of the next Conference he will probably lead the party assuming we have representation and further assuming that the Forest Products Research laboratory is still in existence.

2. In June 1961 a small forest products research exercise was mounted in P.N.G. with the establishment of a woodworking shop in Port Moresby with a staff of three (3) expatriates and six (6) local people. In May 1973 the staff position is - 22 expatriates (including 11 professional and 11 technical officers) and 53 local officers (including 1 professional and 25 technical officers). Of the local officers 8 are assuming normal responsibilities. This statement could be indicative of empire building rather than progressive achievement. I prefer the latter interpretation.

3. On July 1 1964 preservation of all timber for use in building construction and in the manufacture of furniture for government became compulsory. This was achieved by contract specification under two patents held by CSIRO. At this stage when P.N.G. is almost ready to take over complete control of its preservation industry - the said patents having practically time expired - there is little doubt that the original decisions taken were basically correct. Although we have experienced falldowns and will continue to do so, the operation has been well worthwhile, and its financial benefits have been more than satisfactory. I am not by any means claiming full marks for this achievement as obviously the process of "Dip Diffusion" to which I refer was developed by CSIRO. I do however suggest that without our insistence on what we regarded as necessary variations the success of the operation would not have been of the same order. I would like to refer to this preservation exercise again later.

4. Prior to 1961 it was not possible to identify from the wood - locally - more than the very few species then in general use. All other material was forwarded for identification to CSIRO. At present the laboratory provides practically 100% identification service for all species described in P.N.G. Although it has often been stated that there can be no utilisation without identification, I often wonder, if in fact species identification is as necessary as we have assumed and if it may not actually inhibit utilisation of tropical hardwoods. It is in my opinion becoming more essential that we start to think in terms of wood for end use.

5. Some three years ago we commenced, under the wings of CSIRO, a project designed to increase our knowledge of the pulp and thence paper possibilities of mixed tropical hardwoods. Although the project is by no means finished it has already proved successful and will continue so. Our achievement is not so much in the results obtained at our end so much as in the fact that we are in the project at all. It remains true as it was four years ago that a country "hoping" to show a return from chip export must have sufficient knowledge of the product and its end use to be able to "deal" with the producer/user. Being part of this project will assist in that at least some of our people now think and talk the pulp/chip language.

6. We have I think thrown some much required light on seasoning of timber with particular reference to the tropics. The ideas put forward on the economics of drying will I think "pay off" in the not too distant future.

Short-comings - "Wrong Turnings"

1. I mentioned earlier that the forest products exercise in P.N.G. started with a joinery shop - at the time one of the most complete shops in the country. At the same time we operated two sawmills. We were ideally equipped to learn an enormous amount about the species in which we were interested - information which would have allowed us to put species into most end uses. The joinery shop was installed with this purpose and yet at this stage we realise that very little was achieved. Why was this?

2. The Forest Products complex in Port Moresby covers approximately 12 acres all of which apart from the central laboratory was built by the carpenters and joiners who should have been recording their impressions but were always too busy achieving construction deadlines. We had the naive idea that by saving money in this self help exercise we were on the right track. We might have been but the resultant joy has been somewhat restrained, to say the least.

3. Somewhere along the line we talked ourselves into thinking that it was not possible to obtain worthwhile results without the use of sophisticated equipment. This has proved - particularly in the light of what may happen in the future, to have been a wrong move although it is difficult to pin point the particular equipment. The "move" was rather a change in outlook.

4. Over the past twelve months we have changed our name to include the word "Development" - Forest Products Research and Development. The need to make this name change indicates I think one of our major short-comings of the past few years. There is no mileage in carrying out work, obtaining answers unless the information so obtained is promulgated. "Go ye out and spread the gospel etc.". I could quote innumerable examples to back up this statement - however the latter should suffice. I have just finished studying the specification for major wharf complex improvement in P.N.G. designed to cost $9 million and no timber was included and basically all materials with the exception of concrete aggregate being imported. This happens at a time when we would have thought that we were in a position to supply material for wharf construction with a fair degree of certainty.

5. I have arrived at the debatable conclusion that to be effective a forest products research organisation must have a large measure of autonomy and with it the right of vertical promotion of staff. We have failed in achieving

either of these requisites. There can be no ties to a parent organisation which controls the industry. You cannot advise and control under the same hat.

I have not attempted to list all the achievements nor consider all the short-comings but have listed only those which appear to me important and worthy of discussion. To those members of Conference who consider that the achievements listed are minimal I would point out that although achievements are difficult to measure particularly in monetary terms - which measure is currently popular - we have achieved something worthwhile.

(a) The basic information to allow forest based industries to grow is available.

(b) We are being used by those who know we exist.

(c) We are prepared to advise on the best information available even though it may not be 100% certain.

(d) We have established a reputation for honesty.

Crystal Ball Gazing

It is quite certain that P.N.G. will take the following three steps in its development -

(a) Assume responsibility for the Public Service as at August 1, 1973.

(b) Assume Self Government on December 1, 1973 and between these two dates take over an increasing number of presently Commonwealth functions in P.N.G.

(c) Become completely Independent at a date yet to be determined but certainly within eighteen months from the date of this Conference.

Given the terms of the Commonwealth Employment Security Scheme and lacking any financial inducement to remain, it becomes almost mandatory for all expatriate officers to leave P.N.G. on declaration of Independence.

Where does that leave us?

The answer to this would appear to be reasonably obvious - a perfectly good organisation with buildings and equipment and very limited staff - a "nogo" operation unless some rapid moves can be made to extend its life.

What Will Happen?

Given the above conditions the following options are open:

(a) The operation will cease to exist. This alternative is possible as "Research" as such has never been popular in P.N.G. and is less so now due to apparent large expenditures on basic research projects which would appear to produce little or no applicable results.

(b) The operation will continue but at a very much reduced level under similar control to the present. This would result probably in reduced effectiveness but would allow build up when required as it would retain a nucleus of local staff. The possibility of "buying" research on a project basis as required would remain.

(c) The operation will continue at similar level to the present, include the function of building research plus some of functions of the presently constituted Building Research Section of CSIRO but become autonomous or almost so.

(d) The operation continue as a Forest Research Institute under wing of Department of Forests or Department of Natural Resources. Under these conditions it would include function of Forest Research and of a National Herbarium and most likely some Agricultural Research function. Financial support would be sought from outside P.N.G. - probably Australian Foreign Aid.

Of these options (a) is a possibility which must be considered (c) would be preferable and is possible with necessary action taken immediately, (b) is highly probable and (d) most unlikely.

In order to achieve (b) it would be necessary to attract sufficient local graduates so that they themselves have the interest in and see the necessity of maintaining the work.

In order to achieve (c) it would be further necessary to make urgent moves towards autonomy in order that outside financial support is made easier and then move to obtain this support. It would be necessary also to designate expatriate officers required for present level continuance and by financial and other means induce them to stay on for the requisite time, say three years after Independence.

It may well be asked why worry and why bring this to a Conference of this nature - it is possible that I am mixing personal bias - maybe even personal pique with P.N.G. country needs.

The economic and social gap between the developed and developing countries is ever widening. The hope of closing this gap lies in sound development of natural resources - development which shows the maximum return to the developing country. Forests are one of the major of those resources renewable at an attractive rate in the tropics - attractive compared to similar temperate exercises. Depending to a large extent on foreign investment to develop these resources limits the possibility of return to the developing country - forest products research - obtaining the information necessary to foster increasing sophistication of industry is one of the ways remaining to maximise return to the country.

I bring the matter to this Conference as it effects all of us. It is an economic necessity for the developed countries to do all they can to close this gap separating them from the less developed peoples of the world.

I have been asked a number of times whether I would follow the same pattern in developing a forest products research unit if I was given a second opportunity.

It would be expected that I would avoid the mistakes and short-comings that I have discussed above. Further I now consider that the following points should be kept well in mind.

(a) Most of technology required in developing country forest products industry is already available from the more developed areas. This does not however mean that such technology can be automatically transplanted. In many

cases it requires to be tailored to meet particular requirements. Research should therefore be designed to apply techniques rather than initiate them.

(b) I think it sometimes escapes us that people in P.N.G. have used wood for generations and have quite a good appreciation of its properties. They know what species for instance are the most durable in ground contact. We often mount quite sophisticated laboratory experiments to determine what we could find out by asking the right questions in the right places.

(c) A forest products research organisation in a developing country must I feel assume a training role. By this I do not mean "teach us to do research". I am rather thinking of training people at all levels to take their places in a developing industry - from sawmilling to post graduate work.

(d) There should be allowance for basic research by persons or groups - after careful consideration - for prestige purposes. However projects must have application.

Wood Preservation

I mentioned earlier that I would mention preservation again. There are two points which should be so mentioned.

1. Wood Preservation Seminar

U.N.F.A.O. have proposed that a Seminar on wood preservation be held in Port Moresby early in 1974. The idea behind the Seminar came from a strongly worded recommendation to the F.A.O. Committee on Forestry early in 1972 made by delegate countries including Malaysia, India and Pakistan that F.A.O. should include in their programme of work "Training in the practice of Wood Preservation".

Papua New Guinea was suggested as the most suitable venue for this Seminar because of the existence of a well established wood preservation system based on a universally applicable process for protection of timber used in buildings as a result of which Papua New Guinea has one of the most highly developed wood preservation industry in the tropics and is held in high regard by international authorities on wood preservation.

The state of wood preservation in Papua New Guinea was brought to the notice of F.A.O. Officers as a result of a paper presented by one of the staff of the F.P.R.C., at the 4th plenary meeting of the International Research Group on Wood Preservation held in Berlin in October, 1972 and later in discussions at F.A.O. headquarters in Rome.

The main purpose of the Seminar would be to provide basic information about wood destroying agencies, techniques of preservation and economics of wood treatment in the context of developing countries' needs.

F.A.O. envisage up to 30 delegates from about 22 countries as well as one or more prominent international authorities on wood preservation taking part in the Seminar.

Because of the long standing support which we have received from CSIRO in the establishment and development of the wood preservation industry in P.N.G., it is hoped that their collaboration and support for this Seminar will be forthcoming.

Funding of the Seminar is still uncertain and at this stage F.A.O. is seeking support from UNDP. However it is not unlikely that the direct assistance of the Australian Government and/or Australian aid groups will be sought.

We are confident that we will obtain at least moral support from our Australian colleagues and hope to be in a position to invite at least some of Australia's eminent wood preservation specialists to participate.

2. Wood Preservation Authority

At the time of writing a Bill has been tabled for consideration by the House of Assembly - P.N.G. This is a Bill to establish a Forest Industries Council. And an Executive Committee under control of the Council is the Wood Preservation Authority. Control of preservation in P.N.G. will thus pass to a statutory body.

Introductory Paper 2

SUMMARY OF ACTIVITIES OF THE WORK PARTY OF FORWOOD INTO RESEARCH ACTIVITIES

by W.E. Hillis

The Working Party concerned with Research into Forestry and Wood-Based Industries is one of the parties of Panel 8 of the FORWOOD activities. There will be meetings shortly before the Forest Products Research Conference and a summary of the situation at that stage will be presented to the Conference.

INTEGRATED PHOTOSYNTHETIC PROCESS INDUSTRIES

by D. E. WEISS

I. Introduction

In this discussion I wish to raise the complex subject of national objectives and pose questions - difficult questions - such as the following. What are our natural advantages and resources on which Australian consumer industries for the future should be based? How can we reduce transport disabilities in this vast continent of ours? What can we do about high labour costs? How can we increase employment prospects and quality of life in country centres so as to reduce the rate of growth of our cities? What are some of the environmental hazards of the future and how might we reduce or preferably profit from them? And on a world scale - where is the world's protein in the future to come from and how can the need for more space to grow food be reconciled with opposing needs for more urban, forest, recreational, watershed and wilderness space? What, in the long term, will replace liquid fuels, and how will Middle East politics influence world oil prices over the next twenty years or so? These are major issues way beyond my field of competence. But who is competent to cope with them?

The answer I believe, at least for Australia, lies in part in better utilisation of our photosynthetic potential, or solar energy if you prefer, along lines familiar to the forest products industries.

II. Aspects of the Petrochemical Industry

But before considering the concept of integrated photosynthetic process industries, IPPI, let us consider some economic trends. Figure 1 shows the relative price changes in Australia for wood, steel, aluminium and plastics, while Figure 2 compares the relative change in all manufacturing costs in the USA (upper curve) with that of chemical manufacture (lower curve). Figure 3 shows how plastic costs in the USA have changed. Only very recently, and even in Australia where chemical costs are about twice those overseas, have chemical and plastic costs checked their steady fall over two decades, despite large increases in labour and other costs over that period. Why is this so? There are important lessons to be learned in how this has been achieved in the petrochemical industry. For traditional industries to ignore them is to invite extinction.

In part it is due to economies of scale. As shown in Figure 4, ethylene production, the cornerstone of the petrochemical industry, has been rising sharply and so has the optimum size of a production unit (the latter applies also to pulp and paper mills). However, the optimum size of an ethylene unit today is about five times that of total Australian ethylene production which is shared by three plants! But there is much more to it than economics of scale.

Introductory Paper 3

More than a century ago the chemical industry learnt in Widnes that to be socially acceptable it had to convert a high proportion of its cheap raw materials into valuable marketable products with little waste. In this it has been spectacularly successful. A key feature of the modern petrochemical industry is its remarkable flexibility in being able to efficiently convert virtually all of its raw material into a wide array of products serving many industries and needs.

A petrochemical plant is usually closely associated with a petroleum refinery. Figure 5 illustrates the situation at Altona, Victoria. The refinery provides a stable base load and converts crude oil into a series of fuels of varying value which it sells on a large scale. The cheapest product, the fuel oil, provides a valuable sink for the disposal, but at a profit, of many combustionable residues arising during processing. It also sells relatively small amounts of hydrocarbons to the petrochemical plants which transform them into a whole range of chemical products for a multitude of uses. There is often considerable interchange of chemical materials between these factories and residual hydrocarbons go back to the refinery and are sold in fuels. The result of the whole complex is then the sale on a large scale of a variety of fuels and, on a smaller scale, chemicals and plastics of varying value. Because of the considerable number of conversion steps the system has great market flexibility; synthesis materials can be diverted from one factory to another to meet changing market needs. This flexibility is invaluable in today's era of rapid market changes and is a key factor which has led to the amazing growth rate of this industry.

Another feature of the industry is that it succeeds in converting virtually all of its raw material - crude oil - into marketable products. It converts its raw material, which costs about 3 cents per kilogram for example in Melbourne, into chemicals which, with very few exceptions, sell from $0.33 to $4.5 per kilogram ($0.15 to $2 per pound). The high value of the products reflects not the cost of the raw materials, which is comparatively insignificant, but mainly the high capital cost of the conversion plant. Hence the industry is highly capital intensive and its costs reduce rapidly with increasing size.

The ability of the chemical industry to so dramatically contain its costs through greater productivity is due, in part, to the increasing size of its production units - the result of an aggressive international, competitive marketing policy for its products - to its willingness to rapidly replace an old product with a new, better one, and to its policy of employing large numbers of scientists and technologists of the highest calibre in its research laboratories and plants. Figure 6 compares the research expenditure of this industry with some others. It tells its own story.

We see then the value of an integrated industry which utilises virtually all of its raw material and has a large built-in base-load component which supports smaller, specialised industries and which contains an in-built sink where many process residues can be disposed of and converted into profit. We see also the value of persistent, high-calibre research to a dynamic industry.

But here the value of the petrochemical industry as a model for Australian industry ends. Being highly capital intensive it lacks in Australia its prime requirement - a large local market. Consequently the Australian industry is almost exclusively the product of massive research abroad and the local industry is dominated by foreign, often multinational, interests.

III. Integrated Forest Products Industries

Now the concept of an integrated photosynthetic process industry, but with trees as the plant species, is no news to you. You will know, better than I, the advantages of an integrated forest products industry such as is shown in Figure 7. You will also know, better than I, the many social, financial, political, technical and transport problems that often stand in the way of such logical development. Yet there is no doubt that this is the path that must be followed.

In favour of this trend is the fact that the industry, in terms of tonnage, is indeed very large even in Australia. As can be seen from Figure 8, the tonnage production of timber in the USA is comparable with the tonnage of steel, cement, plastics, aluminium, and all other metals combined. In Australia the production in 1968-69 of about 5 million tonnes of saw logs (dry basis), or 450,000 tonnes of pulp and paperboard, compares with the production of about 225,000 tonnes of synthetic polymers. Even the total production of plastics in Japan in 1970 amounted only to 5.7 million tonnes. In terms of value, however, the situation is very different. The total value of production from the Australian pulp and paper and converting industries is comparable with that of the plastics industries and employment in both is about the same.

But even in a highly integrated forestry industry the utilisation of total biomass is not high. The Australian national average is about 15-20%, and of the 1986 sawmills operating in Australia in 1969 only 83 were classified as large. It is true that some of the biomass must recycle to the soil to maintain its structure and supply nutrients. The question is how much, particularly if coppicing were practised so that soil structure is not disturbed? Clearly there is much that remains to be done in achieving better utilisation of our forests quite apart from the even broader issue of multiple use.

IV. Integrated Agricultural Process Industries

Just as the forest products industry is substantially bigger than the chemical industry, so is the agricultural industry considerably bigger than the forest products industry, with which it forms the photosynthetic industry. Both industries produce fibrous ligno-cellulose, carbohydrates, protein and fats. Whereas the forest industries concentrate on the fibre components in the bole of the tree, and discard the rest, the agricultural industries are primarily concerned with the nutrients in the plant, such as the protein, fats and edible carbohydrates and throw away the remainder; fibres function mainly as roughage since it is carbohydrates, like sugars and starch, which provide the main energy component in an animal diet. Just as the forest products industry operates large integrated process industries which exploit its fibres so too does the agricultural industry operate large integrated food and animal-feed industries which process their nutrients. Both industries resort to large-scale burning to discard their wastes.

The waste from agriculture is enormous. For example, let us look at the biggest single Australian crop - wheat. In 1968-69 Australia produced about 17 million tonnes of wheat on 68 million hectares which amounted to 57% of the land utilised for crops (1). At the same time it produced about 28 million tonnes of wheat straw a little of which was used as fodder, some was burnt and some was recycled to the soil. This quantity of straw is about one-fifth the weight of dry logs harvested from Australian forests

in that period. Even a minor Australian crop like lucerne contained over a million tons of fibre in 1968-69; this is equivalent to all the fibre in Australian paper and fibreboard products which were made that year. Clearly there is a very large, virtually untapped fibre resource in the wheat industry alone. This applies also to other segments of agriculture. Sometimes the disposal of agricultural wastes pollutes the aqueous as well as the air environment. For example, a single cannery at Shepparton, Victoria, produces an effluent with a B.O.D. load equivalent to that from a town containing about a quarter of a million people.

The net result of discarding so much of the organic matter produced in our photosynthetic industries is that although we derive no profit from these wastes, we are nevertheless using more land, more labour, more transport facilities, more fertiliser and more pesticides than would be necessary if somehow we could use all these products efficiently including returning the right amount to the soil. An important way of relieving the environmental pressures which are building up at such a rapid rate today, and at the same time to increase the world's available resources in which Australia has a major role to play, is clearly to develop a more integrated photosynthetic process industry - an industry where forestry and agriculture combine to provide the natural industrial fibre and nutrients for the world. Such an integrated industry would serve both consumer and food markets, but at the same time make available more land for use as watershed, recreational and wilderness areas. Yet whilst the forest industries have learned, like the chemical industry, that a high degree of integration is essential for aurvival, the agricultural industry is only now having to learn this important lesson - to learn that it is in fact also a major producer of fibres which have potential for major consumer use if research could show how they could be fabricated into useful products.

The key to such an integrated photosynthetic industry can be seen from a consideration of the basic principles behind the petrochemical industry. Here a complex mixture - oil - is first fractionated into a series of simpler, but impure products. Each of these in turn are the raw materials for another factory aimed at raising their value and meeting specific consumer needs. Just as the primary distillation column in the refinery is the heart of the petrochemical industry, so there needs to be developed an analogous primary separation plant for use in the photosynthetic industry. This separation plant must separate natural fibre bundles from the rest of the cell components which should emerge as a slurry containing the protein, carbohydrates, amino and other acids, oils, fats, waxes and mineral salts. As a result two major process streams are formed - the fibre stream and the nutrient and oil stream.

V. Integrated Photosynthetic Process Industries

Figure 9 shows what a hypothetical integrated photosynthetic process industry might look like. Plants are considered in four categories - the seed crops, forestry trees, grasses, and together the vegetables and fruits.

In the seed crops nature conveniently separates the fibres from the nutrients which concentrate into the seeds. Man's harvesting completes the separation. The seeds enter food and vegetable oil processing streams; the hay enters the fibre stream. Major components of the forest trees and mill ends from the sawmill are chipped except for the sawlogs. The chips are separated from the twigs and leaves by sieving or air classification.

Grasses and components from the fruits and vegetable crops, except for the edible components, are combined with the leaves and twigs for primary separation. The fibres and cell components thus separated then enter further processing streams.

There is already technology for performing the primary separation although so far this has been utilised only for recovery of protein. The desirability of recovering the fibres in a usable form has not been attempted. Dr. Gartside has begun recently a study of plant fractionation techniques which he will describe later.

It can readily be seen that the processing of plant cell components could lead to many associated industries interwoven as in the petrochemical industry in addition to the existing food processing industries. Just as the petrochemical industry uses its associated petroleum refining industry to provide a base-load sink for the profitable disposal of its many residues, and for coping with fluctuating demands for its products, so too would an integrated photosynthetic industry possess analogous base-load sinks in the form of large scale requirements for animal feeds and, to a lesser extent, for building materials. Animal feed could come, as at present, directly from the pastures or crops or from any of a series of intermediate steps in the processing.

VI. Some Market Considerations

Given the technology for plant fractionation, be it the fractionation of trees, shrubs or grasses, what can one do with the products? This is too large a subject to be dealt with here but aspects of it may be summarised as follows.

(a) Nutrients

There is a rapidly developing need for protein and in the future much of this will need to come directly from plants. Increasing attention is being devoted in CSIRO to improving the efficiency with which animals convert plant feed nutrients into foods through the use of protected feeds, and to the preparation of meat and dairy products of greater dietry value through the use of vegetable oils protected with protein. In collaboration with the Division of Animal Physiology, Dr. Gartside has erected a fractionation plant at Prospect where the use of the nutrient fraction in animal feeds and protected products is being investigated. We are studying the properties of the fibre components here. Although beginning with lucerne this technique will be applied also to a variety of plants including the leaves of eucalypts and pine needles. The possibility of recovering the essential oils will form part of this study.

(b) Composites

As I will be describing later there is, I believe, a bright future for the development of lignocellulose-plastic composites for use as packaging, containers, building boards and even some structural elements.

(c) Liquid Fuels

Recent work in the USA has shown that carbon monoxide at high pressures (200-350 atmospheres) and 250-400°C can reduce wood and agricultural wastes to liquid fuels. About one-third of the weight of dry raw material

Paper 3

Paper 3

Paper 3

including many structural elements. In the long term, photosynthetic by-products may well provide a practical raw material for the production of liquid fuels.

We should stop trying to build, as we are at present, a mini Northern American or European industrial society for which we lack the essential natural advantage - a large local market. We should avoid too the glamour and pitfalls of "advanced technology". It is high time that we realised that we now have a sophisticated technological base and began to think for ourselves on a national scale. There is much that can be learned with profit by Australian industry from the history and outstanding achievements of the forest products and sugar industries in this country.

REGIONAL CO-OPERATION IN PULP AND PAPER RESEARCH

by H.G. Higgins

The CSIRO Forest Products Laboratory has played a considerable part in moves to develop a more co-operative approach to research in the pulp and paper field within the region bounded by India, Japan and Australia. These efforts can be conveniently divided into three parts:

1. Activities relating to Papua New Guinea
2. South East Asian Regional Co-ordination
3. Specific co-operation between Australia and Japan

Papua New Guinea

The Division of Forest Products accepted a major grant in 1970 from the PNG Administration, acting in conjunction with the Australian Department of External Territories, for the development of a three-year programme of research into the pulping and papermaking possibilities of the PNG forests. This was renewed in 1973, the Division of Applied Chemistry accepting an increased grant for a further three-year period. Several visits have been made to PNG in the course of this work, which has involved technical and economic assessments of specific resources. F.H. Phillips and A.F. Logan have spent the major portion of their time on this work, and other officers, notably V. Balodis and H.G. Higgins have been deeply involved in specific aspects. In response to an invitation by the organizers of the World Forestry Congress in 1972 a general paper on the pulping of tropical hardwoods, dealing with individual and mixed species, wood and paper properties and resource assessment was prepared, and is now in course of publication (1).

The PNG investigations have been carried out in the closest collaboration with the staff of the Department of Forests. Some of the essential work has been done at the Forest Products Research Centre in Port Moresby.

South East Asia

H.G. Higgins accepted an assignment from ECAFE in 1970 as Regional Co-ordinator for research in pulp, paper and cellulose products. Under the sponsorship of the Department of Foreign Affairs, visits were paid to relevant research institutes and mills in Indonesia, Singapore, Malaysia, Thailand, India, Bangla Desh (East Pakistan), Japan, Taiwan, Korea and the Philippines. As a follow-up to this project a meeting was organized in Singapore in 1972 under the sponsorship of the International Development Research Corporation, and was attended by one person from each of ten countries. Forming itself into a Working Group, the meeting identified a number of areas of common interest, mainly connected with the potentialities of raw materials for pulp and paper manufacture within the South East Asian region, and with their assessment. The countries most concerned with each area of interest are as indicated below:

Mixed Tropical Hardwoods	Japan, Malaysia, Indonesia, Philippines, Australia and Papua New Guinea, Singapore.
Rubberwood	Indonesia, Thailand, Japan, Malaysia.
Eucalypts	Australia, Japan, India, Thailand, Malaysia, Philippines, Singapore, Indonesia.
Pines	Indonesia, Malaysia, Thailand, Japan, Australia, Philippines.
Bagasse	Singapore, Australia, India, Taiwan, Philippines.
Bamboo	Indonesia, Thailand, India, Burma, Taiwan.
Straws	Indonesia, Thailand.
Abaca	Philippines.
Secondary Fibres	Japan, Singapore, Australia, Thailand.

Of these the areas of greatest mutual research interest were:

1. Tropical hardwoods
2. Rubberwood
3. Eucalypts
4. Agricultural Residues

The meeting discussed the facilities available for technical and research training within the region in the specific field of pulp and paper, and it was agreed that the best use should be made of the following organizations: Institute of Paper Technology, Saharanpur, India; Cellulose Pilot Plant, Bandung, Indonesia; University of Singapore; Forest Experiment Station, Tokyo; CSIRO Forest Products Laboratory; Asian Institute of Technology, Bangkok; Forest Products Research and Industries Development Commission, Laguna, Philippines. The possibility was discussed of making use of a particular pulp and paper mill for training in production methods, and research into technical and economic aspects of the manufacture of pulp and paper on a small scale from indigenous raw materials.

It is hoped to arrange a further meeting on the topic "Utilization of Raw Materials of the South East Asian Region for Pulp and Paper Manufacture", at which technical papers on each of the four topics listed above would be presented and attempts made to apply the research results to the industrial requirements of the region.

A.J. Watson undertook an assignment in India for $2\frac{1}{2}$ months (1971-72) for the United Nations Development Programme as a consultant to make an assessment, in relation to pulp and paper developments, of the country's forest resources. He worked in the headquarters of the Pre-investment Survey of Forest Resources in Delhi.

Australia and Japan

The development of wood chip export industries in Australia and PNG in recent years has led to greatly increased contacts with Japanese foresters, paper technologists and chip importers, both in Australia and Japan. A.J. Watson was a member of the Forestry Council Technical Mission to Japan in 1968, which investigated various aspects of wood chip utilization. Further contacts were established by H.G. Higgins during his Asian trip in

REGIONAL CO-OPERATION IN PULP AND PAPER RESEARCH

by H.G. Higgins

The CSIRO Forest Products Laboratory has played a considerable part in moves to develop a more co-operative approach to research in the pulp and paper field within the region bounded by India, Japan and Australia. These efforts can be conveniently divided into three parts:

1. Activities relating to Papua New Guinea
2. South East Asian Regional Co-ordination
3. Specific co-operation between Australia and Japan

Papua New Guinea

The Division of Forest Products accepted a major grant in 1970 from the PNG Administration, acting in conjunction with the Australian Department of External Territories, for the development of a three-year programme of research into the pulping and papermaking possibilities of the PNG forests. This was renewed in 1973, the Division of Applied Chemistry accepting an increased grant for a further three-year period. Several visits have been made to PNG in the course of this work, which has involved technical and economic assessments of specific resources. F.H. Phillips and A.F. Logan have spent the major portion of their time on this work, and other officers, notably V. Balodis and H.G. Higgins have been deeply involved in specific aspects. In response to an invitation by the organizers of the World Forestry Congress in 1972 a general paper on the pulping of tropical hardwoods, dealing with individual and mixed species, wood and paper properties and resource assessment was prepared, and is now in course of publication (1).

The PNG investigations have been carried out in the closest collaboration with the staff of the Department of Forests. Some of the essential work has been done at the Forest Products Research Centre in Port Moresby.

South East Asia

H.G. Higgins accepted an assignment from ECAFE in 1970 as Regional Co-ordinator for research in pulp, paper and cellulose products. Under the sponsorship of the Department of Foreign Affairs, visits were paid to relevant research institutes and mills in Indonesia, Singapore, Malaysia, Thailand, India, Bangla Desh (East Pakistan), Japan, Taiwan, Korea and the Philippines. As a follow-up to this project a meeting was organized in Singapore in 1972 under the sponsorship of the International Development Research Corporation, and was attended by one person from each of ten countries. Forming itself into a Working Group, the meeting identified a number of areas of common interest, mainly connected with the potentialities of raw materials for pulp and paper manufacture within the South East Asian region, and with their assessment. The countries most concerned with each area of interest are as indicated below:

Mixed Tropical Hardwoods	Japan, Malaysia, Indonesia, Philippines, Australia and Papua New Guinea, Singapore.
Rubberwood	Indonesia, Thailand, Japan, Malaysia.
Eucalypts	Australia, Japan, India, Thailand, Malaysia, Philippines, Singapore, Indonesia.
Pines	Indonesia, Malaysia, Thailand, Japan, Australia, Philippines.
Bagasse	Singapore, Australia, India, Taiwan, Philippines.
Bamboo	Indonesia, Thailand, India, Burma, Taiwan.
Straws	Indonesia, Thailand.
Abaca	Philippines.
Secondary Fibres	Japan, Singapore, Australia, Thailand.

Of these the areas of greatest mutual research interest were:

1. Tropical hardwoods
2. Rubberwood
3. Eucalypts
4. Agricultural Residues

The meeting discussed the facilities available for technical and research training within the region in the specific field of pulp and paper, and it was agreed that the best use should be made of the following organizations: Institute of Paper Technology, Saharanpur, India; Cellulose Pilot Plant, Bandung, Indonesia; University of Singapore; Forest Experiment Station, Tokyo; CSIRO Forest Products Laboratory; Asian Institute of Technology, Bangkok; Forest Products Research and Industries Development Commission, Laguna, Philippines. The possibility was discussed of making use of a particular pulp and paper mill for training in production methods, and research into technical and economic aspects of the manufacture of pulp and paper on a small scale from indigenous raw materials.

It is hoped to arrange a further meeting on the topic "Utilization of Raw Materials of the South East Asian Region for Pulp and Paper Manufacture", at which technical papers on each of the four topics listed above would be presented and attempts made to apply the research results to the industrial requirements of the region.

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1970, referred to above, and in a later visit to Japan, sponsored by W.A. Chip and Pulp Co. and the Department of External Affairs. A reciprocal understanding has been acquired of the problems facing the industry in both countries (2).

Other Regional Activities

A limited amount of pulping work has been done on Fiji timbers.

Various research scientists from Asia have worked in the Forest Products Laboratory and have helped to strengthen the research connections between the countries of the region.

References

1. Higgins, H.G., Phillips, F.H., Logan, A.F. and Balodis, V. - CSIRO, Division of Applied Chemistry, Forest Products Laboratory, Technological Paper No. 70 (1973).

2. Higgins, H.G. and Phillips, F.H. - Aust. For. Ind. J. 39 (1): 46-53; 39 (2); 39 (3).

(b) REGIONAL COOPERATION IN FOREST CONVERSION

by M. W. Page

The Division of Building Research sector of the Forest Products Laboratory has continued cooperative work with overseas and international organizations in the same manner as the previous Division of Forest Products.

The following summarizes our activities in various regions:

Papua/New Guinea

N. Tamblyn's Preservation Group, in cooperation with the Papua New Guinea Forest Products Research Centre, have current the following projects:-

(a) Field tests at two sites of various preservative treatments of radiata pine and round and sawn eucalypt.

(b) Field tests of about ninety P.N.G. timbers which were originally treated with creosote and C.C.A. salt at F.P.L. as part of the work to determine their permeability.

(c) Licensing of the patented dip diffusion preservative treatment to about seventy users in P.N.G. so that their treatment can be legally controlled by the P.N.G. Department of Forests.

(d) Licensing of the manufacture of the dip diffusion salt, so that its quality can be controlled. Last year about 600 tons of dip diffusion salt was made under C.S.I.R.O. licence and used in the Territory.

(e) Investigations of problems associated with degrade caused by micro-organisms of stored pulp chips.

(f) Work on *Lyctus* susceptibility and permeability to preservatives of a number of P.N.G. timbers.

B. McCombe of Forest Conversion Engineering Group, again in co-operation with the Forest Products Research Centre, is assessing the suitability for plywood of a number of P.N.G. species. Also, I have been advising a New Guinea sawmilling company on problems associated with the conversion and export marketing of a number of New Guinea species.

Fiji and British Solomon Islands

The Groups of both Timber Engineering (H. Kloot) and Forest Conversion Engineering (E. McArthur) have been engaged in determining the properties and uses of a range of Fijian and British Solomon Islands species. In addition, R. Liversidge of the Forest Conversion Engineering Group has been investigating the viability of using thinnings of the Fijian *Pinus caribaea* plantations for the production of blockboard.

Malaysia

Four members of the Forest Conversion Engineering Group, L. Barker, B. McCombe, K. Fricke and myself, are acting as design consultants to a company, formed jointly by the Federal Government of Malaya and the State Government of Pahang, to establish an integrated forest conversion complex. Ultimately the complex will include sawmilling, kiln drying, moulding, dressings and the manufacture of plywood, blockboard, prefabricated housing and furniture components. To date this company has purchased approximately $1 million worth of Australian sawmilling and kiln drying equipment.

Recently two members of the Division of Building Research (N. Tamblyn and J. Pattison) visited Malaya as part of a British Mission which, at the request of the Malaysian Government, investigated and reported on the re-structuring of forest products research in Malaya to make it more "industry oriented".

Indonesia

I have recently visited Indonesia, at the invitation of the Department of Overseas Trade, as a member of a Government-Industry Survey Mission to ascertain the potential use for Australian forest industries equipment and the opportunities for joint ventures.

Throughout the Asian and Pacific area another member of the Forest Conversion Engineering Group (L. Wymond) acts as "Forest Products Advisor to the Registry of Scientific and Technical Services of the Asian and Pacific Council".

South America

F. Christensen and B. McCombe of the Forest Conversion Engineering Group have, in recent years, visited South America as United Nations advisors; Frank to assist the industries in Paraguay and Uruguay to improve drying practices and Barry to Paraguay to assist in improving the quality of plywood production. In both cases the officers worked in cooperation with the relevant Forest Products Research Organizations in these regions.

International Organizations

Members of the Groups are actively cooperating with various International organizations. N. Tamblyn is a member of the Working Group on Wood Protection of the International Research Group, while B. McCombe is preparing assessments of suitability of species growing in and around Australia for plywood manufacture on behalf of the International Union of Forest Research Organizations.

W. Kauman and myself were invited by F.A.O. to prepare papers on the utilization of multi-species forests and the sawmilling of tropical species respectively, for the recent World Forestry Conference, and I have since been requested by U.N.I.D.O. to prepare guidelines for the manufacture of forest conversion equipment for use in tropical regions.

W. McKenzie of the Forest Conversion Science Group is Convenor of the I.U.F.R.O. Working Group on Basic Cutting Studies, whilst Ron Liversidge of Forest Conversion Engineering Group is Convenor of the Seasoning Correspondence Sub-Committee of the Commonwealth Forestry Conference.

From Forest Conversion Engineering Group, K. Hirst is to be involved in a joint project with the Forest Products Laboratory, Princes Risborough, in testing clear lacquers at the Joint Tropical Research Unit in Queensland, while E. McArthur is a member of a Committee set up by the Centre Technique de Forestal Tropical to centralize available information on tropical species. K. Hirst is also a member of the Committee on Plywood of the International Standards Organization.

The Groups receive enquiries by correspondence from a large number of developing countries and are also involved in training people from these regions. In recent times people from Uganda, Chile and Malaya have been trained, while J. Barnacle is just completing a 3 year term in Ghana and F. Christensen is about to depart for one year's work advising on seasoning in Paraguay.

Introductory Paper 5

RESEARCH IN THE TROPICAL ENVIRONMENT - SOME REVOLUTIONARY THOUGHTS!

by JOHN BEESLEY

WHEN A SENIOR CIVIL SERVANT says, in all seriousness: "Teach us to do research and when we have learned how to do it, we will be in a position to discuss the philosophy of research" – it becomes apparent that some fundamental questions need to be asked – and answered – if any good purpose is to be served by 'research'.

The first question which comes to mind is, of course, for a definition of research. No less important is a statement of what is to be achieved by the research, how will the results be used and by whom. And, the still, small voice might well persist with the question: Is this research really necessary?

In broad terms, the World's more technologically sophisticated nations are to be found in the temperate regions. Until quite recently many of these nations dominated an empire, largely tropical, from which flowed resources of manpower and minerals, foodstuffs and fibres. With the dissolution of these empires, the colonial peoples have formed themselves into what are now known as 'the emerging nations' – or underdeveloped countries – still rich in many wanted raw materials but sadly deficient in qualified, competent and experienced executives for government, education and research, and industry. For political and economic reasons, these developing countries tend to emulate the forms of government and administration which have been evolved, over a long period, by the one-time Colonial Powers. Few travellers in these regions will have failed to notice the endless form-filling, the repetitive questions on name, age, date and place of birth and much else. As often as not, such personal data, so painstakingly gathered is merely filed – and repeated on the next form. But why? – "Because it is on the form" is the stock answer. To ask who prepared the form and why certain questions were included is futile, to say the least.

Again, in general terms, the peoples of these tropical regions lead a relatively unsophisticated life, particularly in the rural areas, and are more or less self-sufficient for food and shelter, albeit at a level that is little better than subsistence level. Hence, the local market for the products of industry, whether food, fibre or shelter, is limited in both size and purchasing power.

In many developing tropical countries, timber is a resource which is relatively abundant, which can be exploited with relatively inexpensive equipment and which is capable of earning foreign exchange without depriving the local population of any (or many) of life's essentials. In short, timber harvesting provides employment for many and profit for some.

With few exceptions, tropical forests are hardwood forests. Forests in which the multiplicity of species is a characteristic. In East Malaysia, for example, 50 species of *Shorea* make up 32% of the total

volume, 5 species of kapur (*Dryobalanops*) account for another 11.4%, 5 species of *Anisoptera*, together with 28 *Dipterocarpus* species make up only 9.7% of the total volume. Thus, 88 species provide 54% of the total net industrial volume at stump and over 60% of the net commercial volume available to industry under current marketing practices. Only a limited number of non-dipterocarp species occur with sufficient frequency in any one area to be considered as economically marketable under existing conditions. It should be noted, however, that roughly half of this non-dipterocarp volume is of heavy density wood classed as 'sinkers' and that less than 30% of the non-dipterocarp volume is classed as high quality. (Private communication).

Again, using East Malaysia as an example, it is fair to say that the rural community obtains its timber requirements directly from the forest and, in any case, presents only a small, sparse and intermittent market for sawn timber. For a number of reasons, the demand for timber in the towns is limited, with dwellings, furniture and packaging representing by far the greatest outlets, (i.e. no railways, few timber fences and a limited use of poles for power lines and telecommunications).

The only logical market for a commercial timber industry, in East Malaysia, is an overseas market. In terms of international trade, timber is a bulky commodity of low unit value. Hence transport charges tend to be proportionately high on timber entering an overseas market. In the importing country, exotic tropical timbers tend to be more costly than equivalent home-grown stock so that consumers try to get the best value for their dollar by using the imported woods for decorative purposes, fittings and furniture. Meanwhile, local timbers (possibly of lower quality) are used for structural purposes where appearance is of lesser consequence.

Unfortunately, in East Malaysia, there is virtually no market locally, for timber which fails to meet requirements for species or quality on the overseas market. Inevitably, such timber is wasted.

Professor Richardson (see RICHARDSON, S. D. "Manpower and Training Requirements in Forestry Development Planning"; Indicative World Plan for Agriculture, F.A.O. 1967), suggests that there is no justification for the establishment of Forestry and Forest Products Research Institutes in developing countries and supports his thesis with the following arguments:

> There are few countries where forestry development is currently limited by problems which local research could solve in a short period of time. The major limitations are of finance and trained personnel.
>
> Modern research in forestry and forest products to be effective requires expensive facilities and extensively trained specialists.
>
> Ordinary forestry training is inadequate for research. The common practice of appointing such men to research positions accounts for the paucity and poor quality of research in developing countries and the wasteful nature of research expenditure.
>
> Few developing countries can realistically afford to release their best men for advanced training (9 year minimum suggested), to support them with necessary facilities and to forego their services in field forestry and administration.

The most pressing requirements of developing countries are generally held to be in product utilization, economics (including marketing and industrial economics) and work science. In fact, many of the more urgent problems call for 'development' rather than 'research'.

The research component of developing countries' forestry problems are seldom unique; for most relevant projects there are well-established precedents in experimental design, method and analysis.

The planning and direction of research is not a logical process. The effective direction of research demands energies and qualities in personnel that, in a developing country, could be more fruitfully used in field forestry or administration than dissipated in research.

Expensive research facilities in developed countries are often under-utilized; their employment by developing countries would be cheaper and more efficient than attempting to duplicate them locally.

Richardson goes on to emphasize that teaching, like research, must be concerned with local, important and practical problems and warns against research paths that lead to an ivory tower. In fact, he claims lack of facilities for post-graduate research training has prompted many developing countries to send large contingents of students overseas for training - often in specialised fields which have little relevance to indigenous problems. He concludes by stating that: "A science policy which stresses applied technology, rather than basic research, is the one most likely to serve development needs. To the traditionalist, such advocacy doubtless savours of heresy and academic servitude; realism often does".

Conferences such as this could do developing and other countries with a tropical rainforest resource a considerable service by defining in unequivocal terms the tests, or other criteria on which local buyers are most likely to pass judgment on the acceptability of an unknown rainforest timber - or group of timbers.

With the notable exception of oregon - which has special virtue because of the large sizes which can be procured - Australia imports little structural timber to a strict specification for mechanical properties. In flooring, furniture etc. imported timbers are favoured for appearance - not mechanical properties. In any case, what properties are common to the dozen or so flooring timbers usually used in Australia, from north to south, east to west? Is it fair to ask our Timber Engineers to specify a value in a simple test (e.g. static bending) which would suffice for most categories of board? It is reasonable to presume that any foreign-grown hardwood with a high starch content in the sapwood will be attacked by Lyctus in Australia - and appropriate treatments can be applied, but is there a real need for any other durability test of Malaysian timbers shipped to Australia in board-form? Are not the techniques for seasoning wood, and for developing kiln schedules sufficiently well developed that existing knowledge could be applied as readily in Malaysia as in Australia? Does this call for post-graduate training?

In my experience, Australian timber importers look for three things: a competitive price (including freight); acceptable quality and good presentation; continuity and reliability of supplies. Price is a matter for the Industry. Continuity of supply is a problem for the

supplier. Technical bodies, such as this Conference and the research facilities we represent can help both Australia and the developing country by advice on the preparation, grading and presentation of their product. Will we?

TOPIC 1. WOOD QUALITY ASSESSMENT

1. WOOD QUALITY AND ITS ASSESSMENT

2. ARE INTER-RELATABLE SYSTEMS FOR WOOD QUALITY ASSESSMENT POSSIBLE?

3. WOOD QUALITY AND PROPERTY EVALUATION OF RE-GROWTH HARDWOODS

4. SUBJECT COMBINED WITH 1/1

5. RELATIONSHIP BETWEEN SOME PHYSICAL CHARACTERISTICS OF *E. REGNANS* WOOD

6. GROWTH STRESS AND ANATOMICAL CHARACTERISTICS IN *E. REGNANS*

....

7. BETWEEN TREE VARIATION OF SELECTED GROWTH AND WOOD CHARACTERISTICS IN PLANTATION GROWN HARDWOODS

8. CRITERIA FOR REFORESTATION FROM THE VIEWPOINT OF THE PAPER INDUSTRY

9. WOOD DENSITY IN RELATION TO PULP AND PAPER PROPERTIES

10. THE RELATIONSHIP BETWEEN GROWTH RATE AND WOOD CHARACTERISTICS IN BIFURCATED STEMS OF *PINUS RADIATA*

11. STUDIES OF WOOD CHARACTERISTICS

    (a) ASSESSMENT OF WOOD QUALITIES IN POPLAR FROM VICTORIA

    (b) THE EFFECT OF FOREST FIRES ON WOOD CHARACTERISTICS

    (c) WOOD CHARACTERISTICS OF COLCHICINE-TREATED *PINUS RADIATA*

    (d) ORTET RAMET RELATIONSHIP IN PINES

12. HOW SERIOUS A PROBLEM IS JUVENILE COREWOOD?

13. PRELIMINARY STUDIES ON THE PREDICTION OF HEARTWOOD VOLUME IN PINE TREES

14. KINO VEIN FORMATION

    (a) KINO VEINS, THEIR FORMATION, ANATOMY AND FINE STRUCTURE

    (b) THE INITIATION OF KINO FORMATION IN MATURE EUCALYPTS

15. NATURAL DURABILITY AND HEART ROTS

16. PROGRESS IN A QUANTITATIVE ASSESSMENT OF DEFECT IN WOOD QUALITY FOR PULP IN PLANTATION GROWN *E. DEGLUPTA*

Topic 1/1

WOOD QUALITY AND ITS ASSESSMENT

by W.E. Hillis

Wood quality results from the interaction of the process of wood formation in the living tree and the influence of the variety of environmental conditions acting on the tree at different times. Differences in wood quality are the largely undetermined area between forest inventory and forest production. An understanding of those conditions which affect wood quality, and of those features of wood quality which are important for certain purposes is particularly important at this time. This understanding will assist the production of material with uniform quality. It will assist in an increase in efficiency in the utilisation of available forests, which in turn will help meet the increased consumption of forest products in Australia. Efficiency will improve also as more integrated conversion facilities are established, and will assist in meeting increased competition from substitutes.

A knowledge of wood quality is needed for the following situations:

(i) mature and overmature forests

(ii) intensively managed forests which will be more completely utilised for forest products, recreation, water collection, etc.

(iii) short rotation plantations, coppice, etc.

(iv) silvicultural practices

(v) tree improvement

(i) Mature and Over-Mature Stands. A large proportion of the anatomical data of mature eucalypts collected by the late H.E. Dadswell has been collected and summarized by some of his former colleagues and Miss J. Lanyon and Mr K. Bamber of W.T.D., N.S.W. It has been issued as Forest Products Laboratory, Division of Applied Chemistry Technological Paper No. 66.

A further number of species was partly examined by Dr Dadswell but as such material is becoming less readily available the work is not being completed.

Wood identification keys based on anatomical features have been completed for the timbers of the Fijian and British Solomon Islands by H.D. Ingle and Miss M. Parsons. A similar key for the Papua New Guinea timbers is being prepared by Mr Ingle.

The extensive compilation of "African Timbers - The Properties, Uses and Characteristics of 700 Species" by Mrs E. Bolza and Mr W.G. Keating (Div. Building Research Publication) has been issued. These publications and keys are useful in assessing the quality of local species and related species imported into this country and indicating their most suitable applications.

Kino veins and pockets are common defects in mature and overmature eucalypts. Mr H. Dowden (W.T.D., N.S.W.) in collaboration with members of the staff of F.P.L., CSIRO has been assessing ground rules to indicate the extent of them in standing trees. When developed this information should enable a rapid assessment of a forest from this aspect and furthermore indicate ways in which the greatest amount of sawn wood can be obtained from a log.

(ii) Intensively Managed and Utilised Stands. The products of intensively managed forests require quality criteria appropriate to their end use. Prediction of the amount of impermeable, resin-containing heartwood is useful in selecting pine stands to provide poles for preservation or raw material of a certain standard for certain pulping operations. (See Paper 1/13) The amount of juvenile wood in raw material is important for the strength of pulps, the seasoning and stability of boards and strength of building material. Some of these features are associated with anatomical characters which can be rapidly assessed by physical methods. Stress grading is being more extensively applied. J.E. Nicholson and collaborators (Papers 1/5 and 1/6) have collected valuable basic data on parameters which will assist more rapid assessment of wood quality in the standing tree.

Forests will be used increasingly for recreation and other purposes as well as for wood production. Recreation is likely to result in an increased disturbance of ecology, damage and transmittance of disease which will affect wood quality. It is necessary to distinguish in the living tree the early stages of the quality differences between discolored wood and heartwood. Both sorts of wood can be used at that stage but the former can advance into a state of decay. The stages of degrade to decay and rapid methods of detection of decay in the living tree are reviewed by A.L. Shigo and W.E. Hillis in the Annual Review of Phytopathology 1973.

(iii) Short Rotation Forests. Overseas experience has shown in several instances the great value of fast-growth, short-rotation (less than 10 year old) eucalypts grown either from seed or coppice. However there is a serious defect in growth stresses and lesser but significant defects in brashness, discoloration and decay, and kino vein formation.

Although eucalypts have a high reputation as reforestation species these wood defects are hindering their planting in some localities. There is a IUFRO Working Party on Growth Stresses. Recently I convened another IUFRO Working Party "Defects of Fast-Grown Eucalypts" to collect world-wide information concerning the optimum species for a particular site, and the possible causes of the defects.

The extent of brittle heart in some *E. grandis* samples from Zambia is severe and more than 50% broken fibres in some samples recorded. Such material is of low quality as a building material or a pulp material source.

The work of J.H. Hart and W.E. Hillis has produced evidence that ellagitannins of eucalypts and oaks inhibit fungal degrade when present above a certain concentration. As fast-grown eucalypts have low quantities of these materials in the heartwood insufficient may be present to inhibit discoloration and decay. It is probably significant that Y. Yazaki and W.E. Hillis have found that the heartwood of *E. deglupta* lacks these compounds as there are frequent reports of decay and decoloration in this species. Consequently the determination of these extractives could become a quality assessment for both the wood in the living tree and for utilisation.

The assessment of anatomical features of young regrowth eucalypts will be considered under Topic 5.

(iv) Silvicultural Practices. The increasing adoption of controlled burning has raised the question of its effect on wood quality. The work of J.W.P. Nicholls has shown that if the fire intensity is below a certain level, and at a level which is considered safe for field purposes there is little adverse effect on wood quality, as gauged by density, of *P. pinaster* and *E. marginata*. Strong fires can cause trunk and crown damage and could result in kino formation, and if these take place in the autumn, loss of radial growth in *E. marginata* results. Also severe fires can cause areas of resin accumulation in pines.

It has been shown by L. Shain and W.E. Hillis that small amounts of ethylene can induce the formation of polyphenolic materials in *P. radiata* and that the ethylene content of woody tissues is high when polyphenols are being produced. The amount of ethylene varies seasonally and as injury can also produce it thinning should preferably be done at a time when ethylene is unlikely to initiate changes. One weedicide which results in the formation of large amounts of ethylene produces copious amounts of kino. Accordingly the use of weedicides and the period of the year they are used should be watched in order to minimise the extent of kino veins formation in eucalypts.

(v) Tree Improvement. These studies aim to improve known species so that more and better wood at a uniform quality is produced at cheaper prices for particular purposes. For example, industrial co-operatives are establishing extensive plantations in south eastern U.S.A. of pines producing wood of a particular quality in order to enable different companies to produce a particular standard of paper (and other products) at a minimum cost. Most of the work done in this country has been done with pines and reported at earlier conferences. Very little work has been done on eucalypts. J.W.P. Nicholls has studied pine treated with colchicine in order to obtain further genetic diversity but the wood properties were inferior to untreated pine. An assessment of the spiral grain and density of wood of *Populus angulata* and *P. monolifera* has shown that the spiral grain in general was not troublesome and that it should be possible to raise the mean average density with advantage by selecting appropriate planting stock. A study has also been made of the characters retained by cuttings or grafts according to the position of the pine trees from which they arose and the age of the shoot from which they originated.

Wood Quality Specifications

The specifications of wood quality vary according to the needs of different facets of the industry. In the future we will need to consider bark quality also. The specifications may be modified, as indeed new industries and new specifications will arise. For example wood-plastic impregnates may become important and methods to assess the quality (e.g. penetrability and effect of extractives) of wood for this purpose will be needed. Although attention is being given to the improvement of wood quality, it may become increasingly necessary to adapt industrial procedures to the quality of material that is available. Accordingly basic information is necessary to enable the development of raw material grading procedures and to provide information in essential properties so that industry is assisted in making reliable decisions

without delay. Attention should be given to development of quick, low cost, non-destructive methods to assess wood quality so that the optimum material can be selected for a particular product. It is at meetings like this that the difficulties foreseen by the industry, the changes in quality assessment needed as well as new quality requirements likely to be needed should be brought out. This will enable long-term research workers to be properly orientated in their approach to problems.

ARE INTER-RELATABLE SYSTEMS FOR WOOD QUALITY ASSESSMENT POSSIBLE?

by W.J. Smith

There is often considerable difficulty in effecting comparisons between wood characteristics and related quality assessments made by different laboratories not only internationally but within Australia.

Such comparisons are frequently highly desirable for management or tree breeding purposes, whether at the species, variety, provenance, progeny group, or individual tree level.

Methods of determining a characteristic will obviously differ appreciably depending on a laboratory's resources and, sometimes, workers' individual preferences. This is not believed to be a serious bar to reasonably valid comparisons.

The difficulty lies mainly in readily extracting from published data, information which gives weighted average values for the various wood quality indicators at spaced age intervals.

It is suggested considerable benefit could be derived from attempting to agree to standardize on the publication of weighted mean or average values for, say, 5-year cumulative growth increments (i.e. the 0-5, 0-10, 0-15, 0-20, 0-25 year etc. increments) as well as in the frequently used feature/age from pith graphical or tabular form.

The former is more economically meaningful, for consideration in conjunction with mean growth paramters, wood yields/hectare, or average strength, shrinkage and other wood property values at particular marketing intervals. Rotational stages will vary with species and locations but it is felt the suggested five-year cumulative increment should provide a reasonable approximation. Standardization of means of expressing pith to bark trends would be a desirable further refinement.

It is intended to attempt to achieve international uniformity through IUFRO, and national agreement would be a helpful first step. Discussion between representatives of laboratories engaged in wood quality assessment work is suggested, with a view to preparation of a recommendation with the general support of Australian workers.

WOOD QUALITY AND PROPERTY EVALUATION OF REGROWTH HARDWOODS

by W.J. Smith

The proportion of regrowth material in the total cut of open-forest hardwoods is progressively increasing and is already posing some problems in conversion and utilization.

Whether planted or naturally regenerated, this younger, often faster-grown wood can exhibit markedly different behaviour in conversion and in properties than that from virgin growth logs.

It is understood that plantation-grown blackbutt (*Eucalyptus pilularis*) from quite large (but fast-grown) logs in New South Wales has sprung and bowed badly in sawing, possibly due to higher than usual growth-stress intensity gradients. Surprisingly, fast-grown eucalypts planted in South America reputedly do not behave as badly. An objective comparison of their stand parameters, growth rate, wood properties and behaviour on conversion could possibly shed light on factors meriting attention in attempting to minimise local problems.

Regrowth material tends to have lower basic density but higher tangential and radial shrinkage in at least two species studied, viz. blackbutt (*Euc. pilularis*) and mountain ash (*Euc. regnans*) but others, such as rose gum (*Euc. grandis*) do not seem really different from virgin growth (1).

Lower density is probably indicative of lower strength, lower extractives content, lower durability, and altered seasoning and preservative absorption rates and moisture content correction factors.

It is felt the general application of published species average ratings for strength, durability, shrinkage and moisture content correction, developed on mature, often over-mature, virgin grown samples, is probably not valid for regrowth material and their separate determination for the latter in the major species being regenerated is required.

Many conversion problems are probably associated with the relatively sound heart present in the newer crop, encouraging recovery-chasing in this zone requiring extra care in conversion and marketing. In virgin growth, pipe development tended to remove this potentially troublesome zone and probably allowed in-tree adjustment of growth stresses.

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RELATIONSHIPS BETWEEN SOME PHYSICAL CHARACTERISTICS OF *E. regnans* WOOD

by J.E. Nicholson and N. Ditchburne

The efficient utilization of timber is adversely affected by variation in wood properties existing within and between trees of many species. For example, variations in strength and shrinkage are of considerable importance to the manufacture of both sawn and laminated products, and the efficiency of pulp and paper production is affected by variations in wood density and reaction fiber content. Hence the understanding of property variations, and the relationships between them, can be of considerable value to various wood using industries.

Most physical properties of wood are ultimately determined by fiber cell structure. With this common element, close relationships should exist between the various physical characteristics of any particular sample. The objective of this study was to identify relationships existing between the following properties of re-growth ash-type eucalypts.

1. Longitudinal strain (resulting from the release of growth stresses in the standing tree).
2. Modulus of elasticity (in compression).
3. Longitudinal stress (computed from longitudinal strain).
4. Basic density.
5. Volumetric shrinkage before recovery.
6. Volumetric shrinkage after recovery.
7. Collapse.

The following general procedure was used in the investigation:-

1. Sample trees were selected with various degrees of lean.
2. Measurements of properties were made at 20 equally spaced positions around each tree at a height of 2 metres.
3. All data were analyzed by multiple regression to examine linear relationships between properties.

An example of the data is shown in Table 1. Partial analysis of these data, plus that from other trees, is shown in Table 2. A total of 10 regrowth *E. regnans* and 12 regrowth *E. obliqua* have been investigated to date. All trees have shown the same basic relationships, however severely leaning trees have produced the highest statistical correlations, as they contain the widest range of wood properties.

Conclusions drawn from this study are:

1. All of the wood properties studied were closely correlated, with the exception of shrinkage before recovery, and collapse, which apparently are dependent upon other factors.

2. Volumetric shrinkage after recovery was well predicted by the properties studied (Fig. 1).

3. Longitudinal strain, modulus of elasticity, and basic density are known to be related to stem form, hence form may become a useful variable in predicting wood which is slow to dry, and which shrinks more than normal.

Table 1

Various physical properties determined at 20 equally spaced positions around TREE No. 10 (severely leaning 32 year old *E. regnans*).

Station	Growth Strain (10^{-3})	Modulus of Elasticity (MN/m^2)	Growth Stress (MN/m^2)	Basic Density (gm/cc)	Shrinkage before Recovery (%)	Shrinkage after Recovery (%)	Collapse (%)
1	.22	7.9	1.7	.424	10.8	7.4	3.4
2	.20	8.0	1.6	.429	10.0	6.8	3.2
3	.22	7.5	1.6	.430	11.4	6.4	5.0
4	.26	8.5	2.2	.416	11.5	7.4	4.1
5	.30	11.4	3.4	.437	12.7	9.2	3.5
6	.44	12.8	5.6	.446	13.0	10.1	2.9
7	.78	14.1	11.0	.467	18.7	13.0	5.7
8	.78	13.7	10.7	.472	18.2	13.3	4.9
9	1.64	15.6	25.6	.523	22.0	17.6	4.4
10	1.84	14.7	27.0	.559	23.8	20.8	3.0
11	1.64	14.2	23.3	.534	21.7	16.9	4.8
12	1.54	15.4	23.7	.550	24.8	21.2	3.6
13	1.60	16.6	26.6	.571	24.1	21.0	3.1
14	1.34	16.0	21.4	.554	22.6	19.2	3.4
15	.70	13.6	9.5	.511	20.2	15.1	5.1
16	.76	13.5	10.3	.500	18.2	12.2	6.0
17	.60	14.1	8.5	.493	13.8	10.1	3.7
18	.34	12.4	4.2	.478	13.8	9.9	3.9
19	.14	10.5	1.5	.440	10.7	7.9	2.8
20	.12	8.6	1.0	.422	10.9	7.1	3.8
MEAN	.77	12.5	11.0	.483	16.6	12.6	4.0

Table 2

Data from some multiple regressions of y on x for various *E. regnans* trees. y = shrinkage after reconditioning.

Item	Independent variable	R^2	S.D.
Tree No. 10 (20 measurements)	x_1 = Strain x_2 = Density	.95	1.19
Trees 9, 10, 11 pooled* (60 measurements)	x_1 = Strain x_2 = Density x_3 = M. of E.	.89	1.65
Mean values for each of 10 trees** (10 measurements)	x_1 = Strain x_2 = Density x_3 = M. of E. x_4 = Stress	.88	0.70

* Trees 9, 10 and 11 were severely leaning.
** This group includes trees 9, 10 and 11.

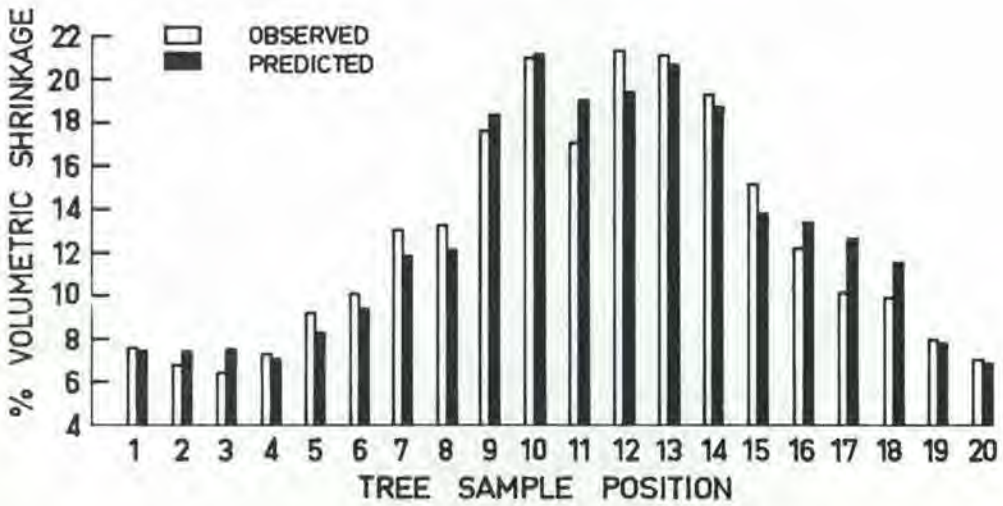

Figure 1 – Observed and predicted values of volumetric shrinkage (after reconditioning) for each of 20 samples from tree No. 10, based on analysis of strain and density.

GROWTH STRESS AND ANATOMICAL CHARACTERISTICS IN *E. regnans*.

by J.E. Nicholson W.E. Hillis and N. Ditchburne

The association between various characteristics of *E. regnans* wood was presented in Topic 1/5. Fibre cell structure is apparently the fundamental controlling element in these associations, and it is hypothesized that the achievement of a desired level of longitudinal stress is a major objective of wood development. Tree stem growth is seen in the content of a supporting structure which enables the tree crown to assume the most advantageous position in relation to its immediate environment. Spatial position of the crown is controlled by the level of longitudinal stress generated in maturing xylem cells on the stem surface as the tree grows. Hence it is felt that the structure of new xylem tissue is determined predominately by the requirement that the crown be maintained in a particular spatial position, or as is often the case, that it be re-orientated as surroundings and environment change.

The present study was initiated to investigate the relationship between level of stress and fibre wall structure. Parameters for cell structure were wall thickness and presence of a gelatinous layer. Three of the trees described in Topic 1/5 are included in this paper, and the data in Table 1 of that paper are applicable to corresponding data in Table 1 of this paper.

The following general procedure was used in the investigation:

1. Cross-sections 15μ thick were prepared, stained, and mounted for each of 20 sample positions around each tree (see Topic 1/5).

2. Each cross-section was scanned radially along 2 lines, and area percentages of each of the following fibre-cell types determined:-

   (a) Thin-wall normal fibre
   (b) Medium-wall normal fibre
   (c) Thick-wall normal fibre
   (d) Medium-wall fibre with a gelatinous layer
   (e) Thick-wall fibre with a gelatinous layer.

   The product of basic density and percentage of fibre-cell type was used as the measure of cell structure in the analysis.

3. All data were analyzed by multiple regression to determine the linear relationship between level of longitudinal stress and fibre cell parameters.

Examples of the relationships are shown in Tables and Figures 1 and 2.

The conclusions drawn from this study are as follows:

1. The level of longitudinal stress generated at any point on the surface of a tree is closely related to the structure of fibre cells comprising the wood, and may be predicted by them (Fig. 1).

2. The structure of new xylem cells laid down at any position on the stem surface is controlled by the tree for the purpose of achieving a particular level of longitudinal stress, which in turn regulates the spatial position of the crown, keeping it in the best position in relation to its immediate environment.

3. Volumetric shrinkage after recovery is closely related to the structure of fibre cells comprising the wood, and may be predicted by them (Fig. 2).

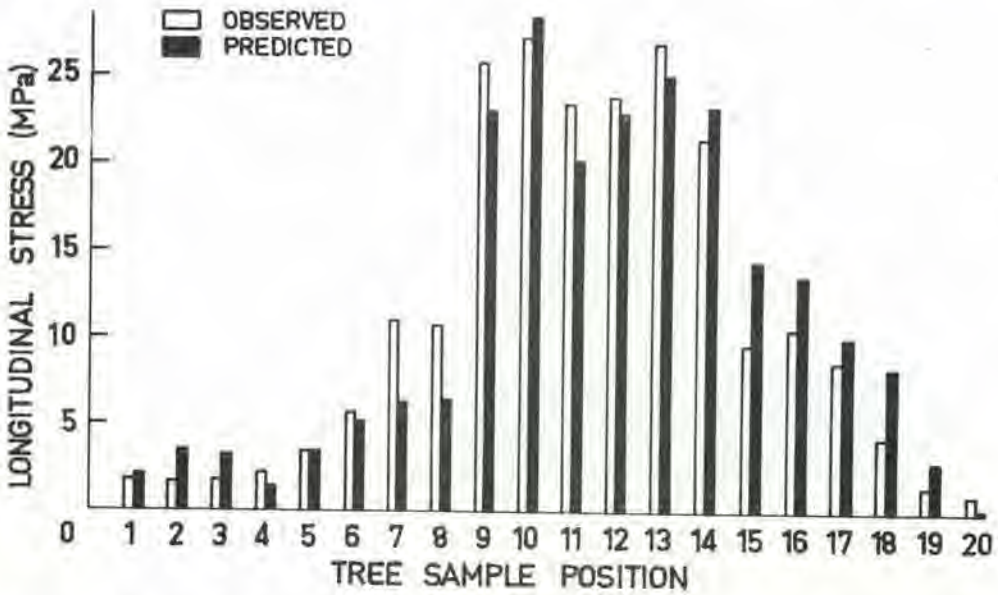

Figure 1 - Observed and predicted values of longitudinal stress for each of 20 samples taken around tree No. 10, based on analysis of fibre-cell types.

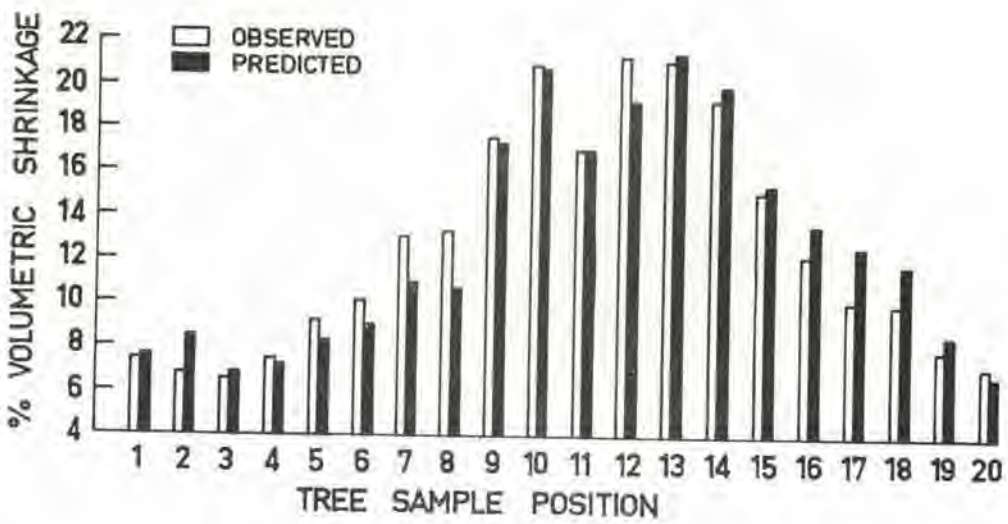

Figure 2 - Observed and predicted values of volumetric shrinkage for each of 20 samples taken around tree No. 10, based on analysis of fibre-cell types.

Table 1

Percentage of fibre cells falling within each of 5 classifications at 20 equally spaced positions around TREE No. 10 (Severely leaning 32 year old *E. regnans*).

Station	Growth Stress (MN/m^2)	Thin Wall Normal (%)	Medium Wall Normal (%)	Thick Wall Normal (%)	Medium Wall Gelatinous (%)	Thick Wall Gelatinous (%)
1	1.7	25.0	44.9	13.0	1.4	0
2	1.6	32.5	46.2	7.8	.4	0
3	1.6	19.4	57.8	7.8	0	0
4	2.2	31.4	49.0	4.4	0	0
5	3.4	23.0	46.2	11.6	0	0
6	5.6	21.2	46.2	10.2	0	0
7	11.0	17.6	39.7	19.4	0	0
8	10.7	13.0	43.6	23.0	0	0
9	25.6	13.0	33.6	25.0	8.4	.2
10	27.0	10.2	31.4	19.4	16.0	7.3
11	23.3	13.0	46.2	25.0	2.6	0
12	23.7	13.0	36.0	28.1	5.8	.8
13	26.8	9.0	28.1	29.2	11.6	6.8
14	21.4	13.0	36.0	33.6	5.8	.4
15	9.5	9.0	33.6	36.0	4.4	.2
16	10.3	15.2	43.6	17.6	1.0	0
17	8.5	9.6	41.0	27.0	1.4	0
18	4.2	15.2	41.0	20.3	.1	0
19	1.5	20.3	46.2	16.0	0	0
20	1.0	19.4	42.3	19.4	0	0
MEAN	11.0	17.1	41.6	19.7	2.9	.8

Table 2

Data from some multiple regressions of y on x for various *E. regnans* trees.

Dependent variable: y = longitudinal stress

Independent variables:

x_1 = (basic density) (% thin-wall fibres)

x_2 = (basic density) (% medium-wall fibres)

x_3 = (basic density) (% thick-wall fibres)

x_4 = (basic density) (% medium-wall + gelatinous layer)

x_5 = (basic density) (% thick-wall + gelatinous layer)

ITEM	R^2	S.D.
TREE No. 10 (20 measurements)	0.93	3.1
TREES No. 9, 10 and 11 pooled (60 measurements)	0.82	4.1

BETWEEN TREE VARIATION OF SELECTED GROWTH AND WOOD CHARACTERISTICS IN PLANTATION GROWN HARDWOODS

by G. Waugh

Introduction

Excessive variation in the physical properties of wood is a constant problem to the wood using industries, and is a factor which the forest manager should strive to eliminate from his forest growing stock. However, he is rarely equipped to conduct any intensive investigation into this field. The solution of such problems relies heavily on the close liaison between the wood using industries, the forest manager and the wood scientist in order to define the problem area, to carry out basic research, and to test and evaluate recommendations arising from such research.

Distortion of wood during utilization is the manifestation of several wood properties related closely to cell wall structure. Investigations have been carried out in two areas where distortion is a major problem to industry, namely:

(i) bending of poplar match splints, and

(ii) end splitting of eucalypt logs, and the distortion of sawn material during conversion.

Exploratory investigations have shown that most of the severe bending in match splints takes place during seasoning, and is due to the high longitudinal shrinkage in tension wood cells which vary in relative numbers across a match splint cross section. On the other hand, end splitting of eucalypt logs and distortion during conversion is known to be related directly to high growth stresses. In eucalypts, growth stress can be mostly resolved into its longitudinal component, and as tension wood cells are also known to contain a high longitudinal stress, field measurements for both investigations can be carried out using a technique developed by Nicholson that measures the longitudinal strain associated with the release of such stresses.

Previous work has shown that adjacent trees of *Eucalyptus regnans* growing on a similar habitat exhibited a large between-tree variation in longitudinal strain, thus pointing out the possibility that growth stress may be under a genetic influence. Experimental work described in this paper has been carried out with the aim of determining what proportion of the total variation in a population may be attributed separately to genetic and environmental influences.

Experimental

Studies already carried out on poplar clonal material (which forms the bulk of our commercial poplar plantations) have examined some of the factors contributing towards high longitudinal stresses. Eight clones of *Populus nigra* and its hybrid with *P. deltoides* *P.* x *euramericana* were studied on each of four localities extending from inland Victoria to the north coast of New South Wales. The results are expressed graphically in Figure 1. The analysis of the results showed that while there was a highly significant between-clone variation for both longitudinal strain and density at all

localities, the overall analysis indicated a highly significant clone-locality interaction for both of these properties, indicating that not all clones will react in a similar way to a particular change in environmental conditions.

Further preliminary investigations into the effect of thinning on the level of growth stresses in poplar have shown an average increase of about 30 per cent in longitudinal strain one year after a 50 per cent thinning. Unthinned controls showed less than a 5 per cent change during the same period.

Distortion during conversion and severe shrinkage on seasoning are two of the many difficulties associated with the efficient utilization of ash-type eucalypt species. The severity of these two problems can be assessed from growth stress and density measurements. Currently, with the cooperation of the Forest Research Institute, Canberra, a study is being carried out on growth stress and density variation in standing *Eucalyptus regnans* trees, comprising a population of 25 half sibling (maternal parent known only) families established in replicated field plots in 1960 and 1962. Preliminary investigations which have indicated the need to obtain some 1600 wood samples for the main experiment, have shown smaller within tree and between tree variances for growth stress than is normal for a naturally established forest. The reduced between tree variance may be attributed to reduced genetic variance within each half sibling family plot, whereas the reduced within tree variance may be associated with the more even environmental conditions for each tree. The latter can be mainly attributed to more even spacing of the trees and therefore more truly vertical stems with more even competition (due to less genetic variation) with the surrounding tree. This preliminary investigation did not show any significant differences in either growth stress or density between crown or diameter classes of trees. However, a more accurate assessment will be available from the results of the main experiment.

Conclusions

From studies completed to date on both poplars and eucalypts, it appears that environmental conditions are a significant factor contributing towards the level of growth stresses and tension wood. As tension wood is probably the biggest problem in the utilization of poplar it is important that further work should be carried out in order to reduce the presence in commercial plantations. This could probably best be achieved through a careful selection of genetic material, based not only on growth parameters, but also giving strong consideration to wood properties.

There appears to be a real need to develop a deeper understanding of how an individual tree (or genotype) reacts to its surrounding environment, and the influence which this may have on wood quality. This understanding is important if we are to determine how environmental factors may be best manipulated through silvicultural techniques so as to produce the most desirable final product.

CRITERIA FOR REFORESTATION FROM THE VIEWPOINT OF THE PAPER INDUSTRY

by H.G. Higgins and F.H. Phillips

It has often been the practice to select plantation species on the basis of silvicultural criteria and of their suitability for the provision of logs for the sawmill, and little attention has been paid to the specific requirements of the pulp and paper industry. For example, one of the principal indices of the economic potential of a pulpwood resource managed in perpetuity might be the annual yield of chemical pulp per unit area. This is given by the product

$$10^{-5} \Delta V.D.Y \text{ (in tonnes of o.d. pulp/ha/yr)}$$

where D is basic density, in kg m^{-3}, Y is pulp yield (wt. of o.d. pulp as percentage of wt. of o.d. wood) usually measured at a specific residual lignin content, expressed for example as constant kappa number, and ΔV is the mean volume increment in m^3/ha/yr (which is often itself taken as a criterion of satisfactory growth rate).

Specifications which should be met by prospective plantation species are commonly given, from the forestry point of view, as fast growth, tolerance to site quality, ready availability of seed supply and adaptability in respect to genetic improvement. From the viewpoint of the forest products industries, consideration should also be given to the chemical and morphological characteristics of the wood, the response to various pulping processes and the suitability of the pulp for various end uses in the paper industry, the macroscopic properties of the wood and its suitability in various fields of solid timber utilization and for derived products such as plywood or particle board. Silviculturalists and forest products scientists need to work in close collaboration in arriving at decisions in respect to the most suitable species for reforestation. It may well be that one species will not fulfil all the desiderata and this may lead to the selection of a range of species for a particular region.

Much attention has been paid to reforestation problems in Australia, but considerably less in tropical regions such as Papua New Guinea. Species which have been considered (1) for reforestation in PNG include Eucalyptus deglupta (kamarere), Terminalia brassii (brown terminalia), Anthocephalus cadamba (cadamba), Elaeocarpus spp., and Tectona grandis (teak), with Pinus caribaea and Pinus merkusii to supply the softwood component. This list might be extended by the inclusion of Araucaria spp. and Gmelina arborea, which have been used satisfactorily for plantations in other areas. The range of end uses suitable for these various species has not yet been determined fully; such information is needed before planning for efficient utilization of both thinnings and mature wood can be completed. For some species, at least, the younger trees will be more suitable for pulping than older material, whereas the more mature trees will be preferred for sawmilling. Peeler logs will be selected on the basis of good form, suitable size, attractive wood properties, intermediate basic density, gluing properties, etc. The general aim of a reforestation programme would be to attempt to provide the raw materials for an integrated industry in the proportions likely to be required in the future. A maximum rotation for pulpwood might be in the

vicinity of 15 years, with 30-40 years for logs for other purposes. As the pulp and paper industry begins to utilize mixed tropical hardwoods, attention to the wide range of problems involved in reforestation is becoming a matter of urgency if the provision of a continuing resource, suitable for a variety of uses, is to be ensured.

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WOOD DENSITY IN RELATION TO PULP AND PAPER PROPERTIES

by H.G. Higgins

The relationship between wood density and paper properties is of growing economic interest in Australia and in other countries concerned largely with hardwood pulping or with the export or import of hardwood chips (1,2). A wide range of density is encountered within the genus Eucalyptus and throughout the large number of genera occurring in the tropical rain forests which will probably supply increasing quantities of pulpwood in the near future. An understanding of the effect of wood density and structure on paper properties is already contributing to the wider utilization of hitherto unused species, either individually, as components of heterogeneous chip mixtures or as pulps with special properties for inclusion in tolerable proportions in papermaking furnishes (3).

In the relationship between wood and paper properties, the lateral conformability of the fibres occupies a central position (4). On the wood side it is largely dependent on the ratio of fibre diameter to wall thickness, which is normally the principal morphological factor in basic density, and on the paper side it controls the relative bonded area of the sheet and hence a range of sheet properties.

For Australian eucalypts, wood basic density, which ranges from 300 to 1000 kg m^{-3}, and extractives content are considered to be the main determinants of their pulping and papermaking properties. Hall et al. (5) have recently shown this in a quantitative way for a range of Victorian eucalypts. Strength properties directly associated with interfibre bonding (breaking length and burst factor) decline steeply (1,6) as wood density rises from 300 to 650 kg m^{-3}, but much more gently at higher densities; paper density declines over the wood density range from 300 to 650 kg m^{-3} but is then fairly constant. This behaviour can be largely correlated with that predicted from a simple model involving the effect of cell wall thickness on the number of fibres in a sheet of constant basis weight, and on the extent to which the fibre collapses during the papermaking process. However, the scatter of points around the curves relating basic density to the various properties appears to exceed the experimental error, suggesting that factors other than density are also contributing to the observed behaviour, but in a subsidiary way.

Batchelor et al. (7,8) pulped Tasmanian eucalypts by the soda and kraft processes and showed a marked decline in paper strength over the basic density range 430 to 630 kg m^{-3}.

Over the wider range of basic density (6), unscreened pulp yield was found under constant pulping conditions, to pass through a maximum at about 450 kg m^{-3}, with a serious decline in yield above 600 kg m^{-3}.

A study of paper profiles (4) has shown that at constant Kappa number surface roughness passes through a maximum with increasing wood density, but at constant yield it rises continuously. For thin-walled fibres beating has little effect on surface roughness but for thick-walled fibres roughness decreases. Pulps from high density species can offer an advantage for fine papers in that the development of paper strength by beating is not accompanied by a reduction in opacity and brightness (4). The work of Colley (3) has shown that substantial amounts of pulp from eucalypt species of high basic density can be tolerated in blended furnishes with pulps from

softwoods and low-density hardwoods.

Pulping studies on about 30 individual tropical hardwoods from Papua New Guinea (9) indicated that with increasing wood basic density there is a highly significant decline in paper strength properties associated with interfibre bonding. Bulk and freeness were significantly higher for pulps from the denser woods.

It has become apparent that with present technology the high density species do not have the wide range of usefulness, in the paper industry, of the low density species, as shown somewhat tentatively for the eucalypts in Tables 1 and 2. Account has been taken of economic as well as technical aspects in arriving at the ratings given (10). It would be unwise, however, to ignore the potentialities of some of the higher density material when considered as a component of blends for specific purposes such as high grade printing papers.

The use of wood species which are not pulped commercially at present can allow improved management techniques to be practised in established forests and can open up a number of remote areas for development as well as increasing the availability of the raw material supply. The studies of the effect of wood density on paper properties have provided a good appreciation of the potentialities and limitations of the higher density species and have also established quantitative relationships between wood density and pulp yield, strength properties and surface properties of paper. Some of this basic information has been of great use in assisting in the development of the wood chip export industries in Australia and in Papua New Guinea.

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TABLE 1

ACTUAL AND POTENTIAL UTILIZATION OF EUCALYPT PULPWOOD

INTERMEDIATE USES: PULPS

Pulp	Basic Density					
	Low (<550 kg m^{-3})			Intermediate		High (>700 kg m^{-3})
	Old	Regrowth	Plantation	Old	Regrowth	Old
Bleached kraft	1	1	1	1	1	2
Unbleached kraft	1	1	1	1	1	5
Pre-hydrolysis kraft	2	2	1	2	2	3
Soda	1	1	1	3	3	3
Cold Soda	1	1	1	4	4	5
Neutral Sulphite	1	1	1	1	1	5
Bisulphite	5	5	1	5	5	5
Sulphite	5	5	1	5	5	5
Chemi-groundwood	5	1	1	5	4	5
Groundwood	1	5	5	5	5	5
Refiner Groundwood		5	5	5	5	5

1 = Commercial production

2 = Technically feasible from laboratory work

3 = Should be suitable from general technical considerations

4 = Tolerated, but not favoured

5 = Unfavourable, technically and/or economically

Blank indicates no reliable information

TABLE 2

ACTUAL AND POTENTIAL UTILIZATION OF EUCALYPT PULPWOOD

ULTIMATE USES: PAPER AND BOARD

Product	Basic Density					
	Low (<550 kg m^{-3})			Intermediate		High (>700 kg m^{-3})
	Old	Regrowth	Plantation	Old	Regrowth	Old
Newsprint	1	1	1	5	5	5
Magazine grades	2	1	1	4	2	5
High-grade printings	1	1	1	1	1	2
Writings	1	1	1	2	2	2
Duplicating Paper	1	1	1	3	3	3
Kraft liners	1	1	1	4	4	5
Corrugating medium	1	1	1	1	1	5
Wrappings	1	1	1	5	5	5
Glassines	1	1	3	4	3	5
Tissues						
Rayon etc.	3	3	1	3	3	3

1 = Commercial production

2 = Technically feasible from laboratory work

3 = Should be suitable from general technical considerations

4 = Tolerated, but not favoured

5 = Unfavourable, technically and/or economically

Blank indicates no reliable information

THE RELATIONSHIP BETWEEN GROWTH RATE AND WOOD CHARACTERISTICS IN BIFURCATED STEMS OF *PINUS RADIATA*

by J. W. P. NICHOLLS and A. G. BROWN

Summary

Wood specimens were taken at breast height from a position above the fork in stems which exhibited two leaders. Stems were chosen which did not exhibit discontinuous growth rings and which had a large difference in diameter between the major and minor stems. The specimens were examined for such wood characteristics as average tracheid length, spiral grain, maximum, minimum and average density, and late wood ratio. No relationship was observed between these characteristics and ring width as an index of growth rate.

Introduction

The relationship between growth rate and wood characteristics has been the subject of much controversy and for many characteristics both positive and negative relationships have been reported (see for example reviews by Dinwoodie 1961, Goggans 1961 and Nicholls 1963). Confusion has arisen because the separate effects of age and position in the tree have not been sufficiently appreciated.

The relationship of growth rate, as measured by ring width, and wood characteristics, may be investigated within a stem by comparing characteristics along radii of different length in a transverse section. The range of variations in radial growth rate, however, is normally small unless the stem is markedly eccentric, and such eccentricity is commonly associated with the presence of reaction wood which is known to have different characteristics to those of normal wood (Dadswell and Wardrop 1949).

Abrupt changes in growth rate have been shown to modify structural characteristics (see for example, Wardrop 1951, Bisset et al. 1951), but this is only one aspect of the general relationship between growth rate and wood characteristics.

In a previous paper (Nicholls and Fielding 1965) the between-tree effects of growth rate were investigated using clonal material to eliminate genetic effects. With due regard to age and position in the tree and within the range of growth rates investigated average tracheid length, spiral grain angle, basic density, longitudinal shrinkage and late wood percentage were not affected significantly by environmental variation between trees as expressed by differing growth rates.

The recent inception of radiation absorption techniques for the investigation of wood density (Phillips 1960, Polge 1966) has introduced several new parameters to characterise the density profiles provided by these methods. Little is known of the effect of growth rate on these parameters. The present investigation was undertaken to supplement previous work and in particular to study the influence of growth rate on such densitometric characters as maximum and minimum density and late wood ratio.

Material that appears to have been overlooked is provided by trees which have developed two leaders preferably early in life. Reaction wood is avoidable if specimens are taken above the curved portion of the stems associated with the fork, and it is desirable to choose pairs of stems which exhibit large growth differentials.

The present study is based on such pairs of stems and the relationship between ring width and wood characteristics has been investigated over a range of environments.

Materials and Method

Trees were sampled at four localities in the Australian Capital Territory. Details of these sites are set out in Table 1.

During the period December 1971 to January 1973 wood specimens were collected from the trees for examination at a nominal breast high position. All specimens were positioned to avoid branch whorls and extended from bark to bark and included the pith. The specimens were sawn pieces measuring 25 mm x 25 mm. The orientation of the specimens relative to true north were recorded. The vertical axis of the stem at the point of sampling was marked on the ends of each specimen prior to extraction as a datum for grain angle determinations. Details of the trees for examination are set out in Table 2.

Determinations of spiral grain angle, average tracheid length and X-ray densitometric data were carried out according to techniques described elsewhere (Nicholls 1971, Nicholls and Brown 1971). The specimens used for densitometric determinations were treated with methanol in a Soxhlet apparatus to remove resinous material. Determinations were carried out on individual growth rings along both radii of the diametrical pieces. Material from the growth ring adjacent to the pith was not used because the ring is invariably incomplete and non-representative. Tracheid lengths were only measured on selected growth rings, viz. 2, 4, 10 and 14 for the trees from Kowen and rings 2, 4, 7, 10 and 14 for the Blue Range material. It was considered unnecessary to investigate this feature for the trees from Vanities Crossing which exhibited the least growth difference between stem pairs.

The position of growth ring boundaries was determined for all specimens using both the wood and the densitometric charts. For this phase of the work the profiles for the major stems from each site were compared and the sequence of growth rings found for each locality. The known sequence for the major stems could then be used for the more difficult task of locating ring boundaries for the smaller stems of the pairs.

Harris (1952) and Larson (1956) have discussed the phenomenon of discontinuous growth rings in *Pinus* species. It will be seen from Table 2 that 9 complete growth rings are observed in all specimens from the Blue Range and Vanities Crossing plantations. These two sites have mean annual rainfalls of 1090 and 750 mm respectively (Table 1). At Kowen, which has an annual rainfall of 675 mm, two of the major stems (DLK1 and DLK6) have ring counts which are less than the proper count of 13 and three of the minor stems (DLK1, DLK2 and DLK6) have missing growth rings. Finally at Green Hills both of the minor stems have 7 and 8 missing rings and the rainfall for this site is 600 mm. As far as could be determined the missing rings were from the outer portions of the specimens.

Trees with discontinuous growth rings are not suited to the investigation of the relationship between growth rate and wood characteristics. Therefore only trees with proper ring counts were considered and three trees were selected from each site, excluding Green Hills, and with the largest differences in growth between the members of each stem pair. At each locality, data for each characteristic were grouped on the basis of ring number from the pith and means were calculated for the major and minor stems. The means for the three trees from Vanities Crossing plantation are shown in Figure 1, those from Kowen viz. DLK3, DLK4 and DLK5 in Figure 2, and those for the Blue Range plantation comprising trees DLB2, DLB4 and DLB5 in Figure 3.

Results and Discussion

Ring width

For the trees from Vanities Crossing the mean ring width for the major stems is 27 per cent. greater than that for the minor stems (Figure 1) but the differences are largely confined to growth rings 2 to 5 from the pith. At Kowen, the mean ring width for the major stems is 55 per cent. greater than that for the minor stems (Figure 2). The differences are most marked in the early growth rings, but nevertheless are reasonably large from pith to bark. For the trees from Blue Range (Figure 3), the difference amounts to 65 per cent. and is almost equally distributed throughout growth rings 3 to 10.

Average tracheid length

From Figure 2 it appears that a slower growth rate favours the production of longer tracheids. Such a finding would support work by Bannan (1954, 1957) dealing with the frequency of cambial division and its effect on tracheid length. However analysis showed that the average difference in tracheid length between the major and minor stems was not significant compared with the variation in this difference from tree to tree; the effect varied with ring number and was significant in rings 7 and 10. It may be seen from Figure 3 that there is no difference in average tracheid lengths associated with the major and minor stems from the Blue Range plantation in spite of an increased difference in growth rate with respect to the Kowen trees.

In view of work by Liese and Dadswell (1959) which showed that consistently shorter fibres were formed on the "sun" side than on the "shaded" side of the tree, explanations for the differences in tracheid length for the Kowen trees were sought in terms of the orientation of specimens, and the cardinal relationship of the two stems in each pair. No obvious pattern in relation to tracheid length was found.

As compression wood tracheids are shorter than normal tracheids (Dadswell and Wardrop 1949) the presence of compression wood in the major stems could also have accounted for the differences in tracheid length for the Kowen trees. However compression wood is denser than normal wood (Dadswell and Wardrop 1949) and an inspection of Figure 2 shows only minor differences in the means for average density.

Spiral grain

No consistent difference in the magnitude of spiral grain angles between the major and minor stems is evident at any site (Figures 1-3).

This finding supports the observations of Fielding (1967) carried out on *Pinus radiata* stands in the Australian Capital Territory.

Maximum density

Only minor differences are shown in Figures 1-3 between the means of maximum density for the major and minor stems at each site. Clearly no relationship is apparent for this feature and growth rate.

Minimum density

From Figures 1-3 it may be seen that there are no differences of note between the means of minimum density for the major and minor stems at each locality. That is, there is no relationship between growth rate and minimum density.

Late wood ratio

This is the proportion of late wood in a growth ring, assuming a linear change from early wood to late wood and an early wood/late wood boundary at the mid-density point (Nicholls and Brown 1971). An inspection of Figures 1-3 shows that there are no important differences between the means for the major and minor stems for this feature at any of the sites. Late wood ratio is therefore not affected by the changes in growth rate observed in the present study.

Average density

No meaningful difference is discernible for average density between the means for the major and minor stems at any of the three sites (Figures 1-3). The lack of a relationship between this feature and growth rate is not unexpected in view of the results for maximum and minimum density and late wood ratio, as these features have been shown to be related to average density (Nicholls and Brown 1971).

Conclusions

The results presented herein indicate that wood characteristics are not affected by changes in ring width. These findings fully support a previous study based on clonal material (Nicholls and Fielding 1965).

Acknowledgments

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Table 1

DETAILS OF *P. RADIATA* PLANTATIONS IN THE AUSTRALIAN CAPITAL TERRITORY SUPPLYING TREES FOR EXAMINATION

Plantation	Compartment	Location Relative to Canberra	Elevation (m)	Year of Planting	Tree Spacing (m)	Mean Annual Rainfall (mm)	Soil Derivation
Vanities Crossing	192	22 km W	640	1957	2.4	750	Upper silurian Uriarra volcanics
Kowen	60	16 km E	790	1954	2.7	675	Ordovician sediment
Green Hills	67	6 km W	560	1947	2.4	600	Complex from Mt. Painter porphyry
Blue Range	231 and 232	24 km W	700	1960	2.4	1090	Paddy's River volcanics Middle silurian

Table 2

DETAILS OF DOUBLE LEADER *P. RADIATA* TREES FROM FOUR LOCALITIES IN THE AUSTRALIAN CAPITAL TERRITORY

Site	Tree No.	Stem Height (m)	Diam. BHOB (cm)	Height of fork above ground (cm)	Fork Orientation** (deg.)	No. of Complete rings in specimen	Specimen Orientation** (deg.)
Vanities Crossing Plantation	D1	16.5	12.8	0	034	9	122
		15.0	9.8			9	126
	D2	15.5	12.2	36	013	9	103
		14.5	10.1			9	055
	D3	16.8	10.6	18	005	9	178
		15.5*	9.0			9	178
Kowen Plantation	DLK1	19.5*	16.2	62	093	11	175
		13.5	11.0			8	178
	DLK2	17.6	13.4	42	055	13	147
		10.5	11.1			10	143
	DLK3	18.0	19.5	0	130	13	049
		13.7	10.2			13	037
	DLK4	14.5*	16.1	6	014	13	007
		11.9	12.3			13	010
	DLK5	13.9	14.3	42	054	13	151
		10.2*	9.7			13	050
	DLK6	15.4	10.4	32	081	9	073
		15.0	9.1			9	073
	DLK7	16.5	19.2	50	040	13	148
		14.6	16.2			13	115
Blue Range Plantation	DLB1	10.7	13.5	115	122	9	122
		10.7	9.9			9	122
	DLB2	12.3	13.1	28	106	9	006
		11.2	8.9			9	034
	DLB3	16.0	14.6	100	101	9	102
		13.7	12.0			9	101
	DLB4	14.0	16.7	37	092	9	092
		12.9	9.5			9	092
	DLB5	13.6	14.7	22	117	9	117
		9.7	7.9			9	129
Green Hills Plantation	D4	19.8	21.3	29	110	20	041
		16.0	10.8			12	173
	D5	20.4	21.2	65	087	20	172
		17.1	13.5			13	082

* This stem forks again above the sampling position.

** With respect to true north.

STUDIES OF WOOD CHARACTERISTICS

(a) The Assessment of Wood Qualities in Poplar from Victoria

by J. W. P. Nicholls

Wood specimens from twenty-four-year-old trees of three clones, viz. *Populus robusta*, *P. deltoides* var. *angulata* 'Smooth bark' and *P. deltoides* var. *angulata* 'Rough bark' varieties were examined. These trees were growing in irrigated plantations in northern Victoria and in each case had been propagated vegetatively as sets or as barbatelles. The wood was examined to ascertain differences between clones and between propagation techniques for those characteristics which are important in conversion to match splints.

Results showed only minor differences in wood characteristics between propagation methods and between species and varieties. Crystalline deposits of calcium carbonate were observed in the inner growth rings and a suggested explanation for their presence is given.

The raw material should be suitable for the intended application to the production of match splints.

(b) The Effect of Forest Fires on Wood Characteristics

(i) Prescribed burning in a forest of *Eucalyptus marginata*

by J. W. P. Nicholls

Wood specimens have been examined which were collected from three positions along the merchantable bole of *Eucalyptus marginata* trees growing in Western Australia. These trees had been subjected to a series of two experimental fires at either of two intensities in either spring or autumn. The more intense fire caused crown and trunk damage and could result in kino vein formation. If such burning took place in autumn loss of radial growth resulted. The less intense fire treatment was satisfactory for controlling litter accumulation and did not result in external damage. Minor disturbances to the density profiles in the immediate post-fire year were the only observed changes in wood quality.

(ii) Experimental and wild fires in pine plantations

by J. W. P. Nicholls and N. P. Cheney

Sawn timber production was investigated in a 28 year-old stand of *Pinus radiata* subjected to a series of experimental fires covering a wide range of intensities. The effect of the burning treatment on radial growth rate and density characteristics was also studied and augmented by 44 year-old material of the same species which had been burnt in a wild fire. These wood characteristics were also investigated in 17 year-old *P. pinaster* trees.

The experimental fires caused a reduction of 0.4 per cent of the total possible sawn volume. There was no effect on growth rate and only a slight reduction in density in the immediate post-fire year. The accumulation of traumatic resin is discussed.

(c) Wood Characteristics of Colchicine-Treated *Pinus radiata*
by J. W. P. Nicholls and A. G. Brown

In 1951 seedlings of *Pinus radiata* were treated with colchicine to induce polyploidy. Fifteen of these trees and five untreated trees growing in the same area were sampled in 1969, and wood specimens were examined for ring width, average tracheid length, spiral grain and densitometric features. Spiral grain angles and average tracheid lengths were not affected, but wood density was significantly reduced by the treatment. The radial growth rate of the treated trees was less than that of the untreated stems in the first four rings from the pith, but was superior thereafter.

(d) The Ortet-Ramet Relationship in Wood Characteristics
by J. W. P. Nicholls and A. G. Brown

In view of recent studies leading to the possibility of establishing pine plantations from cuttings rather than from seedlings, it is necessary to know whether clonal material will exhibit the same wood characteristics as the selected trees (ortets) from which the cuttings are derived.

Twenty selected trees (plus trees) from *Pinus radiata* plantations in the Australian Capital Territory provided material for the establishment of a clonal seed orchard at Tallaganda, New South Wales. Wood specimens from the plus trees and members (ramets) of the associated clones were examined for such characteristics as average tracheid length, spiral grain, ring width, maximum and minimum density, late wood ratio and average density.

For these features it appears that the effects of topophysis and cyclophysis are the main source of differences observed between ortets and their ramets. On average, ramets exhibited greater tracheid length, larger spiral grain angle and produced less dense wood than their ortets.

HOW SERIOUS A PROBLEM IS JUVENILE COREWOOD?

By W. J. SMITH

The developmental phase for wood characteristics has been referred to as a "juvenile" period leading to a "mature" condition (e.g. 1, 2).

The age of maturity for various wood properties varies greatly within and between species and may be vastly different for various characteristics even in the same tree. Wood with some juvenile characteristics may be produced in a coniferous tree for 25 years or more (3). Most features tend to reach mature values, on the average, at about 20 years. However, for individual characteristics such as fibre length and micellar angle, particular trees may mature as early as six to nine years (1).

Spiral grain usually increases with age to a maximum at about two to five years, and then decreases rather rapidly to reach a more or less stable value at around 10 to 20 years (depending on species) to Queensland rotational age limits (unpublished data, Queensland Department of Forestry). Longer rotations would show a tendency for a continued decrease, then an increasing reverse-directional twist.

Juvenile corewood is generally recognised as being weaker, more liable to distortion on drying, softer and could be expected to have lower cellulose yields (4). In the absence of heartwood formation, it would also be lighter.

However, experience has shown that wood technically not fully "mature" exhibits properties which, in combination, make it reasonably acceptable for almost any intended end-use long before full maturity. Although the core of juvenile wood may technically contain up to 25 rings, for practical purposes the core of wood with some limitations in conversion and utilization is less than this and is usually contained within the first four to five rings from the pith. For most species in Australian plantations, a four-inch "heart" would encompass this. This is recognised in some Australian Standard Specifications for structural grades of timber (e.g. 5) by prohibiting or restricting, depending on grade and cross-sectional dimension, the use of wood with a radius of curvature of growth rings less than two inches. Wood from outside this zone is not restricted, even though much of it is technically not "mature".

Distortion of corewood in seasoning of sawn stock is no longer the problem it once was, due to the development of modern techniques such as high-temperature drying of weighted, reverse-twisted stacks.

The lower latewood percentage of juvenile wood also provides a more uniformly textured material with less problems in machining and paint retention in weather-exposed situations than wood produced at a later stage of growth.

For pulp and paper production, the recovery percentages are so little lower than for more mature wood as to pose no practical objection (6). The thinner cell walls, lower percentage latewood and lower average density of "juvenile" wood provide more conformable fibres which, at least in slash, loblolly and Caribbean pines, give higher burst and tensile strength at lower processing costs than does wood from older trees containing wood at or approaching maturity in respect of relevant properties (6). Tear strength

is almost invariably lower in paper from juvenile corewood but, for the four major conifers planted in Queensland, tear values even for juvenile wood are higher than those for more mature wood of the major commercial species, radiata pine (6).

Thus, whether production be for sawlogs or pulpwood, it is suggested that juvenile corewood in conifers poses no problems which cannot be handled in conversion and utilization and that any attempts to restrict its extent by management practices will result in the loss of a large volume of very useful raw material.

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PRELIMINARY STUDIES OF PREDICTION OF HEARTWOOD VOLUME IN PINE TREES

by N. Ditchburne and W.E. Hillis

A preliminary assessment of the heartwood present in trees in different compartments in the Tumut region has been made. The provisional conclusions made are as follows:

1. More rings of heartwood are found at the bottom of the tree on good sites than on poor sites.

2. The heartwood diameter of dominant trees is larger than that found in co-dominants which in turn is larger than that found in other trees. There is a correlation with crown class and this trend is consistent with both sites.

3. The effect of site quality on heartwood diameter is noticeable at ground level but is negligible at 4 and 8 ft.

4. The average diameter of heartwood at the bottom of the tree is less than at 4 and 8 ft.

5. The percentage heartwood area over disc area is higher on poor sites.

KINO VEIN FORMATION

(a) Kino Veins, their Formation, Anatomy and Fine Structure
by H. Dowden and R.C. Foster

Introduction

Although kino veins have long been known as sources of degrade in eucalypt timbers (Jacobs 1955) little has been published on their gross morphology, their anatomy or their aetiology and nothing on their fine structure.

Jacquiot and Hervet (1954) described the anatomy from a single mature tree of *Eucalyptus maculata* and only Skene (1965) has investigated the time course of kino vein formation in mature trees. No doubt this dearth of information is due to the technical difficulties occasioned by the kino deposits themselves and because until recently kino veins could not be induced in juvenile trees, small enough to be grown under controlled conditions in the laboratory.

This work describes the gross morphology of natural kino veins, in mature trees, and the anatomy and fine structure of kino veins induced experimentally in juvenile trees by the application of NAA or Ethrel.

Materials and Methods

In order to reconstruct the gross morphology of kino veins in mature trees and to correlate their occurrence with possible morphological and anatomical causal features, logs of *E. grandis* Hill ex Maiden were rotary peeled and the resulting veneer sheets photographed in sequence. The coordinates of kino deposits and various anatomical features e.g. knots were taken for each photograph and fed into a computer, programmed to mathematically reconstruct the log and to produce maps of kino vein distribution at given positions in the transverse tangential and radial planes, and to correlate kino vein formation with anatomical features.

For the anatomical investigation, trees of species falling in the major taxonomic groups of the genus *Eucalyptus*, growing both in the greenhouse and under field conditions, were treated locally with hormone (NAA or ethrel) dispersed in lanolin, with and without prior wounding and were sampled from time to time. The production of kino veins was indicated by swelling of the stem at the site of hormone treatment and by exudation of kino through the protective covering.

The induced kino veins were cut into small pieces and fixed in glutaraldehyde-acrolein. For light microscopy the tissues were embedded in glycol methacrylate and microtomed sections stained in toluidine blue. For electron microscopy the fixed tissues were washed and post fixed in osmium prior to dehydration and embedment in Araldite. Ultrathin sections were stained in Reynolds lead citrate and examined in a Siemens EM 1 electron microscope.

Results

Examination of many hundreds of cross sections revealed that kino veins are never found in juvenile trees under about 3 years old in nature. In mature trees, they vary from 1-2 mm in tangential extent to veins which completely ring the log, and extend longitudinally from a few millimeters to several meters. Adjacent trees in natural forests and plantations

vary remarkably in the number and distribution of kino veins. Only where the forest had been injured by fire did adjacent trees have similar patterns of kino vein formation and then only in the growth rings corresponding to years of fire damage. Computer analysis of kino vein distribution in normal unwounded material revealed no highly significant correlation of kino vein formation with any anatomical feature other than knots i.e. kino veins appear to be randomly distributed both within and between trees.

In marked contrast to untreated juvenile material, trees treated with either NAA or ethrel invariably produced kino veins even in the absence of wounding.

Gross Morphology of Kino Veins

Computer mapping of kino veins combined with extensive observations on transverse sections of logs and associated anatomical investigations showed that the general shape of a typical kino vein is that of a highly vertically-elongated ellipse with fimbriated ends, curved tangentially along the growth ring. The vein is maximally developed both tangentially and longitudinally at the site of stimulation whether hormone, (in experimental material) or wounds (in the mature tree). Where there is continuous stimulation of the cambium over a series of years there is maximal tangential spread in the early wood contracting laterally in the late wood and expanding laterally again in the next early wood band.

Microscopic Anatomy

A typical kino vein consists of a tangential series of kino filled lacunae separated in the radial and transverse planes by parenchyma bridges composed of radially elongate cells devoid of kino. A typical lacuna is radially elongate in transverse section especially towards the lateral boundaries of the vein and is many times longer than wide. Since reversion to normal wood formation starts in the bridge tissue, and gradually encroaches on the lacunae, lacunae are often wedge shaped in transverse section with the base towards the previously formed wood.

When the cambium is stimulated to form kino vein tissue three types of anomalous parenchyma are produced. (1) The cells at the center of the lacunae which are crushed and partially collapsed, extremely thin-walled, isodiametric parenchyma. These later become filled with kino secreted by (2) the surrounding brick-like cambial-like cells. These are tangentially elongated on the tangential faces of the lacunae but radially elongated on radial faces of the lacunae adjacent to the parenchyma bridges. The outer cells undergo multiple division to produce layers of cells which secrete kino into their vacuoles. On the death of the cell the kino is released to impregnate the thin walled isodiametric parenchyma at the center of the lacunae. (3) Within the bridges highly radially elongated parenchyma cells are found.

The transition from normal wood to kino vein tissue is very abrupt; every cell along the inner tangential face of the kino vein becoming modified anatomically and biochemically. Polarised light studies show that in place of the thick walled vertically elongate xylem elements, thin walled tangentially (in the lacunae) or radially (in the bridges) elongate parenchyma are produced.

Where a cambial ray initial is (located in a region which differentiates into) a lacuna, it completely loses its ray-like nature until normal wood production is resumed. But if it is located at a site of bridge formation it retains its identity within the bridge. In the outer part of the bridge where normal wood production is resuming, the cells become progressively more vertically elongate and begin to produce secondary walls and pits with vestures.

Ontogeny

Following the application of auxin to the unwounded bark of a young stem or at the tips of naturally occuring developing vein in a mature tree, the ray cells in the cambial regions become enlarged. The cambial initials undergo rapid tangential and transverse division so producing pockets of isodiametric thin walled cells. The cells at the center of these masses remain thin walled and devoid of contents. Those at the periphery become organised into kino secreting cells. Between the lacunae, bridge tissue develops consisting of thin walled radially elongate brick-like cells.

In the event of prolonged stimulation the production of anomalous tissue proceeds progressively up and down the stem as well as laterally from the site of stimulation. Thus the development of the kino vein may be investigated either by looking at a stimulated site after increasing time intervals or by sectioning a differentiating vein from the tip to the center.

As the lacunae enlarge they become locally fused in the tangential plane to form a network of canals filled at first with thin walled cells. These later break down especially where the kino exudes from the tree. The kino secreting cells lining the canal accumulate polyphenols within their vacuoles, the innermost cells becoming greatly extended crushing the thin walled cells within. They are replaced by continuous division of the cambial like layer surrounding the lacuna. In very active kino veins, the area of kino secreting tissues is increased by the formation of hemispherical or elongate protuberences on the external surface of the lacunae.

When the kino formation stimulation ceases, the parenchyma surrounding the lacunae secrete thick cell walls which may become progressively more birefringent and later, suberised. They then have characteristic patches of plasmadesmata.

Ultrastructure of Kino Veins

Ultrathin sections through mature kino veins confirm the abrupt transition from the thick walled normal wood fibres with S1, S2 and S3 to thin walled cells which contain only a primary wall. Although sometimes transitional cells are seen with S1 or S1 + S2 only. The inner thin walled cells of the lacunae are devoid of cytoplasmic organelles and may be completely impregnated with kino. In an undisturbed vein where there has been no external flow of kino, the thin walls of the central cells may be detected apparently intact within the kino masses. They appear to be composed of only one or two layers of microfibrills. It is uncertain whether they are mechanically ruptured by the flow of kino or whether they are broken down by enzymatic degradation.

Within the bridges the inner cells next to the ray cells are full of mitochondria, rough endoplasmic reticulum and amyloplasts filled with starch. In kino forming cells the cytoplasm becomes extremely osmiophyllic, due to the presence of polyphenol precursors, in marked contrast to the inner bridge cells. The kino forming cells become progressively more rich in polyphenols which are secreted into the vacuole. As polyphenols increase the starch grains disappear and the amount of cytoplasm in the cells becomes progressively more restricted so that the enlarged cells towards the center of the lacunae are virtually filled with kino with only the nucleus and a few mitochondria remaining. The developing kino forming cells are characterised by their large nuclei and prominent nucleoli.

The newly affected cambium at the tips of the veins differentiate into isodiametric cells with prominent nuclei. They contain more cytoplasm than in normal fusiform initials. The cells become rounded forming intercellular spaces often with curious aggregations of electron dense particles Particles are also seen within the differentiating cells and in some cases they resemble virus particles.

As normal wood production is resumed the cambial cells gradually become longer and begin to secrete secondary walls. At first the pits are simple and unvestured, but later normal bordered vestured pits are formed.

Discussion

Only Jacquiot and Hervet (1954) Day (1959) and Skene (1965) show anatomical details of kino vein structure, and in general their results are similar to ours. Skene remarked on the dilation of the ray cells and the multiple cambial initials produced at early stages of kino vein formation. No comparable fine structural observations have been made on kino veins but the secretion of polyphenols into the vacuoles is usual for eucalypt tissues (Bland, Foster and Logan 1965). The induction of kino veins by NAA and Ethrel without wounding is probably the major innovation of this work. The complete cessation of normal wood formation, the complete reorganisation of the tissue caused by the cambium differentiating into parenchyma of various sorts and the accompanying changes in polyphenol biochemistry are one of the most interesting aspects of this work. What causes these changes in the unwounded standing tree is still unknown although it is possible that bacteria or viruses may be responsible, and further work along these lines is being carried out.

(b) The Initiation of Kino Formation in Mature Eucalypts
by W.E. Hillis and L. Shain

Earlier work (Hillis, 1965) had shown that of the enzyme inhibitors tested on mature eucalypts only sodium arsenite and iodoacetic acid initiated kino vein formation in the growing season. Other compounds including IAA failed to do so. Recent work (Shain and Hillis, 1972) showed that ethylene was produced by the xylem of *Pinus radiata* which was mechanically injured or attacked by *Sirex noctilio*. *Sirex* lesions in dominant trees produced considerably more ethylene than mechanically induced lesions which produced more than the controls or the *Sirex* lesions in suppressed trees. Trees which produced large quantities of ethylene produced greater quantities of polyphenols at a faster rate. Also (Shain and Hillis, in press), the transition zone produced considerable amounts of ethylene in the dormant season, and ethylene formed polyphenols in sapwood blocks *in vitro*. Blocks of eucalypt wood containing active

kino veins produced more than double the amount of ethylene than adjacent blocks containing normal cambium. We have introduced Etherel (which produces ethylene under physiological conditions) to the cambial region of mature species. Injury of the phloem was necessary for this introduction but Etherel treated samples produced kino consistently more than the controls. The composition of the kinos from *E. calophylla* and *E. astringens* from treated and untreated zones were identical chromatographically.

NATURAL DURABILITY AND HEART ROTS

by E.W.B. Da Costa

Summary

Fast grown plantation trees of *Eucalyptus grandis* have shown severe losses from heart rot in very young trees both here and overseas and similar losses can be expected in other species. The incidence of heart rots can probably be predicted from measurements of decay resistance of first-formed heartwood. Such measurements should be one of the criteria used in selecting species, seed sources and silvicultural practices to be used in reafforestation of areas clear felled because of wood chip exports, eucalypt dieback, fire or other causes. The hereditability of decay susceptibility of "juvenile" heartwood should be assessed by measurements on progenies and prevenances of various eucalypts obtained from Australian or overseas plantations.

Most of our earlier work at this Laboratory on natural durability was concerned either with assessing the decay resistance of eucalypts and of rain forest species or in establishing the chemical nature of the heartwood extractives responsible for resistance. Such work is still important but we now wish to discuss another aspect which enters into quality assessment, both of species and of genetically defined material of the one species.

This is the relationship between decay resistance and losses from heart rots in the standing tree. Most of our past research, especially with eucalypts, has been on the mature heartwood of fairly old slow-grown trees and this type of wood has been that used commercially both as sawn timber and for pulping. The incidence of heart rots varied with the species and though often very high, was apparently outside the control of the forester.

Now we are entering a very different era. Many eucalypt forests are now intensively managed to produce high rates of growth, plantations of eucalypts are becoming common, and where large areas are clear felled either for wood chip export, or because of "eucalypt dieback", reafforestation gives large numbers of young very fast grown trees. The "juvenile" heartwood of these trees may have properties quite different from slow grown trees of the same species, and may have very low decay resistance. This is clear from our earlier work in eucalypts (Rudman 1964, 1965) and has recently been re-emphasized by the work of Nelson and Heather at the ANU Department of Forestry on *Eucalyptus grandis*. The surprisingly high incidence of severe heart rots in *E. grandis* plantation trees only 5-10 years old has caused major economic losses not only in N.S.W. but in Africa, and similar problems have been reported in other eucalypts.

The probable incidence of heart rots should be one factor considered in deciding which species are favoured for seeding or natural regeneration of clear-felled or devastated areas and possibly in deciding on silvicultural practices. Attention is now being paid to the use of coppiced eucalypts for production of very young stems for pulping, but these may show a much higher incidence of heart rots (coming from the old stump) than would seedlings. At present, the Preservation Section is cooperating with the Forestry and Timber Bureau in a survey of the nature and causes of heart rots in eucalypts felled for the Eden chip export project. While the fungi found will not necessarily be those concerned

in early heart rots of young trees of the same species, they are quite likely to be, and would be of use in assessing the decay susceptibility of the various species. Laboratory determinations of decay susceptibility of juvenile heartwood should give a much more rapid evaluation of species than waiting for heartrots to develop and determining their incidence directly.

Even greater importance will attach to the determination (directly or indirectly) of genetic variation of heart rot susceptibility within the species. The Forestry and Timber Bureau has for some years collected seed from individual trees of various eucalypt species and whilst few of these potential progenies have been planted in Australia, a number of progeny trials and more provenance trials have been established overseas. Evaluation of decay resistance of samples from these would enable the most suitable progenies to be selected on this criterion. At the same time, other criteria such as colour of heartwood, heartwood:sapwood ratio, and density, important in utilization for pulp or other wood-based material could be assessed.

No tests appear to have been made directly in the amount of genetic variation in decay susceptibility of eucalypts, but the range of variation in decay susceptibility of first formed heartwood found by Nelson and Heather among plantation trees of *E. grandis* carefully selected for similarity in site and in rate of growth suggests that it is very high.

Summing up, experience with young fast grown trees of *Eucalyptus grandis* here and overseas suggests that severe losses from heart rots of young trees may be expected in reafforestation of clear-felled areas with eucalypts and should be a factor in selection of tree species and in use of superior seed provenances. Research into specific variation and hereditability in decay susceptibility of young eucalypts should be given priority.

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Topic 1/16

PROGRESS IN A QUANTITATIVE ASSESSMENT OF DEFECT AND WOOD QUALITY FOR PULP IN PLANTATION GROWN *EUCALYPTUS DEGLUPTA*

By E. D. HARRIES

Introduction

Eucalyptus deglupta Bl. was one of the first indigenous trees of Papua New Guinea to be recognized as a potential plantation species. The first trial planting dates from 1948. Planting on a relatively small scale has been maintained in most years since then at the Forestry establishment at Kerevat on the Island of New Britain, and in recent years at a number of other locations throughout Papua New Guinea. Seed has also been distributed to many other countries.

The mature Kamarere tree is noted for its excellent lumber, of moderate density and durability and good working properties, and the wood is also useful for veneer. It was initially expected that plantations would yield sawn products, however early evidence of its suitability for this end use has been disappointing.

Tests as early as 1956 (1) indicated the suitability of plantation grown *Eucalyptus deglupta* for a range of pulps, and the timber was compared to the Ash type Eucalypts, in particular *E. regnans*, by Dadswell and Watson (3) who had foreseen its potential as a source of fast grown hardwood pulp.

In recent times the potential for large scale plantations on tropical lowland sites has become more apparent as such plantations may form the basis for large scale industries, in particular pulping. Although a number of potential species are being considered for such projects, Kamarere has been the first to be examined because of its availability in plantations up to the age of 20 years.

Objects and Scope of this Project

Apart from the work of Davidson (2) there has been little work done on the properties of plantation grown *Eucalyptus deglupta*. Davidson reported the nature and extent of variability of basic wood properties within trees of one age class and examined the feasibility of a tree improvement programme incorporating genetically controlled wood properties.

This project was designed to obtain an indication of the range of wood quality within and between trees and between different ages from 3 to 20 years. A quantitative assessment of the nature and extent of degrade was also incorporated in the project.

Specific gravity (oven dry weight/saturated volume) was chosen as the major parameter for indication of wood properties as recommended by Davidson. Vessel size and number, fibre length, lumen diameter and cell wall thickness were also planned for examination initially on a limited scale. Following the initial examination of these wood properties a pulping study is planned to cover the range of wood properties disclosed as well as to test representative mixtures of each age class.

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The Sample

Five dominant or co-dominant stems in each available age class from 3 to 20 years were cut. Each stem was measured for basic volume data and sample sections taken from the ten per cent intervals of the merchantable log, the top of which was defined for simplicity as 6 inches (152.4 mm) diameter or first live branch. From each of the eleven sample "biscuits" per stem a 2 inch (50.8 mm) thick disc has been cut to provide the basic test sample. On each sample disc sub-samples located along three radii from pith to cambium have been selected on a systematic basis and again sub-sampled to give test pieces in triplicate each occupying the 10 per cent intervals of a centimetre wide strip located along the radius. The triplicates are located linearly within the stem section, they range from 1 to 2 cubic centimetres in size. Associated with the sample radii indicated above three wedges are marked on the disc to provide future pulping sample material. The size of the total pulping sample from each disc is calculated to yield approximately 600 grams of wood on an oven dry basis.

Besides this test programme the sample has permitted an evaluation of the extent of defect and a comparison of the actual log volume with the volume based on girth measurements. Both of these sub-projects are based on photographs taken of each stem section disc with a 10 cm square grid superimposed to give the scale.

Progress Results

The project is not yet sufficiently advanced to give other than a rough appraisal of any trends, and these should be treated with caution.

1. Specific Gravity

Any within-tree pattern of variation which might be expected is likely to be masked by the existence of decayed wood in many trees. In ages 3 and 5 years, the only ages in which whole stems have yet been evaluated, there is no apparent pattern of variation. The approximate S.G. range with a stem is from 0.320 to 0.360 in these age classes.

An increase in mean tree S.G. with age has been indicated in tests to date. The approximate order of increase is from about 0.350 in the younger age classes to about 0.380 in the older age classes.

2. Defect

Three forms of degrade have been recognized, staining, brittle heart and soft rot or decay. All three appear to be closely associated and to occur in an overlapping range. It has been necessary to make a subjective estimate of the level of degrade which would render the wood unacceptable for pulping, however generally degrade boundaries are clearly visible and the error due to the subjective nature of degrade boundary definition should not be very great.

At this stage of the study a qualitative assessment is that staining, brittle heart and soft rot occur in about equal proportions. However there are cases where brittle heart is predominant throughout a stem. Most staining appears to be associated with either cambial tissue damage or occluded branch stubs. It appears that staining is a precursor of decay. Brittle heart has been generally found in sections which are not stained but appears to degenerate into soft rot with time.

Results to date indicate a range of from 1 to 40 per cent of the merchantable stem volume being occupied by degraded wood unacceptable for pulping. However it appears the percentage will rarely be above 10. We have not been able to indicate any trend in the percentage degrade with age at this stage of the study, however there may be an association of higher levels of decay with certain site factors and this is being investigated.

3. Tension Wood

The extent of tension wood in the sample material was initially thought to be of considerable importance. No method of satisfactorily measuring this factor has been found. The nature of the distribution of tension wood appears to be in fairly regular narrow bands of 1 mm to 4 mm width. This feature may be a desirable one for pulping purposes, as the extent of cell wall thickening does not appear to be very great.

4. Volume Studies

Average stem volumes range from 0.3 cubic metres in the age 3 samples to 5.5 cubic metres in the age 20 stems. The calculation of log volume based on section area measurements has indicated that the log volume based on girth measurements is an over estimate in the order of 5 to 10 per cent.

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TOPIC 2. UTILIZATION OF SMALL HARDWOOD LOGS

1. UTILIZATION OF 1939 ASH REGROWTH IN VICTORIA

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2. INTRODUCTORY STUDIES OF THE BEHAVIOUR OF REGROWTH BLACKBUTT ON CONVERSION

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5. EFFECT OF TREE AGE ON PULPING CHARACTERISTICS

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Topic 2/1

UTILISATION OF 1939 ASH REGROWTH IN VICTORIA

by

G. GRIFFIN and D. J. McKITTRICK

Summary

A forest resource of close to 100,000 hectares of 1939 ash species regrowth exists in the Central Highlands of Victoria. It is expected that utilisation of this resource will commence within a time scale of approximately ten years. Utilisation techniques for the original forest resource are well developed, but efficient techniques for the utilisation of regrowth material still have to be developed. The differences between the original resource and the regrowth resource are discussed, and some suggestions are made as to fruitful areas of investigation.

The hardwood based wood using industries in Victoria have traditionally been supplied with forest produce from original growth mature and over-mature forests. Harvesting and conversion methods for this resource have been developed over many years, so that most of the problems are understood. The development of utilisation techniques is in the refinement stage. The supply of timber from such sources for the production of structural grade timber is likely to be available for many years into the future, but the supply of logs for processing into seasoning quality grades from such forests is limited.

A forest resource of close to 100,000 hectares (over 200,000 acres) of 1939 ash species regrowth exists in the Central Highlands of Victoria as a result of the wildfires of January 1939. Something over half of this resource consists of mountain ash (*E. regnans*) species, with the remainder being of alpine ash (*E. delegatensis*) and shining gum (*E. nitens*) species. It is anticipated that this resource will provide part of the future supply to the seasoning quality sector of the wood using industry and that for this and other technical reasons utilization should commence within a time scale of ten years. If utilisation is to commence within this period, many of the traditional methods of harvesting and conversion will not be applicable, because of the smaller tree size and the different quality characteristics of the regrowth forest.

The problem facing the industry then is the development of utilization techniques for the regrowth resource. These methods must be at least as efficient in terms of costs and product recovery as those which have traditionally been employed.

How Different is the Regrowth Resource?

1. Differences in log size

The histograms shown as Figures 1 and 2 demonstrate the difference in volume distribution by size classes between logs from the current resource and the regrowth resource.

Figure 1 is an example of the volume distribution by size classes currently being supplied from original growth forests of the ash type to an industry based on the production of seasoning quality material.

Figure 2 is an example of a predicted size class distribution from regrowth forests likely to be obtained from a clear falling operation within the time scale referred to earlier. The prediction has been made by use of simulation techniques, and should be regarded as being an approximate estimate. The Divisions of Management and Research of the Forests Commission are continuing work along these lines, and more accurate data will follow.

The histograms are presented as an attempt to quantify the size differences between the original resource, and the regrowth resource. As the regrowth crop matures with time, the higher size classes will have greater representation. An estimate made of the size class distribution at the end of the first liquidation period of the whole resource is that approximately 30% of volume will be less than 5 ft. c.g.u.b., approximately 30% between 5 ft. and 6 ft. c.g.u.b., and approximately 30% of volume will be in logs greater than 6 ft. c.g.u.b.

2. Differences in log quality characteristics

Many of the differences in log quality are due to the smaller size of regrowth logs. The proportion of the sawn output which can be cut on the quarter is smaller. Growth stress gradients are steeper. The proportion of timber containing overgrown knots is larger, as is the proportion of "narrows" and "shorts" in the select grades. The opinion of some people in the industry is that there is a "generation gap" in log quality, but it is impossible to know what the effect of age will be on the quality of the regrowth resource.

Future Work Required

Because of the differences outlined, traditional techniques may have to be modified and some new techniques developed. Some of the areas in which investigation should be made are as follows:-

1. Development of log grades

The development of log quality grades would assist in the correct use of the forest produce, in that particular tree sections could be assigned to the most efficient conversion process. Mill studies have been carried out within the Forests Commission on logs from the regrowth forests, and analysis of the results is proceeding. A multiple linear regression computer programme is being used to relate log characteristics with sawn timber out-turn. It is hoped that reliable predicting equations can be developed.

2. Investigation into harvesting systems

Because of the relative homogeneity of the even-aged regrowth forest, with the possibility of whole tree integrated operations, it is likely that particular logging systems could be developed which would result in cost savings. The possibility of the re-introduction of winch systems could be investigated.

3. Sawmill equipment and design

Conversion equipment must be tailored to the size and type of log being utilised. Substantial cost efficiencies are achievable in this area. The

installation of equipment which does not match log type and quality can have disastrous effects on sawmill profitability.

4. Sawing pattern research

The topic of computer simulation studies in sawing pattern research was discussed at the last Forest Products Research Conference. The actual techniques for this work are understood and a computer programme is available. However, the work of collecting a data bank is considerable. The usefulness of such work is currently being considered by officers of the Forests Commission.

5. Economies of scale in the sawmilling industry

Knowledge of the relative cost efficiencies of different annual mill through-put would enable a more intelligent allocation policy to be developed by the forest owner. Before such work could be attempted, some assumptions would have to be made in relation to log size assortment, sawing equipment, and type of product. There may be different answers for a scantling mill and a board mill. It is suggested that further work be carried out along these lines.

INTRODUCTORY STUDIES OF THE BEHAVIOUR OF REGROWTH BLACKBUTT ON CONVERSION

by K. R. BOOTLE

The longitudinal stresses that cause excessive spring and bow when relatively young (40 years old) blackbutt is sawn are said to arise from the shortening of the stem as it grows in diameter, thereby imposing a longitudinal compression on the inner wood. The shortening effect decreases in rate as the diameter of the stem increases so it may be true that rapid diameter growth could lessen the problem considerably and local studies on this aspect are desirable. Australian visitors to Chile during the recent World Forestry Congress were intrigued by the lack of stress in fast-growth large diameter logs. In New Zealand Mr. H. Bunn of the Forest Research Institute and Mr. N. Barr, that enthusiastic planter of eucalypts in Northland, favour wide early spacings such as 25 ft. x 25 ft. (7.6 m x 7.6 m) and endorse Dr. M. Jacobs' suggestion of 16 ft. (4.88 m) spacing for each foot (30 cm) of diameter sought. They have found that *Eucalyptus saligna* logs, open grown with about 1 in. (2.54 cm) annual increment, gave a mild easily sawn log from about 20 in. (51 cm) diameter onwards. After the first 10 years as much wood should be put on over this fractious juvenile core as is possible.

For some years various workers have been trying possible pre-treatments to relieve stresses. Skolman's work with *Eucalyptus saligna* in Hawaii showed that considerable improvement was possible by boiling 4 year old logs in water for 24 hours, though end splitting was an inevitable accompaniment. Giordano found that girdling of the trees some considerable time before felling produced a significant improvement with *Eucalyptus rostrata*. Page called for a change in conversion equipment, to log edgers, multiple gang saws or pony carriages.

In our own pilot studies in Sydney seven trees of apparently fast growth blackbutt from the Wyong area (between Sydney and Newcastle) were cut into 9 ft. (2.74 m) lengths. Some lengths were boiled, some steamed, for 48 hours and after passing through a twin edger were cut into 4 in. x 1½ in. (102 mm x 38 mm) scantling which was measured immediately off-saw for spring and bow.

Boiling and steaming both improved the behaviour of the timber to a considerable degree but at the cost of many more end splits in the logs, such splits extending several feet from each end and reducing recovery. In an endeavour to overcome this the ends of a further batch of logs were bound with a double twitch of No. 8 fencing wire fitted about 2 in. (5.1 cm) from each end and boiling and steaming were carried out for 24 hours.

The wire proved effective and did not bite into the logs to any marked extent, but there are obvious hazards if a mill yard becomes liberally sprinkled with discarded wire. While steaming caused wider end splits than boiling the difference was small when the mechanical restraint was provided.

Boiling leaches out a large amount of dark, malodorous extractives and if carried out on a large scale the process would present a serious pollution problem. Steaming requires more complicated control and

equipment but there is far less discoloration of the log and probably no real pollution hazard. The extra handling involved makes such improvement methods rather dubious economically.

The remainder of the Wyong logs were stored in the yard for five months under damp hessian before sawing. The yield was no more stable than the controls cut at the time of the boiling and steaming experiments. The sawn product from the stored logs was used to construct a 9 ft. x 6 ft. x 8 ft. (2.7 m x 1.8 m x 2.4 m) building frame to gain information on carpenter reaction to it: the report was that it took twice as long to erect as the usual run-of-mill blackbutt. Material near the heart opened up badly in the first few weeks but there has been little subsequent deterioration of the frame.

Feeling that a different milling method would be more economic than pre-treatments, arrangements were made to cut 12 logs 3 ft. (0.91 m) to 4 ft. (1.2 m) girth and totalling 5300 super ft. (12.5 m^3) from Orara West State Forest, north of Coff's Harbour. The logs came from an area that had been cut out in the early 1920's. They were passed through an edger followed by a multiple gangsaw which was set to cut 1 in. (2.5 cm) flitches through the heart and 1 7/8 in. (4.76 cm) flitches of the remainder. The thicker flitches were dried from the green in the Murwillumbah kilns of Standard Sawmilling Co., using their normal rainforest timbers schedule which involved a top temperature towards 200°F (93.3°C), and which could be considered very severe for this type of wood. The blackbutt took about four weeks to reach 7% - 8% moisture content (i.e. a week longer than most rainforest species) and was then reconditioned.

The seasoned product was not appreciably cupped. Though surface checks were frequent they were not very deep. Wood near the heart had end-split badly but the general impression was favourable; other than heart material was considered by sales staff as acceptable for under-floor members, for glued-laminated construction and perhaps for studs too, even though the seasoned material is relatively hard to nail. The minimum acceptable top diameter of logs was suggested as 10 in. - 12 in. (25.4 cm - 30.5 cm).

Some glued-laminated beams from this material have been under study in a variety of atmospheric conditions for several months without any sign of opening of wood or glue-line. By conference time the beams will have been tested to destruction and some figures should be available.

It does appear that proper utilisation of current regrowth logs calls for multiple saw conversion. To justify the expense of such equipment it would seem that a guaranteed annual supply of several million feet of regrowth logs is required, and that presents a considerable problem for forestry policy makers. The latter are also faced with the difficulty that if very fast growth is a possible way out then a lot of non-commercial, but relatively expensive, thinning is needed in many thousands of acres of regrowth hardwood forests.

THE ECONOMICS OF MILLING SMALL HARDWOOD LOGS

by E. McArthur and M.W. Page

In many areas of Australia hardwood sawmillers are milling increasing quantities of small diameter logs. This is particularly so in regions where cut-over forests are being re-worked, regrowth forests are coming into production, trees are being clear felled, or where pulp chipping for export is being integrated with sawmill logging.

In most cases the supplies of small logs are being phased into the general log supply, resulting in such logs being milled in sawmills originally designed for much larger logs. These mills now handle a proportion of large logs and an increasing percentage of small logs. Unfortunately, the overall volume of each class is generally not sufficient to warrant the installation of special equipment for each class.

Previous studies in two regions have shown that the volumetric recovery[1] and the monetary return[2] obtained from logs of approximately 1.8 metres (6 ft.) and less in girth are considerably lower than those from larger logs.

Figure 1* shows the decline in volumetric recovery with decreasing girth when sawing jarrah in a Western Australia sawmill[1]. For logs of 2.1 metres (7 ft.) girth and larger, recovery was about 45% HLV, declining to below 40% for girths below 1.5 metres (5 ft.).

In a Tasmanian mill study[2], the graph (not shown) for site quality 150 (clear logs) is very similar to Figure 1 above 1.5 metres girth but drops down to approximately 32% at 1.07 metres (3'6") girth.

Figure 2 shows the relation between monetary return and log girth when sawing *Eucalyptus obliqua* at a Tasmanian mill[2]. This graph is for clear logs of site quality 150. Monetary returns from lower quality logs decrease much more steeply below 1.5 metres (5 ft.) girth, descending to approximately 100 cents per 100 sup.ft. HLV for clear logs of site quality 125 having a girth of 0.9 metres (3 ft.). Sawn recovery at this latter point is approximately 15% HLV.

A more recent study in Tasmania (Figure 3) has indicated that when small logs are milled in a general purpose sawmill, the net monetary return for sawn timber from "Mill" quality logs below about 26" top diameter was much lower than returns from larger logs although even for larger logs net monetary return was unsatisfactory under the cost structure and conditions applying to this particular mill.

Considering the matter generally, there are three reasons for the drastic reduction in net return with decreasing girth:-

(1) Sawn recovery decreases for smaller logs;

(2) Generally, the smaller logs yield lower priced products;

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*Imperial units have been retained for these graphs because the mill studies were conducted using these units and the references given also employ Imperial Units.

(3) Reduced log size results in higher milling cost per unit of log volume.

Figure 4 shows the relation between monetary return from sawn timber and top diameter for *Eucalyptus obliqua*. The similarity to Figure 2 (which refers to the earlier Tasmanian study) is very marked. Logs with 16 in. (41cm) top diameter (Figure 4) or the equivalent 4 ft.10in. mid-girth (1.47m) (Figure 2) both have a net monetary return of approximately 300 cents per 100 super ft. HLV.

Figure 5 shows clearly that reduction of top diameter below about 23" causes a significant rise in the cost of the milling operation. Principally this is due to the fact that small logs increase the frequency of loading, turning and setting operations and so reduce the percentage of total mill working time available for actual sawing.

Obviously the combined influences of the trends shown in Figure 4 & 5 could make it financially disastrous for any hardwood miller attempting to convert too high a proportion of small logs in a general purpose sawmill.

There are two solutions, the combination of which may be necessary to completely alleviate this situation. They are:-

(1) A significant reduction in the cost of logs.
(2) The availability of small logs in sufficient volumes to warrant the establishment of a special small-log sawmill.

In our Tasmanian study royalty represented only about 20% of the total log costs and consequently it is doubtful if even a complete removal of royalty charges would reduce log costs sufficiently to make their milling in general purpose mills profitable.

The volume required and the sawmilling equipment necessary[3] to constitute an economically viable small-log sawmill will to some extent, be influenced by the characteristics of each particular species. The Forest Conversion Engineering Group is carrying out further investigations to establish answers to these questions for a range of species.

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FULL TREE UTILIZATION IN THE LIGHT OF TECHNOLOGICAL DEVELOPMENTS IN HARVESTING

by C. M. KERRUISH

Summary

Today the concept of complete tree utilization is recognised as a future means of producing the basic resource for a wide range of forest products. Reduced growing costs are anticipated as a result of higher yields of material per acre and reduced re-establishment costs.

The feasibility of developing new harvesting concepts in which output is relatively independent of tree size is indicated and the likely impact on forest management is shown. However the evolution of existing roundwood harvesting concepts in conjunction with reduced limbing and barking standards is the most likely immediate path towards full tree utilization.

It is contended that harvesting and transport costs alone will not offer any great incentive to change from advanced round wood logging methods to complete tree utilization in the form of "green chips"*. The reduction will be achieved in the cost of growing the crop.

While the combined cost per ton of growing, harvesting and transporting "green" chips to mill door may be significantly less than for conventional chips under short or medium rotations, this cost advantage can be negated if the recovery or yield is adversely affected. The complete implementation of the full tree utilization concept is therefore dependent on the development of new processes and/or products that can profitably utilize a higher proportion of the total stand.

The Relationship Between Growing Costs and Harvesting Costs

In the growing and harvesting of short rotation crops for pulpwood, individual tree size is the major variable determining current management practice.

Growing costs are largely determined by the yield per unit area and the higher the stocking the greater the total yield (Fig. 1). With short rotations the effect of initial stocking on total yield is considerable as the proportion of the rotation during which the site is not fully occupied, is increased. However increased initial stockings result in a decrease in the average tree size; indirectly then, growing costs are related to the average tree size (Fig. 2).

* "green chips" describe the mixture of wood, bark, twigs and foliage that result from the chipping of whole trees.

Current harvesting practice is extremely sensitive to average tree size, particularly where stem volume falls below 0.15 m^3. This is due to the types of processes used in converting the tree into round wood and the decline in the percentage of the total volume that is harvested where a round wood harvesting method is employed in small diameter stands. The tree size - cost relationship is well established and differs little for various existing and appropriate harvesting methods (Fig. 3).

The combination of growing and harvesting costs largely determine forest management practice where the management objective is to maximise volume production (Fig. 4). Transport from forest to mill has little effect on the relationship as costs are not influenced by individual piece size.

Technological Developments and their Influence on Tree Size/Cost Relationship

Three basic principles (or a combination thereof) are involved in harvesting a stand whether the process is a manual or mechanised one. These are:

- a linear throughput process (A), where individual stems pass through the process in a linear manner. Examples include axe and chainsaw delimbing, most mechanical delimbing devices and debarking by ring type debarkers;

- a unit tree throughput process (B), where each tree is processed in a fixed time, irrespective of tree dimension. Processes approaching this include manual felling or mechanised felling by feller or feller-buncher;

- unit volume throughput process (C), where several stems are processed simultaneously and output is independent of individual piece size. Examples of processes approaching this include drum debarkers, multi stem bucking devices, bundle type delimbing devices and chippers.

The theoretical performance of these three basic processes are shown in Fig. 5. In practice the feed rate can be varied to reduce the influence of piece size for processes A and B but only within certain limits and the effect on output is only marginal in the smaller diameters.

In most harvesting operations individual tree volume is the main variable influencing costs. Mechanisation in itself has had little influence on this relationship, probably because machine development has largely been directed towards increasing labour productivity of existing forest operations. It has generally employed A and B type processes to supply an existing product demand.

The main approach used today in mechanising the harvesting of small wood has been to combine many functions in a single machine. Such machines include harvesters that operate at the stump and the processors that work at landings. There are currently about 20 different machines being developed by the major international forest machinery manufacturers.

Work carried out by the Forestry and Timber Bureau indicates that most of these machine concepts can readily be adapted to remove a high proportion of the bark during the limbing process, under temperate or tropical climatic conditions, resulting in a considerable reduction in costs - particularly in small to medium sized mills that cannot justify a drum type debarker.

Because of the availability of this equipment, its ability to produce log products other than pulpwood e.g. sawlogs, and an acceptable cost structure, it is considered that the immediate developments in harvesting will be along these lines.

However, machine components exist that do offer a means of changing this relationship, particularly in short rotation crops where the tree species, tree dimensions, spacing, ground conditions, etc. can be manipulated. Technically, machine concepts incorporating such components are feasible. Most of the components can be found on various machines today; felling devices capable of permitting the machine to move forward continuously have been seen on the Russian LRB-1, and Soderhamns hold patents on a continuously moving feller-buncher using a circular saw to fell. The Kockums "Scruven" and a Russian bundle delimber both are capable of reducing the influence of d.b.h. on output of round wood as their output approaches that described by the "C" process. The chipper is a conventional component that can be utilised to reduce the influence of d.b.h. Its output is largely related to total sectional area and can be used to process whole trees, approximating the performance of the "C" process. This process is employed in the Morbark "Chiparvester" which is currently undergoing extensive evaluation in the U.S.A.

The output for such machine concepts can be in the form of round wood ± bark, or chips with a proportion of the foliage, bark and small twigs removed by air flotation. The latter concept would result in a higher fibre yield per acre as branches and tops can be utilised but the fibre yield per ton will be lower due to the inclusion of a proportion of bark, foliage etc.

Most chip based processes today utilise between 45 and 95% of conventional chips, the lower figure being related to chemical pulping processes and the upper to reconstituted wood products such as particle board or hardboard. It is suggested that the new harvesting concepts will not greatly reduce harvesting costs but they will permit a reduction in growing costs by facilitating increased biological productivity of the site. However as growing costs only represent 10-35% of the cost at mill door, only a relatively small decrease in the yield during the manufacturing process can be tolerated.

It would therefore, seem reasonable to conclude that the introduction of the full tree harvesting concept is largely dependent on the development of new products or manufacturing processes that can profitably utilize a greater proportion of the stand.

EFFECT OF TREE AGE ON PULPING CHARACTERISTICS

by A.J. Watson

Pulp mills provide one of the largest outlets for the utilisation of small diameter logs. The minimum acceptable log diameter is usually about 10 cm. but rising wood costs and the development of wood harvesting and chipping techniques are directing attention to smaller diameter material. In general, small diameter logs are obtained from young trees but in some cases the small size may be due to poor growth conditions.

Pulp mills are also seen as one of the areas where over-mature trees may be used. In many cases these trees have been rejected by sawmillers in earlier logging operations and remain as trees showing a very small annual increment, deteriorating in quality and inhibiting regeneration of the forest.

It is obvious therefore that the pulp industry especially in areas where it depends on native forests, has to utilise trees in many different age groups. To appreciate the problems involved it is necessary to have some knowledge of the ways in which pulping and paper making characteristics are influenced by tree age. The following comments are directed mainly towards eucalypt woods but some consideration will also be given to plantation grown Pinus spp. In the latter however the age range between young and old trees is much smaller than in the native eucalypts and the changes in wood and fibre properties with age do not necessarily follow the same pattern.

Terms such as "young", "mature" and "old" are often used when discussing tree age because it is difficult to give more than an approximate age in years. However, these terms are relative and can refer to quite different age groups in different countries. For example, in Brazil it is common to refer to eucalypts in the 12-15 year old class as "over-mature" whereas in Australia trees in this age group could be classed as "young regrowth". Where possible the tree age should be given in years and where this can not be done general terms denoting age should be qualified.

Eucalypts

It is well known that the chemical and physical properties of eucalypt woods change with age of the tree. The most pronounced chemical changes are associated with the formation of heartwood which usually takes place when the tree reaches an age of 5 to 10 years. Fibre length also increases steadily from about 0.8 mm to a little over 1 mm during the early years in the life of the tree. As a general rule old trees have a higher basic density than 15 to 25 year old trees of the same species. All of these factors could be expected to influence the pulping and paper making properties of the wood.

Table 1 gives comparative data on alkali requirements, pulp yield and strength properties of sulphate pulps prepared from young and old trees of a number of species. In all cases the wood chips were cooked to give a relatively shive-free pulp and comparisons within species were made at similar Kappa numbers. In making such comparisons it must be kept in mind that the variations in pulping and paper making properties between trees of the same species can be quite high so there is little point in considering minor differences. The results demonstrate quite clearly that,

except for very young trees, pulps made from young trees (say up to 30-40 years old) are superior to those made from older trees in pulp yield, chemical requirements during cooking and in those paper properties associated with fibre bonding. The greater amounts of cooking chemicals required by the older trees and their lower yields of pulp are due mainly to the much higher extractive contents of the old trees compared with young trees of the same species. The better fibre bonding properties of the wood from the younger trees are related to the fact that wood basic density, which is closely related to the cell wall thickness of the individual fibres, increases with tree age. The extractives can also introduce problems in the concentrating and burning of the black liquor and by forming insoluble deposits in pipes and on screens and washers. This problem can be particularly severe when the wood supply of a mill is obtained almost exclusively from old over-mature eucalypts.

The low pulp yields from very young (2-3 year old) eucalypts are also due to removal of extractives during the cooking process. However, in this case they are derived mainly from the carbohydrate components of the wood whereas the extractives in the old wood consist mainly of polyphenolic substances. Pulps obtained from the very young wood have thin walled fibres and consequently respond readily to mechanical processing and have good bonding properties, but because the fibres do not reach their maximum length until the tree is 10-20 years old, the paper made from the pulp has a somewhat lower tearing strength.

The relationship between pulp quality and tree age is well recognised by pulp mills which rely on plantation grown eucalypts for pulpwood. In Brazil with species such as Eucalyptus grandis and Eucalyptus saligna the ideal age for pulping is considered to be between 5 and 8 years. Trees over 12 years of age are considered as "over-mature" and give a less satisfactory pulp. The indications from other countries growing various species of eucalypts for pulpwood are that for the best quality pulp the trees should not exceed 10-12 years.

These findings are no doubt governed very largely by the tree growth conditions in the various countries and details relating to optimum pulping age do not necessarily apply to Australia. While it is generally recognised that regrowth eucalypts produce better quality pulpwood for chemical pulping than old trees of the same species, data are not available as to what is the "optimum" age. In any case this would be governed to some degree by climatic and soil conditions and would vary for different species. Young trees from natural regrowth stands, from plantations and possibly from coppice regrowth can be expected to play an increasingly important role in meeting future demands for pulpwood. Information on the effects of tree age on pulping and paper making properties will be of increasing importance in forest management as well as in the pulp and paper industry.

The above comments have been directed towards chemical pulps but it should be noted that the same general pattern applies to semichemical pulps. However in the production of NSSC pulps for conversion into corrugating medium where the user is interested in the crush resistance of the finished product rather than conventional strength properties, it has been found that the old, over-mature trees can produce a good quality product.

Pines

The problems associated with extreme age do not arise with Australian grown Pinus spp. intended for pulping as they are all grown in plantations and

would rarely exceed 40 years at the time of felling. However, they do show the same trends of increasing wood density, development of heartwood with its higher content of extractives and changes in cell wall thickness and fibre length with tree maturity.

As most pines have wood relatively low in basic density, any increase in this property is advantageous as it permits a greater yield of pulp per digester charge with little or no detriment as regards pulp quality. The increased amounts of extractives reduce pulp yield but only to a small extent as the amounts are usually much lower than with the eucalypts. The extractives in the more resinous pine woods yield a valuable by-product known as tall oil when the wood is cooked by alkaline pulping processes.

The increase in fibre length with age is most important, particularly in Australia, where long fibred pulps have to be added to eucalypt pulps when it is necessary to produce papers with high tearing strength. Very young pines have fibres about 1-1.5 mm long. These increase in length during the first 12-20 years of growth to about 3-4 mm and then remain relatively constant. If pines are being grown to produce pulp with high average fibre length it is necessary to have trees which have been producing fibres of maximum length for several years prior to felling. In these circumstances tree age at felling can have an important bearing on the way in which the resulting pulp will be utilised by the paper mill.

TABLE 1

Effect of tree age on alkali requirements, pulp yield and pulp properties for various eucalypt species

Species and Age	Total Alkali (1) g/100g wood	Yield (2) (unscreened) %	Beating (rev) (3) L	PFI	Freeness C.s.f.	Breaking Length Km	Tear Factor
Eucalyptus regnans	20%	47.5	0		270	9.5	81
2-3 year old			9000		256	12.5	72
Mature ash - mainly	20%	49.3	0		358	6.2	91
E. regnans			9000		248	11.0	107
E. calophylla	14%	54.4	0		580	3.9	60
26-30 year old			9000		338	8.2	118
E. calophylla							
130-400 year old	17%	47.5	0		574	3.5	66
			9000		361	6.3	134
E. viminalis	19%	40.0		0	414	5.7	61
2 year old coppice				2000	393	7.8	70
E. viminalis	19%	43.9		0	445	6.2	76
16 year old coppice				2000	297	9.6	102
E. muellerana	14%	50.4		0	386	4.5	49
about 40 yrs. old				2000	240	7.1	97
E. muellerana	20%	42.0		0	392	5.0	71
mostly 100-150 years old				2000	257	7.4	112
Ash type eucalypts	12%	55.9		0	348	5.4	87
80-90 years old				2000	129	8.5	118
Ash type eucalypts	14%	48.2		0	387	5.1	84
up to 400 years old				2000	146	8.4	131

(1) Sulphate pulps prepared under similar conditions for each species except for the changes in total alkali as indicated.

(2) Screenings less than 1%.

(3) Pulps beaten in either hamper or PFI mill.

Note All comparisons between young and old wood made with pulps of similar Kappa number

COPPICE-GROWN PULPWOOD

by F.H. Phillips and J.W.P. Nicholls

The establishment of eucalypt plantations intended for harvesting as short rotation crops is being considered for Australian conditions both from technical and economic viewpoints. Eucalypts are capable of rapid growth under appropriate conditions and can produce exceptional yields. Whereas the growth stresses and seasoning difficulties which are accentuated in fast-growing plantation eucalypts might preclude their use for certain products, these defects are not disadvantageous if the material is to be utilized as chips. Furthermore, many species are able to regenerate by coppicing and the growth rate of coppice shoots is higher than that of trees grown from sowing or planting. Preliminary studies have therefore been carried out recently at the Forest Products Laboratory to indicate the usefulness of the various components (leaves, twigs, stem and bark) of coppice-generated Eucalyptus viminalis as a source of chip material (Nicholls and Phillips, 1970).

Coppice shoots aged 2, 7 and 16 years were used for pulping and papermaking studies; bark and twigs were included in the investigations of the stem material at each age and leaves from 7 year old samples were also pulped. The unbleached sulphate pulps prepared from each sample were produced under the same conditions.

Stem wood without bark, irrespective of age, produced a light coloured shive-free sulphate pulp that would be readily bleachable for subsequent fine paper production. Pulps obtained from the samples of stem wood with bark, although acceptable, were darker and rawer than those from the stem wood alone. Twigs gave somewhat darker pulps than stems plus bark and the yields were considerably lower than obtained from stem wood samples, except in the case of pulp from the twigs of the 2 year-old sample. The sample of leaves from the 7 year-old stem gave a very low yield of dark brown pulp.

Stem wood without bark gave pulp with adequate strength properties and these strengths generally increased with increasing age of the sample. The pulp produced from stem wood plus bark had properties generally similar to pulp from stem wood alone although the presence of bark became less desirable as sample age increased.

The unbeaten strengths of pulps from twigs and from leaves were similar to those of pulp from stem wood but mechanical treatment to develop these properties introduced other undesirable effects such as considerably increased drainage rates.

The pulps from E. viminalis coppice material stem wood were similar in yield and pulp properties to E. regnans pulp. Pulping E. viminalis bark with the stem wood gave similar strength pulp to that from E. regnans although the former was darker in colour. It has been concluded that coppice regenerated E. viminalis can provide a useful source of chip material for pulp production although the leaves and twigs should be removed before pulping.

Reference

Nicholls, J.W.P. and Phillips, F.H. (1970) "Preliminary Study of Coppice-Grown Eucalyptus viminalis as a Source of Chip Material". CSIRO, Aust. Div. For. Prod. Technol. Pap. No. 58.

BUILDING WITH TREATED TEAK PLANTATION THINNINGS IN PORT MORESBY

by C. Levy and P. Lattey

Introduction

Round timber poles are traditionally one of the most widely used building materials in Papua New Guinea. A large proportion of the population of P.N.G. live in villages and in every village, round timber poles are extensively used. Thus, in our work with treated teak rounds we are not introducing a new building material, rather, improving upon an already existing material.

A. Problem Areas

In the past there have been three problem areas in the use of rounds:-

1. Availability

Although poles have always been readily available in the villages, they have never really been available for commercial supply. A commercial supply demands:-

consistent quality
consistent price
consistent delivery time

With the teak plantations at Brown River providing a steady supply of thinnings to our Hohola treatment plant we have overcome these aspects of the problem.

2. Durability

Timber rots and is attacked by insects. Round timber poles with their ring of vulnerable sapwood decay rapidly in ground contact and must be replaced every few years. While this is a nuisance in the village context where no capital outlay is involved, it is intolerable when a housing authority or commercial enterprise is involved.

This has been solved by pressure treating the poles with copper-chrome-arsenic. With this treatment life of a pole in ground contact is expected to be of the order of 20 years. In dry service treated poles will last indefinitely. This makes it very feasible for commercial use.

3. Prejudice

There is very strong prejudice among both the expatriates and the Nuiginians against the use of "bush materials"; this is especially true in housing but also applies to implement sheds, workshops, warehouses and other utilitarian buildings. The Nuiginian has been indoctrinated to consider poles as impermanent, second grade and inferior to sawn timber, steel, bricks or concrete. This attitude is reinforced by the building practices introduced by expatriates.

Although this problem is by no means solved, we are working on it by:-

(i) Demonstrating the considerable cost savings in using poles instead of steel for sheds, workshops, etc.

(ii) Erecting as many treated teak pole buildings as possible so that people can see that they are not of inferior quality.

(iii) Designing any pole building to be as aesthetically pleasing as possible to make them more easily acceptable.

(iv) Working with the architects and builders around P.N.G. to make them more aware of the possibilities of poles.

(v) Working with the various authorities to get them to "try out" a few pole buildings on an experimental basis.

B. Advantages

On the other side of the coin from these problems there are some considerable advantages to the use of poles. These are factors that are basically inherent in poles and pole buildings.

1. Economics

Poles are cheap. While the exact economics of their use in urban housing has not yet been determined, they have many uses in this field. This would be either as stumps, or as building frames. However, there is no doubt that they are cheaper than steel in sheds and other structures of medium span.

On a national level there are also considerations. P.N.G. is moving towards Self-Government and self-reliance. Round poles are a local product utilizing a renewable natural resource. The country will need more and more to use of this type of product.

2. Steep Sites

There are many sloping sites which are rejected for building due to the extensive sitework required for conventional buildings. These are often sites which,for reasons of servicing and accessibility, would otherwise be useable. The flexibility of a pole structure is such that many of these sites can be utilized with little or no sitework.

3. Ease of Construction

The basic qualities of pole structures make them easy to erect. Cross bracing is seldom required. Further, because poles are a traditional building material, there is always a large reserve of men skilled in their use.

4. Safety

Timber in the sections used has a greater integrity than equivalent steel sections when subjected to fire.

Much of Papua New Guinea is subject to frequent earthquakes. A pole building is one of the ideal building forms for resisting the forces involved.

C. Utilization

At present we are investigating the possibility of using treated poles in as many building types as possible. There are some building types where their usefulness is self-evident, while in other building types they merely show promise.

The types of building in which their usefulness is self-evident are generally open pavilion type structures. We have co-operated in the building of, or are in the process of building:

- a recreation centre of 2000 sq.ft.
- a large (1400 sq.ft.) pavilion for a social club
- two bus stop shelters
- several large rectangular market pavilions
- several storage sheds
- several workshops
- several piggeries
- about 20 small roundhouses as garden pavilions, market vendors' stalls etc.
- trainee quarters at a training farm.

In the area of housing we are currently investigating a number of possibilities. Two of these are poles as a substitute for iron pipe house stumps and poles as a complete housing frame.

Generally the procedure we use for investigating a particular building is as follows:-

(1) We receive a specific request from a client for poles for a building. Generally the client does not have a specific design or a set of drawings from which to get a materials list.

(2) We discuss his needs with him and design a building to suit these needs.

(3) We prepare working drawings and a materials list.

(4) We sell him the poles and, where necessary, supply construction advice.

(5) After the building is finished and in use, we study it. Then in line with this study and what we have learnt during construction we make alterations and improvements to the original drawing.

(6) These drawings then become available to future clients who wish to construct similar buildings.

This technique has proven especially successful with two of our projects, the round house and the rectangular market pavilion. To date we have completed about 18 round houses and 2 market pavilions with a further 2 pavilions under construction. The round house has also proven very versatile. So far it has been used as a market stall (for which it was originally designed),bus shelters, garden shelters and a small shop. In each of our designs we try to design in as much flexibility as possible.

Thus, the multiple use of round houses. We hope our other "standard" buildings will find the same range of usefulness.

D. The Resource

The major source of small poles consists of thinnings from teak plantations established in the Brown River area by the Department of Forests.

Total area planted to date is some 3,000 acres varying in age from 12 years to newly planted areas; in the year ending June 30, 1972, about 400 acres were planted.

In addition to this, there are considerable quantities of post and pole size trees apart from teak in the area, which may be successfully utilized.

Supplies of bamboo, which is often used in conjunction with natural rounds, are patchy and it may prove desirable to encourage the planting of suitable bamboo species for processing.

Teak thinnings will be in continuous supply in the immediate future as more recently planted areas come into production.

At the present time no firm decision has been reached on future planting policy, but as current developments in the use of small round poles are so promising, it is expected that further plantings will be made. It could well be that teak plantations established for small pole supply will be more profitable than plantations managed for more sophisticated end uses.

E. Preparation

Treated teak is sold on the basis of top diameter and length and current demand is such that we have been able to arrange for the teak, culled from plantations, to be cut near to the required size and delivered to F.P.R.C. with the bark on. Out of necessity some early batches of thinnings were kept stacked with the bark on for several months before peeling and we now believe this to be a wise policy as it results in the reduction of starch in the sapwood which may lessen the susceptibility of treated sapwood to decay.

After one or more months stacked with the bark on the teak is cut to the final length required and debarked using a "hydrowhirl" debarker operated from a tractor power take off, except in the case of posts which will be used in ground contact. These are hand debarked when machine debarking would expose untreatable heartwood as there is still some uncertainty about the durability of juvenile teak heartwood in P.N.G. Following debarking, the teak is stacked adjacent to the treatment plant for further seasoning which requires about 3 weeks to reach 25% M.C. in sapwood at which point treatment is carried out. Moisture content is determined in each charge before treatment by moisture meter. Retentions of 2 lbs CCA/ft^3 are aimed at with the minimum acceptable retention of 1.5 lbs CCA/ft^3 sapwood volume.

F. Economics of Teak Treatment

The treatment plant consists of a 3 ft. diameter cylinder 42 ft. long with a rapid closing door and is suitable for use at 200 psi. A 20 ft. extension has recently been acquired and will be fitted as soon as possible to enable treatment of large piles and transmission poles. The size of each charge varies between 100 and 150 cubic ft. of timber and with existing facilities we can complete two charges per 10 hour day. Based on an average

charge of 120 cubic ft. of timber, two charges a day, five days per week, the gross value of weekly production is approximately $1,700 at current treated teak prices.

Production is at present not limited by cylinder capacity but by organizational problems and the fact that the plant is used for treatment of a wide range of products in addition to teak.

Prices currently charged for treated teak are as follows:-

Top dia. in mm.	50	75	100	125	150
Price per meter in cents	20	40	60	90	120

As we are attempting to develop the markets for treated teak poles in a community where this product was unknown and at the same time use our facilities for other research and development projects, it is unrealistic to attempt a detailed economic analysis of our actual operation as the major costs apart from the preservative salts and capital costs would appear to be in the preparation and seasoning and,as earlier described, preparation is currently geared to development of new rather than maintenance of existing markets. However, an economic analysis of production of treated teak in an idealised situation is currently under way. By idealised it is inferred that the raw material supply is not limiting and a market in standard lengths for the total production capacity of the plant exists and that,where necessary, capital input can be made to improve handling etc.

It is hoped that,as a result of this analysis and the development work being undertaken, a successful v/pressure treatment industry based on teak or other plantation thinnings will eventuate in Port Moresby and in other centres.

TOPIC 3. TIMBER FOR CONSTRUCTION

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THE MARKET FOR TIMBER FOR CONSTRUCTION

by A. P. WYMOND

By far the greatest percentage of sawn timber produced in Australia goes directly to the building industry. Various estimates of this percentage have been made in the past, and it is generally agreed to be at least 70%. Hence when talking about the marketing of timber, it must be remembered that its principal market is building, and more specifically, mainly house building. Most of what has been written and spoken concerning the marketing of timber in the past has been from the point of view of the seller - the timber industry. But what of the buyer - the building industry? One hears little from them on this subject, but this does not necessarily mean that they are 100% satisfied customers. All too often the building industry is apparently ignored by the timber industry in relation to its product requirements. If there are borers or knots or sapwood or bark or any others of a number of such defects, then the philosophy is that the building industry must be taught to accept them. We all know that this may be economically essential - we see too much wood wasted already, but in builders' eyes it smacks a great deal of "fobbing off the rubbish", in other words builders see the timber industry as determining what is good for them, irrespective of their thoughts on the matter.

A time of reckoning may come, in fact it may be quite near, when manufacturers of other materials can offer uniform, defect free products, or ones capable of performing better than wood at prices competitive with wood. Then it must be remembered that builders owe no allegiance whatsoever to wood, and will use the material which is the most economical, conditional upon satisfactory performance.

It was to determine the building industry's experiences, thoughts and prognostications concerning timber and timber products and certain competing materials, that a survey of builders and architects throughout Australia was commenced last year, with the ultimate aim of gathering information which could help to determine trends in sawn timber consumption.

Over a period of nearly 12 months the writer has personally interviewed over 150 architects and 100 builders, mainly in Victoria and South Australia, but also in Tasmania and briefly in N.S.W. Further work is to be done in the latter State, and the survey will continue into Queensland and Western Australia later this year.

In general, it is fair to say that results to date indicate that the building industry expects a lot more from the timber industry. As its bigger customer it feels that its requirements should be subject to rather more consideration than has been apparent in the past. Whilst they are not greatly concerned at the price of timber, builders nevertheless want value for money.

Some of the findings of the survey to date under various major headings follow very briefly.

Timber grading: Builders feel that they should not have the task of sorting or grading timber on a building site. No other building material has to be so treated, why timber? Also builders and architects point out that timber is probably the only product they buy which rarely has any brand name or producer's name on it. Their interpretation of this is that producers do

not want to be identified in the event of complaint or rejection. I have no doubt that many people will have ready explanations for these two complaints, but are any answers really justified? Why is not all timber graded properly - why is it not all branded? Is not the biggest customer entitled to be looked after?

Framing timber: The market for framing timber differs markedly from state to state. In Victoria for example over 97% of all houses are timber framed, 90% using green hardwood and about 7% using dry framing, either softwood or hardwood. About 2½% are of all brick construction. The price differential between green and dry framing at the present time renders the latter generally uneconomic, but the gradual increase in use of dry framing indicates that cost is not always the criterion. In many instances quality is all important, and it is significant that the majority of architects designing higher priced houses specify dry framing.

Builders also are becoming more interested in their reputation, and call backs for defects associated with frame shrinkage do nothing to enhance that reputation.

In South Australia on the other hand, only 46% of all houses are wood framed, and virtually all of these use either oregon or radiata pine. Neither of these timbers present any significant problems as a framing timber. Any suggestion to a South Australian builder that he should use green hardwood framing would be scorned, even though a considerable saving would be involved - the industry is just not geared for it.

The South Australian Housing Trust is now building its houses almost exclusively in wood frame construction, and some 80% are brick veneer. There will undoubtedly be a further swing to brick veneer in that State, aided partly by the less massive foundations required for this type of construction compared with all brick. However there is a shortage of framing and structural timber at the present time in South Australia, and the industry will need to watch that its promotion of brick veneer doesn't aid the metal framing market if timber is unable to meet the demand.

Wood framing has two possible competitors, steel and aluminium, both being products of large and well established industries which will not hesitate to start hard selling when they think the time is right. Their chances of holding material costs down are probably better than the timber industry's, so that in time these products could be more economically attractive than they are today. Also situations such as the current under supply of timber in South Australia in particular could lead to these competing materials gaining an important increase in their presently insignificant share of the market. Many builders have already looked at metal framing, and beside cost, have formed the opinion that other disadvantages are lack of flexibility of use, i.e. changes can be made to a wooden frame by a man with a saw, hammer and packet of nails, and that metal framing will undoubtedly in time present labour problems, either through demarcation issues, or shortage of skilled erectors. Many, however, also see advantages, particularly in that the materials are uniform, and there are no shrinkage problems.

Structural timber: In the field of structural timber other than for housing, there has been a gradual trend towards steel for some years. Industrial and farm buildings offered as packaged deals in steel have been widely accepted, although their performance, particularly in farm buildings, leaves much to be desired. One country builder in Victoria has had considerable success by

reintroducing wooden buildings. Timber girts, purlins and rafters have now very largely been replaced by steel in industrial buildings, and the large, engineered timber structure is a rarity today.

Glued laminated members: Glulam structural members have never gained the wide acceptance in Australia that they enjoy in some overseas countries. This is partly a consequence of the relatively low steel price in Australia, but until comparatively recently they have not been widely available, so specifiers have not had the opportunity of giving them serious consideration. In addition the industry has been hard pressed to live down the failures of glulam members which occurred in the 1950's. Currently the industry is still beset by some technical problems, notably where beams are subject to exposure to weather. However there are good prospects for growth in this area, exposed structural members being very fashionable for hotels and similar public buildings.

Roof trusses: Roof trusses in domestic construction are gaining ground in the southern States. In Victoria about 20% of house roofs are trussed, in South Australia the estimate is slightly higher at about 25%. These figures compare with over 50% for A.C.T. and over 25% for Queensland. As the use of roof trusses increases, the volume of timber used per house will decrease, and different methods and materials of construction of non load bearing partition walls could cause a further decrease in timber consumption.

In the structural field generally another important factor to be considered in its effect on total consumption of sawn timber is CA38, the Light Timber Framing Code. Various estimates have been made of the volume of timber which can be saved per house by applying the Code, and figures of up to 20% have been quoted. Whilst there is some hesitancy in the industry at the moment concerning some of the Code's allowances and the attitude of local authorities, there can be no doubt that the less conservative builders will be quick to take advantage of the savings represented.

Flooring: Flooring is another area where very significant changes are occurring. The suspended wooden floor is subject to strong competition from concrete. Architects and builders in Victoria and South Australia are strongly in favour of concrete floors, but are governed to a large degree by the site and by costs. In Victoria it is estimated that some 17.20% of all houses are built on concrete slab; in South Australia the estimate is slightly lower at about 15%. Further penetration of the flooring market by concrete is considered to be inevitable, and will be aided by the availability of a wide range, both in type and price, of attractive floor coverings. In both South Australia and Victoria, the Government housing authorities have indicated considerable interest in concrete slab on ground, and there is every possibility that their use of this method will increase. It is conceivable that the overall penetration could rise to at least 25-30%, in fact it is already considered to be higher than this in Geelong. The nett result will be a considerable loss to the sawn timber market.

Other materials that will compete with the strip flooring market are plywood and particle board. Since these still require the suspended floor structure, the loss to the sawn timber market will not be so great. Sheet materials have not been widely accepted in Australia, but in New Zealand particle board is used extensively. Their use in Australia has been governed by two factors, cost and suitability. In regard to the latter,

The use of urea-formaldehyde bonded particle board has been regarded with considerable suspicion by the building industry and it is only with the more recent advent of the phenolic bonded material that more interest is being expressed. There is no doubt that this interest will grow and we can expect to see much more particle board used as flooring. In the case of plywood, cost has been a major inhibiting factor, but with increasing quantities of structural grade plywood coming on to the market, it is possible that plywood will also gain an increasing percentage of the flooring market.

Window joinery: The only other timber in building use I wish to mention is window joinery. At the present time there is a very strong preference for wooden window framing, which is a reversal of the trend of some 10 years ago when aluminium was being used increasingly. Unfortunately the current preference is tied very strongly to one imported species, western red cedar, which is becoming very expensive and subject to severe fluctuations in supply. Unless suitable alternatives are offered to the building industry there could well be a swing back to aluminium.

Summary

In summary, the total sawn wood market would seem to be under considerable stress at the present time. On the one hand supplies are at a premium at present due to a substantial upsurge in the building industry, on the other hand it appears that there could be a continuing drop in per capita consumption over the next 5-10 years. It is suggested that such a drop will mainly be due to the more efficient use of timber, such as by the use of CA38 and a greater percentage of trussed roofs, but some proportion of the drop will undoubtably be the result of a further swing to other materials, particularly for flooring. Furthermore, there can be no doubt that poor marketing and presentation can only help to accelerate such a swing.

DEFECTS IN HARDWOOD SCANTLING

by W. A. CLIFFORD and I. R. KENNEDY

During the period May 1971 to July 1972 a survey of hardwood scantling supplied to the Melbourne market was conducted.

Samples were allotted to municipalities according to building permits and a total of 80 houses was surveyed. Grading was carried out at the frame completed stage and the timber in the living room and kitchen was graded to A.S.082 (Sawn Eastern Australian Hardwoods). A total of 15,215 pieces of timber was graded.

Analysis of data is proceeding but results obtained point to some conclusions.

1. Almost 10% of all timber graded was below building grade (1250f) (Table 1). About one house in eight of those inspected contained over 20% of timber below building grade. One house contained over 50% (Table 2). As structural failures are rare two points emerge:-

   (a) Is the Standard set too high for Victorian hardwoods.

   (b) Is lack of failure due to load sharing and random distribution of defects.

2. The proportion of scantling which is superior to building grade ranged from 57% to 70% indicating a possible advantage to producers who grade their timber.

3. Plates, rafters and purlins were generally found to have been of better quality than joists and studs indicating that some grading by sawmiller and builder does exist (Table 3).

4. Defects due to gum (kino) were by far the most common cause of downgrading (55% of all defects - see Table 4). Knots and sapwood accounted for 28% of defects. Thus an investigation of these three defects would cover over 80% of the field. It was considered that more precise definition of "tight" and "loose" gum veins was needed.

5. Sapwood was present in 6.4% of all timber graded. In individual houses it ranged from nil to 19.8%. There was a marked increase in sapwood in the houses surveyed in 1972 over those covered in 1971 (Table 6).

During this survey two assumptions were made -

(a) all species were strength group "C", and

(b) all sapwood was *Lyctus* susceptible.

As species which are immune to *Lyctus* and/or above strength group "C" are commonly milled in Victoria, some reduction of the figures quoted can be assumed.

Topic 3/2

Table 1

GRADE PROPORTIONS

Year	Houses	Pieces	Select	Standard	Building	Inferior
1971	38	6869	45.0	24.4	20.7	9.9
1972	42	8346	35.2	22.5	33.8	8.5

Table 2

DISTRIBUTION OF INFERIOR GRADE

Percentage of members/house inferior to building grade		
%	1971	1972
0 - 5	10 Houses	19 Houses
6 - 10	13 "	15 "
11 - 15	7 "	2 "
16 - 20	4 "	-
21 - 25	3 "	2 "
26 - 30	1 "	1 "
31 - 50		2 "
Over 50		1 "

Table 3

Percentage Distribution of Grades by Structural Members				
	1971		1972	
	Select	Inferior	Select	Inferior
Bearers	41.0	9.5	36.8	6.0
Floor Joists	42.7	11.3	29.5	10.0
Plates	51.7	7.7	43.7	5.2
Studs	45.5	11.0	32.7	10.1
Ceiling Joists	40.4	12.9	28.5	10.5
Rafters	46.7	8.4	41.9	5.7
Purlins	52.0	6.4	46.4	6.8
Hanging Beams	37.4	3.3	30.8	4.1
Av. All Members	45.0	9.9	35.2	8.5

Table 4

MOST COMMON DEFECTS (% OF TOTAL DEFECTS)

Defect	1971	1972
Gum		
Tight Veins	26.2	18.9
Loose Veins	12.4	17.8
Pockets	17.6 56.2	18.0 54.7
Sound Knots	19.9	15.9
Sapwood	8.8	11.0
Wane (± Sapwood)	4.5	4.9
Holes	1.4	3.0
Splits	0.8	2.3
Sloping Grain	3.9	2.1

Table 5

DISTRIBUTION OF SAPWOOD

	1971	1972
% Containing Sapwood	5.4	9.26
% With Sapwood exceeding Building Grade A.S.082	2.2	1.36

Table 6

Percentage of members/house containing sapwood		
%	1971	1972
0 - 5	18	11
6 - 10	18	17
11 - 15	2	8
16 - 20	-	6

A LOW COST PROGRESSIVE TUNNEL KILN FOR HARDWOODS

by L. J. BRENNAN and G. S. CAMPBELL

An investigation is in progress using a constant heat input progressive kiln to determine the feasibility of reducing installation and operating costs for the non critical drying requirements of certain hardwood products such as scantling, case and packaging material, posts and poles etc. For such products, surface checking and some distortion can be tolerated and uniformity of the final moisture content is not necessarily important. However it is conceivable that the proposed kiln could be adapted for the drying of check-susceptible joinery stock by using the low temperature, high humidity and low air velocity at the "wet" end of the kiln in the critical early stage.

The cost of kiln drying falls into four general categories.

(1) Capital investment charges
(2) Cost for power and heat
(3) Maintenance charges
(4) Labour

A "Once Through Progressive Tunnel" kiln which operates at low temperature, can be built very cheaply, especially when all equipment is mounted on the floor. Little or no insulation is required and only sufficient strength is required to make the frame and sheathing structurally stable and free of air leaks. The equipment will comprise a fan and a simple oil furnace air heating system. However, the low building and equipment costs will be partially offset by the cost of a set of kiln trucks or bogies.

Power for fans is dependent on the volume of air circulated and the resistance offered by the timber to air flow. Because of the relatively small cross section of the tunnel and the low air velocity required it is expected that the cost for power will be only a fraction of that required for conventional kilns and predryers, even allowing for the expectation that average drying time will be longer in the proposed kiln. The provision of heat in any form is expensive and only in special circumstances can the need for economical use of heat be ignored, hence the kiln is being designed to obtain maximum value from each unit of heat. This can be achieved by allowing air, which has become so moisture laden as to have no beneficial effect on partly dried wood, to continue to pass through successively wetter and wetter material. Finally, it is discharged through the fan in an almost saturated condition, having possibly a 1 to 2°C wet bulb depression, with the dry bulb temperature, preferably below ambient. The air will not be re-circulated, but discharged at the "wet" end only after it has made 100% use of the heat provided by the fuel as well as making use of the original natural drying capacity of the air.

The simplicity of the design and accessibility of all equipment must lead to low maintenance costs on the kiln. Other than for the unavoidable loading operations, the process will require no supervision except for moisture checks on the last stack. The proposed kiln will be in the form of a long tunnel-like shed through which the timber will be progressively moved on trucks against a counter flow of heated air. The stacks will be loaded with their lengths parallel to the sides of the

tunnel to avoid racking or jamming of the trucks that often causes trouble with the sideways movement in some progressive kilns. After initial heating, the air will be directed through the stacks from side to side, with the aid of baffles, along a sinuous path towards the "wet" end.

As hardwood can withstand quite severe drying conditions when nearly dry, the kiln is to be designed to enable the temperature at the "dry" end to be raised by some fixed amount rather than to a predetermined temperature. The magnitude of this rise will be limited only by the amount of degrade that is acceptable in the end product.

A value for this will be based on a study made of weather records for Melbourne. This indicates that in an average year there are not more than a total of 40 hours in which heating the air 14°C to 17°C above ambient results in an EMC condition less than 3%. A 14°C rise will never, under any conditions, produce an EMC above 8%.

A prototype kiln will be built to determine the feasibility of:-

(a) Installing a suitable capacity oil burner and fan

and

Operating to give a constant temperature rise and constant air input without any controls or attention

or

(b) Whether seasonal settings on the oil burner will be necessary

or

(c) Whether variation of fan performance will be necessary to maintain the stipulated low wet bulb depression at the "wet" end of the kiln for maximum economy or when avoidance of drying degrade is essential.

or

(d) Will there be sufficient economic advantage to justify the cost of installing wet and dry bulb thermometers or a humidistat with either manual or automatic modulation of the burner depending on weather conditions. A wood humidistat actually measures the EMC of the air and appears to be an appropriate device.

Because the proposed tunnel dryer will still be dependent on the weather, it will suffer, as air drying yards suffer, from reduced output in winter. However, one advantage over air drying is that it will always be able to produce useful drying conditions, but it cannot, any more than air drying, guarantee optimum drying conditions at all times.

A primary objective will be to determine the month to month drying rates for different classes of timber. This will enable the economic value of the system to be assessed in comparison to existing seasoning processes. It is envisaged that future kilns could then be designed to match the winter output with any over-capacity in summer being regulated by reduced hours of operation.

A pilot study has been carried out in an experimental unit approximately 20 ft. in length and the likely drying potential of the system was examined. Ambient air, between 8 and 13°C was drawn into the dryer at one end, heated from between 7 and 25°C, passed through a series of short stacks and then exhausted at the "wet" end through a fan without re-circulation. The relative humidity at the "wet" end varied between 40 and 94% depending on the degree of heating at the air inlet or "dry" end and on the dryness of the stacks, particularly those located at the wet end.

For this study, the stacks were placed at right angles to the direction of air flow, the speed of which was adjusted to 300 ft./min. As drying proceeded, stacks were moved progressively from the "wet" end towards the "dry" end, with fresh green stacks being introduced at the "wet" end with each move. Typical of the results obtained for scantling material were those pertaining to 1½ in. and 2 in. *E. obliqua*, dried from the green condition as follows.

Thickness in.	Av. Green MC %	Drying Conditions						Drying Time Days	Final Av. MC %
		Initial			Final				
		DBT°C	RH %	EMC %	DBT°C	RH %	EMC %		
1½	85	14.4	80	17.4	34.4	26	5.1	37	15
2	68	14.4	80	17.4	35.6	20	4.0	45	16

With slight modification, it is envisaged that this type of kiln could be adapted to the drying of check-susceptible hardwoods such as jarrah and the Tasmanian ash-type eucalypts. For joinery purposes, it is necessary to restrict the amount of face and edge checking to an absolute minimum which generally means that the cutting and air drying of the thicker sizes - 1½ in. and above - can only be carried out during the cooler months of the year.

Provided early protection can be given before the stacks enter the kiln, it may prove feasible to dry green joinery stock of check-susceptible species over the summer months by making use of the near-saturated conditions at the "wet" end of this kiln.

Topic 3/4

THE CAUSE OF STAINING BY KWILA (*Intsia bijuga*)

by W.E. Hillis and Y. Yazaki

This timber and Merbau (*I. palembanica*) are high strength, dimensionally stable timbers, durable to fungal attack, resistant to termites and relatively resistant to wear. Increasing quantities are being imported into this country. Complaints have been received regarding the staining caused by these timbers when used unpainted for window sills, outside joinery and indoor furniture. They also delay the setting of concrete when used as formwork.

The extractives are readily leached with warm water and rapidly with many organic solvents. A chemical examination has shown the major component to be robinetin - which is responsible for the yellow flecks in the wood - and in the case of *I. bijuga* there are also stilbenes, dihydromyricetin, naringenin and polymerized leucocyanidins. These materials are almost completely absent from the sapwood. Kwila and merbau are readily distinguished by chromatographic examination of the extractives.

Several methods were tried to insolubilize the water soluble extractives and satisfactory stabilisation of small samples of wood was achieved by painting the surface first with formaldehyde solution (40%) and after drying with ammonia (27%). Subsequent heating (above 100° C) for a short period rendered the compounds in surface layers insoluble in water and the solvents commonly used in common varnishes. The process darkened the colour of the timber.

PROBLEMS IN THE PRODUCTION AND USE OF FINGER JOINTED SCANTLING

By A. ANTON

Summary

A survey on commercially produced finger jointed scantlings indicated that glues which are classified as non waterproof but for which the glue manufacturers claim high resistance to water may be and are used for finger jointed products for specified end use. A fresh examination of the long term performance of various adhesives and of the products manufactured using these adhesives is urgently needed to allow finger jointed timber products to economically compete and hence be used as an alternative to ordinary timber and other materials.

Considerable interest has been shown in the last three years in the production of finger jointed timber.

This may be attributed to the developments in the production of Glue-Laminated beams for structural use and to a great extent on the attempts made by the N.S.W. industry to produce structural timber by finger jointing shorts. Finger jointed timber for joinery stock is not included in this discussion.

The use of finger joints, to produce structural scantlings of a designated strength rating, has always been looked upon with some degree of scepticism by research workers, designers and building authorities.

One wonders if a finger jointed length of solid timber is as good as an ordinary length of timber of the same grade, thus enabling it to be used in a situation where it will be highly stressed for prolonged periods.

The above question comes to mind, because, most of our knowledge about end jointing of timber shorts is associated with the production of glue-laminated beams, where end jointing individual laminations is necessary.

Which is to say that we accept finger jointed laminations for the production of glue-laminated beams and there is evidence that laminated beams manufactured with the above joints will perform satisfactorily.

Hence, do we assume that a 4" x 2" finger jointed scantling will perform satisfactorily, for a long period, when used under any given load conditions?

The unconventional presentation of this paper is to give an impression of what is involved in considering finger jointed timber in structural Engineering applications, to raise the question of what is meant by timber framed buildings and finally to look into the existing and recommended practices.

From information collected over the years it appears that:

1. For finger jointed hardwood framing timbers, ash type eucalypts and some gums are used. Essentially everything available is used as mixed species. On the softwood front Radiata Pine, Slash and Hoop pines are known to be successfully finger jointed for framing timbers.

   It appears to the author that, as it is written in A.S. 0123-1970, Framing Timber implies timber used in the frame of a building where there is a high degree of load sharing and the individual members are primarily in compression. It is of interest how the scope of A.S. 098-1966 and A.S. 0123-1970 read.

   "SEASONED SIZE-MATCHED FRAMING TIMBER (INCLUDING FINGER JOINTED PIECES) FROM SOUTH-EASTERN AUSTRALIAN HARDWOODS

   1. SCOPE. This specification applies to seasoned size-matched framing studs, plates and nogging pieces, including finger-jointed pieces, produced from south-eastern Australian hardwoods."

   "FINGER JOINTED AND/OR LAMINATED RADIATA PINE SCANTLINGS

   1. SCOPE. This specification prescribes quality requirements for end-jointed (finger jointed) and/or face-glued (laminated) seasoned radiata pine scantlings intended for use in timber framed buildings and in structural engineering applications. It includes a quality control system for maintaining an adequate standard of manufacture."

2. The situation with adhesives used is quite obscure but it appears that it is common practice to use glues classified as non water-proof but for which the manufacturers claim high resistance to water.

   Our findings with such glues is that an efficient joint can be produced with poor production control and a finger jointed sample gave no indication of distress on either glue-line or timber after thirty cycles of 24 hours soaking in cold water and subsequent 72 hours air drying.

   It is the author's opinion that both standards, A.S. 098-1966 and A.S. 0123-1970, are aiming for production of finger jointed studs. Hence various manufacturers produce and market finger jointed studs all of which perform satisfactorily and for which the consumer is willing to pay a premium price because of the way the product is presented, its stability and straightness.

This might be a good point to finish my paper but I will stretch my luck by asking firstly what minimum qualities and characteristics a glue must have to be classified as waterproof? Secondly, what is the value of an inefficient finger joint, resulting from poor production control, although what is considered suitable waterproof glue has been used which does not tolerate production control discrepancies?

Maybe this is an appropriate time to revise our thoughts about finger jointing and have a critical look into the various aspects and components of importance involved in the above operation.

THE NEED FOR SPECIFIC FASTENING RECOMMENDATIONS FOR BUILDING COMPONENTS

By D. GREVE and W. J. SMITH

The scene today in the light building construction area in Eastern Australia is one of change from the almost exclusive use of unseasoned hardwoods to include seasoned softwoods. Unseasoned hardwood framing does not present many fastening problems due to the progressive development of suitable, now traditional, fasteners and techniques.

However, the exotic softwoods are presenting problems at times due to lower withdrawal resistance and a tendency for the traditional jolt-head nails to pull through, (as, for example, where pine is nailed to hardwood).

In recent attempts to secure information capable of being practically applied from both Australian and overseas sources, it became evident that, while there is an adequate amount of technical information which could be used to solve the problem, this has apparently not been collated in a form in which it is capable of direct practical application; nor are Australian nail manufacturers producing a wide enough range of nail sizes suitable for softwood framing use. Possibly they are unaware of the need.

There is ample evidence that grooved and cement (resin)-coated nails have quantitatively demonstrated improved withdrawal resistance and that flat heads reduce pull-through compared with plain-shank, jolt-head nails.

There are also formulae based on factors including wood density, and nail shank and head diameter from which withdrawal and pull-through resistance can be calculated.

However, grooved nails are far more expensive (in some cases, nearly twice the price) and cement coated nails somewhat (about 10%) dearer than plain-shank nails. Availability is also apparently limited. In addition, despite the basic technical information available, there is no simply set out information on how, where and when to use the different nail types.

What is needed is a set of recommendations similar to those given in the appendix table of a publication issued by the Virginia Polytechnic Institute Wood Research Laboratory, U.S.A. (1). These recommendations could be extended however, to allow a builder or specifier to choose between the different nail types, given the economics of using each type in certain situations (e.g. cheaper but larger gauge plain-shank versus much more costly grooved nails). Where necessary, the variation in properties between different species or species groups could also be taken into account in data tabulation.

The type of information given in the publication referred to includes, for each application (e.g. flooring or ceiling - battens to joists, joists to bearers, etc.), nail type, nail size, type of metal, finish, head diameter and type, point size and type, spacing, and number per joint.

The greatly increased use of fissile cypress pine and harder seasoned hardwood framing also merit consideration and the need for preparation of the required information in a readily useable form for wide dissemination has become a matter of urgency in ensuring the wider use and acceptance of softwood and seasoned hardwood framing.

Topic 3/7

Reference

(1) Stern, George E. (1959) - Better utilization of wood through assembly with improved fasteners. Publicn. No. 38 (Revised), Virginia Polytechnic Inst. Wood Res. Lab., U.S.A.

PNEUMATIC NAILING GUNS FOR HOUSE FRAME CONSTRUCTION

By D. K. GOUGH

Introduction

Substantial savings in the labour content required for the construction of timber house frames can be achieved with the use of pneumatic nailing guns.

Laboratory tests were undertaken in order to evaluate the efficiency of pneumatically nailed joints compared with joints constructed in the conventional manner using nails, hand driven with a hammer.

Testing Procedure

A series of "T" sections was made; these sections representing typical stud and plate joints as indicated in the diagrams (Fig. 1).

Matching specimens of each species and nailing pattern considered were prepared for either pneumatic or hand nailing.

When constructed, the sections were simply pulled apart in straight withdrawal on a universal strength testing machine. Strength of the joint at failure was recorded in kilograms.

The test adopted would by no means cover every type of stress which could be imposed on a nailed joint, however it is considered that this type of test is one which can easily be repeated and that it is certainly of value for comparative purposes.

Two series of tests were undertaken. The first one compared 75 mm 9 gauge hand-driven jolt head nails with 75 mm 10 gauge nails made for and driven by a nailing gun. All timber was 75 mm x 50 mm nominal size. A variety of species was tested. Some was in the green condition and some was dried. Nailing pattern or method was as indicated in the diagrams (Fig. 1) viz. skew nailed, with a 6 mm check into the "plate", straight nailed with a 6 mm check, and straight nailed with no check.

The second series was a limited evaluation of the following types of nails:

(a) 75 mm 9 gauge hand-driven jolt head
(b) 75 mm 9 gauge hand-driven annular ring
(c) 88 mm 10 gauge gun-driven plain shank
(d) 100 mm 8 gauge hand-driven annular ring
(e) 88 mm 10 gauge gun-driven annular ring

The timber used was all 100 mm x 38 mm seasoned slash pine. There was quite a variation in the air dry density of the material. All joints were straight nailed without being checked.

Results and Discussion

Table 1 lists the results obtained for the first series.

For treatment A, skew nailing with a 6 mm check, ten pairs were tested.

The difference, 16 kg, between the mean value for hand nailing (226 kg withdrawal resistance) and the mean for pneumatic or auto nailing (210 kg) was not significant at the 95% level of probability.

For treatment B only six pairs were tested and for treatment C five pairs.

Here again the differences between the means were not significant being only 9 kg and 18 kg respectively.

Individual values do however show appreciable differences between hand and auto nailing in many cases, even with similar treatment of the same species. These differences cannot be readily explained but they do serve to show that quite a percentage of all currently accepted nailed joints must in fact be relatively weak.

Because the number of specimens of each species and in each nailing treatment was limited, it is difficult to draw definite conclusions about the relative strength of the three nailing patterns.

Indications are that straight nailing with a 6 mm check appears to be as strong or stronger than skew nailing. The effect of a 6 mm check or no check would be that the check allows the nail to penetrate more end grain when straight nailing.

Results for the second series of tests are listed in Table 2.

As mentioned, the number of tests was limited, there being only three specimens per treatment.

Treatments (d) and (e) were well matched for density; air dry density ranging from 0.48 to 0.52 g/cm^3 in both instances. For the remaining treatments however air dry density was within the range 0.60 to 0.70 g/cm^3.

The results are thus best considered in two groups, (a), (b) and (c) together, and (d) and (e) together.

In the first group, the 75 mm hand-driven annular ringed nails gave the strongest joints and in the second group the 100 mm annular-ringed nails were the stronger.

Because of the difference in density of the timber used in testing those two nails, it could not be concluded that the 75 mm nails gave a stronger joint than the 100 mm nail.

With timber of similar density the reverse would be expected.

Considering the second group, (d) and (e), where timber density was well matched, the 100 mm hand-driven nail produced an approximately 20% stronger joint than the 88 mm auto-driven nail.

It is of interest to note that after penetrating a 38 mm "plate", a 100 mm nail penetrates approximately 20% more end grain in the "stud" than an 88 mm nail. The question also arises as to whether the extra strength of treatment (d) over treatment (e) is really necessary. In the light of the joint strengths obtained in the first series of tests with 75 mm x 50 mm material, it appears doubtful that this additional strength is required.

Hand-driven annular ring nails are more difficult to drive than plain shank nails and a further point of interest was in the variation of joint strength with density in these two treatments (see Table 3).

Strength of the pneumatically nailed joints increased with increasing density whereas there was no consistent relationship between density and strength for the hand driven nails.

Table 1

TEST RESULTS JOINT STRENGTHS WITH DIFFERENCES AND MEANS FOR THREE NAILING TREATMENTS. Series 1.

Species	Hand	Auto	Difference +	Difference −
Treatment A 6 mm check Skew Nailed				
Hoop pine	190 kg	127 kg	63 kg	kg
Hoop pine	230	113	117	
Slash pine	144	122	22	
Slash pine	76	70	6	
Forest red gum	293	368		75
Tulip oak	425	406	19	
Southern silky oak	253	251	2	
Satinash	200	260		60
Rose gum (Green)	211	248		37
Tallowwood (Green)	228	130	98	
Mean	226	210	16	
Treatment B 6 mm check Straight Nailed				
Hoop pine	234	233	1	
Slash pine	129	121	8	
Brush box	386	432		46
Forest red gum	670	616	54	
Bollywood	72	117		45
Satinash	382	301	81	
Mean	312	303	9	
Treatment C No check Straight Nailed				
Hoop pine	122	153		31
Slash pine	35	82		47
Slash pine	41	47		6
Brush box	392	420		34
Satinash	262	236	26	
Mean	171	189	18	

Table 2

TEST RESULTS JOINT STRENGTHS WITH FIVE DIFFERENT NAIL TYPES USING 100 mm x 38 mm

Slash Pine Series 2

(a)	75 mm 9 gauge hand-driven jolt head	190 kg
(b)	75 mm 9 gauge hand-driven annular ring	336
(c)	88 mm 10 gauge gun-driven plain shank	205
(d)	100 mm 8 gauge hand-driven annular ring	317
(e)	88 mm 10 gauge gun-driven annular ring	260

Table 3

TEST RESULTS FOR TREATMENTS (d) AND (e) WITH CORRESPONDING AIR DRY DENSITY VALUES

Treatment (d) Hand-driven annular ring		Treatment (e) Gun-driven annular ring	
Density	Joint Strength	Density	Joint Strength
0.48 g/cm^3	232 kg	0.48 g/cm^3	201 kg
0.49	445	0.50	248
0.51	274	0.52	333

Conclusions

From these tests the following observations were made.

1. House frame joints constructed using a pneumatic nailing gun are comparable in strength with those constructed by hand nailing.

2. The pneumatic nailing gun handled relatively dense seasoned hardwoods very well whereas it is usually necessary to pre-drill these timbers before hand nailing.

3. The strength of nailed joints appears to increase with density of the timber and also with seasoned timber.

4. Straight nailing was found to be as strong or stronger than skew nailing. The effect of a 6 mm check would be that it allows the nail to penetrate more end grain when straight nailing.

5. It would appear that quite a large number of currently accepted nailed joints are in fact relatively weak and unless the strength required of a joint has been determined, building regulations could in certain areas be found to be demanding unnecessarily high standards.

NAIL LAMINATION OF UTILITY STRUCTURAL MEMBERS

By D. K. GOUGH

Introduction

Larger size utility structural members such as window heads, bearers, hanging beams, etc. have in the past been installed almost exclusively in the green off saw condition. To season these large sized members, particularly our Australian hardwoods, so as to eliminate shrinkage and also reduce their propensity to sag, is not a practical proposition.

"Stabilised" members can be produced by glue laminating timbers seasoned in smaller sections, or by constructing box beams sheeted with either plywood or hardwood. Both of these products are receiving increasing market acceptance. A third and probably less expensive article, however which has not enjoyed the same acceptance is the nail lamination of vertically oriented laminae.

Pilot testing of miniature nail laminated beams was undertaken in order to evaluate the strength properties of this form of construction.

Method

Two test series were investigated. In the first series each member was composed of equal size full length clear laminae nailed together to produce a cross sectional area of 73 mm x 44 mm.

Matched material was used for all members. Nails were located 12 mm from the margins with the only variable being the distance between nail centres, viz. 75 mm, 200 mm and 125 mm.

The beams were tested in static bending with laminae parallel to the load; loading as indicated in Fig. 1.

In the second series four laminae were used for each member. Small knot defects were allowed and nail espacement of 100 mm was adopted. Material was matched as far as possible and eight members were tested.

The following variables were investigated:-

(a) the effect of one or two butt joined laminae in each member. (Where two butt joins occurred they were spaced 300 mm apart) (Figure 2),

(b) the effect of reinforcing the butt joins with additional nails as indicated in the loading diagram (Figure 1),

(c) the relative positioning of these butt joins with respect to the full length laminae in a member.

Seasoned plantation grown hoop pine was used for both series. Nailing was done with an automatic nailing machine which drove and clenched at both ends, a "nail" of 13 gauge, spirally fluted wire.

Topic 3/9

Results

Series 1

	Distance Between Nail Centres		
	75 mm	100 mm	125 mm
Modulus of Rupture MN/m^2	75.9	70.5	81.34
Modulus of Elasticity MN/m^2	10340	10340	9928

With a total of only three members being tested the variable of nail espacement investigated appeared to have no significance on the values for modulus of rupture and modulus of elasticity obtained.

All values, however, are relatively high when compared with the species mean for clear hoop pine, viz.

Modulus of Rupture	90.32	MN/m^2
Modulus of Elasticity	10470	MN/m^2

given in CSIRO Division of Forest Products Technical Paper No. 25, The Mechanical Properties of 174 Australian Timbers by E. Bolza and N. H. Kloot.

Series 2

While the Modulus of Rupture and Modulus of Elasticity figures obtained in this series are all lower than those obtained with the clear length members in the first series, the Modulus of Elasticity figures are still relatively high and from the Modulus of Rupture figures it could be expected that all members would have a working stress value in excess of F8 (1,250f). Results obtained are listed against diagramatic representations for each member.

No conclusions could be affirmed for any of the variables investigated in this series other than to compare the mean values obtained where applicable.

	Modulus of Rupture MN/m^2	Modulus of Elasticity MN/m^2
Members with two joins	31.5	8687
Members with one join	38.2	9239
Join Reinforced) one) join	41.1	9583
Join not reinforced) only	35.4	8894

Discussion

The purpose of this paper is more to submit evidence that the nail lamination of building components could fulfil a role in the housing industry in this country.

Manufacturers of glue laminated building components are at present producing an extremely good article which is able to command a relatively high price. The greater part of the market can not afford this higher price however, and it is in this remaining sector that the competitors of timber are likely to have most impact.

Seasoning of hardwoods in wide flitches, and thicknesses of 25 mm, 38 mm and 50 mm, prior to resawing has been accepted by a number of sawmillers as a means of reducing distortion and seasoning degrade. A nail lamination production envisages seasoning in the flitch as being the best method for obtaining the basic material.

Nail laminating could be undertaken on site in which case a pneumatic nailing gun would be ideal. Length of nail in this case is limited although to 88 mm.

Factory fabrication however, can be achieved using an automatic nailing machine. Such a machine is available at approximately $16,700, and it is capable of driving "nails" up to 125 mm long. These "nails" are lengths of spirally fluted wire and can be obtained in 9 gauge and 7.5 gauge diameters (approximately) for a cost of 62 cents and 80 cents respectively.

The cost of resorcinal formaldehyde glue per square meter of glued area, applied in conjunction with R.F. curing, amounts to about 43 cents. This same quantity of glue is required in the gluing of a 200 mm x 75 mm window header 3 m long.

It is estimated conservatively that for nail lamination of the same sized member the cost of nails would be 25 cents. The saving here of course is not great and overall savings are not expected to be very large, but capital cost of plant and also manufacturing costs should favour nail lamination.

Details such as the number, spacing and size of nails required in building components designed for a different stress situation would have to be determined and the possibility of butt joins located at other than points of intermediate support would have to be fully investigated.

STANDARDS AND STRUCTURAL TIMBER

by H. KLOOT and W. KEATING

The past two years have seen the publication of a number of significant timber standards, significant in the sense that each reflects a degree of technological sophistication equalling and, in certain aspects, surpassing that of equivalent standards in any other part of the world. In particular, reference is intended to the Light Timber Framing Code, the Timber Engineering Code, and the standards for Glued-Laminated Structural Timber, Mechanical Stress-Graded Timber, a Hardwood Structural Plywood, and for Assessing Metal Fasteners.

It is no criticism of the timber suppliers nor of the timber users that many do not as yet have the necessary knowledge and understanding of these documents to take full and immediate advantage of their provisions. It would indeed be surprising if such were the case when the documents concerned either cover new ground as, for example, the standards for mechanical grading and for metal fasteners, or incorporate considerable advances on anything of comparable nature previously available as do the Light Timber Framing and Timber Engineering Codes.

It is however to be reasonably expected that engineers and architects will soon become familiar with the engineering code which largely parallels the steel and concrete codes. Because the profitability of their operations depend upon it, builders, particularly large estate builders, are familiarizing themselves fairly quickly with the framing code.

It is known that many members of the timber industry have been taking some steps to acquaint themselves with the framing code and no doubt some will also make an effort to examine the engineering and other related codes and standards. However, on past experience it is open to question whether this will be adequate to ensure that within the timber industry there is a wide enough appreciation of these codes and associated standards to enable the needs of engineers, architects and builders to be satisfied and to meet the demands of specifying and regulatory authorities. It is considered essential that these needs and demands be met if timber is to continue to hold its pre-eminent position in the housing field let alone the possibility of a rekindling of interest in timber for larger engineered structures. It would appear that specifying authorities are becoming more and more conscious of standards and the time may not be far off when these authorities will refuse to accept a material that is not in conformity with a recognised standard, and will accept an alternative material that is. Argument based on the past satisfactory performance of similar "not-up-to-standard" material is not likely to carry much weight. In any case, as the standards provide for the efficient use of timber, it is surely in the industry's long-term self interest to take advantage of their provisions.

An editorial in the Forest Products Journal of May 1971 is particularly apt. In this, reference was made to the editorial in another American journal in which the pros and cons of wood and steel framing were discussed. The editor of the original article made the point that "Basic disadvantages of steel are linked with technological problems while those of wood involve problems in marketing and pricing". The Forest Products Journal editor posed the question "Which industry can solve their problems first?" He wonders "what the outcome may be when the research power of the steel industry is weighed against the seeming inability of the timber industry to control price spiralling in the face of increased demand".

In the Australian context, one might well question the outcome in the light of the industry's apparent inability with one or two outstanding exceptions, to supply material with adequate quality control, i.e. graded timber, and the very necessary back-up of technical information that would ensure proper usage for satisfactory service. It is relevant to note that the timber engineering code specifically excludes the use of ungraded timber. On the other hand, it was deemed necessary to include a clause in the light timber framing code to provide for the use of ungraded timber otherwise the code would to all intents and purposes be of little or no practical value at the present time. There is already evidence that authorities who administer building regulations will eventually insist on graded and branded timber in addition to the other code requirements.

Bad building practice is not uncommon. Indeed in this day and age there is far too much of it. Hopefully, the Light Timber Framing Code will go some way towards helping to reduce it. But again with one or two exceptions, there appears to be little done by the timber industry to provide a service to builders, architects and engineers, a service based on the immense amount of technological information freely available to the industry, a service designed to encourage good building practice and improve the image of timber as a structural material vis-a-vis its competitors.

Even if one discounts the out-worn cliché regarding the aesthetic appeal of wood, there is no doubt whatever that timber has tremendous advantages over other materials. It is a renewable harvest. It is a familiar material; it is easy to handle and to work, and is tolerant of a wide range of conditions. To many, its main advantage is its flexibility in being able to be modified on site, to allow alterations to be readily made at some later date, and to accommodate customer preferences. A high proportion of timber in a structure is usually recoverable on demolition, and the balance is readily degradable. Throughout history, timber has an excellent record as a structural material, particularly for framing.

It can be truthfully said that the breadth and depth of technology available in timber is as great or even greater than for any other competing material in the housing field or for that matter in the structural field generally. Yet in spite of all this, there remain amongst many engineers and architects strong reservations against timber as supplied in regard to its reliability as a structural material. Whilst undoubtedly some of this prejudice stems from ignorance, it mostly arises from unfortunate experiences created by a lack of responsibility on the part of timber suppliers, a responsibility to supply material to recognized standards and to provide technical information to ensure that the material supplied is used in the best possible way. There seems little doubt that, if there were a cost advantage no matter how slight, a significant number of builders would switch to another material once any technological problems associated with that material have been solved to the satisfaction of regulatory authorities.

It would be improper to suggest that the outlook for timber in structures over the next quarter of a century was bleak. Equally it would be wrong to adopt a highly optimistic and complacent attitude.

By now the reason for raising this topic at a Forest Products Conference should be obvious. The cost of research to refine the framing and engineering codes even further and to perhaps develop new structural systems is not small. Unless the wealth of technology already available is adequately made use of, and it is recognised particularly by the industry

that quality control of timber as a material and of the structures into which it is built is essential, then the continued high level of expenditure on structural timber research is open to question. It could well be argued that so far as the housing field is concerned, greater benefits to the overall economy might accrue from redirecting the research potential to other facets of the total house structure rather than continuing to concentrate on the timber frame.

It is not proposed to detail here the steps that might and should be taken by the industry itself to upgrade timber as a structural material in the minds of builders, architects and engineers. It is intended simply to emphasize the point that on performance and on the technological information available timber is a first rate structural material. It is believed that the stage has been reached where its continued image as a second-rate building material and a "near-enough is good enough" approach will in the very near future lead to not just token but real and active competition from other materials.

PREPARATION OF PROPOSED AUSTRALIAN STANDARD FOR STRUCTURAL GRADE PARTICLE BOARD

by A. STASHEVSKI, N. H. KLOOT and K. F. PLOMLEY

Particle board has already found a large market in building and construction. This is largely due to a number of desirable properties it possesses which may be worthwhile to list at this stage:-

Availability in large sizes

Improved flatness

Easy machining with hand and power tools

Small and isotropic hygroscopic movement in the plane of the board

Tight dimensional tolerances

Comparatively good strength properties for its density

Unlimited supply of quality, well controlled product

Competitive price

So far the Australian particle board industry has very thoroughly investigated the building and construction market and has established itself primarily in non-structural interior applications, such as partition walls, furniture just to mention a few. Despite its relatively short history in Australia, particle board is well accepted, a fact which can be largely attributed to the intensive product development program which the industry has maintained in the last ten years.

For a number of reasons the industry is now attempting to penetrate the building and construction market still further, into new areas of use where boards will carry loads, often in situations where extreme moisture content changes or direct wetting will occur.

The industry has selected the lucrative flooring market as its first structural marketing objective and seeks acceptance for its product in building codes and regulations.

Acceptance of a building material for structural applications requires a knowledge of long term material performance under adverse climatic and building site conditions, which in the case of particle board is so far not available in Australia and only to a small degree in overseas countries.

Although particle board possesses mechanical strength properties which in short term loading are at least comparable with other building materials and are certainly adequate for economical use in building and construction, doubts exist whether the strength can be maintained when boards are exposed to prolonged wetting, to repeated extreme moisture content changes and above all to mechanical stressing during repeated moisture content changes and wetting.

Most of the particle boards manufactured in Australia, which have a structural use potential, are of three layer construction and are bonded with urea-formaldehyde adhesives. Boards bonded with phenolic type of adhesives are relatively new on the market.

Earlier work in this Division and also in some overseas laboratories has shown that urea-formaldehyde type of adhesives is not suitable for structural types of plywood or timber laminates.

This work has shown that urea-formaldehyde resins have a low resistance to high moisture content conditions which may result from direct wetting or prolonged exposure to high humidity atmosphere. In the presence of moisture urea-formaldehyde resin is subject to hydrolysis which leads to bond failure. Hydrolysis is usually accompanied by the release of unpleasant formaldehyde vapours.

Recent work by the Division of Wood Technology has confirmed the relatively poor performance of urea-formaldehyde bonded particle board under very damp sub- floor moisture conditions.

Melamine formaldehyde resin, which is often used to increase moisture resistance of urea-formaldehyde adhesives, is also subject to hydrolysis in the presence of water or high humidity, although at a much slower rate.

A further disadvantage of urea-formaldehyde adhesive is its low resistance to higher temperatures which becomes apparent at about 140°F. The effect of higher temperatures is destructive even in dry atmospheres, but is much more pronounced at higher humidity.

Particle board manufacturers have recognized the deficiencies of urea-formaldehyde adhesives for a long time, but rather than change to other adhesives they have preferred to add hygrophobic paraffin wax emulsions to reduce board hygroscopicity and thus reduce water uptake. This system is particularly effective when boards are submerged for a short time in water. Prolonged soaking in water will leach the waxes from the board structure.

So far only phenolic types of adhesive including alkali catalyzed synthetic phenol-formaldehyde, resorcinol-formaldehyde and tannin-formaldehyde have proved themselves in commercial practice and provide a satisfactory water and temperature resistant structural bond with a good long term performance expectancy.

These findings have been largely confirmed for commercial particle boards manufactured in Australia.

Although the adequacy of phenolic type adhesive for structural uses cannot be questioned as well as its superiority over urea-formaldehyde with or without melamine fortifications, two questions remain still open:-

(a) whether urea-formaldehyde type of particle board bond with paraffin wax emulsion protection is adequate for some of the structural uses and, if so, what limitations must be imposed upon its use

(b) whether apart from adequate bond there are other manufacturing factors which will affect the long term performance of particle board in structural applications.

Since there is insufficient practical evidence available, special research projects have been initiated in DBR to provide answers to these questions. It is realized that it would be difficult to provide complete answers experimentally, because it will be necessary to predict long term board behaviour using arbitrarily selected tests which will simulate conditions of use projecting some 50-70 years lifespans.

In the current work two approaches are used:-

(a) Ageing studies which are conducted at temperatures of 40°C and 100°C and which include drying and wetting cycles in oven at 105°C and in boiling water, in humidity controlled rooms and in water bath at 40°C.

This work shows that it is possible to produce boil-proof bonds which, even after seven cycles of alternating boiling and oven-drying, will still retain 50 per cent of the original strength in bending.

Some of the urea-formaldehyde bonded boards have already begun to lose strength after six cycles in humidity rooms operated at 40°C and alternating between 25-90 per cent R.H.

(b) Fatigue test incorporating reciprocating four point bending stress with simultaneous humidity changes and conducted at approximately 180°F and 70 stress cycles per minute.

This type of test, which is unique in particle board research, has already shown that a satisfactory glue bond is not the only criterion controlling the long term structural performance of particle board. It has been shown that even a well bonded board with phenolic type adhesive can perform poorly and give fewer stress cycles before failure than an average urea bonded board.

This investigation has drawn attention to particle geometry and to the relative proportions of surface and core particles.

Although this work is still far from being completed, some conclusions are already emerging in respect of the proposed Australian standard. It is probable that the standard will include the following requirements:-

(i) Bond quality

Bond "A" - permitting unrestricted use of particle board in most situations.

Bond "C" - Restricting board use to specific sheltered situations.

(ii) Thickness stability - setting out reasonably tight limits on thickness movement between 0 per cent moisture content and saturation.

(iii) Strength fatigue limit - requiring a certain number of stress cycles before failure.

(iv) Concentrated loading - requiring certain strength and stiffness limits.

(v) Free formaldehyde - requiring a certain formaldehyde vapour emission limit.

Under consideration also are mechanical strength requirements for different board thicknesses, ageing performance based on special accelerated tests, moisture absorption and industrial quality control scheme.

STUDIES OF TIMBER STRUCTURES

a. DEVELOPMENT OF A NOVEL SYSTEM FOR DOMESTIC TYPE CONSTRUCTION

By H. KLOOT

1. Background

Over the past several years, there has been a rapid increase in the development of types of building panels and of systems for utilizing these panels in domestic and similar small building construction. Generally these panels are limited in size to the length and width of the sheathing material as, for example, the size of a fibro-cement sheet. The need for a greater degree of expertise than is generally available in the on-site labour force tends to reduce the attractiveness of panelized construction and the possibilities of cost savings. Furthermore, at present most of the types of panels produced are intended primarily for walls and are not generally suitable for use, say, as floor panels. These, together with associated problems, presently prevent this form of construction making any significant inroads into the field of house construction.

The thinking behind the scheme outlined below envisages the factory manufacture of plates of a width at least two to three times the normal panel width thus materially reducing the number of joints to be made on-site. The proposed scheme conceives of one type of panel only, a panel which will serve as the basic structural element in the floor, wall, ceiling and roof. As the core of the panel or plate is a wooden grid, the scheme is expected to retain most, if not all, of the advantages the present light timber frame has over competing materials. Structural plywood is used to sheathe the plate on one side, except for panels used for internal walls which are sheathed on both sides.

The basic panel is 2400 mm in length, and in six widths, 900, 1200, 1500, 2400, 2700 and 3600 mm. It is believed that all but the most exotic of house plans can be matched with this limited range of panel sizes.

The system is the subject of a patent application by CSIRO.

2. Basic Thesis

A house is a box-like construction. Its floor, walls, ceiling and roof systems may be considered as flat plates. Ideally, one basic element, i.e. flat plate, can be used for all of the systems, the differing strength and stiffness requirements being met by differing support spans, and the differing resistance to concentrated loads being met by different sheathing materials.

3. Implications of Idea

(a) On-site labour saving

Because the elements would be factory-produced, the on-site labour would be restricted to fastening the several plates together instead of the usual handling and fastening of every single piece of scantling. Even the largest of the basic panels (2400 x 3600 mm) can be readily handled and requires no specialized equipment for placing it into position.

(b) Jointing

The fastening of the plates to one another is achieved using a single type of joint designed to minimize variation in quality of workmanship.

(c) Use of ungraded (or low grade) material

Because of the greater load-sharing potential in the grid system of the panels only a minimum amount of timber grading will be required.

(d) Use of seasoned timber

Because the timber sections proposed are small (not exceeding 20 mm in thickness) use of seasoned timber would be economically practicable thus reducing or eliminating problems arising from the use of green timber.

(e) Reduction in quantity of timber

Although no immediate savings in amount of timber in floor, wall or ceiling are expected, the use of the folded plate construction for the roof system would result in a significant saving.

(f) Class of structure

In purely domestic construction, the basic element could be used for high quality construction (with brick veneer or other high class sheathing) or for low cost housing, the standard depending only on the sheathing not on the structural element.

(g) Inspection

Apart from the quality control that would be expected to be exercised in the factory, on-site inspection of the structure would be greatly simplified.

4. Present Position

A full-size prototype covering an area of 53 m^2, and representing approximately one-third of an average size house, was constructed for the purpose of assessing and solving practical problems associated with the assembly and subsequent finishing.

To the present, no attempt has been made to develop a new type of sub-floor support system. The panelised structure can be erected on a concrete floor or, as was the case with the prototype, on a conventional stump and bearer support system. One point of practical importance learnt in erecting the prototype is the need for the sub-floor supports to be perfectly level to ensure that the plates at wall junctions and at junctions of the walls and floor are at right angles.

Given level support, the assembly of the box comprised of floor, walls (both external and internal) and ceiling is of the utmost simplicity. The ordinary gable roof presents no problem, and cutting at the correct angles of plates to form a hipped roof can be reduced to fairly straightforward factory procedure. The cutting of openings for windows and doorways is easy and can be done either in the factory or on-site.

5. Projected Developments

A second prototype of approximately 56 m^2 has been erected both for demonstration purposes and to enable various aspects of the finishing to

be studied. To date, the following areas have been examined and although firm proposals are perhaps premature, the results appear promising:-

Flooring - The laying of 8 mm thick plywood on top of the plywood skin of the floor panels appears to be sufficient to provide the required puncture resistance and general structural performance for a domestic floor. This plywood flooring may be glued down but the glued joint is not structurally critical.

Internal walls and ceiling - Three qualities of finish are being examined. For emergency housing, an adequate finish would appear to be achieved by painting the plywood skin of the panels. Applying a heavy paper to skin before painting appears a possibility for minimum cost housing. On the other hand, the gluing on of 3 mm cellulosic asbestos board not only improves the fire-rating but provides an excellent painting surface and a wall with a resistance to damage by puncture somewhat superior to fibrous plaster and plaster-board.

External walls - Again, three standards of finish are envisaged, although work in this area has not proceeded far as yet. A brick veneer could provide the first class external finish. The mock brick veneer sheeting is also a possibility. Fibrocement sheeting could well be used for a low-cost house, and C.C.A. treated plywood would probably be adequate in the case of emergency housing.

Roof - Tiling or sheet roofing could be applied more or less in the conventional manner. However there appears to be scope here for the development of a lighter roofing than tiles yet a more attractive one than the presently available sheet roofing.

Consideration has already been given to the requirements of other trades, the plumber and the electrician, and no insuperable difficulties are foreseen. As far as is practicable, it is proposed to avoid the need for broaching the fabric of the structure by using joinery of special section designed to provide channelling for services. Where broaching is unavoidable for waste pipes and the like, it is not believed that the strength and stiffness of the panels will be seriously affected. However special attention will be paid to this aspect.

Of all the problems with this system that have so far been anticipated, only one is the cause of some concern. This is the problem of construction in wet weather. The conventional house frame can be left standing for days or even weeks in wet weather without any significant problems arising from this exposure. Serious problems could develop with the panelised structure if exposed to rain before the roof was erected and the roof junctions capped. Except to recognise this problem, no serious thought has yet been given to its solution.

6. Potential Savings

A preliminary estimate indicates that the cost of this panelised construction would compare favourably with traditional framed construction. However, it has not been possible to allow for the likely savings flowing from the mass production of the panels. It is believed these could be quite significant.

With the foundations prepared, it is believed that a 4-man team could erect the full fabric of a 12-square house in 2 to 3 days. Indirect savings might be expected in that the work of other trades could be commenced within one day of the start of erection.

Savings might also be expected from the limited range of material required in the panel fabrication.

7. Reason for Patent Application

Traditional framed construction involves a large on-site "quality of workmanship" (or rather "lack of quality of workmanship") factor which to a significant extent negates the advantages to be gained by the application of technology based on some 40 years of research. By taking the fabrication of the structural elements into the factory, the quality of workmanship can be more strictly policed by appropriate inspection procedures.

Fabrication of the basic panel is relatively easy and well within the capacity of even backyard operators. It is not suggested that, in the long term, small firms should be precluded from using the scheme, or that even a do-it-yourself approach would not be practicable. It is however considered necessary and desirable that in the early stages only those concerns with adequate technical facilities and expertise and able to institute proper inspection procedures be allowed to exploit the scheme to ensure appropriate standards of manufacture are met that will facilitate acceptance by regulatory authorities of this scheme as an alternative to traditional framed construction.

b. IMPROVEMENTS IN TIMBER FRAMED HOUSING

By R. N. BOURNON

Work on this project was initiated after talks between the (Victorian) Timber Promotion Committee and the Division of Building Research CSIRO, where the opinion was formed that an attempt should be made to improve the value of the timber house frame for the benefit of the buyer, the timber and the building industries. In particular it was felt that better use could be made of dry hardwood than by merely substituting it for green hardwood of similar sizes in the walls only. If possible the timber industry wanted a significant reduction in the number of scantling sizes used.

A close inspection had been made during 1970-71 of more than 50 houses in various stages of completion all within 30 miles of Melbourne and in them hundreds of instances of poor detail construction had been found, many of which could be expected to cause trouble in the house at some time. Few people, except plasterers, would admit that such faults did occur and they preferred to accept them, at some expense to themselves rather than complain, for fear of losing business. The general opinion stated was that any troubles that did occur in a new house (such as cracks in brickwork or plaster, opening joints between eaves or gable linings and the brickwork, distortion of door and window frames, or loss of alignment of floors, walls, ceilings or roofs) were caused mainly by the shrinkage of green timber in the frame. Apart from several Council building surveyors, a curious lack of concern was shown over the obvious failure of the foundations of some houses to remain unmoved, adding to the effects of the other faults.

Another possible cause of deterioration in houses is that the effects of high winds can aggravate those of poor construction. It is a fact that high wind-forces sometimes strike and demolish houses and it is obvious that a much larger number of houses must suffer wind forces nearly as high. Racking tests carried out from time to time by the Division on house frames and individual cross walls (all without any obvious construction faults) have shown that deflections measured at the top plates can be large enough at some points for some damage to be extremely likely. If these test walls had had faults similar to some commonly seen, permanent deformation would certainly have resulted.

The real concern that owners feel for the faults that appear in the first few years is hard to gauge and there is a tendency to accept some of them as inevitable; nevertheless, many of the faults listed above can be seen during even a casual inspection of almost any two to five year old suburb. Questions about the direction research and development should take produced a nearly unanimous plea simply for the reduction of costs.

Against this background the project was planned to attempt to satisfy the following aims:-

1. The cost of the house carcass should be significantly reduced.
2. The foundation system should be suitable for brick veneer, adapt to any soil type, and have a predictable performance.
3. The frame should have a stronger and more rigid coupling between roof, walls (including brickwork) and floor, also stiffer wind bracing, it should be more accurate and dimensionally stable, and should encourage or perhaps demand more care in construction. The roof structure should be independent of internal walls, adaptable to hips or gables and to any outline in plan.

4. The number of timber sizes should be a minimum and correctly sized to suit mixed hardwood species down to building grade of strength group S4.

5. The frame must be able to be cut and put together completely on site.

Many new ideas were considered, some were tested individually in the laboratory and those that seemed satisfactory were built into a test frame where their interaction with each other was measured and their practicability assessed. Opinions were sought from the building and supply industries, and from these, together with our own experience, the doubtful features were rejected. The final test frame, which has been broken and repaired many times, is available for inspection for the duration of this Conference. A house of 13 squares is being built in the open at Highett by tradesmen as a feasibility and cost study and test of the acceptance by other trades of the various features included.

Foundations

The new system consists of preservative treated timber piles about 5 in. diameter of either hardwood or softwood, driven with a tractor mounted driver, such as is used for farm fencing. The piles are driven to a depth where effective support and freedom from the effects of ground heaving can be assured, so far this has varied from 5 ft in clay to 14 ft in a marsh. For brick veneer walls, factory made prestressed concrete T-beams span about 10 ft between piles to carry the walls, floor and roof. Similar beams up to 15 ft span or shorter timber bearers can be used for the inner floor support. Beams can be either above ground, where several courses of brick can be saved or below ground where they replace the normal strip footing but where provision must be made to prevent uplift due to ground swelling.

Interest has been shown in several quarters in the system for foundations in difficult sites where the firm bottom is overlaid by unsatisfactory filling or by loose or saturated soils. Rising land prices has brought many such blocks on to the market and the very considerable expense of deep strip or pier and beam foundations can be considerably reduced with timber piles. A brick veneer house with a green hardwood frame is now under construction at a Seaford site where 14 feet of saturated silty clay overlays a firm sand bottom and where a concrete slab of ordinary proportions was thought to be unsuitable. A weatherboard house is being built on piles driven at stump spacings into loose rocky mountain soil and considerable savings achieved over an adjacent house with concrete stumps set in holes dug by hand. Long and short duration trials are being done in both clay and sandy soils around Melbourne to test the assumption that this system can provide more reliable and more economic foundations in any situation.

The Timber Frame

The use of dry hardwood rather than green for framing has always appeared as a potentially more efficient use of material and labour, notwithstanding its higher unit cost. The actual material cost of a frame will be higher unless the quantity of timber is reduced accordingly and this can only be done by a reduction in thickness because the reduced depth of say a 4 or 5 in. deep dry hardwood member due to shrinkage and straightening by machining will always more than cancel its intrinsic increase in strength and stiffness. The economic use of dry hardwood in framing then, depends on the use of members about one inch thick. Drying costs, of course, also favour the thinner material. The maximum recovery of sawn timber of a given grade would probably

produce a range of widths with the greatest quantity as 4 inch and with 7 inch as the largest convenient size. The framing system adopted has been designed to use mainly 4 x 1 inch with about 5% of 6 x 1 inch in the floor structure, all specified as a minimum of building grade strength group S4, i.e. 1250f before drying.

Opinions have been given that edge nailing into inch timber will not be done reliably with average workmanship but, as with the related opinion that development should be directed towards accommodating a lower level of skill, this does not seem likely to lead towards the desired aims - one inch timber can be edge nailed with reasonable care. An argument often used by framers is that low quality timber, particularly excessive spring and uneven sizing, makes accuracy impossible and care in workmanship difficult to maintain. The lightweight, straightened and correctly gauged timbers specified in the proposed system should encourage better workmanship and given familiarity with the system, the less sorting of sizes and heavy lifting required should result in an increased output. The weight of the test frame when erected was only one-third of its conventional equivalent.

Timbers of 12% and 20% moisture content (air-dried and reconditioned where necessary) were used in the test frame with little noticeable difference except the lower cost and slightly easier nailing of the latter. The advantages of applying loads to timber only after it has reached equilibrium moisture content are stronger nail holding and less sag in members. These can be gained with the thinner 20% m.c. timbers in most weather conditions by the further drying of the frame that will occur naturally before use - in our experience without significant loss of alignment. The ability to fabricate the frame wholly on site was demanded and has been maintained, nevertheless, the advantages of precutting at least the studs and prefabricating the glue nailed roof beams should be seriously considered.

Costs

The costs of foundations and frame for a 14½ square B.V. house built

(1) to the proposed system,

(2) to the SAA Light Timber Framing Code CA38, and

(3) to the sizes and spacings normally used with green hardwood

are shown below:-

	Inch dry (1)	CA38 (2)	Conventional (3)
Foundations			
Materials:	$	$	$
24 piles, 180 ft concrete beams.	410		
Strip footings, 30 stumps,			
24 in. high brickwork.		480	520
Labour	180	260	280

Topic 3/12

Frame

Materials:

Floor 1450 sq. ft	140	150	160	
Walls 350 ft	240	300	400	
Roof 1800 sq. ft	200	300	380	
Total timber	580	750	940	
Labour	350	450	560	
Total	$1520	$1940	$2300	

The prices of materials for the inch frame are based on quotations obtained in November 1972. Framing labour is taken as the same rate per lineal foot for 4 x 1 in. dry as for the 4 x 1½ in. equivalent of the green timber used in the conventional frame.

Conclusion

It is too early to say whether the overall concept behind the project has been fulfilled, indeed this judgement must be made by others but in so far as can be assessed by laboratory tests and our own experience up to the time of writing, each of the stated aims has to some extent been met. At least it has been shown that the timber house frame is capable of further development without recourse to unconventional materials.

APPLICATIONS OF FRACTURE MECHANICS IN THE TIMBER ENGINEERING CODE CA65

by R. H. LEICESTER

1. Introduction

During the past decade, an area of structural theory, termed "linear elastic fracture mechanics", was developed to cope with certain design aspects of structures made from high strength metals. Essentially this theory concerns the relationship between fracture strength and the computed theoretical stress intensity at the roots of sharp notches. The results of a few ad hoc tests at the Forest Products Laboratory in 1968 indicated that the theory would also be extremely useful for predicting the fracture strength of timber structural members and consequently an extensive test program was then initiated to obtain the information required to make use of the theory of fracture mechanics in drafting the first Australian Timber Engineering Code AS CA65 (Ref. 3). The method of application of fracture mechanics theory has been described elsewhere (Ref. 5). In the following, some of the more significant implications that arise from the use of this theory will be discussed. It is worth noting that CA65 is probably the first structural code of any building material that applies the theory of linear elastic fracture mechanics.

2. Notched Beams

One of the most significant predictions of fracture mechanics theory is that the nominal stress at fracture of notched members decreases as the size of the member increases. An example of this phenomenon is illustrated in Fig. 1. It is obviously very dangerous to neglect this size effect, but currently only the Australian code CA65 recognises it.

3. Glued Lap Joints

Although it has been known for some time that the conventional assumption of taking the strength of glued lap joints to be proportional to their lengths is not correct, it has been difficult to make firm design recommendations for these joints due to the absence of a satisfactory structural theory that related joint strength to joint geometry. Now however a suitable theory is provided by the use of fracture mechanics. As shown in Fig. 2 this theory, which is applied in AS CA65, provides a good criterion for joint strength. Another feature contrary to the conventional assumptions is that, as for the case of a notched beam, the fracture criterion predicts an effect of size on the strength of glued joints.

4. Glued-Laminated Beams

The theory of linear elastic fracture mechanics provides an extremely simple and accurate method (Ref. 5) for predicting the strength of laminated beams containing butt joints. It has been found that for the typical structural application of Australian timbers, deflection criteria

govern the design of beams and that as a result of this, butt joints may be placed in the top 60-70% of the beams without necessitating an increase in member size. It is to be noted however that beams, tailored in this way for a specific end use, do not have the same strength to stiffness ratio as solid timber; consequently the use of such glulam cannot (without difficult modifications) be specified by tables such as those in the Light Timber Framing Code which have been computed for solid timber members.

The acceptability of butt joints in glulam means that it is possible to manufacture beams without the necessity of purchasing expensive end-jointing equipment. At least one major Australian fabricator now does this. A further useful feature arising from the use of fracture mechanics theory in the derivation of design formulae is that it allows a much closer spacing of butt joints than has previously been permitted by design codes. Fabricators particularly are appreciative of this feature as they have experienced considerable difficulties in the past in meeting the minimum spacing tolerances in random lay-ups.

5. Microlam

In contrast to the methods used in other codes, the fracture mechanics approach of AS CA65 predicts that the tension strength of laminated timber increases with decreasing thickness of laminations. This phenomenon, illustrated in Fig. 3, immediately suggests the possibility of up-grading poor quality wood, especially the softwood species, through the laminating of veneers to form high strength beams. This is currently being done in North America (Ref. 1, 2 and 4). It is of interest to note that 2 years ago extremely long microlam beams containing butt-jointed veneers were fabricated with the use of a continuous laminator that was on trial at that time at the Forest Products Laboratory of CSIRO (Ref. 6). Probably more attractive to most Australian fabricators however, is the possibility of fabricating large high strength beams through laminating low quality veneers with cold setting glues.

6. Conclusions

The several examples discussed illustrate the advantages to be obtained through the application of the concepts of fracture mechanics in timber engineering codes. Probably of most direct benefit to industry is that by clarifying the fracture process, the theory of fracture mechanics indicates a method whereby the fracture strength of timber can be increased. The use of this method, the microlam technique, could contribute significantly to the utilisation of low grade timber.

7. References

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LOAD SHARING PROPERTIES OF SOME AUSTRALIAN STRUCTURAL TIMBERS

by R. H. LEICESTER and G. F. REARDON

1. Introduction

In drafting the first Australian Timber Engineering Code, AS CA65-1972 (Ref. 2), the topic of load sharing factors for multiple element timber structures was the subject of considerable discussion. Difficulties in the choice of load-sharing factors arise from the fact that they are not only a function of variability and load-deformation characteristics of the timber, but also of such man-introduced factors as the choice of method of grading. The decision was made to use factors similar to those recommended in codes of other countries (e.g. CP112, Ref. 1), but several members of the drafting committee felt that experience with local timbers, and in fact even some of the published research overseas (Ref. 3), indicated that the chosen factors may be too conservative for some situations. Consequently it was decided to measure the load-sharing characteristics of some Australian structural timber.

2. Test Material

The following four sets of timber scantling were tested:

(i) Kiln dried, pith-in, slash pine (*Pinus elliottii*), kindly donated by the Queensland Pine Association.

(ii) Kiln dried, 800f grade radiata pine (*Pinus radiata*), kindly donated by the Radiata Pine Association of Australia.

(iii) A mixture of Standard and Select engineering grades of green messmate stringybark (*Eucalyptus obliqua*).

(iv) Mixed green Victorian hardwoods, ranging uniformly from Reject to Select grades and typical of the building scantling used in Victoria. This material was kindly donated by the Victorian Sawmillers' Association.

The sample size for the mixed Victorian hardwoods was 50 and for the other sets was 200. Scantling sizes were 70 mm x 45 mm x 1.4 m long for the slash pine and 100 mm x 45 mm x 2 m long for the other sets.

3. Laboratory Test Measurements

Two samples were taken from each set of timber scantling. One of these samples was tested under centrepoint loading and the other under third point loading. The latter test was intended to simulate conditions for a uniformly distributed load. In all tests the load deformation curves up to failure and well beyond it were recorded. As illustrated by the typical load-deformation curves shown in Fig. 1, the dried pines represent material with "brittle" load-deformation

characteristics, whereas the higher grades of green hardwood have "ductile" load-deformation characteristics. It was found that the mixed Victorian hardwoods contained both brittle and ductile scantling.

4. Load Sharing Factors for Nailed Vertically Laminated Timber

Vertically laminated beams are representative of the most favourable load-sharing conditions. The strength of such beams, when made with the test scantling, can be derived quite simply as follows: since all elements in a vertically laminated member must deflect together at the loading points, then the load carried by the member at a specified deflection is the sum of the loads carried by each of the elements at that deflection in the laboratory tests. Hence with the aid of a computer, the load deflection characteristics can be obtained for a population of laminated beams with each beam made up of elements selected at random from the original laboratory test samples. The results of such a computation are given in Tables 1 and 2. About 2000 members were computed for each sample of laminated beams.

In Table 1, the load-sharing factor given has been defined as the ratio between the 5-percentile value of the modulus of rupture of the population of laminated beams in comparison with that of the population of scantling from which the beams were fabricated. The 5-percentile value was chosen to make the comparison as (with the exception of the English and Australian timber codes) this appears to be the value recommended internationally in structural codes for characteristic strength. It is seen that the results of the tests do not provide grounds for increasing the load-sharing factors in CA65. In the USA, Zahn (Ref. 4) obtained similar factors for structural grades of southern pine and Douglas fir.

Further insight on load-sharing in timber structures can be obtained through a comparison between the test results and the model used to obtain the factors given in CA65. This model is based on elements with elasto-plastic characteristics, having a normal distribution of strength with a coefficient of variation of 14%. The predicted coefficient of variation of the 5-lamination beam made from these elements is 6%, a reduction from 14% by a factor of $\sqrt{5}$. It is this reduction in variability that leads to upgrading of the lower tail of the strength distribution curve and hence an increase in permissible working stress. The coefficients of variation given in Table 2 indicate that not only is the variability of graded Australian timber often far greater than that used in the model, but that the reduction of variability due to laminating is less than that predicted by the model. In the light of these results, it is suggested that the model used for CA65 be regarded essentially as a method for interpolating rather than a true model for timber.

5. Load Sharing Factors for Beam Grid Systems

Grid systems are considerably more complex to analyse than laminated beams and a discussion of these systems is outside the scope of this paper. Briefly, however, the analysis of grid systems made up from beams of the test scantling leads to the following general conclusions:

(i) For uniformly distributed loads on typical grid systems, the load-sharing factor k_g of CA65 (Clause 2.4.5.2) is not conservative.

(ii) For point loads, CA65 errs on the conservative side in not providing a load-sharing factor analogous to k_9. This factor is required in addition to the load-shedding factor C_4 given in Clause 3.2.7.

6. Conclusions

Load-sharing factors computed from the measured load-deformation characteristics of four typical Australian structural timbers indicate that in general the Australian code AS CA65 is not conservative in its recommendations in this regard. One possible exception is the omission in the code of a load-sharing factor for the effect of concentrated loads on grid systems.

7. References

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Table 1

LOAD SHARING FACTORS FOR VERTICALLY LAMINATED TIMBER

TIMBER	LOAD SHARING FACTOR			
	N = 2		N = 5	
	Centre point load	Third point loading	Centre point load	Third point loading
Dry slash pine	1.15	1.12	1.25	1.22
Dry radiata pine	1.10	1.10	1.22	1.19
Green messmate stringybark	1.09	1.03	1.12	1.11
Mixed green Victorian hardwoods	1.10	1.10	1.16	1.17
AS CA65 (Clause 2.4.5.3)	1.14		1.26	

N = Number of laminations in a beam.

Table 2

COEFFICIENTS OF VARIATION

TIMBER	COEFFICIENT OF VARIATION, %			
	Centre Point Loading		Third Point Loading	
	N = 1	N = 5	N = 1	N = 5
Dry slash pine	37	20	41	22
Dry radiata pine	35	19	33	18
Green messmate stringybark	13	8	15	10
Mixed green Victorian hardwoods	16	9	19	11
Model for AS CA65	14	6	14	6

N = 1 Refers to scantling.

N = 5 Refers to vertically laminated timber beams having 5 laminations each.

THE EFFECT OF DEFECTS ON THE STRENGTH OF STRUCTURAL TIMBER

By W. J. SMITH

The strength-reducing effect of defects evaluated in work done many years ago on Douglas fir has, it is understood, generally provided the basis for framing visual grading rules for structural timber in Australia, both softwoods and hardwoods.

These early results have also apparently tended to be conservatively applied, from a comparison of approximately equivalently stress-rated grades in (a) the grading rules of the U.S.A. Southern Yellow Pine Lumber Association and (b) A.S.O. 107, covering Australian-grown softwood framing other than radiata pine. For a particular stress-rating (e.g. 1,200/1,250 f.) in the same species of timber, the former allow (a) larger knot size; (b) unlimited pith and sound heart; (c) steeper slope of grain and (d) more wane compared with the local rules.

In particular, pith and sound heart appear to have been unnecessarily heavily penalised in general framing in Australian grades, to the point of exclusion in all but the lowest rated stud grade and all sizes narrower than 9" in general framing grades in radiata pine.

Mechanical stress-rating of seasoned 4" x 1½" slash pine in Queensland, more than 70% of which contained pith, showed that 92½% graded 1,250 f (F8) or better (some of it 1,600 f (F11)) and the remaining 7½% 800 f (F5), with no capacity in machine setting for separating 1,000 f (F7) material.

Finger-jointed seasoned hoop pine studs, largely of pith-in material, also consistently proof-test at 1,250 f (F8) in commercial production at one installation.

It is suggested there is an urgent need for work to determine quantitatively, for the major Australian-grown species or species groups, the strength-reducing effect of particular defects to determine any inter-specific variability in effect, to allow the preparation of more soundly based structural grades and prevent unnecessary waste.

In particular, comparative evaluation of U.S.A. and Australian assessments of the effect of pith, heart and knot size in the yellow pine group would be most interesting.

Topic 3/16

SUB-FLOOR VENTILATION OF OLD AND NEW BUILDINGS

by E.W.B. Da Costa

Summary

Pending more objective research data, the interim adoption of a high standard of sub-floor ventilation (e.g. that in the SAA Light Timber Framing Code) is advisable, together with increased use of soil cover, especially in remedial work. Prediction of the probability of condensation occurring with various methods of ventilation in various environments appears to involve problems closely analogous to those of atmospheric physics and air conditioning, and the requisite calculations and experimentation should involve collaboration in these fields.

This topic has been discussed at previous conferences and elsewhere over many years but little advance has been made. There are still many conflicting recommendations and specifications for sub-floor ventilation in use in Australia, all based on traditional practices or on arbitrary judgments, rather than on quantitative data. The SAA Light Timber Framing Code (AS-CA3B, 1971) recommends provision of 0.5 in^2 unobstructed vent space per 1 ft^2 of sub-floor area (equivalent to 90-110 cm^2 per metre of perimeter wall or to a stamped metal vent every 1.5 metres). At the other extreme, some N.S.W. specifications call for two terracotta vents per room, which would probably give 10-25 cm^2 unobstructed vent space per metre of external wall. Overseas specifications show a similar diversity, with North American recommendations often higher than either of those quoted. It is possible to construct any number of different formulae based on wall length, sub-floor area or a combination of both and correcting for climate, local topography, prevailing winds and so on, but in the absence of data on which the effects of these can be quantified, this is rather an academic exercise.

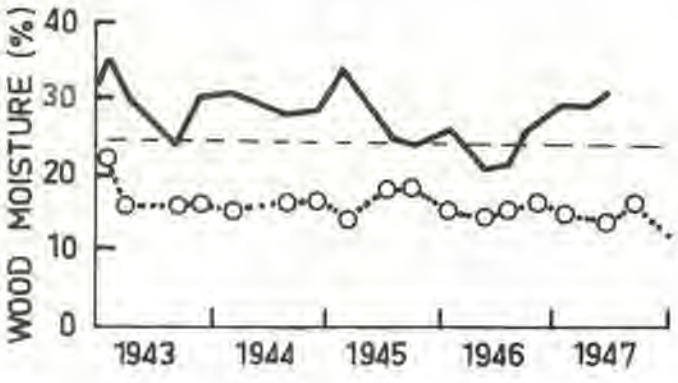
There appear to be two prevailing attitudes. One is that relatively low levels of ventilation have been widely used for a long time and the great majority of houses have shown no adverse effects, so that traditional practices should continue. The other is that, since ventilation to the Light Timber Framing Code standard is cheap and easy to install in new houses, and since some flooring decay does occur, often involving very costly repairs, such a standard represents worthwhile insurance. In favour of the latter view, it may be argued that decay hazards are increasing with use of lower durability flooring; popularity of low-profile houses; more impervious floor coverings (including rubber-backed carpets); and increased use of air conditioning, which might induce condensation on cool floors in summer.

Special problems arise in older buildings, especially in terrace houses and shopping areas, and have become more important with the recent tendency to rejuvenate inner suburban housing. This often involves extensions and new concrete-floored bathrooms or laundries, which may block existing ventilation. It is commonplace in Melbourne for very old softwood floors to develop severe decay shortly after the building has been remodelled. In some of these buildings cross-flow sub-floor ventilation is impossible, and here the use of vertical flues from sub-floor space to above roof level, topped with an extraction cowl, seems a promising remedial measure.

In both old and new houses, far more use should be made of "soil cover", i.e. installation of a water vapour-impervious barrier such as polyethylene film over all or most of the soil surface. This is mandatory in some Canadian specifications and is widely used in U.S.A. where it allows ventilation to be reduced by 90 per cent. It is surprising that it is used so little in this country, especially in remedial work.

Finally, there is an urgent need for research in this field to provide quantitative data on which to base future recommendations. The problems are essentially those of atmospheric physics. The prime objective of sub-floor ventilation is to prevent condensation, usually in flooring under an impervious covering during those periods when the floor is colder than the moist soil below it. The seriousness of the hazard, and the control measures required, depend on the frequency and duration of such periods and on the influence of vent design and spacing, prevailing winds, external and internal obstructions to air movement and so on, on the rate of exchange of sub-floor air in various parts of the sub-floor area. Much of the microclimatic and ventilation engineering information required may already be available, and it is difficult to know how much actual experimentation would be needed. The amount of decay known to occur in Melbourne (apart from distortion of flooring, failure of adhesives under floor coverings, and other effects) would justify a considerable effort.

Summing up, I would urge the interim adoption of a fairly high standard of sub-floor ventilation; an increased use of soil cover; and an understanding of the physical problems involved, sufficient to predict the likelihood of condensation occurring with different methods of ventilation in different environments.



Effect of soil cover on moisture content of sub-floor timbers. Broken line - with soil cover; solid line - without soil cover.

REPORT ON TESTS ON A NEOPRENE BASED FLOORING ADHESIVE

by

K. HIRST

The substitution of nailed strip floors by glued plywood floors appears to have some advantages, and therefore the properties of the adhesives used for the purpose are of interest. It appeared of interest to study the gluing properties of a local flooring adhesive with Australian timber species.

Materials and Methods

One make of the adhesive was tested in accordance with the specification of the American Plywood Association (A.P.A.), except that messmate was used for solid wood, and coachwood for the plywood. Also, Test B (frozen lumber) was not carried out. The messmate was collapsed and cracked in some places.

Tensile tests of the adhesive were carried out on strips of adhesive 75 mm long, 10 mm wide and between 0.7 and 0.92 mm thick which had been exposed to pure oxygen at 70°C and under a pressure of 2 MPa (300 lbs/sq. in.) for 7 or 28 days and similar strips which were kept in the laboratory for the same time.

Creep tests were carried out from samples prepared from 3.2 mm (1/8 in.) coachwood veneers with glue line thickness controlled by 16 ga nails. Specimens were loaded with dead weights at a temperature of 38°C. Loads were 17.6, 26.5 and 39.2 N.

Results

Results of block shear tests are summarized in Table 1, which also compares them with minimum requirements of A.P.A. Specimens with dry wood (both close contact and gap filling) failed predominantly within the adhesive. There was also slight wood failure on a few specimens and heavy wood failure on one specimen. Failures on wet wood were predominantly at or very close to the surface of the wood, the adhesive having largely transferred to the plywood, in spite of the fact that it had been spread to the timber.

No difference could be observed between the samples tested dry and those tested after the soak-dry treatment. All specimens showed signs of heavy shrinkage of the glue. Failures were often where the film was weakened by cavities.

In the oxidation resistance tests, all samples could be bent round at 6.4 mm (¼ in.) mandril without any sign of deterioration. Results of tensile tests can be seen in Table 2.

Of all creep samples only one loaded with the 39.2 N failed. At the end of test creep appeared to have stopped. There was no recovery of the creep 24 hours after removal of the load. Details of the creep tests are given in Table 3.

Conclusions

The adhesive has passed all prescribed tests but with wet wood the minimum requirements were exceeded in some cases by a small margin only.

Variation of results, especially on wet timber, are much larger than are normally experienced.

Some of the relatively low failing loads may have been caused to some degree by the heavy honeycombing of the glue, especially with the thick glue lines. A cause for the variability of results could be variation in spread due to uneven movement of the extrusion gun. There appears to be a tendency of the glue not to wet the green timber. This may be caused by displacement of the adhesive by liquid water enamating from cavities of the wood. Therefore some Australian species may be more difficult to glue when green than Douglas fir.

There was no effect of the soak-dry test on the bond of the adhesive.

The result of the oxygen test is satisfactory and no embrittlement of the film was found. The correlation between the oxygen test and the durability of the adhesive under normal use is not known, but if the test as performed for 28 days is assumed to represent a life of 10 years then the decrease in strength of 25% after treatment indicates that the bond strength of the adhesive would be adequate for a fairly long time. Additional accelerated and long term exposure tests are necessary.

The creep tests showed good resistance under permanent loads, well in excess of those which may be encountered in domestic flooring, where the flooring does not form part of the bearing structure. No explanation can be given for the relatively high creep at a load of 17.6 N and further work on creep is required.

The adhesive tested is likely to perform satisfactorily as an adhesive for plywood flooring on timber joists if properly applied and nailed. It is probable that the gluing of the plywood to the joists would improve the stiffness of the joists but this has not been investigated.

Future development is likely to head toward attempts in savings on the substructure of the floor as mentioned above. However, it would also be desirable to develop an adhesive system which would completely eliminate the need for nailing.

Table 1

RESULTS OF SHEAR TESTS ON A FLOORING ADHESIVE

Test	Shear strength recorded				Specification requirement minimum (lbf/in^2)
	Minimum (MPa)	Maximum (MPa)	Mean (MPa)	Mean (lbf/in^2)	
Gluing on wet timber	0.32	3.28	1.58	229	225
Gluing on dry timber	0.74	3.20	2.09	304	225
Gluing on wet timber followed by soak-dry test	0.26	3.07	1.61	234	not prescribed
Gluing on dry timber followed by soak-dry test	0.91	2.37	1.58	229	225
Gluing on dry timber with thick glue line	0.66	2.29	1.34	195	150
Gluing on dry timber with thick glue line, followed by soak-dry test	0.34	1.60	1.14	166	not prescribed
All specimens	0.26	3.28	1.28	229	-

Table 2

TENSILE TESTS ON STRIPS OF ADHESIVE NORTON 666

(Mean of 3 strips)

Treatment	Tensile Strength		Strength reduction (%) due to treatment
	MPa	lbf/in^2	
Nil control	11.7	1700	Nil
7 days oxygen bomb	10.5	1520	10%
28 days oxygen bomb	8.8	1280	25%

Table 3

CREEP TESTS ON ADHESIVE NORTON 666

Load on area 5 x 10 mm		Glue line thickness	Duration of test	Mean Creep at end of test	Failure
(N)	(lb)	(mm)	(days)	(mm)	
17.6	3.96	0.7	100	0.24	Nil
26.4	5.94	0.8	83	0.18	Nil
39.2	8.8	0.75	64	0.31	1 after 13 days

HOW SERVICEABLE IS PARTICLEBOARD FLOORING?

By W. J. SMITH

Comparatively recent reports from the United Kingdom have shed some doubt on the long-term serviceability of particleboard as a flooring material.

In view of projected preparation of an Australian Standard to cover particleboard flooring and proposals for its ultimate inclusion in ASCA.38; The Light Timber Framing Code, information is sought on two aspects:-

(a) While testing may indicate a potential for satisfactory structural performance based on initial testing, is there any foundation for suggestions that ageing, or other factors associated with long-term loading can seriously affect its performance and, if so, is this due to physico-chemical deficiencies inherent in the material or merely to probable variability in quality between producers operating to produce a board of given density with different proportions of resin and woody components?

(b) In "platform-type" construction, for which this material is being advocated, what would be the likely effect on long-term performance of wetting for periods of up to a week to give a likely unbalanced moisture content condition between upper and lower faces?

If satisfactory answers to these questions are not available, work to provide them is considered necessary to allow safe recommendations to be made and avoid possible loss of consumer confidence in a product finding wider use in covered floors and likely to be of considerable value in developing panelised flooring systems.

PERFORMANCE OF SHEET FLOORING UNDER LONG-TERM CONCENTRATED LOAD AND DIFFERENT SUB-FLOOR MOISTURE CONDITIONS

by P. Chapman

(Note: This is an abstract of a restricted report in which the names of the products tested were used).

Summary

A small scale test was carried out to assess the long term performance of urea bonded particleboard, phenolic bonded particleboard and exterior grade hardwood plywood when used as sheet flooring. The flooring was tested under point load with both dry and very damp sub-floor moisture conditions. Over the duration of the test all types performed in a satisfactory manner when the sub-floor was dry. When the sub-floor was damp both the plywood and phenolic particleboard showed some loss of stiffness, that in the plywood being only marginal; the urea particleboard however, showed a large loss of stiffness at the outset and eventually failed by punch-through of the concentrated load after about 2 years.

Introduction

There is increasing pressure for manufacturers of particle board and plywood to penetrate the traditional strip flooring market and provision is made for these products in the S.A.A. light Timber Framing Code. Because of our interest in the long term performance of these products a test was set-up to assess them when subject to concentrated load and different sub-floor moisture conditions.

Test Material

The sheet material used was 6 ft. x 3 ft. x 3/4 in. (1.8 m x 0.9 m x 19 mm) flooded gum (*Eucalyptus grandis*) plywood, Type A, exterior bond; 6 ft. x 3 ft. x 3/4 in. (1.8 m x 0.9 m x 19 mm) particle board bonded with a phenolic type adhesive which is thought to be mimosa tannin fortified with phenol-resorcinol and 6 ft. x 3 ft. x 13/16 in. (1.8 m x 0.9 m x 21 mm) particle board bonded urea formaldehyde and produced as a flooring grade.

Test Method

A building 24 ft. x 8 ft. (7.3 m x 2.4 m) was built on a poorly drained site. The foundation was masonry piers and walls supporting hardwood floor framing of bearers and joists. The clearance between the ground surface and joists was about 1 ft. (305 mm), which represents the lowest to be found in acceptable building practice in the Sydney area. No ventilation was provided in the foundation walls. The building was conventionally framed, the walls sheeted with fibre board and the roof covered with corrugated G.I. One half of the building sub-floor was sealed off from the ingress of ground moisture by polythene sheet laid over the ground.

Six panels of the flooring under test were nailed to the floor joists which were spaced at 18 in. (457 mm) centres. The layout of the panels is shown in Fig. 1, one panel of each type being exposed to different sub-floor moisture conditions. After the sub-floor moisture content had settled to a steady value the panels were loaded.

To each panel were applied three point loads of 200 lbf. (890 N) each acting on an area of 0.5 sq.in. (3.23 cm^2) placed centrally between the joists and positioned as shown in Fig. 1. Loading of this magnitude and type has been suggested by other workers as suitable for assessment of the performance of domestic flooring and is considered more useful than a distributed load test.

A dial gauge reading, recording the initial position of each loading point relative to the joists, was taken immediately after the load was applied. Measurements were then taken of the further deflections occurring at the loading points with the passage of time. Deflections were measured over a period of approximately 15 months with the interval between readings being gradually extended.

Concurrently with the deflection measurements, readings were taken of the sub-floor equilibrium moisture content of small timber samples using a simple type of indicator.

Results

From the three deflection readings obtained on each panel the mean value was taken as the measure of panel stiffness, the mean being considered the most representative estimator of the flooring stiffness.

The main results are embodied in the graphs of Fig. 2. The flooring was designated Protected and Unprotected, the former being protected from ground moisture by the membrane, the latter being exposed to ground moisture. The upper two curves show underfloor E.M.C., the lower curves show the increase in deflection occurring after original application of the load, all curves being with respect to time.

Readings were only plotted up to about fifteen months as other workers have demonstrated that almost all the long term deflection in timber under constant stress occurs within about the first year. From the trend of the results it did not appear unreasonable to assume somewhat similar behaviour from the sheet flooring. The results of long-term bending tests on particle board by other researchers also lends support to this assumption.

Approximately two years from the commencement of testing, the unprotected urea particle board failed when the loading tool punched through the panel surface at one point. Samples were then cut from each sheet of flooring and tested for moisture content and evidence of attack by fungal hyphae or decay.

No attack was evident on samples taken from the protected flooring. All samples taken from the unprotected flooring had been attacked by fungal hyphae to greater or lesser extents as outlined below.

(i) The urea particle board contained abundant hyphae, but decay could not be confirmed. The original particle board was 13/16 in. (21 mm) thick, but the exposed particle board had swollen to 1 in. (25.4 mm); of this, 5/32 in. - 5/16 in. (4 mm - 8 mm) had not flaked or deteriorated.

(ii) The phenolic particle board showed traces of fungal hyphae only and little increase in dimensions after service.

(iii) The flooded gum plywood had heavy attack by fungal hyphae in the outer veneer but very light attack in the second veneer. There was no distortion or swelling after service.

Moisture Contents of Sheet Flooring After Test

	Protected Flooring	Unprotected Flooring
Urea particle board	10.5%	33.5%
Phenolic particle board	10.3%	19.2%
Flooded gum plywood	12.0%	24.9%

Discussion

The criteria that determine whether a particular floor will perform satisfactorily are not completely defined and in many instances may be largely subjective. No Australian Standard relating to flooring exists at this time, but there is one in the course of preparation. The present study looked at only some of the aspects which may determine overall performance of a floor.

The results indicate that, over the period of the test, there was little practical difference in the performance of the materials when tested under dry sub-floor moisture conditions. Under these conditions, both types of particle board performed very similarly, with the plywood showing up slightly better.

When the sub-floor conditions were very damp a marked difference in the performance of the materials became apparent, especially between the two particle board types. The difference in the deflection of the urea particle board, when compared with the deflections of the other samples, became apparent within the first few weeks and this trend continued throughout the test. The stiffness of both types of particle board was affected by the damp conditions, but that of the urea bonded board much more so. The decrease in stiffness which occurred in the phenolic particle board was probably largely attributable to its gain in moisture content. In the case of the urea particle board, fungal degrade may also have contributed to the decrease in stiffness in addition to that caused by the large increase in moisture content.

Conclusions

Assuming that the 3/4 in. (19 mm) hardwood plywood used in the present study would prove an adequate floor in practice, then the performance of particle board may be compared with that of the plywood in assessing its suitability as flooring material.

If long-duration point loading of the magnitude used in this trial is accepted as a performance test for assessing the suitability of a sheet flooring material then these preliminary results indicate that particle board of the types and thicknesses used may provide a satisfactory floor under conditions of good sub-floor ventilation. Case studies from countries where particle board has been used under these conditions appear so far to have indicated satisfactory performance. However, only data obtained from such studies where the period of usage is comparable with the life of the structure involved will provide final verification of its suitability.

The long term performance of the unprotected flooring has been affected by both fungal attack and deterioration in addition to effects caused by moisture content level and moisture content changes. Whether fungal attack and deterioration have become of significance in their effect on the results is difficult to assess and needs to be the subject of further investigation. The phenolic particle board and plywood seemed relatively unaffected by these factors, but there is little doubt that their effect has been paramount in leading to the failure of the urea particle board.

Under damp sub-floor conditions the urea particle board failed after approximately two years; the phenolic particle board decreased in stiffness and the plywood probably decreased slightly in stiffness. The phenolic particle board performed creditably under the adverse conditions showing little fungal attack and a lower gain in moisture content than either the plywood or the urea particle board. The difference in the moisture content uptake of the two particle boards was very large and is no doubt related to the nature of the binders used. The test conditions were more severe than those normally encountered in practice but nevertheless not unattainable in certain situations.

The point load test seems well suited as a performance test for flooring as in practice this is likely to be the most critical type of loading encountered.

STUDIES OF UNDER FLOOR VENTILATION REQUIREMENTS IN A RADIATA PINE TEST STRUCTURE

by G. E. IRONSIDE

Summary

A small building, in which radiata pine was the framing timber, was erected on a damp site near Sydney.

Moisture contents of timbers increased from spring through summer and autumn to winter and from the underfloor to the roof apex.

Sub-floor ventilation of 5 cm^2/m^2 gross area was only marginally inadequate in summer but 20 cm^2/m^2, which is applicable to much of Sydney's housing, was hazardous in winter.

Application of a vapour barrier over the sub-floor soil provided safe conditions.

As a framing timber, radiata pine has much to commend it - its comparative lightness, easy nailing, relative stability and availability make it attractive to home builders. The taint of past misuse, however, lingers on. Is such an absorptive timber of low durability really suitable, out of sight, as a load bearing structural member? Would it be more prudent to insist that all radiata pine used in framing be preservatised with the risk perhaps of rendering initial cost prohibitive?

The experts were prepared to concede that with proper attention to detail and good building practice, radiata pine was undoubtedly safe as a framing timber in the coastal belt of N.S.W. But at what point good practice ceased was undetermined.

In an attempt to define just how much laxity one could accept with impunity a small building framed in radiata pine was erected at West Pennant Hills on the north western outskirts of Sydney. The structure was 7.3 m x 3.6 m and consisted of two rooms, one clad in brick veneer and the other asbestos cement commonly known as 'fibro'. The gabled roof was covered with concrete tiles over aluminium foil insulation.

In order to provide a reasonable hazard, the site chosen was on clay soil with a southerly aspect on the downhill side of the nearby forest nursery drainage. Brick for foundations and cladding were of the most porous type available locally. The asbestos cement walls were unpainted and the noggins were set full width between the outer sheeting and the internal plasterboard. So that the walls had maximum exposure to weather, roof overhang was minimal.

Initially the building had sub-floor ventilation complying with the minimum requirements of the Lending Authorities at that time. Terracotta air vents were installed at 1.8 m centres and not more than 0.9 m from the corners at a height immediately under the bearers and opposite to each other. Each ventilator had 24 holes of 15 mm average diameter providing ventilation of 20 cm^2/m^2 gross area or 25 cm^2/m^2 floor space.

Apart from the gap between timber frame and brick veneer the roof space was unventilated.

The building was unoccupied except for routine inspections and recording of data.

Test pieces of radiata pine were installed throughout the structure from close to the ground to near the roof apex.

As active fungal decay of timber is not known to occur at moisture contents of less than 22-24%, timber with moisture contents in the teens is perfectly safe from such attack, no matter how lacking it may be in natural durability. But 20% and over must be regarded as risky.

Strictly speaking every house is unique and the test structure, being small, is not even typical. The data obtained, however, provided a good guide to ventilation requirements of an unoccupied residence under somewhat adverse conditions in coastal N.S.W.

Moisture contents were generally highest under floor, particularly near the ground, and lowest in the roof.

Although in the period under review (from October 1970 to December 1972) rain was highest in summer and lowest in winter, moisture contents were lowest in spring (mean 14%)and increased through summer and autumn to winter (mean 17.6%). In summer cross ventilation of 10 cm^2/m^2, achieved by masking the lower half of each ventilator, was satisfactory and ventilation of 5 cm^2/m^2 only just insufficient to maintain a moisture content below the danger level of 20% in the underfloor area.

In winter however ventilation of 5, 10 and 15 cm^2/m^2 proved totally inadequate and for short periods moisture levels in the lower twenties were sufficiently prevalent to cause disquiet with full cross ventilation of 20 cm^2/m^2. This was particularly noticeable sub-floor and in the two brick veneer walls closest to the source of moisture. It is noteworthy that such levels were reached although the surface of the soil under the building was still <u>apparently</u> dust dry.

Somewhat more rapid fluctuations in moisture content were observed in the asbestos cement walls due to the incidence of direct sunshine, rain beating on the wall, or accidental spillage from gutters, but danger levels were not reached and surges tended to be of short duration.

In no instance could excessively high moisture contents be attributed to the use of a minimum overhang roof, porous brick wall or to unsealed asbestos cement; high moisture contents were associated with proximity to ground damp from sub-floor soil and the outer walls nearest the forest nursery drainage.

As alarmingly high levels of moisture content were reached in winter with ventilation of 20 cm^2/m^2 gross area, a ratio commonly found in the Sydney area, an attempt was made to ameliorate conditions by applying a 0.1 mm thick polyethylene vapour barrier as a cover for the sub-floor soil, whilst maintaining ventilation of 20 cm^2/m^2. This proved to be an effective answer.

In the sub-floor, and thus protected from the weather, recorded differences of moisture content attributable to the vapour barrier were over 4% at 4 cm off the apparently dry ground after 4 days. After 7 days the reduction of moisture content attributable to the vapour barrier ranged from a mean of 0.8% m.c. at 160 cm above ground level to 2.4% at 4 cm; a further reduction to 1.8% at 160 cm and 4.2% at 4 cm was recorded after 21 days. A straight line relationship was found between reduction in moisture content and the logarithm of height from the ground.

Where ventilation is sub-standard, application of a vapour barrier can make the difference between safety and disaster; simply, cheaply and without structural alterations.

The beneficial effect of the vapour barrier is also relevant to the storage of seasoned timber during house construction. It is common practice for the more conscientious builder to cover such timber stacked on site, but frequently the underside is ignored. Provision of polyethylene sheeting between the timber and the ground would minimise the chance of a substantial moisture gradient occurring.

We now know that a full soil cover vapour barrier is of considerable benefit, but we have still to discover whether, under adverse conditions, particularly in winter, moisture contents can be kept within acceptable limits by means of sub-floor ventilation alone.

It is intended to double sub-floor ventilation in the test structure to study the effect on moisture content levels during the critical winter months. At a later date the effect of supplementary ventilators near eaves level in the two susceptible walls should also be studied as should the effect of human habitation - preferably by simulation of appropriate factors.

Sub-floor ventilation requirements are frequently much higher overseas. Judging by our test structure and the incidence of extension enquiries the local minima are satisfactory except in problem cases.

AVAILABILITY OF FUTURE SUPPLIES OF RAIL SLEEPER TIMBERS

by F. A. DALE

Railways in Australia are at last getting the attention they deserve as an essential and increasing part of the national transport scene. Not only are the State systems getting much more attention but the proliferation of railways for mineral extraction has made new demands on the timber industries. Engineers are asking for bigger sleepers to carry much heavier welded rail and improved fastenings are being used in lines carrying heavy traffic. The concrete industries quite rightly see big business in these developments and it is up to us to meet their challenge and show that wooden rail sleepers will be both economic and essential in Australian railways for several decades at least. We should be grateful to the concrete sleeper industry for shaking our complacency if for nothing else.

This will not be possible unless adequate supplies of suitable timbers are available. The proper species alone are not enough; quality must be at least as good and in some cases better than is available at present.

Most permanent way engineers have now agreed that pressure treatment with preservative oil is essential for lower density, less durable timbers such as those in group 3 of the "Classification of Australian Sleeper Timbers" produced in co-operation with State forest services in 1969. Some would like to see more sleepers in group 2 or even group 1 treated. Jarrah is already being treated in Western Australia and yellow and white stringybark in Victoria. In Tasmania, the native "ash type" species are being treated because their life untreated was 11 years or less. In N.S.W. pilot scale commercial treatments of blackbutt and Sydney blue gum have been made within the last few years.

Our concern is whether the forests will continue to supply sufficient sleepers to meet future demands. In Western Australia we have been assured that 1 million sleepers per annum or more can be supplied up to 1990, allowing for some over cutting and an increasing use of karri. At present the industry is producing below capacity.

South Australia could draw from Western Australia and Victoria but at present is largely using Victorian red gum. Victoria uses roughly 300,000 red gum, ironbark and box with about 100,000 Gippsland sleepers, mostly yellow and white stringybark, each year.

Tasmania can probably supply its own limited requirements for future new work and replacements.

New South Wales used 672,000 million ironbark, 118,000 blackbutt and 360,000 other sleepers in 1970/71. Figures for Queensland are not available but they now accept 49 species ranging from ironwood, tallowwood and turpentine to spotted gum.

Average lives of untreated sleepers range from 10-25 years, depending on location and species. The total number of sleepers in all systems is about 78 million and even assuming a fairly generous 22 years average life this should require an annual replacement of over 3.5 million sleepers. The actual figure is probably not 2.5 million. This leaves an increasing deficit and implies that many sleepers in minor lines at least are overdue for replacement.

Can the forest industries meet the increased demand if the railways get sufficient finance to overcome this backlog? They will want better sleepers and more of them. Preservative treatment can offer no magic cure, it will not turn firewood into sleepers conforming to AS-097.

For first class lines the demand will be for group 1 and group 2 sleepers, with increasing demand for treatment of the latter. The supply of group 1 sleepers is dwindling and the corresponding increase in demand for group 2 timbers must inevitably result in lowered standards of acceptance. Treatment will improve the long term supply position by reducing future demands for replacement, but in the meantime the deficiency can only be met with <u>treated</u> group 3 timbers, preferably those with better mechanical properties and heavier than 55 lb/cu.ft. Of these silvertop ash (*E. sieberi*) karri, brush box, and mountain grey gum are all performing well in test. Lighter species such as messmate stringybark are suitable for use in Southern Victoria and Tasmania but their performance in N.S.W. suggests that anti-splitting devices such as spiral dowels, Gang Nails or bands will be needed to give better protection against splitting and spike kill.

What of the raw material? We are assured that there are ample supplies of karri and brush box, but will there be enough blackbutt, Sydney blue gum, mountain grey gum, silvertop ash and other species to make treatment worthwhile? If these timbers are too valuable for other purposes or are needed in quantities for chipping which will threaten sleeper supplies, we may be wasting our time in further investigations of their treatment properties.

Now that the need for incising before treatment is fully appreciated, it should be possible to establish boultonizing schedules for these timbers which will give adequate penetration in a reasonable time without degrade. This can only be justified if the material is going to be available for treatment.

FACTORS AFFECTING RAILWAY SLEEPER UTILIZATION

by W.J. Smith

In view of recently publicised higher competition from concrete sleepers, especially in relation to their use by Commonwealth Railways, the results of a survey of the causes of service failure of railway sleepers in Queensland should be of interest.

This survey, covering 136,000 condemned sleepers, was conducted in 1971 by the Queensland Railways Department and is probably the most comprehensive survey of this type so far attempted.

The sleepers were all of high durability rating species and all hardwood, with the exception of a very small number of cypress pine sleepers in restricted local use.

The age of the sleepers condemned was not reported but the Railways Department indicates an average in-service life of 20 years in Queensland, as far as can be ascertained.

The causes of failure were listed as follows:-

Decay (Including frequent localised decay at rail seat)	- 61.7%
Spike kill	- 18.5%
End-splits (to or beyond rail seat)	- 10.4%
Termite attack	- 7.3%
Rail cut (more than ½ inch)	- 1.0%
Miscellaneous (fire, derailment, etc.)	- 1.1%

Decay was obviously by far the most serious factor and, with termite attack, accounted for 69% of failures. These results pinpoint the need for further work to inhibit biological degradation through preservative treatment. They also provide an argument against any moves to introduce untreated lower durability species or to condone lower standards in respect of allowed untreated sapwood, splits and other defects. Any such moves could possibly further redound to timber's disadvantage in future timber/concrete comparisons.

An interesting observation was the reported reduced incidence of decay as well as rail cut where sleeper plates were used on main lines. As would be expected, wider rail flange, increased track curvature and elastic spikes tended to be associated with a reduction in mechanical damage.

Further surveys are planned by the Railways and Forestry Departments working in collaboration to check the effect of timber species and area of use as additional variables.

It has been noted that modern track-laying techniques often require the availability of large quantities of sleepers within a very short time interval, necessitating stockpiling of hundreds of thousands of sleepers for up to a year. The prevention of seasoning degrade in storage of sections up to

9" x 6" requires attention, as available end-sealants do not seem adequate.

The immediate problem of the economics of timber versus concrete sleeper use merits urgent attention by timber producing interests, particularly in view of some of the bases of cost analysis comparisons influencing opinion concerning the use of concrete sleepers by Commonwealth Railways.

One most important factor possibly not given due attention is the proven performance of timber sleepers (based on severe Queensland conditions over 20 years or more), whereas concrete has yet to prove itself over a comparable period. It is understood there have been some failures in less than 10-12 years here and that, in Germany at least, there is a trend back towards timber for this use after a switch to concrete.

In the meantime, the most profitable area of research here is evidently in extending service life and reducing maintenance costs by preservative treatment.

SUB-TOPIC B - WOOD PRESERVATION

24. REPORT ON WOOD PRESERVATION COMMITTEE (1971-1972)

....

25. STUDIES OF PERMEABILITY

    (a) PERMEABILITY OF RADIATA PINE AND SERAYA TO MINERAL TURPENTINE

    (b) ARE DIP TREATMENTS WITH WATER REPELLENTS WORTHY OF SUPPORT

26. ORGANIC SOLVENT PRESERVATIVE

....

27. FIXATION OF CCA SALT IN *EUCALYPTUS MACULATA* POSTS IN SERVICE COMPARED TO *PINUS RADIATA* POSTS

28. CREOSOTE LOSSES IN HARDWOOD POLES

29. THE NEED FOR A PRESERVATIVE TREATMENT TO REPLACE CCA SALTS

    (a) PROPOSED STUDY OF THE EFFECT OF STARCH AND EXTRACTIVES ON A SUSCEPTIBILITY OF CCA TREATED SAPWOOD

....

30. LABORATORY EVALUATION OF NEW PRESERVATIVES

31. ARE CHLORINATED HYDROCARBON COMPOUNDS SAFE TO USE IN WOOD PROTECTION?

32. IMPROVEMENTS REQUIRED IN WOOD FOR IT TO KEEP ITS PLACE IN OUTDOOR USE

REPORT OF WOOD PRESERVATION COMMITTEE (1971-73)

Prepared by N. Tamblyn (Convenor)

1. General

The previous report on the activities of the Wood Preservation Committee was presented at the last Forest Products Research Conference in June 1971. At this last Conference there was some comment on the need for the Committee (which then comprised Messrs. W. Clifford, K. Cokley, D. Edwards and N. Tamblyn) to join with industry representatives in many of its discussions. On this matter the President of the Timber Preservers' Association of Australia (Mr. J. Moss) indicated that his Association intended to set up a Technical Committee which would be pleased to join with or assist the Wood Preservation Committee.

The Wood Preservation Committee has acted in this matter and at the last two meetings (Sydney, April 1972, and Brisbane, October 1972) has held both a"closed" session and an "open" session. In the open session, we have been joined by the TPAA Technical Committee (comprising Messrs. J. Foxton, D. Price and S. Retter) and it is indicative of the value of their help that in the first meeting 15 topics were scheduled for discussion in the closed session, compared to 18 in the open session, while in the second meeting the minutes record only 3 topics which we did not confide to our industry colleagues. I believe that both Committees have benefited mutually from these joint meetings and that we have now established a pattern of frankness and cooperation greater than was foreseen at the last Forest Products Conference. Our sincere thanks are due to members of the TPAA Technical Committee for the time and effort they have given to these joint meetings. Our thanks are also due to Mr. L.R. Thornton (Chief Engineer) and Mr. K. Garland, both of the State Electricity Commission, Queensland and to Mr. H. Mason of Brandon Timbers who attended discussions on the problem of soft rot in CCA-treated poles in Queensland.

There have been some changes in the personnel of the Wood Preservation Committee. Because of changing emphasis in his work, Mr. Dare Edwards has resigned and Mr. Rex Johnstone has taken his place. Prior to the last meeting of the Committee, an approach was made to the Department of Forests, Papua-New Guinea, to nominate a representative and Mr. Colin Levy has now become a member. Unfortunately, because of absence abroad, he was unable to attend the last meeting but we look forward to his assistance in the future and to the possibility of holding a joint meeting of the two Committees in Papua-New Guinea so that more attention can be given to problems in wood preservation in this area.

2. Work of the Committee

Since the last Forest Products Research Conference almost 50 topics have been discussed in the closed and open sessions of the Committee during a total meeting period of 6 days. Over such a large area it is not possible in this report to summarize even the conclusions or decisions reached. However, a list of the more important topics dealt with by the Committees is here given and I, or other members, will be glad to answer questions on any item if requested. It should be remarked that many of the items listed below involved a review of existing knowledge and of work in progress or of new work needed. As such they may not all be readily summarized but we will try if required either here or in later personal discussion.

Topic 3/24

The main topics were :-

1. Soft rot in CCA-treated eucalypt poles in Queensland and Possible remedial treatments.
2. Centre rots in creosoted eucalypt poles in Victoria.
3. Loss of creosote from standing eucalypt poles by drainage from the butt.
4. Use of PCP-mineral oil solutions for treatment of poles and sleepers.
5. Preparation of specifications for treatment of rail sleepers.
6. Marine borer tests - results of existing tests and plans for new work.
7. Distribution of marine borer species in Australian waters - results of survey by Dr. Ruth Turner.
8. Leaching of CCA preservatives from treated wood in sea water.
9. Need for further testing of modified Australian high temperature creosote.
10. Estimation of creosote in wood by toluene and D.M.F. extraction methods.
11. Accuracy of X-ray spectrographic methods for estimation of CCA components in treated wood.
12. Need for a rating list of the treatability of commercial timbers and plywood.
13. Decay resistance of naturally durable and treated timbers exposed above ground - use of a climate index.
14. Results of tests on the decay resistance of untreated heartwood in CCA-treated radiata pine.
15. Current research on soft rot.
16. Preservative treatments for plywood.
17. Use of Basileum S.P.I. as a glue additive for preservative treatment of plywood.
18. Tests on effectiveness of arsenic as a termiticide in urea glues.
19. Need for insecticides of low mammalian toxicity.
20. Development of improved techniques for laboratory termite tests.
21. Tests of treated wood slats in cooling towers.
22. Classification of timbers for Lyctus susceptibility.
23. Use of organic solvent preservatives for dip and pressure treatments of joinery and building timbers.
24. Committee policy re acceptance of new preservatives.
25. Education of industry and the consumer in production and use of treated timber.

STUDIES OF PERMEABILITY

a. PERMEABILITY OF RADIATA PINE AND SERAYA TO MINERAL TURPENTINE

By R. K. BAMBER

Some evidence has been obtained supporting the use of dip treatments for the preservation of exposed joinery (see paper by K. R. Bootle). Before undertaking more comprehensive testing of dip treatments it has been thought desirable to obtain fundamental data on the anatomical nature of the penetration of dip type solutions into timber.

The timbers selected were commercial samples of seraya (ex Weyerhaeuser Pty. Ltd.) and radiata pine (ex N.S.W. Forestry Commission). Two cm cubes were cut from the air-dried sapwood and heartwood of these species and dipped in mineral turpentine for 5 minutes. The turpentine was stained with either Sudan IV or Waxoline blue (I.C.I.) to enable the regions of penetration to be observed. The blocks were then oven-dried (85°C) for 2-3 hours.

The dried blocks were split along the grain radially and tangentially and the split faces examined microscopically with incident light and the presence of staining in the wood observed.

The penetration of the turpentine appeared to be confined to the lumina of cells and to interstitial spaces open or connected to the wood surfaces. This has resulted in the following penetration patterns:

(a) radiata pine sapwood: very shallow penetration into the lumina of the surface tracheids and deep penetration along the rays and along the radial and axial resin canals;

(b) radiata pine heartwood: similar surface penetration to (a), but only rare, deep penetration along the rays and resin canals;

(c) seraya sapwood: very shallow penetration of the lumina of the surface fibres and parenchyma, deep penetration along the vessels and the radial resin canals;

(d) seraya heartwood: similar surface penetration to (c) but only rare penetration of vessels and radial resin canals.

It appears that there are two main types of liquid movement into timber, free movement which only occurs in vessels free of tyloses, in interstitial spaces formed by collapse or natural growth as in canals (Bamber, 1972) or in splits or cracks, and restricted movement which occurs from cell to cell through pit membranes. A third type could be considered in which movement occurs from the cell lumina into the thickened wall. I have not seen any evidence for this third type of movement with non-polar liquids under atmospheric pressure and consider that it should be discounted for dip treatments using solvents such as mineral turpentine.

In both radiata pine and seraya only free movement was observed, penetration of mineral turpentine being confined to those cells or interstitial spaces connecting with the wood surfaces. If restricted movement occurred (i.e. cell to cell) it was minimal as it was not detected by microscopic examination.

Topic 3/25

The reduction in permeability of the rays and resin canals in radiata heartwood is due to the changes in the chemical properties of the walls of this tissue with the transformation from sapwood to heartwood and to the deposition of tannins and resins in the interstitial spaces. Lignification of the heartwood ray parenchyma cell walls appears to prevent these cells from collapsing as much as in the sapwood. The resin canals frequently become blocked with tylosoids in the heartwood.

In seraya both the vessels and the radial resin canals become blocked in the heartwood. The vessels develop tyloses and the radial resin canals a similar type of growth. This latter growth does not appear to have been described in the literature and an illustration will be provided of it for the conference.

The high permeability of the radial resin canals in seraya revealed in this study appears to explain the low durability of the sapwood of the various species in this botanical group. Similar resin canals are found in various species of *Shorea* spp. red meranti.

Reference

Bamber, R. K. - J. Inst. Wood Sci. No. 32 (1972).

b. ARE DIP TREATMENTS WITH WATER REPELLENTS WORTHY OF SUPPORT?

By K. R. BOOTLE

Dip treatments have been used for a long time with apparent success in North America, though the degree of hazard in many parts of that country is possibly less than applies to Australia's eastern seaboard.

In New South Wales, seven window manufacturers supply 80% of the wood window market and probably set the standard of construction for most of the remainder. In a survey at the end of 1972 all seven agreed that the demand for wood windows was increasing and that the trend would continue so long as timber prices kept in step with those for aluminium. However the shortage of western red cedar and the considerable difference in wage rates for joiners and metal process workers makes for an uncertain basis of hope.

At time of writing (January 1973) only two of the seven companies were using water repellent dip treatments; both had abandoned the use of products containing pentachlorphenol because of employees' complaints regarding its "burning" effect on their skin. Products relying mainly on wax seem to be currently favoured.

With uncertain supply of western red cedar for the window joinery market, what other timbers are likely to be used? Apart from Douglas fir, radiata pine, some ash eucalypts and the Shoreas are the obvious possibilities but they do lack durability and some form of treatment, not containing arsenic, is called for.

The progress of a test that has been under way at our Pennant Hills exposure site since July 1966 may be of some interest when considering the possible effectiveness of dip treatments locally. The site has a 45 in. (1043 mm) average annual rainfall, reasonably well distributed through the year and represents quite a severe decay hazard.

The test pieces were somewhat like those used by Verrall in the United States, and consisted of segments of 4 in. x 2 in. (90 mm x 45 mm) radiata pine, one 12 in. (30.5 cm) long, one 8 in. (19.5 cm) stub-tenoned together at 60°, fixed vertically and facing north. The housing for the stub tenon provided a cavity retentive of rain and nightly dew fall; the joint was slack and without adhesive, the two pieces being held together by a galvanised pin.

After 6½ years exposure the controls, both painted and unpainted have nearly all suffered gross decay (7 of 10 painted and 8 of 10 unpainted). All the other pieces are still apparently unaffected by decay. They had been given the following range of treatments:

1. dip for 3 minutes in pentachlorphenol in mineral spirit;
2. dip for 3 minutes in pentachlorphenol laurate in mineral spirit;
3. dip for 3 minutes in copper naphthenate in mineral spirit;
4. pressure impregnation with copper-chrome-arsenic;
5. pressure impregnation with boron salts.

Topic 3/25

This is just one small experiment in one location, yet it does seem to confirm that dip treatments do some good. Should we make a greater drive to secure acceptance by finding a less hazardous fungicide than pentachlorphenol and can such a surface treatment be considered acceptable for low durability wood, as in radiata pine and *Shoreas*?

Should we direct our energies more towards "Vac-Vac" types of treatment?

Topic 3/26

ORGANIC SOLVENT PRESERVATIVES

by N. Tamblyn

1. General

A few years ago it was widely believed that sawn timbers of low natural durability would give long and trouble-free service in exterior use above ground provided they were adequately treated with CCA preservatives. In terms of resistance to decay and termite attack this concept has proved wholly valid but it is now clear that many of these CCA-treated timbers are not only subject to degrade during redrying but also require painting or equivalent protection to prevent considerable splitting and checking in service. This is particularly so with radiata pine and ramin and the treating industry is now facing growing resentment from buyers using these timbers for exterior decorative purposes where, in the modern trend, the only protection from weathering is often a thin semi-pigmented flat oil coating. In some cases it is claimed that CCA treatment has rendered the wood even more prone to splitting and checking than would be expected from similar timber in untreated condition.

The use of clean paintable preservatives dissolved in volatile organic solvents which avoid any redrying degrade or the need for re-machining, and which contain water-repellent additives to improve weather resistance, is an attractive answer to this problem. Preservatives of this type have been used for some years for dip treatments of prefabricated joinery with reasonably good results where sufficient penetration has been obtained. They have kept the timber clean during handling and installation, reduced unsightly fungal staining under clear finishes and given worthwhile improvement in decay resistance, dimensional stability and paint holding capacity.

Unfortunately dip treatment has definite limitations because in most timbers the penetration is shallow and in the more impermeable species is often little better than a surface coating on the side grain and often less than $1/16$ inch at the end grain. We therefore cannot recommend it as a reliable treatment for exterior joinery or other exposed timbers where long protection against decay, insect attack or weathering (20-50 years) is required under average Australian conditions.

A far preferable alternative to dipping is to use the same type of water repellent preservative in a pressure treatment designed to give substantially complete penetration of permeable timbers, or in the case of less permeable species to give as much end grain penetration as possible in prefabricated material. The purpose of this paper is to discuss briefly these more intensive treatments and the problems we foresee in their application to Australian requirements.

2. End Grain Treatment

If joinery or other exterior building timbers are highly permeable and have low natural durability substantially complete penetration with permanent preservatives is usually desirable as discussed under the next heading. For other timbers which are more impermeable, resistance to decay in above-ground exposure, particularly in the critical joint area, can be greatly increased if the timber is prefabricated and then treated to obtain an end grain penetration of at least 15mm (.59 inch) and preferably 25-50mm (1-2 inch). In many of these timbers such as the heartwood of eucalypts, red meranti, Douglas fir etc., this penetration

can be obtained readily with water repellent preservatives at pressures ranging from atmospheric to about 200 psi depending on the permeability of the species. Such treatments do not use much preservative and the actual solution retention in the treated ends can be adjusted if required by varying the treating schedule.

The main disadvantage of this type of end grain treatment is that side grain penetration, particularly in straight-grained hardwood, is unlikely to be sufficient to give much resistance to weathering. The treatment is therefore most suitable for timbers which will be painted or at least given some weather protection. With reasonable care painting difficulties are unlikely as volatilization of solvent should occur within a few days from exposed ends without the need for post treatment stripping. However, if more complete penetration is obtained some of the problems discussed in the next section may apply.

3. Substantially Complete Penetration

Permeable timbers such as radiata pine and ramin can be treated readily with water-repellent preservatives to the same penetration patterns as are at present obtained in CCA pressure treatments. The main difference is that in the usual full cell water-borne treatments high solution absorptions are obtained while in organic solvent treatments it is economically essential to reduce solvent retention to the minimum compatible with the desired penetration and toxic loading. In our work with radiata pine sapwood and ramin we have been able to obtain complete penetration at a final solvent retention of about 40-48 kg/m^3 (2½-3 lb/cu.ft.) by applying Rueping schedules. This means that wood completely penetrated with preservative and water repellents should contain no more than about 3 gallons of mineral turpentine or other volatile solvent per 100 super feet when removed from the cylinder. At the present bulk price of about 25 cents per gallon for mineral turpentine the cost of solvent lost by volatilization should not exceed about 75 cents per 100 super feet of treated wood. Whether or not this complete penetration with economical use of solvent can be translated simply to commercial practice depends largely on answers to the following questions.

(a) What precautions are necessary to avoid fire danger at the treating plant and the possibility of an explosion hazard when compressed air and solvent vapour are mixed in the initial air pressure stage of a Rueping cycle and later discharged?

(b) Can a sufficiently concentrated solution be easily made and used to distribute effective amounts of preservative, resin and wax in the wood at solvent retentions of only 40-48 kg/m^3 (2½-3 lb/cu.ft.)?

(c) Will the very high "kickback" during release of pressure and application of final vacuum result in component imbalance in the preservative solution?

(d) Will it be necessary to strip out the treated wood to volatilize solvent before it can be safely despatched in summer when ambient temperatures may exceed the flash point of the solvent?

We have posed these questions to some of our colleagues in the preservative industry and have directed our own work to their answer. We hope it will not be necessary to use higher solution retentions with consequent higher cost in solvent loss and greater need for stripping after treatment but even if so, the treatment should still have merit.

4. Solvent Recovery Treatments

It was our intention, expressed at the last Conference, to examine the practicability of a water repellent preservative treatment based on use of a highly volatile solvent such as methylene chloride or a fluorinated hydrocarbon which would completely eliminate any fire or explosion risk and which would be recovered from the timber before removal from the cylinder. Such treatment would require more sophisticated and costly plant with heat input in the cylinder to volatilize the solvent and a condensing system for its recovery. On further consideration we decided to shelve this project for the present in favour of work in the areas already discussed. However, it merits attention in the future and we have no abandoned it.

5. Water Repellent Treatments in U.K.

Water repellent preservatives applied by dipping or at absolute pressures below atmospheric (double vacuum processes) or at very low gauge pressures are already in commercial use in the U.K.. They typically contain one or more fungicides such as pentachlorphenol, tributyltin oxide, zinc naphthenate etc., an insecticide such as lindane, water repellents (wax and resin) and if necessary, a co-solvent to prevent blooming of any component likely to crystallize on the surface of the wood. They are carried in light petroleum distillates which may have a flash point as low as 38°C (100°F). They do not differ greatly from water repellent preservatives which have been used for several years for dip treatments in Australia.

The treatments used in U.K. are mainly applied to prefabricated softwood timbers and aim at a minimum end grain penetration of about 40mm (over 1½ inch) and a side grain penetration of about 3mm (less than ⅛ inch). It is doubtful whether these penetrations are obtained in the heartwood of European conifers and questionable whether this envelope treatment would prevent face checking and internal decay in exposed timbers such as pine or ramin under Australian climatic conditions. Also these treatments have not been in commercial use for more than several years and it still remains to be seen whether they are adequate, even in England, to protect exterior softwood building timbers for the long periods which we would consider necessary. On present evidence we could not recommend them for average Australian use against the alternative of substantially complete penetration obtainable by more intensive pressure treatments.

6. Preservatives

Although most conventional water repellent preservatives are satisfactory by present standards, their development has been based more on practical considerations than on fundamental research. It is therefore not unreasonable to expect that considerable scope exists for their improvement. Apart from the search for new fungicides and insecticides of higher effectiveness or lower mammalian toxicity a study of factors affecting the distribution, permanence, toxicity and weather resistance of the preservative components in the wood substrate is likely to be rewarding.

Distribution at cell wall level as well as the concentration gradient set up in the wood by volatilization of the petroleum distillate are likely to affect toxicity and permanence and these factors may themselves be affected by the type and content of co-solvent, wax and resin. Where pentachlorphenol is used the extent to which it remains in permanent solution in the co-solvent after volatilization of the distillate is also likely to be an important factor affecting its toxicity and permanence.

We hope to examine some of these factors in the future. In the interim we can comment on formulations at present available only in general terms as follows.

(a) Fungicides

At present the choice has mainly been between pentachlorphenol (PCP) and tribulyltin oxide (TBTO) either used alone or in mixture. There is reasonable evidence that a PCP loading in the treated wood of about 4.8 kg/m^3 (0.3 lb/cu.ft.) as dry chemical should be adequate for average Australian decay hazards but with TBTO it is more difficult to suggest an equivalent safe loading. The tendency to rate TBTO as ten times as effective as PCP is considered unjustified and we would suggest a loading based on a factor of five. On this basis the equivalent figure for TBTO would be 0.96 kg/m^3 (0.06 lb/cu.ft.). Mixtures of PCP and TBTO may or may not be technically preferable but would certainly have practical advantages over PCP alone if solvent retentions as low as 3 lb/cu.ft. are to be achieved. More evidence is needed before equivalent loadings for mixtures can be proposed.

(b) Insecticides

In the U.K. lindane (gamma BHC) has been preferred as the insecticide possibly because its mammalian dermal toxicity is lower than that of aldrin or dieldrin. Unfortunately in our laboratory tests it has shown low toxicity to termites but has proved effective because of repellency at about 1.3 kg/m^3 (0.08 lb/cu.ft.). At the low solution retention of 48 kg/m^3 (3 lb/cu.ft.) a lindane concentration of at least 2.5% would be required in the preservative solution to approach this loading. While more tests are necessary to determine the lindane termite threshold in the presence of other preservative components it would appear desirable to look at alternatives including organic arsenical compounds. Because of lower health hazards we would tend to favour use of arsenical compounds in preference to organochlorine insecticides. Also it should not be forgotten that at the higher loadings of PCP and TBTO likely to be required in Australia there may be no need for an additional insecticide.

(c) Water Repellents

The water repellent additives (typically ½-1% paraffin wax and about 3-7% resin) are generally considered to have served their function if the water absorption or swelling of the treated wood meets the requirement of a prescribed water immersion test and if paintability remains satisfactory. This concept overlooks the fact that these additives are part of a total complex system and are likely to affect the distribution, toxicity and permanence of the preservative components. There is need for investigation in this area particularly as preservative manufacturers do not always publish details of the additives used. There is also need for investigation

of the effect of purity and melting point of the wax on paintability under hot Australian conditions and the possibility of using polyethylene waxes or other water-repellent compounds as alternatives. The type of resin used and its degree of condensation is also likely to be important both fundamentally in regard to the extent of cell wall penetration obtained and practically in regard to its stability in the storage tank.

(d) Solvents

The petroleum solvent used in dipping and low pressure treatments is one of the mixed aliphatic-aromatic distillates with properties usually within the range from white spirit to power kerosene. Some typical properties (Mobil products) for these solvents are as follows :-

Solvent	S. Gravity at 15.5°C	Flash Point (Abel) °C	Boiling Range °C	Aromatics % by Vol.
white spirit	.78	38	155-190	17
min. turpentine	.81	38	150-195	48
power kerosene	.82	38	150-246	45

These solvents all have a flash point lower than we would like for safety and a final boiling point (190-246°C) sufficiently high to cause the last fractions to volatilize only slowly from the treated wood. At ambient temperatures very little is volatilized during the final vacuum and it appears impracticable without heat to reduce much below 3 lb/cu.ft. solution retention before removal from the cylinder. At present we do not know the effect of the solvent and its aromatic content or other properties on the final distribution of preservative and water repellent in the wood. There is some evidence that solvent properties may affect preservative toxicity and permanence and this area needs investigation. There is also a need to try solvents with higher flash points which within limits can still be achieved within the boiling ranges in the above table.

FIXATION OF C.C.A. SALT IN *Eucalyptus maculata* POSTS IN SERVICE COMPARED TO *Pinus radiata* POSTS

by R.S. Johnstone and K.L. Owen

Summary

Tests were carried out on posts of *Eucalyptus maculata* and *Pinus radiata* treated with copper-chrome-arsenic salts that had been in service for 11 and 9 years respectively.

Sample plugs were taken above ground and below ground level and analysed for copper chromium and arsenic. Samples were also taken from one *E. maculata* post to determine the preservative gradient in the sapwood.

A significant difference occurred between the above and below ground samples of *E. maculata* with respect to arsenic and copper. Chromium in *E.maculata* and copper chromium and arsenic in *E.maculata* at both positions were not significantly different.

1. Introduction

The reasons for the poor performance of the fixed copper-chromium-arsenic salts in *E. maculata* have been in doubt for a number of years.

Research workers including Da Costa, McCarthy, Tamblyn, and Wilson, all from the C.S.I.R.O., have investigated by various means the leaching of C.C.A. salt from Eucalyptus species, notably *Eucalyptus regnans*. In addition, Belford, late of Hickson & Welch (Holdings) Ltd., has carried out experimental work on *E. maculata* and has summarized research on factors affecting the permanence of these salts in a paper in the Journal of the Institute of Wood Science dated July, 1970.

Much of this work was carried out on internal laboratory tests designed to simulate service conditions i.e., to artificially produce an accelerated test equivalent to years of in-service conditions.

Nicholson and Levi of Hickson's at the British Wood Preservers' Association Convention of 1971 reported the results of leaching tests on treated *E. maculata* poles that had been in service for six years, in addition to correlative laboratory leach tests.

Their findings on *E. maculata* poles in service were that no statistically significant loss of copper and chromium below ground level had resulted when compared to above ground level. A small but significant loss of arsenic had occurred.

This was not in agreement with their laboratory leaching tests in which losses of copper were of a greater order of magnitude then arsenic. Chromium was highly fixed and no significant losses were evident.

In this paper we have examined posts of two species, *Pinus radiata* and *E. maculata*, that have been in service for 9 and 11 years respectively and compared their C.C.A. salt retention at both above and below ground level.

To determine possible losses from exposure to weathering on the outside of the posts above ground, a retention gradient from the outside to the inner sapwood has been reported for one post (*E. maculata*) only.

2. Experimental Procedure

Sample plugs were taken from each of 12 *E. maculata* and 12 *Pinus radiata* posts that had been in the ground for 11 and 9 years respecitvely. The posts had been commercially treated (Tanalith C) to a nominal 16 kg/m^3 (1 lb/ft^3) sapwood retention (*E. maculata*) and 8 kg/m^3 (0.5 lb/ft^3) full cross-section retention (*P. radiata*) and were located at Wallaroo State Forest and Cumberland National Forest respectively.

Samples in the form of 12.5mm diameter plugs were taken at 75mm below ground level and 1 metre above ground level on the same longitudinal axis in each post to the full depth of the sapwood.

Twelve additional plugs were taken from one *E. maculata* post above the groundline, the plugs cut into 5mm lengths from the outer face, and at each depth the samples were pooled for analysis. The copper content and the retentions calculated from these results are shown in Table 1. The percentage copper is shown graphically in Table 1.

The remaining plugs were analysed for copper, chromium and arsenic. Analytical results of copper content and estimated retentions are shown in Table 2. The copper content of each plug from each species is presented in Table 2.

Table 1

Concentration gradients, above ground, in copper-chrome-arsenic treated *E. maculata* post after 11 years' service at Wallaroo State Forest.

Retention	Depth of sample from surface of post (mm)					
	0-5	5-10	10-15	15-20	20-25	25-30
Copper (%)	0.24	0.25	0.24	0.22	0.18	0.21
Copper-chrome-arsenic) kg/m^3	27.1	28.4	26.3	24.2	20.4	23.2
(based on copper)) lb/ft^3	1.69	1.77	1.64	1.51	1.27	1.45

3. Discussion of Results

3.1 Preservative gradient

The samples taken from the single *E. maculata* post followed the expected retention pattern. It is probable that preservative losses above ground would be minimal except at the outer face of the timber.

Table 2

Retentions of preservative in copper-chrome-arsenic treated *E. maculata* and *P. radiata* posts below and above groundline after 11 and 9 years' service respectively.

E. maculata posts						
Post No.	Above groundline retention			Below groundline retention		
	Copper	CCA salt based on copper		Copper	CCA salt based on copper	
	%	(kg/m^3)	(lb/ft^3)	%	kg/m^3)	(lb/ft3)
1	0.14	15.7	0.98	0.07	7.9	0.49
2	0.11	12.5	0.78	0.08	9.5	0.59
3	0.09	10.4	0.65	0.06	6.9	0.43
4	0.11	12.2	0.76	0.04	4.5	0.28
5	0.13	14.6	0.91	0.11	12.2	0.76
6	0.13	13.9	0.87	0.11	11.9	0.74
7	0.16	17.9	1.12	0.13	13.9	0.87
8	0.13	15.2	0.93	0.16	17.8	1.11
9	0.18	20.5	1.28	0.17	18.4	1.15
10	0.19	21.3	1.33	0.15	16.7	1.04
11	0.12	13.8	0.86	0.07	7.4	0.46
12	0.14	15.2	0.95	0.09	10.4	0.65
P. radiata posts						
1	0.21	12.3	0.77	0.23	13.3	0.83
2	0.23	13.2	0.82	0.21	12.1	0.75
3	0.20	11.6	0.72	0.16	9.4	0.59
4	0.28	16.3	1.02	0.29	16.8	1.04
5	0.26	14.9	0.93	0.21	11.8	0.74
6	0.17	9.7	0.60	0.14	8.1	0.51
7	0.23	13.2	0.83	0.19	11.0	0.68
8	0.28	16.2	1.01	0.28	16.2	1.01
9	0.22	12.8	0.80	0.24	13.7	0.85
10	0.15	8.7	0.55	0.20	11.3	0.70
11	0.31	17.8	1.11	0.27	16.0	1.00
12	0.24	13.8	0.86	0.19	11.0	0.68

3.2 Retention below and above ground level in *E. maculata* based on copper content

The difference between above ground and below ground copper contents was highly significant.

In spite of the relatively high variation expected in any preservatively treated post, only one post failed to show loss of copper below ground level. The mean loss of retention was equivalent to 3.8kg/m^3 (0.24 lb/ft^3) over the period of 11 years in the ground.

At this stage it is not possible to predict whether the loss in copper has now become stabilized or will continue beyond this mean drop in copper content of about 24%.

3.3 Retention below and above ground level in *P. radiata* based on copper content

There was no significant loss of copper when each below-ground result was compared to the corresponding analysis above ground level. This result is indicative of the increased fixation of the copper component in *Pinus* species even when severe leaching hazards are encountered.

3.4 Performance of arsenic and chromium in *E. maculata* and *P. radiata*

Loss of the arsenic component from *E. maculata* posts was highly significant when compared to no significant loss of this component from *P. radiata*.

In both timber species the fixation of chromium was high.

The performance of arsenic and chromium in this test of posts in service followed the trend experienced by most research workers in this field in laboratory permanence tests.

3.5 Factors influencing the degree of permanence of C.C.A. salts

The available evidence points to some structural or chemical factor in hardwoods in general and *Eucalyptus* species in particular that increases the tendency towards leaching of the copper and arsenic components of C.C.A. salts.

No work was been done on the possible influence of soil types on leaching but this factor is unlikely to have significant effects when the relatively poor performance of C.C.A. treated *Eucalyptus* species in marine environments, or in the type of hazard encountered in cooling towers, is considered.

The similarity in pattern of the tests reported here on posts in service to the laboratory leach tests of Nicholson & Levi gives credence to accelerated tests as a means of predicting the permanence of the copper-chrome-arsenic salts in service.

4. Conclusions

(1) The sapwood of *E. maculata* and *P. radiata* when treated with C.C.A. salt will perform in service below ground level as follows:-

(a) Copper and arsenic will be substantially leached from *E. maculata*.

(b) Copper and arsenic will remain well fixed in *P. radiata*.

(c) Chromium is well fixed in both *E. maculata* and *P. radiata*.

(2) Analyses of C.C.A. salt components from *E. maculata* and *P. radiata* in service showed a similar pattern of results to work by Nicholson and Levi using a standardized leaching procedure.

CREOSOTE LOSSES IN HARDWOOD POLES

by R.S. Johnstone

Creosote has been established as an effective preservative for the treatment of transmission poles for many years. Both field and laboratory tests have confirmed the ability of timber treated with this material to resist both fungal and insect attack provided that:-

(1) the composition of the creosote conforms to the requirements for maximum toxicity.

(2) the creosote retention is adequate for the hazard to the treated timber.

(3) physical or chemical losses do not occur to such an extent that the creosote is reduced to below an acceptable toxicity level.

A major problem confronting the user of creosote-treated transmission poles is to be able to evaluate the creosote level at the time of purchase and,in addition, to predict whether there will be a reduction in biological toxicity over a period of years.

1. Discussion

1.1 Creosote determination

Attempts to correlate the standard procedure of toluene extraction with the less time-consuming toluene/dimethylformamide system of creosote extraction from plugs taken from treated poles has met with mixed success. Means of controlling the variables within the system of sampling and extraction and the high degree of variability of creosote within a pole treated by vacuum/pressure methods results in difficulties in planning correlative techniques.

A number of workers including Hudson and Stasse have reported work done using dimethylformamide but these studies have been carried out on softwoods and the conclusions drawn have been indecisive.

No exploratory work of any consequence appears to have been done on the extraction and estimation of the currently produced high temperature creosote in native eucalypts with toluene/dimethylformamide combinations.

Relying as we do on results-type specifications in the preservation industry then it is essential that an effective standardized technique be available. At this stage the toluene procedure appears to be the most satisfactory system available and experimental evidence should be produced before it is discarded and a new method substituted.

1.2 Losses of creosote

The second problem is a means of estimating creosote losses from timber by liquid or vapour movement of the creosote either in part or as a whole.

Losses of creosote may occur by drainage under gravity down the vessels of hardwood timber or perhaps by creosote being forced out through radial checks by the vapour pressure of volatile constituents.

It would be expected that these phenomena would occur early in the life of a transmission pole.

An additional and perhaps more serious factor influencing the effectiveness of creosote is the volatilisation of individual components. The resultant reduction in toxicity over the years could reduce the loading of creosote and vary the composition to such an extent that biological breakdown could restrict the period of usefulness of the timber.

In this instance reported experimental work covering changes in composition has again been done almost entirely on softwoods with creosotes of overseas origin.

The assumption has been made in new standards and specifications that locally produced high temperature creosote is at least the equal in toxicity to overseas products.

This may well be correct but it is in the interests of the users of creosote-treated timber that a plan be formulated to examine the possibility of gradual loss of active constituents.

2. Conclusion

If creosote as a pole treating medium is to be used with confidence, it is important that two problems be evaluated and solved within the context of Australian creosote and native hardwoods:-

(1) A purchaser of poles should be able to apply a suitable test to estimate the actual creosote retention at the time of purchase.

(2) It should be possible to approximately predict the likely characteristics of the creosote throughout the useful life of a treated pole, particularly in the initial period after installation.

THE NEED FOR A PRESERVATIVE TREATMENT TO REPLACE C.C.A. SALTS

By R. M. COWAN

The Radiata Pine Industry, as represented by the R.P.A.A., is currently pressure treating 42,500 m^3 of *Pinus radiata* annually. Of this total, approximately 25% is sawn timber treated with C.C.A. salts and this paper refers specifically to this product.

The sawn products range from purely structural to decorative or aesthetic end-uses and include flooring, decking, lining and cladding, scantling, fascia, house stumps and palings.

Three types of products can be recognised:

(a) Structural, engineering and covered uses.
(b) Low exposure risk, decorative end-use.
(c) High exposure risk, decorative end-use.

C.C.A. salts are satisfactory for type (a) products apart from an apparent brittleness in the twisted grain around knots. The checking, resulting from physical weathering, although unsightly, is of little consequence.

It is in the area of decorative end-uses, that is, groups (b) and (c) above, that C.C.A. salts pose problems when used as a preservative. These problems occur in the areas of:

(a) production - including treatment, drying and finishing;
(b) end-use - gluing;
(c) performance in service - weathering; and,
(d) market acceptance - colour.

Elaborating a little on these problem areas -

(a) Production

The use of water-borne C.C.A. salts in pressure impregnation results in "bulking" of the sawn timber which causes a change in dimensions. Drying is necessary and great stress is imposed on the treated timber. The drying is a lengthy process and unevenly dried patches or "wet spots" are usually evident in the finished product.

The length of time involved in the treatment and handling processes means a tie up of valuable capital and problems in accurate sales forecasting.

Penetration of *P. radiata* by C.C.A. salts is irregular and the heartwood of this species is often not adequately impregnated with preservative. This situation could become even more serious if the treated material is further processed by dressing or profiling, necessary because of dimensional changes occurring as a result of treatment. Such processing is not possible before treatment anyway, if a clean finish is required for decorative purposes.

This is a major disadvantage of the C.C.A. salts treatment processes.

(b) End-use

Treatment with C.C.A. salts has an effect on the performance of timber in various end-uses.

Of particular interest to Woods and Forests, is the performance of C.C.A. treated material in glue-laminated products.

The uneven drying of this material, and the resultant "wet spots" create many problems in R.F. curing of glue in the Department's continuous laminating press. In addition there is evidence to suggest that higher-level C.C.A. salt retentions cause reduced bond strength.

The change in dimensions which results from C.C.A. salts treatment precludes the possibility of effectively treating after gluing.

(c) Performance in-service

Pinus radiata is very hygroscopic and large dimensional changes occur in service as a result of rapid absorption and loss of moisture. These dimensional changes cause differential stresses in the timber resulting in physical weathering.

Some factor(s) in the C.C.A. treatment processes appear to aggravate the effects of this physical weathering and C.C.A. treated Radiata pine is notorious for its frequency of checking and splitting when exposed in-service. This causes concern in decorative and aesthetic end-uses.

A treatment which will eliminate or reduce the rate of moisture movement in timber in-service is required. Tanalith-C "Plus" has been tried, but while results are promising, many difficulties are encountered in its handling.

(d) Market Acceptance

A major factor in market acceptance of C.C.A. salts treated Radiata pine is, surprisingly, the colour. It is known that many expressions of disappointment are received from clients who had mistakenly believed that their timber would be a nice even green colour, which would last indefinitely. It is appreciated that this misconception should be corrected by adequate publicity but at the same time the factor of colour is of obvious importance in the market-place.

Stains applied as a surface coating are not necessarily the answer because of the physical weathering and poor "take" on resinous areas of the timber.

A possible solution is deep impregnation with a stain or colouring agent mixed with the preservative.

It is considered desirable that major research into possible alternative preservatives to C.C.A. salts should be initiated at an early date. Such research should recognise, among other factors, the problems mentioned above. In addition, it should consider the following points of vital importance for commercial application of such alternatives.

An alternative preservation to C.C.A. salts should be:

(a) suitable for use in high volume commercial plants operated by personnel with only reasonable training and degree of skill;

(b) effective in resisting attack by insect and fungi and other agents of decay;

(c) not so expensive that treated softwoods, such as *P. radiata*, cannot compete with local and imported durable timbers;

(d) capable of deep, even penetration;

(e) of such a type that will allow the timber to remain dimensionally stable during treatment;

(f) such that post treatment drying is reduced or eliminated;

(g) able to eliminate or reduce moisture movement in timber in service to alleviate the severe effects of physical weathering;

(h) of clean finish, not messy or prone to collect dust; and,

(i) so far as possible, of an attractive, even, fast colour.

In conclusion, I emphasise that the scarcity of durable local and imported timbers, is opening an ever-increasing market for treated Radiata pine. The product has considerable potential and the market is aware of its advantages. The situation augurs well for the product but difficulties in production and poor performance in service will soon sap market enthusiasm for its use, particularly in decorative or aesthetic areas.

It is recommended that research to seek effective and economical alternative preservatives to C.C.A. salts begin as a matter of urgency.

PROPOSED STUDY OF THE EFFECT OF STARCH AND EXTRACTIVES ON THE SUSCEPTIBILITY OF C.C.A. TREATED TEAK SAPWOOD

by C. Levy

Since the recognition of the problem of soft rot by Bailey and Vestal[1] and Tamblyn[2] in 1937, a great deal of effort has been made by various workers to increase our knowledge of the nature of the organisms responsible, their mode of action and the reason for the much higher susceptibility of hardwoods than softwoods to soft rot attack.

Our efforts to improve the utilisation of indigenous and exotic hardwoods in Papua New Guinea through v/pressure impregnation with C.C.A. preservative salts have been tempered with the realisation that our knowledge of the permanence of C.C.A. in tropical hardwoods in the wet tropics is very sparse indeed. For this reason we aim at a retention of 2 lb/ft.^{3} which,as it adds considerably to the end cost of the product, makes it all the more important that we satisfy ourselves that this retention will indeed give the required durability.

While this short paper is not intended as a review of the literature or current studies on soft rot, it will be convenient at this point to consider briefly some of the work presently being undertaken in laboratories which the author was recently priveleged to visit.

In Scandinavia significant decay has been found in birch treated to high retentions of C.C.A. while pine treated at much lower retentions has performed excellently after 3 years exposure in a co-operative test in Sweden, Norway, Denmark and Finland.

Enzymes systems involved in soft rot decay are being studied in laboratories in Europe and Japan. The International Research Group on Wood Preservation has organised a co-operative investigation of methods of determining toxic thresholds of preservatives for soft rot fungi.

Electron micro-probe techniques are being used in Germany and England to determine the location of C.C.A. components in treated hardwoods.

Out of discussions with various workers the following ideas emerge:-

(1) The nature of the nitrogen and carbon source grossly affects the mode of attack of soft rot fungi: Production of cellulolytic enzymes is influenced by concentration of simple sugars present, for example glucose; manipulation of the nitrogen source can change attack of soft rot fungi from cavity formation to erosion using certain nitrogen compounds.

(2) Delignified softwoods are not as susceptible to soft rot as softwoods pretreated with certain other decay fungi; the most important factor giving rise to the greater susceptibility of hardwoods than softwoods to soft rot is thought to be the nature of the hemicelluloses present, rather than differences in the nature of the lignins present.

(3) In C.C.A. treated hardwoods the copper is largely restricted to the vessels, very little finding its way into the fibre bundles.

We have been able to demonstrate[3] the rapid reduction of hexavalent chromium by acetone soluble extractives in a number of tropical hardwoods to an extent where the extractives present may often account for the reduction of virtually all the hexavalent chromium introduced in retentions up to as high as 3 lb. of C.C.A./ft.^{3}. As these extractives, in seasoned timber, would line the vessel walls, and also be present in parenchyma, it is reasonable to postulate that this reduction may take place within the vessels and parenchyma and,together with other associated fixation reactions which then take place in the lumen,limit the access of all three components of C.C.A. to the fibres.

In hardwoods which contain free starch, it is expected that this starch would also reduce hexavalent chromium and in addition limit the access of preservative solution to the cells where it was present and after exposure in service, still provide abundant accessible carbohydrate reserves for soft rot fungi.

It would thus appear that hardwoods provide an ideal environment for soft rot fungi because:-

(a) of the presence of utilisable hemicelluloses and sometimes starches.

(b) fixation of C.C.A. type preservatives is not as complete as it is in softwoods.

(c) the preservative is not evenly distributed throughout all the wood elements.

Because of the importance in P.N.G. of hardwoods and the fact that there does not appear to be any work being currently undertaken on the role of starches and extractives in fixation of C.C.A. and the consequent increased susceptibility of hardwoods to soft rot, the investigation which is now briefly described is being undertaken.

Proposed Experimental Procedure

Teak from plantation thinnings has been selected as the substrate because of its availability and its importance in our preservation programmes. Starch free teak will be obtained by selection from stocks of harvested thinnings kept with their bark intact for several months. Teak with starch will be obtained by selection from freshly felled thinnings.

Cubes accurately cut to 2cm from green sapwood will be used throughout and all oven drying will be carried out under vacuum at 50^{o}C to limit side effects of high temperature on the results.

It has been decided to use field exposure in garden soil of known quality in preference to laboratory soil block tests because of reported difficulties in obtaining reproducible results with laboratory cultures.

The following treatments are proposed:-

Table 1

Treatments to be applied to 2cm Teak sapwood cubes[5]

Pretreatment Soxhlet Extraction	Vacuum Impregnation with C.C.A. to: (lb /ft^3)	Post Impregnation Leaching	Exposure in Garden Soil F	Total Treatments
(1)	(2)	(3)	(4)	
Nil	Nil	Nil	Nil Samples retained for analysis.	
Water	.35 .75	(30 days (soxhlet (extraction	6 weeks	
Water Acetone	1.00	(with warm (water		
Water Acetone Benzene	2.00		12 weeks	
Total Treatments 4	5	2	3	120

Notes:

(1) 150 samples for each extraction treatment; to be vacuum oven dried at 50°C and weighed before and after extraction. 450 samples will be extracted with running water for one week. Of these 300 will be soxhlet extracted with acetone for 48 hours and of these 150 will be soxhlet extracted with benzene.

(2) There are 30 samples at each treatment level for each pre-extraction treatment; i.e. 120 samples in all at each treatment level. Retentions will be determined by weighing before and after impregnation.

(3) There are 300 samples for the post impregnation leaching treatment, divided into 15 replicates of each of 4 pretreatment extractions and 5 C.C.A. loadings.

(4) Of the 15 replicates of each pretreatment extraction and C.C.A. loading class, making up the total of 300 cubes leached and the 300 cubes not leached, 5 will be chemically analysed for copper, chromium and arsenic and the remaining 10 will be exposed in garden soil in the open.

The garden soil will be analysed for major exchangeable cations, nitrogen, phosphorous, organic matter, ph and conductivity.

After 6 weeks exposure half the cubes will be removed and the loss of wood substance determined. Those cubes which have not lost more than 25% of their wood substance will be re-exposed. After 12 weeks exposure all remaining cubes will be removed and loss of wood substance determined.

(5) The treatment listed will be applied to two classes of teak, one class containing starch and one class without starch in sapwood as determined by the iodine/potassium iodide test for starch.

A set of *Araucaria spp.* sapwood cubes will be treated to the five C.C.A. treatment loadings and post impregnation water leachings and exposed as controls.

From this investigation we expect to find significant differences in the permanence of C.C.A. and the susceptibility to soft rot of the teak as a result of the pre-extraction treatments and the initial presence or absence of starch. If extractives play as important a role in fixation as we expect, it may be that the Boucherie process, in which the sap is forced from the wood by the incoming preservative, gives better in-service performance in hardwoods than v/pressure impregnation at similar retentions. Harvesting of hardwoods when starch is low and/or a preseasoning ponding of hardwoods may also improve the performance after C.C.A. impregnation.

Ponding would, of course, improve penetration in many hardwoods species quite apart from the beneficial effect this treatment may have by removing water soluable extractives.

It is hoped that when this investigation is completed it may be possible to devise a much simpler procedure for evaluating a wide range of hardwood preservative systems as we recognise the necessity to consider all species as completely different substrates.

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LABORATORY EVALUATION OF NEW PRESERVATIVES

By L.D. Bezemer and E.W.B. Da Costa

Summary

New preservatives developed by industry and by Preservation Section are compared in laboratory decay tests with established preservatives to determine their suitability and required retentions. Recently, new techniques have been developed for testing preservatives against soft rot fungi, for testing water-soluble diffusing preservatives and for assessing decay by measuring carbon dioxide evolution.

Preservation Section has carried out a wide range of bioassays of preservatives in pure culture laboratory tests against wood-rotting fungi. Relatively quick laboratory tests have been necessary to answer many problems facing the preservation industry on promising new preservatives, as it has not been possible to wait for results from longer-term service or field tests. Such preservatives have been and are being developed both by industry and by Preservation Section itself. Sometimes, several closely related alternatives are developed and it is necessary to decide which will be the best to use commercially. This was the case with the fire retardant preservatives developed by McCarthy and Seaman of the Section for pine fence posts. Several similar formulations were developed and their fungitoxic properties were important as well as their fire resistance and resistance to leaching in deciding which was most suitable.

Similarly, we have tested promising new preservatives developed by industry, comparing them with well-known commercial preservatives which they may replace or compete with. Unless the new preservative performs as well as the presently-used preservative on a cost-benefit basis, we would be reluctant to recommend it. It should be stressed it is not our policy to do routine quality control testing for industry. This is within the capabilities of any large chemically-orientated supply company. However, the Section has always been willing to help investigate any new preservatives which have a wide research interest.

These investigations cover a range of both oil-borne and water-borne preservatives, and include preservatives for plywood and other sheet materials such as hardboard, chipboard, etc., besides the normal timber treatment. In this regard, the Section and industry have been looking at the problem of treating plywood with copper-chrome-arsenic-type preservatives. Difficulty has been experienced in industry, both in treating the assembled product and in gluing pre-treated veneers. Incorporation of a fungicide in the glue would be the most convenient method of treatment, but to date, incorporation into a phenol-formaldehyde glue of proprietary additives, sodium pentachlorophenate, thiabendazole or arsenic trioxide has given insufficient protection when compared with plywood made of CCA-treated veneers.

When evaluating a completely unfamiliar preservative, we may first get a rough assessment of its toxicity to a few wood-destroying fungi by quick tests involving production of "inhibition zones" around the material applied at one point on agar uniformly seeded with test fungus, or by weight losses of sawdust impregnated with the material in a range of concentrations. Before proceeding to a detailed evaluation, we would then screen it, either by the same rapid methods or in soil-block tests, against a wide range of fungi to select fungi relatively tolerant of it for test purposes. In the actual evaluations, the preservative is incorporated into small sapwood

blocks which are subjected to intensive laboratory weathering before exposing it in a soil-block test, usually against a well-known preservative as a yardstick. In using laboratory tests to predict adequate commercial retentions, we either determine the threshold value (i.e. the minimum retention which will just stop decay) and add a safety margin to cover variability in treatment, weathering or decay hazard; or compare it directly with an established preservative of similar type for which the adequate commercial retentions are well known.

At the moment, tributyltin oxide (TBTO) is rapidly becoming a popular new preservative. It is very effective at low concentrations, but not having been in service long, it is difficult to know just what retentions should be specified. It is mainly competing with pentachlorphenol, and overseas laboratory tests and specifications suggest that one part of TBTO is as effective as 10 parts of PCP. We have done laboratory tests with three decay fungi, comparing four concentrations of TBTO and of PCP, and we have found a wide variation in the ratio of effectiveness depending on the fungus and the timber, ranging from approximately 30:1 to 1:1. Further tests with a wider range of fungi are required.

As well as evaluating new preservatives for commercial use, it is often useful to investigate further properties of these preservatives. For example, comparing a number of Australian low temperature creosotes of differing phenolic content showed that those of low phenol content gave much less protection to the wood. These findings resulted in an alteration of SAA specifications which limited removal of phenols from the creosote for other uses.

Similarly, we have tested CCA formulations with various proportions of arsenic and have shown that reducing the arsenic content reduces the effectiveness of the preservative against fungi. When evaluating fire retardant preservative formulations, we found that addition of phosphorus for fire-retardancy purposes counteracted the toxic effect of arsenic present in the basically CCA-type formulation. It is thus important to balance the effects of these two elements. A relationship between chemical structure and fungitoxicity has been demonstrated for a range of organo-tin and organo-lead preservatives, especially the trialkyl compounds.

These laboratory tests have given a good estimate of relative value of preservatives for use in ground contact as poles or posts, as sleepers or as building timbers exposed to continuous wetting. Their relevance to preservative evaluations for timbers exposed to intermittent wetting such as external joinery or cladding has not been so well established, but they probably give reliable comparative data. Because the nature of the hazard is so variable it seems preferable to use outdoor exposure tests under conditions approximating those of use, rather than try to develop standardized laboratory tests.

Previously our laboratory tests have concentrated mainly on decay by wood-rotting basidiomycete fungi. But it is becoming more and more apparent that the soft rot group of fungi play an important role in the biodeterioration of timber. And we now need new information on how to combat this class of wood-inhabiting fungi, as their sensitivity to fungicides is different from that of the basidiomycete wood-rotters. Until recently, our main interest in soft rot control has been in relation to cooling towers, where exposure tests in towers give rapid and reliable

comparisons of preservatives. But the recent discovery that soft rot fungi can cause severe losses in treated eucalypt sapwood in ground contact, especially in tropical climates, has presented us with a number of new problems.

Firstly, a satisfactory method of testing with soft rot fungi in the laboratory must be devised. Like European laboratories in the International Research Group, we have found it difficult to get standardized reproducible results. We have tried testing with pure cultures of soft rots growing on various agar media, with pure cultures inoculated onto wood blocks buried in sterile soil, and with blocks buried in non-sterile soils. The highest weight losses obtained so far have been with burial in non-sterile compost.

Secondly, *in situ* remedial treatment of soft rot - affected poles would probably involve the use of a diffusible preservative. Normal laboratory techniques are useless for testing this type of preservative as the chemical diffuses away into the substrate of soil or agar. We have therefore devised a technique using a sandwich of about eight wet, infected slips of sapwood which is sealed around the outside with paraffin wax except for a small area on the top and bottom of the sandwich. The killing action of a concentrated diffusing preservative applied to the top surface is checked in successive layers of the sandwich.

A third technique we are trying is rapid measurement of decay rate by measuring the carbon dioxide produced from the wood. This method may be used with basidiomycete wood-rotting fungi or with soft rot fungi. It is laborious and time-consuming so is unlikely at the moment to replace the bulk of our soil-block decay tests. However, it could be an important tool in comparing the viability of fungi in infected wood before and after the application of inhibitory or eradicant treatments.

ARE CHLORINATED HYDROCARBON COMPOUNDS SAFE TO USE IN WOOD PROTECTION?

by R. Johanson

The object of this communication is to remind all concerned of a probable health hazard that may be associated with the use of some of the chlorinated hydrocarbons commonly used in protection of timber against destructive organisms, especially insects

Not all of the chlorinated hydrocarbons may produce a similar hazard. The term is omniembracing, it includes relatively tolerable and extremely dangerous compounds. It is the chemical structure with often quite subtle differences in molecular arrangements of the atoms that produces profound biological effects. The difference between aldrin and dieldrin consists of one extra oxygen atom but it is an epoxy oxygen, and it endows dieldrin with an extra physiological activity. An epoxy oxygen is also a carcinogen.

A hydroxyl radical in chloropentaphenol molecule enables formation of very dangerous dioxane compounds, whereas benzene hexachloride (and its active gamma isomer)lacks this property and it may be tempting to regard it as relatively safe. However, there are indications that benzene hexachloride may contribute to liver cancer (Ehrlich and Ehrlich, 1970). In general all chlorinated hydrocarbons are 'nerve-type' poisons for insects and a broad-spectrum poison for other living organisms - they all possess extreme range of biological activity, chemical stability, mobility and affinity for living systems.

Recent events have shown that the usual measure of toxicity to mammals, e.g. the LD_{50} in mg/kg (lethal dose to 50% of the test animals) is not a measure or even an indication of various deleterious effects which an insecticide may have on mammals and environment. Thus in a recent issue of Nature (1972) a report is presented of a test where a single injection into peretoneal cavity (inside abdomen lining) of a mg quantity of dieldrin in pregnant mice produced mentally retarded offspring. The affected mice were indistinguishable in other respects from the control litters used in the tests.

Information by Jervis (1967) describes changes in the metabolism of phenylalanine as related to altered homeostasis (normal body states) of brain enzymes and mental deficiency in mammals induced by dieldrin. In the current publication Mehrle et al. (1972) described how dietary dieldrin effected phenylalanine metabolism in rainbow trout and that this chemical can induce manifestation of the well known phenylketonuria syndrome.

It is beyond the scope of this note to give more than just an example and a few references. The new situation needs projected thinking and a new approach. Each decision to use a chlorinated compound, in a situation however safe it may appear, should be made with the utmost caution and with the knowledge than such a use may be fraught with risk to an environment including an unborn child. Acceptance of a transient economic advantage may be tempting but repayment could be too costly as was found by Faust in Von Goethe's epic poem

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IMPROVEMENTS REQUIRED IN WOOD FOR IT TO KEEP ITS PLACE IN OUTDOOR USE.

by F.A. Dale

In spite of the many substitutes on the market wood is still much in demand for exterior use on buildings, particularly for dwellings and in many cases, better class architect designed houses.

In the past, timbers of the necessary dimensional stability and resistance to insects and decay were readily available. Western red cedar was the elite timber but many Australian hardwoods performed very well if they were regularly painted. Within the last ten years the situation has changed, more so recently as supplies of western red cedar and good quality Douglas fir have become scarce and the price has been climbing rapidly. Many builders and architects have been using CCA treated pine instead, sometimes under the impression that this treatment would stabilize pine as well as protect it from decay and termites. At the same time, clients have started to demand that the timber be left unpainted or stained to give a natural look and have naturally become upset when the timber moved and split while the surface started to lift. Restaining only partly hides this deterioration, most noticeable in barge boards, fascia and other exterior trim where the timber must stay straight and flat in service.

The situation is further confused by the very large differences in assessment of appearance by different people. Owners of holiday homes are far less concerned with appearance, particularly in sheathing, than those with homes in the suburbs.

All this is past history, what are the possible solutions to the problem? There is no doubt that inadequate redrying after CCA treatment is still the major cause for complaint with radiata pine. However, even the best material, cut away from the pith and perfectly dried, will not stay straight and true in service without additional protection. If kept painted, any slight distortion may go unnoticed but if only stained or oiled gradual deterioration will occur, particularly if maintenance is neglected.

What is wanted is a permanently water-repellent impregnant which will reduce annual and daily moisture changes to a very low level. Ideally it should be colourless, paintable, toxic to insects and decay, clean and safe to handle. If it is to be painted it should not cost much more than existing treatments but as it would be applied to dry mouldings it would eliminate the waste inherent in CCA treatment, where much treated wood is machined off in moulding. If it is intended as the only protection for the timber during its lifetime, it can cost more and still be economic.

Impregnation with a preservative oil using accepted methods meets only some of these requirements. Creosote, creosote/oil mixtures and pentachlorphenol in mineral oil all give very good weather resistance and after some years weathering the treated timber usually as a bleached surface which is clean and attractive. The disadvantages of these oils are their initial odour, long term "bleeding" and the fact that where the timber is sheltered the oily surfaces pick up dust and spoil the total effect. The Rueping treatment required to give the necessary low oil retentions makes control of bleeding very difficult. "Clean" oils do not overcome this problem, although their initial appearance is often excellent and their smell not offensive.

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There are two possible approaches to the overall problem. One is to impregnate with a preservative dissolved in light volatile solvent with the addition of a water repellent, such as paraffin wax, a bulking or swelling agent such as polyethylene glycol and a polymer such as an alkyd resin. After treatment the volatile solvent is removed under vacuum and recovered. The ideal treatment should be colourless and paintable but perhaps still giving good weathering protection after 10-20 years. The retention of such preservative after removing the solvent might be about 32-48 kg/m^3 (2-3 lb/cu. ft.). Such a treatment is the obvious first choice for exterior joinery and trim.

The second approach is to use higher loadings, say, 80 kg/m^3 (5 lb/cu.ft.) or even more of stable oil preservatives having a very high distillation range, perhaps with a bulking agent. The main problem of bleeding can probably be overcome only by using a treatment process which does not involve forcing air into the cells first, or even trapping atmospheric air. At the same time penetration and retention must be controlled. Even creosote may be suitable in this case as there are many who do not find the odour offensive and who like the ultimate colour and appearance.

Permanent colours may be possible with both types of treatment, green copper napthenate being an example. If finished mouldings are treated, some penetration of very finely ground pigments into the surface of pine may be obtainable.

Cost of the treatment should not be a prime consideration. The minimum cost of a good 3 coat paint system applied to clean weather-boards is $1.50 per sq. yd.. This is equivalent to $16.50 per 100 sq. ft. of painted surface. Allowing for overlap this would require 120 super ft. of weatherboard equivalent to a treatment cost of $13.80 per 100 super feet. Even if treatment costs this much it would only have to eliminate perhaps two re-paintings to be more economic. Obviously a treatment intended to be painted over would have to cost less, but the current difference in price between treated pine and WRC is already 20 cents/sq.ft. or $20 per 100 sq.ft. so that a treatment cost of even $10 per 100 sq.ft. would not necessarily be uneconomic although it would be harder to sell to the builder or householder.

Treatment of hardwoods to meet the same requirements will certainly prove much more difficult. Eucalypts accept treatment at high pressure along the vessels and uniform heartwood treatment is only possible in some "ash-type" timbers. It may be possible to apply the solvent type of stabilizing to pre-fabricated joinery components but any cutting on site would require swabbing or dipping of the freshly cut surfaces and this is a second rate treatment. Most meranti is as hard to treat as the eucalypts. Some island timbers are permeable, e.g. ramin, but the uncertainty of future supply rules them out.

Heavy oil treatment has proved very effective in protecting karri cross-arms and there could be some market in treating sawn timbers for buildings. The final appearance of oil treated dressed timbers is less attractive, and special treatments hardly seem warranted for hardwood mouldings unless a surface can be obtained which dries out fairly quickly.

SUB-TOPIC C - BIO-DETERIORATION

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SOME OBSERVATIONS ON SOFT ROT IN TREATED TIMBER

by D. W. EDWARDS and R. S. JOHNSTONE

Summary

Some observations are made on the occurrence of soft rot in timber treated with various wood preservatives.

No correlation was found between the retention of copper-chrome-arsenic salts, (C.C.A.), based on copper content, in pressure treated *Eucalyptus maculata* Hook. sapwood, and the depth of penetration, or intensity of soft rot attack after 11 years ground contact. Deep penetration of soft rot was shown to occur in *E. maculata* sapwood treated with C.C.A. by sap replacement.

Results of C.C.A. treatment by vacuum/pressure impregnation of *Pinus radiata* D.Don posts, (9 years in ground), and small *P. radiata* blocks, (1 year soil burial), and their relation to soft rot are presented.

Similar small block test data for 1 year soil burial of *P. radiata* are given for a number of dip treatments.

1. Introduction

In some parts of Australia the degrade of copper-chrome-arsenic (C.C.A.) treated hardwood poles has become a matter of serious concern to pole users.

Investigations of this type of damage are being carried out by the Queensland Department of Forestry in conjunction with State Electricity Authorities; by the Division of Building Research, CSIRO, and the Wood Technology Division, Forestry Commission of N.S.W.

The nature of soft rots, and the problem of soft rot damage in treated poles will be familiar to most delegates. In brief, soft rots under some conditions notably in tropical, subtropical or very wet soils, are able to invade and damage timber treated to high retentions of well established wood preservatives. This attack is likely to be more severe in hardwoods for reasons which are not yet clear.

This paper presents a collection of observations on soft rot attack in treated wood made by the Commission's Wood Technology Division. The material is part of a soft rot investigation programme which will be published more fully elsewhere.

2. Materials and Methods

2.1 Copper-chrome-arsenic treated *E. maculata* posts

Two fence lines of *Eucalyptus maculata* Hook. natural round posts were studied. One was treated by vacuum-pressure impregnation to a nominal retention of 16.0 kg/m^3, (1.0 lb/ft^3) of Tanalith C in the sapwood. This fence had been in service at Wallaroo State Forest, north of Raymond

Terrace, N.S.W. for 11 years. The other fence posts had been treated by sap replacement with either Tanalith C, or Celcure A, and had been in service for 14 years at Pennant Hills, a Sydney suburb.

2.1.1 Wallaroo fence posts

Plugs of treated wood 12 mm in diameter were taken with a power-operated plug cutter, at two points on the same longitudinal axis of the post, i.e., 1 metre above the groundline, and 75 mm below ground.

Each plug was divided into 5 mm zones measured from the outer face. From the centre of each of these zones transverse sections of wood were cut by hand, and mounted in lactophenol cotton-blue mountant.

These sections were examined microscopically for the presence of soft rot attack in the cell walls. The relative intensity of the soft rot attack was determined by counting the number of "boreholes" in 10 microscope fields at 600 x magnification.

Each plug was then analysed for copper, and the results evaluated statistically for relationships between preservative concentration, and the depth and/or intensity of soft rot attack.

One additional post was analysed to determine an average concentration gradient by taking 12 plugs of treated wood above groundline. These plugs were each divided into 5 mm long samples, and at each depth the samples were pooled, and analysed for copper. Results are shown in Tables 1, 2, and 3.

2.1.2 Pennant Hills fence posts

In this test the sample plugs were taken 75 mm below groundline and tested for soft rot as described above but at two positions only, i.e., ¼ and 3/4 of the plug length. All plugs were then analysed for copper. Results are shown in Table 4.

2.2 Copper-chrome-arsenic treated *Pinus radiata* D.Don posts

These posts were treated with Tanalith C to a nominal cross-sectional retention of 8.0 kg/m^3, (0.5 lb/ft^3), and had been in service for 9 years at Pennant Hills, near Sydney.

The presence of soft rot was determined as before in plugs of treated wood taken 1 metre above and 75 mm below ground at the ¼ and 3/4 points of each plug. The whole plug in each case was then analysed for copper. Results are shown in Table 5.

2.3 Small wood block tests - vacuum/pressure and dip treatments

A number of small (25 x 25 x 25 mm) *Pinus radiata* wood blocks were buried in soil 50 mm below ground at Pennant Hills for 1 year. The blocks were then removed, cut in half, and examined for soft rot as before. The occurrence of soft rot was determined at the edge of the block, using transverse and longitudinal sections, and at the centre using transverse sections only. In each case 10 microscope fields were examined at 600X.

Two groups of treatments were studied:-

(i) copper-chrome-arsenic vacuum/pressure impregnation to two retention levels

(ii) copper naphthenate; copper 8-hydroxy-quinolinolate; pentachlorophenol; copper naphthenate/tributyltin oxide; and borax/pentachlorophenate dip treatments for one or more dipping times.

Results are shown in Tables 6 and 7.

3. Discussion and Conclusions

3.1 Copper-chrome-arsenic treated *E. maculata* - Wallaroo fence line

It can be seen from Table 1 that there were significant losses of the copper component of the C.C.A. preservative in many of the posts. However, when correlation coefficients were calculated between this component, and either the depth of soft rot penetration, or the relative intensity of attack, (Table 2), no significant relationships were found. This led to the conclusion that for the range of retentions studied, soft rot attack in treated *E. maculata* sapwood could not be simply ascribed either to losses by leaching or to the final retention of preservative in the wood.

Table 3 shows the pooled concentration gradient of copper across one such C.C.A. treated post above groundline after 11 years. This gradient is very slight, and does not suggest severe leaching above ground.

3.2 C.C.A. sap replacement treated *E. maculata* - Pennant Hills

Table 4 shows the occurrence of soft rot in *E. maculata* posts treated by sap replacement with Celcure A and exposed in ground contact for 14 years. It is interesting to note that this soft rot has appeared at quite high copper concentrations.

Despite the appearance of soft rot in posts treated with Celcure A but not in those treated with Tanalith C it is felt that the test method does not allow any valid toxicity differences to be inferred between the two preservatives.

3.3 C.C.A. pressure treated *Pinus radiata* D.Don

These posts had been in service for 9 years. The clear picture which emerges from Table 5 is the freedom from soft rot of all except two posts, and even in these soft rot penetration has been very slight. This lends support to the now generally accepted view that the performance of C.C.A. treated softwoods against soft rot is better than that of C.C.A. treated eucalypts.

In the same area a short term test using small blocks (25 mm x 25 mm x 25 mm) of C.C.A. treated *P. radiata* buried 50 mm below soil level for one year as described in 2.3 showed (Table 6) the good initial protection given by this type of preservative under severe soil exposure conditions.

3.4 Dip treatments for *Pinus radiata*

Using the soil burial technique described in 2.3 above a number of dip treatments were compared in a preliminary investigation of the value of surface treatments in checking soft rot attack.

These results are presented in Table 7 and suggest that copper naphthenate, copper 8-hydroxyquinolinolate (0.3% Cu), and perhaps 5% pentachlorophenol are suitable short term inhibitors of soft rot. No firm conclusions have yet been drawn since more test blocks in each sub-group remain to be examined. These figures are merely an indication of trends, and must not be interpreted too rigidly.

Acknowledgments

We wish to thank Mr. Omar, Biometrician, Forestry Commission of N.S.W. for the statistical analyses.

Table 1

OCCURRENCE OF SOFT ROT IN COPPER-CHROME-ARSENIC TREATED SPOTTED GUM POSTS AFTER 11 YEARS IN GROUND AT WALLAROO N.S.W.

Post No.	Retention of preservative: Copper	C.C.A. salt based on copper		Depth of soft rot Penetration	Relative intensity of soft rot (3)
	(%)	(lb/ft^3)	(kg/m^3)	(mm)	
Above groundline (1)					
1	0.14	0.98	15.7	2.5	1
2	0.11	0.78	12.5	2.5	1
3	0.09	0.65	10.4	2.5	1
4	0.11	0.76	12.2	NIL	0
5	0.13	0.91	14.6	2.5	1
6	0.13	0.87	13.9	2.5	1
7	0.16	1.12	17.9	7.5	2
8	0.13	0.93	15.2	2.5	1
9	0.18	1.28	20.5	NIL	0
10	0.19	1.33	21.3	2.5	1
11	0.12	0.86	13.8	NIL	0
12	0.14	0.95	15.2	2.5	2
Below groundline (1)					
1	0.07	0.49	7.9	7.5	3
2	0.08	0.59	9.5	7.5	3
3	0.06	0.43	6.9	7.5	3
4	0.04	0.28	4.5	22.5	4
5	0.11	0.76	12.2	12.5	4
6	0.11	0.74	11.9	2.5	2
7	0.13	0.87	13.9	2.5	4
8	0.16	1.11	17.8	22.5	4
9	0.17	1.15	18.4	NIL	0
10	0.15	1.04	16.7	NIL	0
11	0.07	0.46	7.4	2.5	1
12	0.09	0.65	10.4	2.5	1

(1) Above groundline samples taken 1 metre above soil level. Below groundline samples taken 75 mm below ground level. Both samples taken on same longitudinal axis.

(2) Based on estimate of number of soft rot 'boreholes' in 10 microscope fields at 600X.

(3) In outer 5 mm.

Table 2

CORRELATION COEFFICIENTS BETWEEN DEPTH AND INTENSITY OF SOFT ROT ATTACK: AND PERCENT RETENTION OF COPPER IN *EUCALYPTUS MACULATA* FENCE POSTS AFTER 11 YEARS SERVICE

Soft rot attack	Copper Content (%)
	(r)
Intensity of attack in outer 5 mm	
Above ground	0.1672
Below ground	- 0.1839
Depth of penetration	
Above ground	0.1645
Below ground	- 0.2181

Table 3

CONCENTRATION GRADIENTS, ABOVE GROUND, IN A COPPER-CHROME-ARSENIC TREATED *EUCALYPTUS MACULATA* POST, AFTER 11 YEARS SERVICE AT WALLAROO STATE FOREST, N.S.W.

Retention		Depth of sample from surface of post (mm)					
		0-5	5-10	10-15	15-20	20-25	25-30
Copper	(%)	0.24	0.25	0.24	0.22	0.18	0.21
Copper-chrome-arsenic (based on copper)	(lb/ft^3)	1.69	1.77	1.64	1.51	1.27	1.45
	(kg/m^3)	27.1	28.4	26.3	24.2	20.4	23.2

Table 4

OCCURRENCE OF SOFT ROT IN *EUCALYPTUS MACULATA* FENCE POSTS TREATED WITH COPPER-CHROME-ARSENIC SALTS BY SAP REPLACEMENT AFTER 14 YEARS SERVICE AT PENNANT HILLS N.S.W. (SAMPLES TAKEN 75 mm BELOW GROUND)

Preservative	Preservative retention			Depth of sample from surface of post	Presence of soft rot
	As Copper	As CCA salt (copper basis)			
	(%)	(lb/ft^3)	(kg/m^3)	(mm)	
Celcure A	0.09	0.69	11.1	8	+
				24	+
	0.16	1.22	19.6	9	-
				26	-
	0.41	3.12	50.0	7	+
				20	-
	0.38	2.89	46.3	9	-
				26	-
	0.27	2.06	33.0	9	+
				26	+
Tanalith C	0.20	1.39	22.3	8	-
				24	-
	0.26	1.81	29.0	7	-
				23	-
	0.16	1.11	17.8	7	-
				21	-
	0.32	2.23	35.7	7	-
				21	-
	0.29	2.02	32.4	8	-
				25	-

Table 5

OCCURRENCE OF SOFT ROT IN COPPER-CHROME-ARSENIC TREATED *PINUS RADIATA* FENCE POSTS AFTER 9 YEARS SERVICE AT PENNANT HILLS, N.S.W.

Post No.	Preservative retention			Presence of soft rot	Maximum depth tested
	Copper	CCA salt based on copper			
	(%)	(lb/ft^3)	(kg/m^3)		(mm)
Above groundline[1]					
1	0.21	0.77	12.3	-	29
2	0.23	0.82	13.2	-	29
3	0.20	0.72	11.6	-	27
4	0.28	1.02	16.3	-	21
5	0.26	0.93	14.9	-	24
6	0.17	0.60	9.7	-	18
7	0.23	0.83	13.2	-	25
8	0.28	1.01	16.2	-	28
9	0.22	0.80	12.8	-	24
10	0.15	0.55	8.7	-	24
11	0.31	1.11	17.8	+[2]	24
12	0.24	0.86	13.8	+	3
Below groundline[1]					
1	0.23	0.83	13.3	-	27
2	0.21	0.75	12.1	-	9
3	0.16	0.59	9.4	-	26
4	0.29	1.04	16.8	-	30
5	0.21	0.74	11.8	-	26
6	0.14	0.51	8.1	-	21
7	0.19	0.68	11.0	-	23
8	0.28	1.01	16.2	-	21
9	0.24	0.85	13.7	-	13
10	0.20	0.70	11.3	-	16
11	0.27	1.00	16.0	-	17
12	0.19	0.68	11.0		

(1) Above groundline samples taken 1 metre above soil level. Below groundline samples taken 75 mm below ground level. Both samples taken on same longitudinal axis.

(2) Soft rot penetration detected to 3 mm.

Table 6

OCCURRENCE OF SOFT ROT IN SMALL, (25 x 25 x 25 mm) *PINUS RADIATA* BLOCKS TREATED WITH A COPPER-CHROME-ARSENIC PRESERVATIVE

Retention		Occurrence of soft rot	
(lb/ft^3)	(kg/m^3)	Edge of block	Centre of block
NIL	NIL	6 (8) (1)	6 (8)
1.4	22.4	0 (70)	0 (70)
2.1	33.7	0 (45)	0 (45)

(1) 6 (8) means 6 blocks showed soft rot out of 8 examined.

Table 7

OCCURRENCE OF SOFT ROT IN DIP-TREATED SMALL (25 x 25 x 25 mm) *PINUS RADIATA* WOOD BLOCKS AFTER 18 MONTHS BURIAL 50 mm BELOW GROUNDLINE AT PENNANT HILLS, N.S.W.

Treatment	Dip time (sec.)	Occurrence of soft rot	
		Edge of block	Centre of block
Untreated (Water only)	30	6 (8) (1)	6 (8)
Copper naphthenate type			
Product A. (3.0% Cu)	30	0 (10)	0 (10)
Product B. (3.0% Cu)	10	1 (8)	1 (8)
	20	0 (10)	0 (10)
	30	0 (5)	0 (5)
	60	0 (10)	0 (10)
	180	0 (10)	0 (10)
	300	0 (7)	0 (7)
Product C. (3.0% Cu & 0.5% TBTO)	10	0 (11)	0 (11)
	20	0 (10)	0 (10)
	30	1 (11)	1 (11)
	60	0 (8)	0 (8)
	180	0 (11)	0 (11)
	300	0 (10)	0 (10)
Copper 8-hydroxyquinolinate type			
Product A. (0.2% Cu)	10	0 (9)	0 (9)
	20	0 (10)	0 (10)
	30	0 (9)	0 (9)
	60	1 (8)	1 (8)
	180	1 (8)	0 (8)
	300	0 (6)	0 (6)
Product B. (0.014% Cu)	30	6 (8)	5 (8)
(0.0047% Cu)	30	5 (9)	4 (9)
(0.0014% Cu)	30	1 (9)	0 (9)
Pentachlorophenol type			
Product A. (5.0% PCP)	30	0 (7)	0 (7)
Product B. (5.0% PCP)	10	0 (3)	0 (3)
	20	2 (9)	2 (9)
	30	0 (9)	0 (9)
	60	1 (7)	1 (7)
	180	1 (7)	0 (7)
	300	2 (8)	2 (8)
Sapstain dip (0.4% PCP; 1.2% borax)	30	6 (8)	5 (8)

SOFT ROT IN TREATED WOOD

by N. Tamblyn

The first field tests of wood preservatives installed many years ago by the (then) Division of Forest Products were concerned mainly with demonstrating that sleepers, poles and fence posts of less durable eucalypts could be given long life by adequate treatment with the best preservatives then available. For convenience, most of these tests were set up in the southern States and it was not until the post-war period that attention could be given to new tests with the somewhat different objective of comparing many different preservatives in different timbers over a wide locality range including tropical sites. The planning, preparation and installation of these new tests occupied some years and was not completed until 1963-64 when a total of over 6000 specimens treated with over 40 preservatives were installed in the following 8 sites *[1]. (Table 1)

TABLE 1 SITE DETAILS

Site and Date Installed	Location	Mean Annual Rainfall (inch)	Vegetation
Keravat	New Britain near Rabaul	about 100*[2]	Tropical rain forest
Brown River	Papua near P. Moresby	about 60*[2]	Tropical rain forest
Innisfail	N. Queensland coastal	143	Tropical rain forest
Millaroo	N. Queensland inland from Ayr	about 30*[2]	Savannah woodland
Manning River	New South Wales	about 46*[2]	Wet sclerophyll forest
Pennant Hills	New South Wales near Sydney	42	South coast eucalypt forest
O'Shanassy	Victoria near Warburton	57	Eucalypt mountain forest
Walpeup	Victoria near Ouyen	13	Dry Mallee scrub

*[1] For further details of this test see "The Small Specimen Test" by J. Beesley - Forest Products Newsletters 310, 311 (Aug. and Sept. 1964).

*[2] Not official meteorological records but estimated from nearest official recording stations.

The specimens were stakes about 460mm (18 inch) long of radiata pine sapwood dressed to 51mm (2 inch) square, of *Eucalyptus regnans* heartwood 48mm (1 7/8 inch) square and of *E. regnans* natural rounds varying in diameter from about 44-89mm (1 3/4 - 3 1/2 inch).

These tests are now yielding valuable information on the effect of locality and timber species on the performance of many different preservatives in preventing decay and termite attack. It is impossible here to present all the information available but the main trends for decay resistance only are summarized in Table 2. The figures given are expressed as marks out of 100 where zero marks represents failure of all specimens

and 100 marks indicates that no decay has occurred. In the table an average score is given (for 20 specimens) and a range (figures in brackets) which refer to the individual tests units of 5 specimens in each site except that in Papua-New Guinea results for the two sites were averaged in our detailed tables before Table 2 was prepared. Averages for the northern sites are therefore strictly an average of three figures and are probably a little higher than would be the case if all 4 sites had been averaged separately.

Conclusions which we have drawn from these tests at their present stage, and which are mostly reflected in Table 2, are :-

1. Average decay scores for the northern sites are consistently lower for all preservatives and treatments than corresponding scores in the southern sites and except for CCA treatments of pine are often very much lower. From specimens so far examined there is little doubt that deterioration is mainly the result of soft rot and that we are faced with a problem where the best preservatives at present available (creosote, PCP and CCA) are unsatisfactory for tropical ground contact use at retentions which give long life under more temperate conditions. In some cases it appears that even doubling of the retention may be unsufficient to achieve a satisfactory result for tropical ground contact.

2. In almost all cases the lowest score in the range given in Table 2 was recorded in Papua-New Guinea, despite the fact that the rainfall at Innisfail (143") is considerably higher than at either Keravat (about 100") or Brown River (about 60"). The most likely reason for this is mean temperature which is higher (by about 2-3°C) in the Papua New Guinea sites than at Innisfail and that this is the main factor favouring more rapid development of soft rot. This conclusion seems also to apply to other sites. Thus, with few exceptions, scores at Millaroo (about 30" rainfall) are lower than at Manning River (about 46" rainfall). There is even an indication that this pattern is developing between Manning River and Pennant Hills. The tentative conclusion from this is that within limits, rainfall is less important than temperature in determining the life of preservative treatments where there is a high soft rot hazard.

3. All preservative oils and salts listed in Table 2 produced higher decay resistance in radiata pine sapwood than the corresponding treatments in *E. regnans* heartwood and sapwood. Possible explanations for this are that distribution, toxicity or permanence of all preservatives are better in pine or that the result is due simply to the naturally high resistance of conifers to soft rot. Although a combination of both explanations is quite probable, the uniformly better result for so many different preservatives suggests that the natural resistance of pine to soft rot is the main factor.

4. The sapwood of *E. regnans* is more difficult to protect against soft rot than the heartwood of this timber. It is unlikely that better distribution of preservative is obtained in heartwood than sapwood and since scores for both heartwood and sapwood are lower for the PNG sites than for the higher rainfall site at Innisfail, it appears that a difference in resistance to leaching is not a major factor. Of the remaining factors - higher toxicity of preservatives in *E. regnans* heartwood or higher natural resistance of the heartwood to soft rot - the latter appears to be the more likely.

5. The three creosotes used for treatment of pine sapwood have so far shown only a small difference in performance though there is an indication that Australian K.55 creosote is slightly superior to the AWPA (American coke oven) creosote. Despite this slight superiority the K.55 creosote has proved most unsatisfactory (average score of 28) for protection of *E. regnans* sapwood at 128 kg/m^3 (8 lb/cu.ft.) in the northern sites. Even in the southern sites the average score of 75 after only 6-8 years service cannot be regarded as satisfactory. In the northern sites doubling the loading to 16 lb/cu.ft. has raised the average score to only 79 which is still inadequate. At this high loading it is only just satisfactory (89 marks) in the southern sites. On the evidence of this test it seems that we should be cautious in recommending the use of creosote for treatment of eucalypt sapwood in ground contact much beyond the northern coastal limit of Sydney. This conclusion, which appears to conflict with the practical evidence from commercial treatment of poles does not take into account the factor of specimen length. We now accept that in eucalypt poles there is some replenishment of creosote in the butt sapwood by gravity movement from the top section. It is suggested that both conclusions need careful consideration before recommending use of creosote in northern areas particularly for timbers of short length where there is a soft rot hazard.

6. Pentachlorphenol at 5% w/w concentration in furnance oil has performed at least as well as K.55 creosote in radiata pine sapwood and in *E. regnans* heartwood. In *E. regnans* sapwood it has generally performed better, particularly at the lower loading of 128 kg/m^3 (8 lb/cu.ft.). However, in the northern sites it is still an unsatisfactory preservative for *E. regnans* sapwood even at the higher loading of 256 kg/m^3 (16 lb/cu.ft.). Further comparative tests of the present Australian coke oven creosote and PCP in a range of different oils are needed before final judgements can be made. On present evidence PCP in furnace oil does appear to be the superior preservative but it must be remembered that initial toxicity and permanence are separate factors and that the stake test may not yet have sufficiently evaluated the latter.

7. The three CCA preservatives at 12 kg/m^3 (0.75 lb/cu.ft.) in pine sapwood have so far performed well in the southern sites with scores between 95 and 100. At this loading in pine they have performed equally well at Innisfail and Millaroo (95-100) but not in PNG (scores of 80-86). However, at 19 kg/m^3 (1.2 lb/cu.ft.) the score in PNG of 90-95 are satisfactory and are in the same range as most of the preservative oils at 256 kg/m^3 (16 lb/cu.ft.).

   In *E. regnans* sapwood at 12 kg/m^3 (0.75 lb/cu.ft.) average scores for the three CCA preservatives in Table 2 have ranged from 71-73 in the northern sites with an individual score as low as 56 for one preservative in PNG. It is clear that this loading is inadequate to protect eucalypt sapwood against soft rot under tropical conditions and the score range of only 80-82 for the three preservatives at the O'Shanassy site is a warning that it is also inadequate in cold wet southern sites. Unfortunately when the test was planned, loadings higher than 12 kg/m^3 (0.75 lb/cu.ft.) were not included for eucalypt sapwood. However, the occurrence of soft rot in eucalypt poles in Queensland treated to 19 kg/m^3 (1.2 lb/cu.ft.) is sufficient evidence that even this loading is

inadequate for ground contact use under our northern coastal conditions. At present we do not know whether higher loadings will prove effective but the evidence from a few treatments of *E. regnans* heartwood at 1.2 lb/cu.ft. in the PNG tests (not included in Table 2) are not very promising.

8. In conclusion, it must be said that at present we have no preservative treatment which can be guaranteed to protect fully against soft rot in eucalypt sapwood under tropical conditions. There is no difficulty with radiata pine sapwood and there is evidence that some non-eucalypt hardwoods can be adequately protected with available treatments. This is a problem which must be solved and which should be made an urgent recommendation of this Conference.

A NOTE ON SOFT ROT IN TREATED TEAK PLANTATION THINNINGS

by C. Levy

For more than 6 years small quantities of teak thinnings have been treated either with C.C.A. salts by v/pressure impregnation at Hohola or by hot and cold bath with creosote at Keravat in New Britain, the thinnings being drawn from plantations in those areas. Observations by the author of soft rot, or what has been diagnosed by visual examination as soft rot have been made in only two instances in treated teak in that period.

In 1969 some fence posts were treated with creosote at the Forestry Station at Keravat by REgional Forestry staff and exposed adjacent to the C.S.I.R.O. graveyard there. The loadings used were not determined. After two years these fence posts were examined and several were found to be completely decayed just above or at ground level in small sections of the posts where creosote appeared to be completely absent. Both the sapwood and truewood were decayed to a soft ill-defined mass of fibres. The rate of decay was much greater than has been noted previously in untreated teak exposed in ground contact in the same locality. It is believed that the posts had wet spots in them at the time of treatment which were not penetrated effectively by the creosote, and that when exposed in ground contact the creosote in surrounding wood retarded loss of moisture from the untreated patches and thus enhanced decay. It is possible that the wet patches were affected by decay before treatment but this is considered unlikely.

In 1972 some teak posts which had been treated by v/pressure impregnation with C.C.A. were placed in service as part of an aviary in Port Moresby in an area which had been filled with sawdust to a depth of about 1 foot some 4 years previously. The posts had been treated some 12 months before installation. After 6 months exposure, severe decay of the sapwood at ground level in 3 out of 4 posts was noted.

Some of the decayed and sound wood from each post was analysed for copper and amounts equivalent to about 5 and 8 kg of C.C.A. (8.9% Cu)/m^3 were found in the decayed and sound wood respectively. The extent and rate of decay was much greater than normally observed in untreated teak posts which may last for several years in the ground before significant decay is observed.

The area where those posts were exposed was prone to flooding and continually wet for four of the six months exposure and also had large amounts of decayed wood derived from the sawdust fill. It is believed that the high moisture content coupled with the high organic matter content and low preservative retentions contributed to the very rapid decay of these posts.

Subsequent to these observations an inspection was made of all treated teak in service in the ground of the F.P.R.C. and no sign of similar attack was observed. It should be noted that sapwood retentions are controlled at between 24 and 32 kg of CCA/m^3 and also that soils in the area are generally very poor quality, having low exchange capacity dominated by calcium and magnesium and high ph (about 7.5 to 8) and are low in nitrogen phosphorous and organic matter; so that there should be reduced prospects for soft rot attack in these circumstances.

PROBLEMS IN IN-GROUND USE OF TREATED HARDWOODS

by K.V. Cokley

For practical purposes application of hardwoods for in-ground service using preservative treatments commenced with installation of creosote plants at Grafton in the late 1950's. Prior to that time studies were confined to materials such as sleepers, experimental hot and cold and a few limited C.C.A. poles in Victoria.

The large scale use of C.C.A. treated hardwoods began in early 1960's (approximately 1963) and large scale useage of C.C.A. treated engineering timbers has been for a number of reasons, including economics, confined to Queensland and New South Wales. In more recent years there has been some application in Tasmania.

At the 1969 Forest Products Conference the author reported failure of 50 C.C.A. treated hardwood piles at Bowen, and raised the question of the suitability of C.C.A. treatment for hardwoods. Since that date the following experiences and questions have emerged.

1 Soft Rot

The occurrence of 'soft rot' in hardwood treated poles. Whilst a limited number of what is now recognised as 'soft rot' attack was noted 1969-1970, major occurrence has been found since September, 1971, such that all areas (see attached map) have been affected, and in many cases an attack of the order of 10% of poles inspected has been found, even inland from a line drawn north-south through Aramac, which is of the order of 400 miles inland from the coast. In many cases after a mean service life of approximately 6 years, complete mechanical failure of the treated sapwood has occurred. Retentions equal to and above recommended retentions as prescribed in AS0117 have failed to stop attack. Leaching is significant in many poles.

It emerges that 'soft rot' attack was known in overseas countries, but had apparently been overlooked. Attack has been confirmed in creosote poles in South East Queensland and an order of attack of approximately 20% of those inspected. 'Soft rot' has been confirmed as far south as Tasmania.

2. Occurrence of Heart Rot

A variable proportion of significantly attacked poles in Victoria have been reported. It would appear inter alia to be directly related to Group 3 and Group 4 durability species.

3. Further Developments in Piles

Since original report in 1969,detailed surveys made by and in conjunction with Department of Harbours and Marine have shown continued incidence of marine borer attack and three additional major sites have been involved. Two of these involve small landing jetties; one on the north coast from Brisbane involved complete replacement of moving piles after a service of 4 years.

Hardwood oyster stakes have been destroyed in under twelve months at Southport. We understand that oyster stakes in the Hawkesbury area have had a life of less than 8 years.

4. Treatability

It is now apparent that with the exception of a limited number of species, such as Blackbutt, which can be treated completely by oil, that the heartwood of our hardwood species involved is commercially untreatable. There is very limited availability, except in certain areas,of such treatable hardwood species. The economics of high pressure treatment plants for Queensland conditions is limited. Our experience raises the following questions which we consider require investigation if hardwoods are to continue to be used with confidence by engineering industries:-

These are:-

(a) The postulate of a treated sapwood periphery enclosing a non-durable zone which may be eaten out or removed, is no longer valid, and as such there must continue to be a rigid segregation of low durability hardwood species.

(b) Forestry policy in marketing and regeneration of hardwood is now vitally dependent on the application of treated material. This would apply more so in the southern States for low durability species. Restriction or exclusion of all but durability 1 and durability 2 species would interfere with those marketing policies.

(c) Distribution of preservatives. Examination of many thousands of samples show penetration in hardwoods confined to the vessels, with at least some penetration into the vessel walls. There has been no evidence to justify any contention that the fibres are treated. As such the fibres are unprotected. This would not be significant for macro attack, such as insects, but is important in terms of micro attack such as fungi. Recent work by the Forest Products Laboratory indicates that the salt form is also significant.

5. Fixation and Leachability

The distribution pattern does also involve an effect on fixation and leachability. The mechanism of fixation appears to be influenced in variable amounts by reducing compounds, method of attachment of metal ions to wood constituents and in turn the availability of those ions or radicals as toxicants in particular to fungi. This effect of distribution can be readily shown by the form in which the wood is leached; to date no authority has been able to correlate laboratory leach studies within service leachability. This is of particular importance in tropical and sub-tropical areas subject to monsoonal rains. There is an apparent relationship between maximum residual concentration in the wood and species.

6. Application of New Preservatives

In view of our present experience, we in Queensland doubt the wisdom of continuation of major emphasis on C.C.A. or creosote formulations and results based on overseas softwood experience, as being sufficiently applicable to justify commercial application on formulation basis.

In conclusion whilst there are many other factors that could be dealt with in this appraisal, these may be summarised by submission to this Conference, that unless we review our existing Standards to allow for variable climate and hazard problems, and investigate these questions in the treatment of hardwoods,

the using industry will not continue to have confidence in our products. This is exemplified by the present decision in Queensland, and which is endorsed by Port Authorities, to withdraw marine uses from general approvals under the "Timber Users' Protection Acts of 1949-1965" and to require specific approvals for each application.

ASSESSMENT OF DECAY HAZARD APPLYING TO VARIOUS STRUCTURAL TIMBER COMPONENTS

By K. V. COKLEY

The utilization of in excess of 300 species in Queensland, and the choice of, and limitations on, preservative treatments for structural timbers are dependent on a valid and realistic assessment of the decay hazard potentially present. This is of particular importance in Queensland where the tropical and sub-tropical climate ranges from areas subject to severe decay to areas of slight to insignificant decay but where constructional methods or micro climate and or flood may introduce a degree of hazard.

The present large number of Australian Standards involving structural timber components are also dependent for effective application on similar assessments. Examination of durability records and in service utilisation has led to a classification by the Department in "Queensland Building Timbers, Pamphlet No. 5" of a relative durability rating, determined by resistance to decay:-

(a) In contact with the ground or continuously damp situations.

(b) Exposed to the weather but well drained and ventilated.

(c) In continuously dry situations under cover.

The Forest Products Laboratory ratings are however clearly defined only as average life in ground for both decay and insect attack in a temperate climate. No separation of structural timbers is made outside of those ratings.

In addition there are also several classifications issued by authorative trade sources, such as Associations. If one makes a valid assumption that only in a very limited number of species is there any significant heartwood penetration, the commercial use of preservative treated timber is in fact limited to the recognised decay durability of the heartwood. For most rain forest species this is of course regarded as low. It has been an item under consideration by the Wood Preservative Committee for some years without to date any finalisation. All authorities recognise the need for such classification of structural hazards.

This Department has decided to undertake a survey of the performance of various timber species over a range of structural situations and hazard levels. Completion of such a survey and correlation of results will take some time, but it does appear from general service experience that the performance of species of relatively low durability has been satisfactory in certain incompletely protected structural situations, even under the relatively high hazard conditions prevailing over much of coastal Queensland. Some reassessment of the hazards actually existing in these situations therefore seems to be possible.

With modern structural and maintenance techniques, particularly in the cottage industry, a faulty component can in many cases be readily and cheaply replaced. The question arises in such cases whether it is really necessary or desirable to specify high durability species for these situations.

It is not felt that as advisers to the using industry that we as Forest Products organisations should require total service, i.e. 100% efficiency, for a lengthy period, e.g. 20+ years, before recommending or otherwise a species for a particular application.

There are however particular conditions that do cause concern in some structural components, for example to slab on ground construction, particularly when used with green concrete, or portable buildings, inclusive of caravans, where the structural members are completely sheeted with a stressed skin component which plays an integral part in the rigidity of the structure,such units may be stored under conditions that apply to structural components of boats.

Our industry has now reached the position where timber is used in conjunction with sheeting or lining materials other than timber and of which the characteristics are variable. In many cases these are extremely porous or absorbent in terms of water vapour, and in consequence structural timber components can increase to a critical moisture content and be subject to decay. A number of insulating boards, brick cladding, asbestos cement sheeting, and concrete tiles fall into this category. The effect is quite often accentuated by the attainment of dew-point due to drop in cavity temperature overnight.

It is submitted that the following questions should be examined to enable the effective and maximum utilisation of our timbers with particular reference to rain forest and plantation softwood species.

Assessment of hazard

1. An accelerated test procedure for structural components is essential. Under modern facilities this could be done in variable climates, in controlled environmental rooms. It is inefficient to wait 20-25 years as at present for an answer.

2. Quantitative measurements of humidities, temperature and moisture contents which occur in structural areas and components in an average building; with modern instrumentation this can be readily obtained. It is suggested that in the first instance a random selection of average construction buildings where the service life is known, be examined, the climatic data can be obtained from relevant authorities, and using this sample an assessment of the hazard zones can be made from deterioration which is found.

From the correlation of this data an effective statistical prediction of service life under various climatic conditions should be predicted with at least 95% probability.

If these recommendations are followed it would follow that each individual State could be divided into hazard areas which could be applied as a basis for selection of durability requirements by the building and using authorities.

A representative map of such hazard classifications for the State of Queensland prepared by this Department is attached as a typical illustration. Construction can then be more flexible in terms of species and preservative treatments.

These studies I feel should be primarily carried out by the Division of Building Research, Experimental Building Station and Building Operations Economic Section of CSIRO in co-operation with State Authorities and Timber Associations.

Unless this is done it is considered that the traditional role of timber as a favoured structural component will be threatened even more by substitute materials which in many cases have less desirable characteristics; in illustration I would quote the use of metal studs in place of timber.

DECAY AND DISCOLOURATION IN OLD AND NEW STRUCTURES

By N.E. Walters and E.W.B. Da Costa

The purpose of this item is to mention some of the problems facing us and to ask for collection of information on a national basis which will enable a clearer assessment of problems and more efficient control measures.

In the title, we distinguish old and new structures because old houses and other buildings present much greater decay problems than modern (post-war) buildings. Apart from an increasing number of buildings being preserved for historic reasons, there is increasing interest in the renovation and remodelling of older dwellings in the inner suburbs. And remodelling has many traps.

As a first step, we need information on the identity of the fungi causing decay. Descriptive notes of this type of fungus are being published (FPL Technical Note No.13 'Australian House Fungi' by N.E.M. Walters) but these are rather biassed towards Victoria. Information from other States and particularly their large cities is urgently needed. If possible, samples of fungi causing severe decay in buildings would be welcome. We particularly need information on the distribution in other States of *Serpula (Merulius) lacrymans*, the very destructive European dry rot fungus and of *Fuscoporia*, which is, in Melbourne, the cause of severe losses in above ground external timbers, since these may warrant specialized control measures. We also need more evidence to support our belief that several other fungi described, particularly *Coniophora* and *Poria*, are both widespread and damaging.

We would like to get some estimate of the prevalence and rate of decay in external joinery at various localities, as they relate to timber species, type of use (window stile, window sill, weatherboard, bargeboard, verandah rail etc.), aspect, paint condition, etc.. Probably Housing Commission maintenance departments would have the best records of such data. Preservation Section is trying to devize a "Climatic Index" which will enable the decay hazard in any locality to be computed from available meteorological data. It should be remembered that insect attacks and even fire hazard can be seriously increased if certain species of fungus have gained a foothold first and cases of the reverse situation, especially with stain fungi, require wider reporting.

Sub-floor ventilation is discussed under another item, but more information is needed in the effectiveness of such control measures as cover strips over weatherboard joints, etc..

In many newer dwellings, the major fungal problem is discolouration of natural finished external cladding or joinery. This may occur after treatment with preservative oil such as the 'Madison formula' and its commercial equivalents. "How much of a problem is this in various States and how effective is Madison formula or commercial equivalents in controlling it?"

In Melbourne areas of heavy dews, that is, with a wide diurnal temperature range, it has been observed that the hollow spaces behind weatherboards trap condensation water near the bottom plate and so induce decay there. The higher levels of the inter-stud spaces are slightly warmed and hence set up a slow convection current which draws in moist air through any spaces near the ground. Moisture is then deposited on the lowest boards if, as in the early morning, they are cool enough. The effect is particularly noticed above faulty base plates. We seek confirmation of this effect from other States - especially semi-arid areas, in which other factors may well deter the development of decay.

NEEDS FOR PRESERVATIVE TREATMENT OF WOOD BASED PANELS

By E.W.B. Da Costa

Summary

Information is sought on the desirability (in terms of extra cost which can be tolerated) of preservative treatment of particleboard, hardboard, Plywood and similar building materials in various uses. Protection against termites and other insects can cheaply and safely be given by incorporation of insecticides such as arsenic during manufacture. Protection of particleboard and hardboard against decay can probably be given by incorporation of fungicides, but for plywood satisfactory protection by addition of preservatives to the glueline has still to be developed, whilst treatment of veneers presents some gluing difficulties and disruption of normal operations. Permanent protection against surface discolouration in exposed cladding with "natural", stained or clear finishes is very difficult. The potential long-term market, and the justification for expensive research programmes, for the last-named use are questionable.

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A great deal of the wood used in construction today, especially in dwellings, consists of wood-based panel or sheet materials including plywood, particleboard, hardboard, insulating board and so on. Some are used for decorative linings, some as structural materials, some in the course of construction (e.g. formwork for concrete). We continually receive enquiries relating to biological attack on these materials and its control, but are hampered by lack of knowledge as to the nature and degree of protection which is economically essential or desirable.

To take one example, what types of particleboard are likely to be sufficiently water resistant to be used for bathroom or laundry floors? Should these be rot-proofed? What added cost for rot-proofing is justified (a) for all production, (b) for a distinctively marked premium rot-proof grade? Again, since experience has shown that marine plywood is very likely to be used in situations of high decay hazard in boat and caravan building, should all marine plywood be rot-proofed? How much extra cost can be tolerated (even if disliked) and does the treatment have to leave the natural colour of the face veneers unaltered?

The most difficult questions arise with regard to preservation against decay or surface fungal discolouration. It is doubtful whether much wood-based panel material really needs insect-proofing. Where it does, it is normally possible and cheap to provide this by incorporation of arsenic or other insecticides during manufacture. Arsenic is cheap, highly effective, easily controlled and presents relatively small and well understood health and environmental hazards. It has been widely used in fibreboards, and it is probably that its use can be made considerably more efficient and even safer by research into greater fixation of arsenic on wood fibre.

Protection of hardboards and particle boards against decay by addition of fungicides during manufacture seems to be technically feasible, but as the cost is likely to be greater than that of termite-proofing, it should probably be used only on a distinctively marked portion of total production, to be sold at a premium for use in high hazard locations. Decay protection of plywood is more difficult. Research is being carried out on two lines - incorporation of fungicides in the glue and treatment of veneers before gluing. The first would be more acceptable to the

industry but technically difficult, the second seems technically feasible at present but involves some re-arrangement of manufacturing operations. Choice of method is likely to be influenced by appearance, assessment of degree of leaching and decay hazard, and tightness of quality control in the industry.

Protection of panels against surface discolouration is technically very difficult, particularly where they are exposed to the weather and are given a "natural", stained, oiled or clear-finished appearance. It is doubtful if any economically viable process is available at present. Would it be justifiable to spend considerable research time on developing suitable techniques, when existing structures developing discolouration may easily be painted over, and when the present fashion for "natural wood finish" may lose its architectural popularity in a few years to inherently cheaper substitutes?

We would appreciate some information from industry, not so much on the desirability of preservation of these materials, since it is clearly desirable, but on the order of the maximum extra cost which would be tolerable (even if only for specialized items rather than for mass treatment), and on the potential long-term market.

THE DISTRIBUTION AND ABUNDANCE OF TERMITES ATTACKING WOOD IN SERVICE IN THE SYDNEY AREA

by J. L. REYNOLDS and R. H. ELDRIDGE

Summary

A survey was made to determine the distribution and relative abundance of termites attacking wood in service in the Sydney area. Eleven species out of a total of 21 in this area were found to attack wood and wood products in buildings, transmission poles, wharves, fences etc. *Coptotermes acinaciformis* (Froggatt) proved to be the species responsible for most of the damage caused by termites in these situations. It alone bridged termite caps and shields installed beneath buildings with a suspended floor construction and damaged wood and wood products in buildings with a concrete slab-on-ground construction. Similarly, it was the only species found to attack wharves and structures built on them in the Sydney Harbour area. All of the eleven species caused damage to transmission poles, however their failure only resulted from attack by *C. acinaciformis*, and the combined action of fungal decay and *Glyptotermes tuberculatus*. Several species caused damage to fence posts.

Introduction

During the last few years there has been an increasing demand from Commonwealth and State Government Departments, Timber and Pest Control Industries and home owners for information on the distribution, relative abundance and damage caused by termites which attack wood in service in N.S.W. Although there were numerous reports that certain termites were prevalent in specific areas, there was little concrete evidence to back up these reports. In response to this demand, a survey was commenced early in 1970 to obtain this data.

This paper is concerned with the termite problem in the inner city, suburban and semi-rural areas of Sydney. Later papers will deal with economically important termites in other specific regions of N.S.W. In the Sydney area, interest was focussed on termites attacking wood in service, e.g. structural timber in buildings, fence posts, wharves, bridges, and transmission poles; and wood products such as cardboard, paper, and hardboards. Termite attack in these structures has already been described by Calaby and Gay (1949), Gay (1946, 1970), Gay and Calaby (1970), Gay and Wetherly (1971), Hill (1942), Radcliffe, Gay and Greaves (1952), and other authors, including Howick (1966) who conducted a survey to determine the incidence and distribution of termite attack in Melbourne and environs.

Methods

Since the present authors could not do all the inspections necessary to obtain the required data, some of this was obtained from selected records and samples housed in the Australian National Insect Collection, CSIRO, Canberra; The Australian Museum, Sydney; and the N.S.W. Department of Agriculture Insect Collection, Sydney. Additional material came from Commonwealth and N.S.W. State Government officers,

Pest Control operators and private individuals. All samples included in this survey were identified and checked, either by the senior author or by CSIRO, Division of Entomology's termite specialists.

Because of a rapidly expanding population and ever-increasing industrialization, during the last few decades, urban Sydney has increased greatly in area and changed markedly in shape. Such urbanization has brought about changes in the species composition and abundance of termites in various parts of Sydney, e.g. by affecting the availability of their food sources. As a result termites which, a few decades ago, were prevalent in what are now regarded as inner suburbs, (e.g. *N. walkeri* which builds aboreal nest in natural bushland areas was collected by W. B. Gurney from Manly in 1906), are no longer to be found there. For this reason also nearly all termite samples collected from the general Sydney area prior to 1949-50 have been excluded from evaluation in this survey.

Results and Discussion

The results of the survey are shown in Figure I and Table I.

More than 1106 termite samples, including over 100 taken from the Australian National Insect Collection and various N.S.W. State Government Department Collections were evaluated in the survey. Space limitations prevented all of these samples from being shown on the map in Figure I, especially in areas of high density such as the inner Sydney city area and some of the North Shore, Eastern and inner Western Suburbs.

Altogether 21 termite species were collected in the Sydney area. However only 11 are pertinent to this survey. These are the ones that have been shown to attack timber in service, viz., *Glyptotermes brevicornis* (Froggatt), *Glyptotermes iridipennis* Froggatt, *Glyptotermes tuberculatus* Froggatt, *Coptotermes acinaciformis* (Froggatt), *Coptotermes frenchi* Hill, *Coptotermes lacteus* (Froggatt), *Heterotermes ferox* (Froggatt), *Schedorhinotermes intermedius intermedius* (Brauer), *Nasutitermes exitiosus* (Hill), *Nasutitermes fumigatus* (Hill) and *Nasutitermes walkeri* (Hill).

Since the collection of samples for this survey relied greatly on Sydney County Council and Pest Control officers who were stationed in particular suburban areas, it does to a limited extent reflect the distribution of the collectors. This can be seen most clearly in the scarcity of samples collected from the north-eastern, south-western and far southern sections of the greater Sydney area. There are, according to reports from Pest Control operators, pockets of termite infestation in these areas. However, because these operators were not able to collect from these areas during the period of the survey, such infestations could not be shown in Figure I or Table I.

Similarly, it can be seen from Figure I and Table I that some samples have not been collected from timber in service, but have, in fact, come from parks and natural forest areas e.g. National Parks. These samples have been included here because they are of termite species that do attack wood in service and may, in fact, be attacking such wood in their immediate vicinity.

Nevertheless, the results of this survey are useful in that they show which species are responsible for damage to timber in service in the Sydney area; their general distribution and relative abundance; and their order of importance as pest species in this area.

All infestations assessed in this survey are backed by samples housed in the A.N.I.C., Canberra, the Forestry Commission of N.S.W., Wood Technology Division Insect Collection or other N.S.W. State Government Department Collections.

Coptotermes acinaciformis is the species responsible for most of the damage to timber in service in the Sydney area. Of all the samples collected during this survey, 63% were of this species. From this survey, it appears to be responsible for all the damage done by termites in wharves and structures built on them in the Sydney Harbour area. The same applies to underground cables surrounded by lead and P.V.C. tubing. All of the species mentioned above, attack transmission poles in service. However, 86% of the termite damage detected in these structures was attributable to this species, which by hollowing out the centre of these poles and building its nest there, often causes them to fail in service.

Although several other species, e.g. *C. frenchi*, *C. lacteus*, *H. ferox*, *S. intermedius intermedius*, *N. exitiosus*, and *N. fumigatus* will attack structural timbers in (and stored under) buildings, *C. acinaciformis* is responsible for most of this attack. Indeed, (with the exception of one isolated case of *H. ferox* attack) it was the only species found entering buildings with a concrete slab-on-ground type of construction. In such situations it gains access to structural timbers, paper, cardboard, linen tea-towels, etc., stored on top of the slab, by way of hair-line cracks, expansion joints and other breaks in the concrete for plumbing etc., and through vents in cavity walls. Because of the recent trends in Sydney toward this type of construction, this species is assuming increasing importance as a pest in such locations.

On many occasions *C. acinaciformis* has gained access to buildings with a suspended timber floor by building galleries over, and so by-passing termite caps positioned between the top of brick or concrete piers, and the floor bearers or termite shields installed in sub-floor walls. This occurs even when these physical barriers have been erected according to the Australian Standard CA50-1968 "Code for Physical Barriers used in the Protection of Buildings against Subterranean Termites". Other termite species found in N.S.W. are not known, so far, to bridge these barriers, and thus, although they are not 100% effective, they are still of value in protecting buildings against subterranean termite attack. For this reason, the Standard clearly warns the user that regular inspections of sub-floor areas must also be carried out.

Fences although attacked by other species e.g. *C. lacteus*, *H. ferox*, *S. intermedius intermedius*, *N. exitiosus* and *N. fumigatus* are more often attacked by this species.

Thus, it is obvious that timber in service in the Sydney area should, wherever possible, be protected from termite attack either by preservation methods where applicable, or by the construction of physical barriers, such as those mentioned above, or by chemical (e.g. soil poison) barriers.

The methods used on constructing such soil poison barriers are clearly set out in the Australian Standard CA43-1966 "Soil Treatment for Protection of Buildings against Subterranean Termites".

It is obvious from discussions with householders, architects and other people participating in this survey that the Australian Standard CA43-1966 is either not known, or is seldom used by the general public and people engaged in the Building Industry. Similarly, many termite caps and shields installed in new houses are not fitted in accordance with the Australian Standard CA50-1968. In light of the findings of this survey, every effort should be made to bring both of these Standards to the attention of people who can most benefit from applying them.

Schedorhinotermes intermedius intermedius has been shown, from samples collected in this survey, and from reports by Pest Control operators, to be second only to *C. acinaciformis* as a pest in Sydney houses, where, because of its habits, it is difficult to control.

The three species of *Glyptotermes*, viz. *G. brevicornis*, *G. iridipennis* and *G. tuberculatus*, although relatively scarce in the Sydney area, are important in that they attack transmission poles in service, and *G. tuberculatus*, when combined with fungal attack has been known to cause several poles to fail.

The distributions of the three species of *Nasutitermes*, viz., *N. exitiosus*, *N. fumigatus*, *N. walkeri*, and *H. ferox* are usually confined to the outer suburban and semi-rural areas where there is natural bushland. Here they may attack transmission poles and nearby fences, but seldom attack wood in buildings. They are not known to cause failure of transmission poles in the Sydney area.

Coptotermes frenchi is abundant in the National Parks to the north and south (just beyond the southern limits of the map in Figure I) of Sydney, and in isolated pockets of the inner metropolitan area. Somewhat surprisingly, *C. lacteus* has not yet been collected from these National Parks. However, there are scattered occurrences of it in the Sydney Metropolitan area. Apart from occasional infestations in buildings and transmission poles in service, these two species do little other damage in this area.

This survey is continuing, and the results will be published elsewhere later this year.

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TABLE I: Frequencies of Termite Species Recorded in Survey

Termite Species	Total No. of samples from wood in service a + b	No. of samples from transmission poles only a	No. of samples from other wood in service b	No. of samples from trees, stumps logs & mounds c	Total No. of Samples a+b+c	Species % of Grand Total
Glyptotermes brevicornis (Froggatt)	6	6	0	11	17	1.5
Glyptotermes iridipennis Froggatt	4	4	0	2	6	0.5
Glyptotermes tuberculatus Froggatt	2	2	0	4	6	0.5
Coptotermes acinaciformis (Froggatt)	633	446	187	62	695	62.9
Coptotermes frenchi Hill	10	8	2	6	16	1.5
Coptotermes lacteus (Froggatt)	6	2	4	0	6	0.5
Heterotermes ferox (Froggatt)	37	7	30	39	76	6.9
Schedorhinotermes i. intermedius (Brauer)	44	13	31	31	75	6.8
Nasutitermes exitiosus (Hill)	29	14	15	53	82	7.4
Nasutitermes fumigatus (Hill)	18	9	9	44	62	5.6
Nasutitermes walkeri (Hill)	13	10	3	52	65	5.9
Totals:	802	521	281	304	Grand Total 1106	100.0

RESPONSES OF SOME AUSTRALIAN SUBTERRANEAN TERMITES TO SOLID WOOD AND SAWDUST OF FOUR WOOD SPECIES

By M. LENZ and J. W. CREFFIELD

Introduction

Australian entomologists working with termites have always had the good fortune to be able to collect directly from the field, the necessary number of insects for any experiment. This is, of course, due to the richness of the Australian termite fauna and the abundance of wood-eating species of economic importance such as *Coptotermes acinaciformis* (Froggatt), *C. lacteus* (Froggatt), *Nasutitermes exitiosus* (Hill) and *Mastotermes darwiniensis* Froggatt (Hill, 1942, Gay and Calaby 1970). Much of the laboratory work with termites in Australia has been primarily concerned with bio-assay assessments and has produced extensive information on the effects of wood preservatives, the natural resistance of a wide variety of timbers and the susceptibility of plastics and other materials to termite attack.

The situation in Europe and often in the United States of America is rather different. Termites for bio-assay work in these areas must be obtained from stock laboratory cultures, some of which have been successfully maintained for decades. However, the number of termites that can be taken from such cultures is limited. A greater appreciation of the differences imposed by these conditions may be obtained by a comparison of the amounts of termites used. In the proposed standards for Europe (Becker, 1970, int. al.) and the U.S.A. (AWPA, 1970), 0.6 to 2.0 grams of termites, representing from 250 to 2,000 individuals (depending on species) are required per test replicate. Alternatively, in Australia, the standard method requires the use of 25 grams of termites, representing 5,000 to 6,000 individuals (Gay, et al., 1955). Although recent developments in this country have tended to reduce this figure (Howick and Creffield, this Conference), 10 grams of termites are currently being considered for each test replicate. In fact, the only occasions on which Australian assessments are conducted with similarly small numbers of termites to those used in Europe, are for special projects only (Johnson, 1972).

Laboratory Cultures of Termites

There is a lack of information on the best methods and conditions under which to keep and breed smaller groups of Australian termites in the laboratory. Much of the experience in this field of termite research has been gained in Europe and the U.S.A. (Becker 1969). For bio-assays, trials and any type of laboratory experiment with termites it is most advantageous to be able to culture them in amounts smaller than 25 grams or 10 grams over a period of several weeks or months. The termites should be housed in a suitable matrix in such a way that temperatures, humidities and other variables can be controlled according to the differing requirements of individual species. Furthermore, for each species of termite in laboratory culture, experiments must be conducted to determine its nutritional requirements. It is particularly important to establish these criteria when the candidate species occurs rarely or not at all in the vicinity of the laboratory. For example, much of the work with *Mastotermes darwiniensis* is carried out in Canberra or Melbourne, hundreds of miles away from the areas in which this species occurs.

Topic 3/40

Termites and Nutrition

The feeding preferences of termites and the effects of different foods upon them are influenced by factors, the complexity of which is not yet fully understood (Smythe and Carter, 1970 a and b, Becker, 1971). These variable factors are concerned with (a) the termites, (b) the timber, and (c) the conditions under which the two are brought together. The most important are summarized below:-

(a) Termites

(i) Biology - variations between termites of different types (drywood, dampwood, subterranean);
- variations between species of similar types;
- variations within species due to seasonal effects, developmental stage, caste representation, caste ratios, locality etc.;

(ii) Physiology - differences in digestive systems between species;
- differences in intestinal symbionts (protozoa and/or bacteria);

(b) Timber

(i) Physical properties - variations in structure (hardwoods and softwoods);
- variations in density between species;
- other variations within and between species;

(ii) Chemical properties - differences in repellent or toxic compounds;
- differences in starch, cellulose and lignin contents;
- differences in metabolic products (toxins, attractants etc.) of wood-inhabiting micro-organisms;

(c) Test Conditions

(i) Microclimatic - variations in temperature;
- variations in humidity;

(ii) Form of food - solid wood or sawdust;
- oven-dried or air-dried.

Responses of Australian Termites

In order to obtain information on culture techniques and nutritional aspects, the responses of three species of Australian subterranean termites to four species of timber were examined. The termites were selected to represent as wide a biological range as possible within the subterranean type. The timber species were selected on the basis of availability and also because of some prior knowledge of the responses of termites to them. The wood was presented as solid blocks and/or sawdust, prepared from oven-dried and air-dried material.

Details of the termites and timbers used in this experiment are given below:-

Termite species	Family
Mastotermes darwiniensis Froggatt	Mastotermitidae
Coptotermes lacteus (Froggatt)	Rhinotermitidae
Nasutitermes exitiosus (Hill)	Termitidae

Timber species	Common Name
Eucalyptus regnans F. Muell.	mountain ash
Populus sp.	poplar
Pinus radiata D. Don	radiata pine
Pseudotsuga mensiesii (Mirb.) Franco	douglas fir

The termite groups were established in glass jars containing a certain amount of vermiculite to which 250% water was added. Blocks and sawdust were placed on top of the vermiculite except that in the case of *Mastotermes* groups, the matrix and the sawdust were thoroughly mixed prior to installation.

For all species, groups contained 100 workers plus 1 soldier in the *Mastotermes* groups and 10 soldiers for the two other species. The test period for all groups was eight weeks.

Assessment Parameters

Various parameters have been used by different workers to assess the responses of termites to wood. For the purposes of this study, an assessment was made by taking account of four criteria. They are:-

(a) Termite survival rate (weight loss).
(b) Amount of wood eaten per gram of termites.
(c) Changes in numbers and composition of the protozoan fauna.
(d) An analysis of total amounts of sugars, proteins and lipids in the termites after exposure to the wood.

Results

Some aspects of the results are summarized in Tables 1-3.

Mastotermes darwiniensis (Table 1):- Oven-dried *Eucalyptus regnans* was found to be the most suitable wood for this termite, although oven-dried douglas fir also produced relatively high rates of survival. The number of protozoa was highest with these timbers regardless of whether oven-dried or not, indicating differences in the effect of wood compounds on the symbionts and on their host. This finding is consistent with information obtained from a separate study where incipient colonies of *Mastotermes* clearly preferred oven-dried blocks of *E. regnans* to those of douglas fir (Howick and Lenz, unpublished data).

Coptotermes lacteus (Table 2):- Within a given wood species, there was no significant difference between oven-dried and air-dried wood, with the exception of the pine sawdust. However, sawdust produced higher rates of survival than did solid blocks. In several cases, the influence of diet on the protozoa was considerable, and produced apparent consequent effects on the host.

Nasutitermes exitiosus (Table 3):- As expected, there was no survival of this species on the two softwoods. It is well known that radiata pine is nutritionally unsatisfactory for *N. exitiosus* (Gay, 1957) and this also appears to apply to douglas fir. It is however interesting to note that there was a statistically significant increase in the amount of oven-dried as opposed to non oven-dried douglas fir eaten by the termites.

Discussion

It is not within the scope of this paper to present or discuss all aspects of the study. These will be reported elsewhere (Lenz, Creffield and Speck, in preparation).

When termite survival rates are considered, it should be remembered that even under optimum conditions, small groups of termites show a higher mortality than larger ones (Schultze-Dewitz, 1962). This is particularly the case with *Coptotermes lacteus* when one compares survival figures given by Gay (1957) for larger groups.

This study has shown again that to take as criteria the effects produced by diet or preservatives on the symbionts, is as important as survival rates and feeding behaviour of the termites (Speck et al., 1971, Lenz and Becker, 1972).

One practical implication of the results is that for transportation of groups of *Mastotermes*, a mixture of *E. regnans* oven-dried sawdust with vermiculite (as used in the experiment) has proved to be most satisfactory. In this matrix, 1500 and more individuals of this large termite were kept for several weeks in comparatively small boxes (as described by Howick and Creffield - this Conference).

Summary

To obtain information about laboratory culturing and aspects of nutrition of some Australian subterranean termites, four wood species were assessed in regard to their effect on survival, feeding, behaviour patterns and intestinal symbionts of three termite species. The wood was presented as solid blocks and/or sawdust, prepared from oven-dried and air-dried material.

Acknowledgements

Presenting this paper is one way to express the senior author's many thanks for the hospitality and co-operation he has found at the Forest Products Laboratory (Melbourne), especially the Preservation Section and the Entomology Group. Both authors wish to thank Mr. C. D. Howick for critical review of the paper.

Table 1

EFFECT OF SAWDUST FROM FOUR WOOD SPECIES ON SURVIVAL AND COMPOSITION OF THE SYMBIOTIC PROTOZOA OF *MASTOTERMES DARWINIENSIS* AFTER 8 WEEKS

Wood species	Non Oven-Dried					Oven-Dried				
	Termite weight loss (%)	Protozoa (a) (b)				Termite weight loss (%)	Protozoa (a) (b)			
		1	2	3	4		1	2	3	4
Eucalypt	35.1	*	*	*	*	11.0	*	*	*	*
Poplar	77.4	+	+	+	*!	74.0	*	*	*	*
Pine	53.1	(*)	(*)	(*)	*!	66.8	*	*	*	*!
Douglas fir	49.9	*	*!	*	*	35.2	*	*!	*	*!

(a) 1 = *Mixotricha paradoxa*

2 = *Deltotrichonympha operculata* and *D. nana*

3 = *Koruga bonita*

4 = *Foainia* sp.

(b) * = 100%)
) of protozoa species compared with the controls
+ = 10%)

! = more than

( ) = less than

Table 2

EFFECT OF FOUR WOOD SPECIES ON SURVIVAL, FEEDING AND COMPOSITION OF THE SYMBIOTIC PROTOZOA OF *COPTOTERMES LACTEUS* AFTER 8 WEEKS

		Non Oven-Dried					Oven-Dried				
Wood Species	Form	Termite Weight Loss (%)	Feeding(a)	Protozoa (b)(c)			Termite Weight Loss (%)	Feeding(a)	Protozoa(b)(c		
				1	2	3			1	2	3
Eucalypt	Block	73	1.28	*	*	*	68	1.32	*	*	*
	Saw-dust	55	-	*	*	*!	59	-	*	*	*
Poplar	Block	94	1.31	*	*	*	89	1.26	*	*	*
	Saw-dust	68	-	(*)	*!	*	74	-	*!	+!	+
Pine	Block	85	0.97	*	+	(*)	77	1.01	*	(*)	*
	Saw-dust	39	-	*	+	+	66	-	*	*	*
Douglas fir	Block	67	1.42	*!	(*)	*	62	1.33	*	*	*
	Saw-dust	48	-	*!	(*)	*	48	-	*	*	*

(a) Feeding = amount of wood eaten (g) per gram of termites

(b) 1 = *Pseudotrichonympha hertwigi*

2 = *Holomastigotoides hemigymnum*

3 = *Spirotrichonympha flagellata*

(c) * = 100%)
) of protozoa species compared with the controls
+ = 10%)

! = more than

( ) = less than

Table 3

EFFECT OF THREE (b) WOOD SPECIES ON SURVIVAL AND FEEDING OF *NASUTITERMES EXITIOSUS* AFTER 8 WEEKS

		Termite Weight Loss (%)		Feeding (a)	
Wood Species	Form	Non oven-dried	Oven-dried	Non oven-dried	Oven-dried
Eucalypt	Block	57	43	0.78	0.73
	Sawdust	34	38	-	-
Pine	Block	100	100	0.10	0.08
	Sawdust	100	100	-	-
Douglas fir	Block	100	100	0.04	0.07
	Sawdust	100	100	-	-

(a) Feeding = amount of wood eaten (g) per gram of termites

(b) Due to a fungus infection, nearly all groups on poplar wood died.

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RECENT DEVELOPMENTS IN AUSTRALIAN LABORATORY TERMITE ASSESSMENT TECHNIQUES

by C.D. Howick and J.W. Creffield

Introduction

The Australian standard laboratory termite bio-assay method has been much used, but little changed since it was developed and described by Gay and his co-workers in 1955 (Gay, et al, 1955). Since that time, assessments of the termiticidal efficacy of wood preservatives, the natural resistance of timbers and wood products, as well as the susceptibility of plastics and other materials, have been carried out. In this work, conducted mostly by the C.S.I.R.O. Division of Entomology, approximately ten thousand 'jar colonies' have been set up, using some fifty million termites of the subterranean species *Nasutitermes exitiosus* (Hill), *Coptotermes lacteus* (Froggatt) and *C. acinaciformis* (Froggatt).

The information gained from these assessments has formed a basis for the acceptance or rejection of wood preservatives and insecticides by Australian authorities. The natural durability and resistance of timber and other materials as determined by the standard technique has also provided valuable information to architects, builders and construction organizations faced with the problem of selecting suitable materials for use in areas of termite hazard.

Some Reasons for Alternative Techniques

In recent years, termite bio-assays carried out at the Forest Products Laboratory have shown the necessity for a re-appraisal of the standard Australian technique. The increasing complexity of insecticides and wood preservatives, their methods of application and the variability in the end-use of the materials to which they are applied, have necessitated that termite assessments be conducted under specialized laboratory conditions.

Three examples may serve to illustrate that a technique which was developed and standardized before their occurrence, cannot always be adopted without unsatisfactory limitations.

1. Diffusion Preservatives:

Preservatives applied to wood by diffusion processes, present a particular problem when their termiticidal effectiveness needs to be assessed. Such preservatives are not 'fixed' in the wood and indeed, their very mobility is an essential pre-requisite to achieve penetration during the diffusion process. As timber treated by diffusion is not intended for external use or in situations where it is in ground contact, the leachability of the preservative is of little importance.

Under standard laboratory termite assessment conditions, where test specimens are subjected to high humidities in a matrix of moist, termite mound material (Fig. 1A), the likelihood of continued diffusion of the preservative is too great to ignore. Furthermore, not only might the preservative penetrate further into the wood by diffusion, thus giving an unrealistic treatment pattern, it may also leach out of the wood into the surrounding moist mound material in which the termites are living.

2. Plywood Preservatives:

The termite-proofing of plywood by the addition of toxic materials to the glue-line is a development which has greatly extended the use of the material (Gay and Hirst, 1963). As a part of the production process, insecticides are added to the glue mix, which is then applied to the veneers in the normal way, at which time only limited diffusion occurs into the faces of veneers. In the finished product, internal laminae are protected on both faces by the treated glue-line, and external veneers on their internal face.

When small specimens of such plywood are subjected to standard termite assessment, the moist conditions may increase diffusion into the veneers, resulting in a degree of protection greater than that obtained in practice. In extreme cases, where water-soluble glues are used, the test conditions may result in de-lamination of the specimens. This exposes the termites to large areas of treated glue-line, which may produce an unrealistically high rate of mortality and consequent low rate of attack.

3. Repellent Preservatives:

The application to materials of preservatives and insecticides having a repellent mode of action, also presents special problems in their assessment against termites. When the termites detect the presence of repellents in or on the wood, their natural reaction is to isolate the test specimens and to avoid them as much as possible. Specimens are then only subjected to attack when the termites are compelled to do so in order to avoid death by starvation. This is implicit in any 'compulsion' assessment technique.

In this situation, the fact that the standard method uses a matrix of termite mound material is seen as a distinct disadvantage. Although it has proved an ideal matrix for the maintenance of laboratory 'jar colonies', it is produced by the termites themselves in the building of their mound. Generally called 'carton', it consists of excreta, often mixed with mineral soil particles and undigested comminuted wood tissue, and may contain as much as 87-95% organic matter (Lee and Wood, 1971).

When subjected to specimens treated with a repellent preservative, termites maintained in a mound material matrix are able to re-process the carton several times, thereby obtaining sufficient nourishment to survive. In these circumstances, the test specimens are not subjected to a sufficiently high hazard. Variations in the organic content of carton both between and within different termite species can affect comparative results and reproduceability of test conditions. Unfed control jar colonies in which no specimens are included, and in which the only nourishment to which the termites have access is that contained in the mound material, have consistently shown significant rates of survival over the 12-week test period. Relevant percentage survival figures for the three most commonly used species approximate 25% for *Nasutitermes exotiosus*, 40% for *Coptotermes lacteus* and as much as 65% for *Coptotermes acinaciformis*.

Development of Alternative Techniques

The problems raised in (1) and (2) above are concerned mainly with the inclusion of the test specimens in a matrix pre-conditioned to the high moisture contents necessary for the well-being of the termites (50% for

Nasutitermes and 75% for *Coptotermes* sp.). Another consequent problem concerns the anomolous weight losses sometimes obtained in the specimens which are attributable not to termite attack, but to decay of the specimens during the test period.

A system was therefore developed whereby specimens were separated from actual contact with the moist matrix, while still being accessible to the termites (Fig. 1B). This technique involved the attachment of a separate specimen box to the top of a test jar and the provision of a pathway or ladder of roughened glass into it from the matrix, up through the hollow fixing bolt in the lid. Preliminary trials of this system using untreated material were most encouraging. However, subsequent, more extensive investigations using a range of treated material, showed that termites were unwilling to leave the comparative security of the matrix for the doubtful benefits to be obtained from eating specimens treated with anything more than low loadings of the preservative. Difficulties were also experienced in the sealing of the specimen box. Termites were able to force the lid upwards by bringing up mound material from the jar below, and compacting it in the corners of the box.

As these and other difficulties were overcome, a more suitable, satisfactory and practical technique gradually evolved (Fig 1C). This technique involves a standard jar lying on its side, with a smaller jar attached to the lid by a hollow bolt. Ventilation is provided in the normal way by means of a brass insert, screened with phospher-bronze gauze, in the lid of the standard jar. The technique appears to have all the advantages of the earlier model, but none of the disadvantages.

An alternative and comparative method has also been developed in which a glass petri dish containing the test specimens is placed on top of the matrix within the test jar (Fig 1D). This avoids direct contact between matrix and specimens except where caused by the termites in building and plastering. Although specimens are exposed to the relatively high conditions of humidity occurring in the jar system, diffusion directly into the matrix is prevented by the glass dish.

Choice of Matrix

The limitations of the mound material matrix as discussed above, became even more abvious in the development of systems where specimens were separated from it. It was therefore necessary to find a non-nutritious matrix in which termites are able to live for extended periods of time. Of the various materials assessed, by far the most satisfactory was vermiculite. This material has been tested for this purpose overseas and is used in the proposed European standard technique. Becker and Lenz (1970),in discussing the suitability of vermiculite for culturing termites and testing materials or preservatives against them, state: "It can be obtained at constant quality, has a high water-holding capacity and water evaporation is low. It is light in weight and obviously is a suitable material for living and gallery building of termites.".

Summary of Developments

Two alternative bio-assay techniques are currently under assessment. Important departures from the Australian standard method are the use of vermiculite as a matrix and the complete or partial separation of specimens from that matrix while maintaining termite access. Other variations, the reasons for which are beyond the scope of this paper, have also been

incorporated into the new techniques. These are concerned with the following aspects:-

(a) Specimen size
(b) Number of replicates per unit under test
(c) Amount of termites per replication
(d) Duration of test period
(e) Specimen weight assessment methods.

Special Notes

(1) In a further paper (Howick and Creffield, in press) all proposed variations to the Australian standard technique are discussed in more detail.

(2) The new techniques described in this paper are included in a large-scale, comparative investigation currently being carried out of laboratory termite assessment techniques used or proposed as standard methods in Europe, North America and Australia.

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A NOTE ON NEW SMALL SPECIMEN MARINE EXPOSURE TRIALS IN PAPUA NEW GUINEA

By S. RAYNER

Except in isolated small wharves, steel piling is invariably used to the exclusion of timber piling in Papua New Guinea. There are no commercial quantities of timber species resistant to marine borer attack in Papua New Guinea and if the use of treated timber piling is to be encouraged, evidence of their resistance to marine borers over an extended period must be obtained. Recent evidence of the difference in performance of C.C.A. treated conifers and hardwoods in Australian waters has prompted us to consider each species separately.

CSIRO have been conducting a marine borer test of treated timbers since 1967 in three ports, Port Moresby, Lae and Rabaul, to ascertain differences in the performance of vertical retort creosote oil and two different formulations of copper-chrome-arsenic salts in three species of Australian timbers, *Pinus radiata*, *Eucalyptus maculata* and *Eucalyptus deglupta*. Although results to date have revealed differences in the behaviour of creosote and copper-chrome-arsenic in the *Pinus* and *Eucalyptus*, it is essential that more information is obtained on the permanance of C.C.A. in Papua New Guinea softwoods and hardwoods.

Fifteen species of Papua New Guinea timbers, chosen for their availability, treatability and suitability of form have been pressure impregnated to a retention of approx. 3 lb (1.36 kg) of copper-chrome-arsenic per cubic foot using the full cell process. Five rounds of each species, approx. 6" (152.4 mm) in diameter by 18" (457.2 mm) in length, will be exposed in Port Moresby Harbour and in the Huon Gulf at Lae. In addition, five sawn segments 3" x 3" x 18" (76.2 x 76.2 x 457.2 mm) of five permeable species will be included in the trial. A half inch (12.7 mm) disc cut from each round and sawn pressure impregnated sample has been analysed for penetration depth, preservative retention, sapwood density and heartwood density.

Regular annual inspections will record the comparative effectiveness of the vacuum pressure impregnated species against marine wood borer attack.

Papua New Guinea Species included in the Exposure Trial

Rounds

Anthocephalus chinensis
Mastixiodendron pachyclados
Homalium foetidum
Eucalyptus deglupta
Tectona grandis
Araucaria hunsteinii
Phyllocladus hypophyllus
Neonauclea papuana
Pterygota horsfieldii
Celtis nymanii
Anisoptera polyandra
Hopea forbesii
Araucaria cunninghamii
Papuacedrus papuanus
Podocarpus cinctus

Sawn

Homalium foetidum
Mastixiodendron pachyclados
Araucaria hunsteinii
Pterygota horsfieldii
Araucaria cunninghamii

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NEW CONCEPTS AND STRATEGIES IN PEST CONTROL

by J.R.J. French

Summary

The main problems and ecological consequences of present pest control practices are discussed and alternatives offered as future strategies. These include replacing compounds presently used with new and cleaner technology (= biological technology), the use of insect growth regulators, micro-organisms and the development of a pest management programme. Other safeguards (e.g. environmental impact statements, legal litigation etc.) are mentioned which will assist all levels of the community in recommendations and resolutions of pest problems.

Introduction

In Australia, wood-destroying insects are one of the chief hazards in the protection and utilization of wood and wood products. Forest resources are further pressured by demands of expanding industry and populations. How can we best minimize damage by wood-destroying insects in order to maximize our dwindling forest resources without degrading our environment in which we co-exist? It would seem that a wider application of existing knowledge in terms of preventive measures and attention to biological constraints are pre-eminent in such wood protection.

This paper mentions inherent problems in the present forest products pest control strategies and suggests future strategies. The term "pest" as used in this paper refers to wood-destroying insects.

Problems in present strategies

(a) Plant Quarantine.

(b) Pest Control Practices.

(c) Community Attitudes.

(a) Plant Quarantine

The introduction of pests into Australia continues in varying degrees via air and shipping lanes. Tamblyn (1963) mentioned the need for an uncompromising attitude in quarantine matters regarding vigilence - but the task is immense. Another of the difficulties is the need to predict the pest status of introduced insects. Often this requires long-term field and laboratory studies. Even when pests are detected, and prompt remedial action taken, it is not always obvious that re-infestation, or establishment, has occurred (Howick and Carr, 1971).

(b) Pest Control Practices

The goal in timber preservation is to obtain protection from pests. Edwards (1971) outlined the provisions taken to ensure the various degrees of protection, and mentioned the problems involved. But I wish to take the cost/benefit picture a step further and involve all the community in the ecological consequences of the chemical approach to pest control. The main problem is in the nature of pesticides, viz. (a) mobility, (b) long active life, (c) movement from non-living environment into living systems. There are never more than five links in any one chain of conversions from

plant to top predator (= man). Although soil poisons (Anon 1966) are considered interim practices, the actual reality of the situation is the continuing introduction of pesticides into the environment. Ecosystem destabilization is brought about because we simplify the ecosystem. Links are removed in food chains whose function we do not even understand. The problem is further aggravated by synergistic actions operating too (e.g. pesticides and air pollution).

Another facet of this overall picture is the methods of test and recommendations to the public as suggested by government and industry. For example, with the introduction of unidimensional timber structures, attack and damage by lyctids may call for the mandatory introduction of immunization of susceptible hardwoods.

(c) Community Attitudes

There is an implicit premise that the solution to our environmental crisis is a technological one (Gofman and Tamplin 1971). The crisis is upon us for a very simple reason: Few technologies are free of side effects - and that includes the pest control industry. Technology is a system for manufacturing the need for more technology. The platitudes of the manufacturers and users of chlorinated hydrocarbons are repeated at regular intervals in order to reassure public fears. The main difficulty is that the side effects are real, yet not obviously apparent.

Suggestions for future strategies

1. Alternatives are needed to replace the chlorinated hydrocarbons. Carbamates and organophosphates have, and are, being used, but this is substituting one "evil" for another. A new approach is wanted, and so we look to the 'third generation pesticides' - or insect growth regulators. Analogues, mimics and antagonists of these compounds such as juvenile hormone (JH) (which are homosesquiterpenic-esters) and ecdysone (which are steroids) may provide the basis for a new approach. Application (orally or topically) of these biodegradable compounds will hopefully replace the compounds now used for pest control which have unwanted ecological side effects.

   Briefly, the key features of this strategy are to disrupt the growth and development of the insects (e.g. termites, and other species). Reproduction (= ovarian development), sex pheromone production, diapause (= physiological arrest), and other vital mechanisms such as DNA replication are all under the influence of JH. If these compounds are applied at the proper time of the insects life span, e.g. on adults and eggs (= ovicidal effects), last larval instar or during metamorphosis by causing production of intermediates (= sterile insects), the life cycle is disorganised. Juvenile hormones are persistant for several weeks and are sold commercially in the United States. There is the possibility of resistance, but it is considered to be a slow process. Currently, we are investigating the effect(s) of several JH on pests in this laboratory.

2. Another avenue is using microorganisms as attractants (Esenther *et al* 1961) and pathogens (Burges and Hussey 1971). Again, we are investigating this line of approach.

3. Introduction of 'new and cleaner technology' - this is largely a political decision. But governments should encourage and help in development of new candidate pesticides, e.g. by allowing longer periods for companies to patent monopolies in order to recover development costs.

4. Bioassaying pesticides on target and non-target organisms (e.g. bacteria, fungi, other insects). If the government can finance plant quarantine against the introduction of possible pests, surely it has an obligation to monitor known detrimental causitives in the immediate ecosystem - especially as they make the recommendations for usage!

5. Decision making practices must be internalized at all levels of the community - e.g. the pest control industry worker and pest control operators, should have (a minimum) annual medical, paid by their employers. Coverage for pest control operators and the public should be internalized in the event of illness caused by pesticides - as there is no guarantee that a "thalidomide-type-affair" will not be repeated with other chemicals. So there must be means for legislation and litigation for all society.

6. Quis custodiet ipsos custodes?

   Governments should minimize harmful ecological consequences, yet, should have built-in safeguards for themselves. The need for a National Environmental Policy Act with its requirement of "environmental impact statements" should be mandatory for all levels of society (i.e. governments, industry and public). These statements force accurate reporting, and allow litigation and ability for placing a 'legal freeze' on technology (Hardin 1972).

7. There is a need for an effective "systems approach" in the practice of pest control (or management). This provides a method for indicating the future consequences of present policy decisions, for anticipating future problems, and for designing alternative solutions so that society has more options and freedom of choice than is likely when problems descend unnoticed and demand an immediate response. It aims to suggest a wide range of "alternative futures" among which choice is possible (Bell 1967). This approach calls for interdisciplinary teamwork and attitudes, as an ecosystem model is built up from mathematical statements and statistical distributions derived from field and laboratory measurements. Developing a pest management system (Campbell 1971) entails stating (a) objectives viz. pests, (b) prediction (population dynamics), (c) understanding (biology of pests), (d) control measures and (e) integration (at all levels of pest control).

   Integrated pest control - (basically, control with occasional small-scale use of pesticides) will surely replace chemical control, and integrated pest control can be considered biological technology (Murdoch and Campbell 1970). In this area there is promise that sophisticated computer modelling techniques applied to strategies of pest control may help us design better techniques.

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8. Cooperation by governments - (a) at International level. Sampling and analysis of residues in the wild and built environment and cooperation with other international organisations (e.g. O.E.C.D., F.A.O., W.H.O.) concerned with pesticides in the environment. Plant Quarantine may fruitfully be tackled with this system or strategy. Programmes designed for temporary suppression (*Hylotrupes*, Sirex and drywood termites) may have to shift emphasis to eradication (= extermination) and then to management (e.g. Sirex - see Geier 1970). In other words, the type of treatment or management is dictated by the use of a strategic master-plan. (b) to the local level - Training of government "generalists" or extension agents. These personnel could make valid economic analyses of requirements for pest control operators and pest industry, backed by latest research data - and the ability to effectively communicate to industry and public; who should at the same time be educated to appreciate ecological complexities in our environment.

Conclusion

Considerations of biological constraints and awareness of ecological consequences of pesticide misuse should be the major strategy for future research and pest control. There is optimism and growing confidence that insect growth regulators like juvenile hormone analogues and mimics will become part of our overall program of integrated pest control. I make no apologies for being subversive - for as an ecologist, consider that my most important contribution is to incalcate basic ecological attitudes in the government and in the people. By such changes in attitudes it may make it easier to force the introduction of 'cleaner technology' (e.g. biological technology) as this is also largely a political decision. Finally, as Schneiderman (1970) pointed out, in the event that we lose the battle against the pests, the war is not entirely lost. Insects are an excellent source of protein - so if we can't beat them, may be we'll eat them!

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TOPIC 4. RESIDUE DISPOSAL AND UTILIZATION

1. WOOD FIBRE-PLASTIC COMPOSITES

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2. RESEARCH INTO THE COMPOSITION OF RESINS AND POLYPHENOLIC WOOD EXTRACTIVES OF *PINUS RADIATA* BARK

3. *PINUS RADIATA* BARK EXTRACT AS AN ADHESIVE BASE

4. MOULDED PRODUCTS FROM THE BARK AND SAWDUST OF *PINUS RADIATA*

5. BIODEGRADATION OF RESIN AND ACIDS

....

6. UTILIZATION OF BARK FROM CONIFEROUS PLANTATIONS

7. SOME ASPECTS OF WOOD RESIDUE UTILIZATION

8. CHIPPING OF SAWMILL RESIDUES

9. TOTAL SAWMILL WASTE INCINERATION AND STEAM GENERATION

10. SOME ASPECTS OF PULPWOOD LOGGING IN MATURE EUCALYPT FORESTS

WOOD FIBRE-PLASTIC COMPOSITES

by D. E. WEISS

I. Introduction

In this session we will discuss the utilisation of wood residues and their disposal. At the previous Forest Products Research Conference it was stressed that there was urgent need to find a short-term answer to the incineration of wood wastes in accordance with tightening pollution legislation. As a result, a Wood Waste Committee was formed in the Forest Products Laboratories under my chairmanship to coordinate our efforts in this area and research on wood waste utilisation has been accelerated.

The Division of Building Research undertook a survey of the availability of wood wastes and increased its efforts on the development of an improved incinerator. A new burner is now at the prototype stage. Possible applications of bark and sawdust for oil slick absorption, and as mulches and soil amendments, have been investigated. The conversion of sawdust into stock foods by partial hydrolysis or microbial degradation have also been reconsidered by both Divisions. The use of pine bark as a source of tannin for a particle board adhesive has now undergone successful factory trials. You will be hearing more of these developments shortly.

In the Division of Applied Chemistry we have taken a longer term approach by considering how defibrated wood or bark products might be used in plastic composites for use as packaging or building materials. Rather than concentrate solely on how existing wood waste might be utilised we are seeking also means for eliminating waste production. If wood could be efficiently defibrated and then reconstituted into composites which could be used to fulfil a variety of market needs, high utilisation of saw logs, or thinnings, could be achieved. The same techniques could also be applied to mill ends and, for lower grade products, sawdust particularly if the latter was coarser than usual. We have also begun anatomical and pulping studies of bark in order to provide a basic foundation for such studies.

II. Plastic Composites

Plastic composites resemble in principle natural wood. Fibres are packed together as closely as possible within a continuous plastic matrix which may be of the thermosetting or thermoplastic type. The matrix serves to transmit a mechanical load to the fibres and when the fibre concentration is high it is the properties of the fibres rather than those of the matrix which is the dominating factor. Of prime importance is the bonding strength between the fibres and matrix. The matrix must completely wet the fibres and be continuous throughout the structure for maximum efficiency in transmitting load. Coupling agents are usually added to fibre glass to promote such wetting and adhesion. Table 1 shows, for example, how incorporation of fibre glass into nylon produces a considerably stiffer and tougher material.

III. Some Market Considerations

As you can see from Figure 1, there is a rapidly developing market for polymer composites such as the fibre glass products. The rapid development of composites today is creating a major market for reinforcing fibres and a need for cheaper, dimensionably stable, strong fibres. As may be seen from Table 2, the usual reinforcing fibres are expensive. But, as Table 3 shows, a vegetable fibre like flax has a tensile strength about twice that of high tensile steel when compared on a strength for weight basis. As may be seen from Figure 2, the biggest single group of polymer composites are the laminated cellulose products although, as we have seen, demand for the fibre glass products is increasing dramatically. Recently, important improvements to asbestos-cement products have also been made in Australia by incorporating wood pulp. There ought therefore be a bright future for using natural fibres in synthetic composites.

However the cheapness and strength of the lignocellulose-based fibres are offset by one major disadvantage - their pronounced ability to swell in the presence of water vapour. Not without reason have the material scientists christened cellulose "swellulose". Because of this failing most of the commercial composites based on cellulose fibres use heavily crosslinked matrices of the thermosetting type which severely limits their utility. However it should be possible to pretreat cellulose, or lignocellulose fibres, so as to inhibit such swelling and we are currently working on this problem.

(a) Paperboard

As shown in Figure 3, the consumption in Australia of paperboard almost equals that of newsprint - the biggest single item. The production of paperboard is therefore an important component of the local forest products industry. If then, like newsprint, paperboard could be made in high yields (e.g. 90%) then pollution from the major part of the pulp and paper industry would greatly reduce and output would increase. The development of such technology would also enable fibreboard products to be made in inland communities, where there are major untapped forest and agricultural residue supplies, without incurring the pollution penalty which would follow from the establishment of an inland kraft pulp mill. For example, major pine forest reserves exist in the Tumut area but these cannot be considered for chemical pulping with existing technology because of possible pollution of the head-waters of the River Murray system.

Now, it does not seem to be widely appreciated that there is an important difference between the requirements of a fibre for making paper or textiles and those for use in reinforcing composites. Wood is of course a natural composite - it is in fact almost a foam composite. Wood utilises lignin to increase the stiffness of the cellulose fibre bundles. Since composites need stiff fibres, to increase modulus, then lignified cellulose should be used; these fibres will be very cheap as separation of lignin from cellulose is expensive. On the other hand, paper and textiles require flexible fibres so it is necessary for these purposes to remove the lignin from the cellulose, or to choose bast fibres which are unlignified; these fibres are expensive.

A well known deficiency in paperboard is its lack of stiffness. Because the "papermaker's bond" is used to hold this product together the lignin is first removed to give flexible,conformable fibres which can be joined through hydrogen bonding. Users then complain that the product is not stiff enough.

In this situation we really want lignified fibres stuck together by other means; the missing link is of course a cheap adhesive, preferably thermoplastic, which could be used to bind together lignified fibres in a dry-forming process which can operate at high production rates. Recent developments have gone a long way towards providing answers to the technology but adhesives still tend to be expensive.

(b) Building Materials

Of course by far the biggest outlet for ligno-cellulose products is in building materials - particularly as sawn timber. Table 4 illustrates an historical problem which will continue to confront the sawmilling industry - the inability to increase total output because of limitations on log supply. This suggests that a growth in production of only about 18% over the next ten years is likely. This supply problem will not allow the industry to grow at a rate which would match the growth rate expected in the economy generally. As shown in Figure 4, the difficulty is compounded by the rapidly rising cost of green Australian hardwood. Possible threats to wood usage are the rapidly reducing cost of plastics (Figure 4) and, it has been suggested, the recent development in Britain of a new fibre glass suitable for the reinforcement of concrete.

As a result of these and other pressures it is probable that over the next decade alternative materials of construction will steadily displace some of the traditional uses for wood. Table 5 compares the cost of various building materials on a cost per unit volume basis. It shows that building materials fall into three distinct categories of cost. The cheapest comprises concrete, foam plastic and sawn timber where inexpensive stone or air is used to give bulk to a dearer building material. Next comes the plastics and then the metals. But wood chips are a very cheap process raw material costing about 0.0012 cents per cm^3 (0.02 cents per cubic inch, less than a cent a pound) in an Australian factory. This fact led to the development of particle board, a product where wood flakes are glued together. The low cost of such board, compared with sawn timber of comparable dimensions, has resulted in a rapid displacement of the latter in many joinery and furniture products in recent years. This use of particle board in turn is now threatened overseas by foam plastics which, as we have seen, are extraordinarily cheap and have the important advantage that they can be moulded. Foam laminates are now being used extensively by furniture manufacturers overseas. Recent developments, such as the new high-impact foam products for example, have resulted in a great improvement in the mechanical properties of foam laminates, whilst new developments, such as styropor-concrete, are extending their use to other building materials.

A major advantage of plastics, which is not shared by sawn timber, is that they can be fabricated into complex shapes very cheaply. The ease with which they can be accurately moulded, coupled with reliable quality, often offsets their greater initial cost. Thus there is the question of "structural efficiency" which is related to the geometry of a structure. Because timber is not readily fabricated into complex shapes, like metals or plastics, and because it is very cheap, it is usually used in structurally inefficient rectangular sections which use a lot of material to achieve a desired stiffness. If however composites can be made which are readily fabricated into channel, T or L beam sections, honeycombs or corrugated forms, then only a comparatively little material is required to achieve a specified stiffness so that a more expensive material can be afforded. A honeycomb panel, for example, can combine great strength with extreme lightness - it

can be regarded as a structured foam somewhat like wood but, unlike the plastic foams, it is suitable for many structural purposes. Cheap fabrication is the key to its commercial development. A further advantage could be gained over wood if a wood-fibre composite could be developed which can be manufactured to close specifications.

If we are to exploit the inherent cheapness of lignocellulose as a process raw material we must therefore do two things. Firstly we must produce it to a closer quality specification than we do at present. Secondly, we must learn to convert it into inexpensive composites which can be cheaply fabricated through moulding, hot pressing or rolling into products with acceptable mechanical properties.

Very recently Japan's Mitsubishi petrochemical company announced that, by grafting methylmethacrylate on to sawdust, it has prepared a composite which can be extruded or formed by injection or compression moulding. Whilst unsuitable for structural supports, the product appears to be promising for window, door frames and the like. This clearly points the way to the type of future research which we should undertake. If we could only turn our wood wastes into useful composite building materials then we could more than double the total availability of wood-based building materials from our forests. As we have seen this would remove the difference between supply and demand from our forests over the next thirty years.

However, although plastic composites can be made today with mechanical properties which could enable them to displace sawn timber, they are unlikely to do so for simple structures in many circumstances in the near future because they are more expensive. But if timber continues its upward climb in price this possibility cannot be discounted over the next decade or two. Since wood-based composites will continue for some time to occupy a place intermediate between the costs of sawn timber and glass reinforced plastics, they are more likely to displace the latter than the former provided they can be made with adequate dimensional stability and can be simply formed into structurally efficient shapes.

IV. Wood-Fibre Composite Research in the Division of Applied Chemistry

Because I believe there are bright prospects for wood-fibre composites in the future, we are steadily getting underway a substantial research effort in the area.

One program, which will be reported later by Dr. Michell, has extended the earlier work of Bryant and Humphries in the 1950's on *Pinus radiata* bark-sawdust mixtures where formaldehyde or hexamine is used to cross-link *in situ* tannins present in the bark under hot pressing conditions. Such composites are of the thermoset type. Unfortunately these have not the dimensional stability that we had hoped for.

Another program, the details of which cannot be disclosed because of patent considerations, is concerned with the development of lignocellulose reinforced thermoplastics. Products with very substantial strength and stiffness have been made but the dimensional stability of the product is at present not as good as we would like. We are concentrating on this problem at present. Nevertheless progress has been promising so far. Such thermoplastic products can be readily joined simply by pressing two hot sheets together. Since there is no curing time, as with the thermosets, the process is very rapid and well suited to mass production

techniques. Such "hot sealing" is of course widely used in the packaging industries. We believe it can be utilised with advantage for fabricating such composites into structurally efficient structures such as corrugated and honeycomb products. The ability of the material to bend while hot, yet be very stiff whilst cold, is also a useful property. Thus hot rolling could probably be used to convert plate products into L or channel sections. In this programme we hope to bring together the natural and synthetic polymer skills in the Division and Dr. D. Willis and Dr. A. J. Michell have been given this task.

The development of small scale dry-forming techniques will, I believe, be a key factor in the future exploitation of Australian inland forests where water pollution considerations prohibit conventional pulping procedures. It also offers the long term prospect of combining conversion of the saw log into building as well as paperboard products in common plant. The development of fibres and adhesives for dry forming is therefore a major aim of the Division. Dry-forming is a field of intense activity overseas judging from the large number of patents that are appearing and I am sure you will agree that we cannot afford to ignore it. However, we are also considering other approaches to the forming process. By endeavouring to get at the forefront of such development, we can ensure that there will always be a place in the building industry of the future for high performance products derived from Australian sunshine.

TABLE 1

EFFECT OF REINFORCING NYLON WITH FIBRE GLASS*

	Unreinforced		Reinforced	
	MPa	(1000 psi)	MPa	(1000 psi)
Tensile strength	81.4	(11.8)	206.8	(30.0)
Flexural strength	79.3	(11.5)	255.0	(37.0)
Compressive strength	33.8	(4.9)	165.5	(24.0)
Elongation (%)		60.0		2.2

*Source: Machine Design, December 12, 1968.

TABLE 2

COSTS OF REINFORCING COMPONENTS*

Reinforcement	Cost ¢/lb (USA)	¢/kg
Flock (cellulose fibres)	25	55
Cotton cloth	40	88
Nylon	50	110
Asbestos	110	243
Glass		
roving	31	68
mat	44	97
cloth	80-200	176-441

*Source: Machine Design, December 12, 1968.

TABLE 3

TENSILE STRENGTH OF VARIOUS MATERIALS

	Tensile strength		Strength for weight
METALS	MPa	(1000 psi)	
High tensile steel	2068	(300)	38.5
Mild steel	414	(60)	7.7
Aluminium (5% silicon)	172	(25)	9.5
FIBRES			
Fibre glass	2068	(300)	120
Flax	689	(100)	70
Cotton	344	(50)	35
SYNTHETIC POLYMERS			
Nylon	81.4	(11.8)	10.4
Vinyls	41.4-48.3	(6-7)	4.9-5.1
Polystyrene	34.5-82.7	(5-12)	4.7-11.2
Polyethylene	7.58-25.51	(1.1-3.7)	1.2-3.9
COMPOSITES			
Polyester fibre glass	1034	(150)	81
Wood (spruce)			
along grain	103	(15)	36
across grain	3.45	(0.5)	1.2
Concrete	4.14	(0.6)	0.3

TABLE 4

POTENTIAL PRODUCTION OF SAWN TIMBER

Year	(Millions of super feet)	Millions of cubic metres
1970	(1400)	3.30
1975	(1530)	3.61
1980	(1638)	3.87
1990	(1769)	4.17
2000	(2350)	5.55

Source:

Report of the Economic Study Group on the Australian Timber Industry, Office of Secondary Industry, Department of Trade and Industry, Canberra 1971.

TABLE 5

COMPARISON OF MATERIAL COSTS
(USA values)

	Cost			
	¢/kg	¢/lb	¢/cm^3	¢/in^3
INORGANIC MATERIALS (AUSTRALIA)				
Concrete	0.88	(0.4)	0.00214	(0.035)
Cement	2.65	(1.2)	0.00732	(0.12)
WOOD PRODUCTS				
Sawn timber (Australia, dry basis)	6.61-20.05	(3-10)	0.00366-0.0122	(0.06-0.2)
Wood chips (Australia, dry basis)	2.20	(ca.1)	0.00122	(ca. 0.02)
PLASTICS*				
Polyurethane foam (1.5 lb/cu ft)	88-176	(40-80)	0.0024-0.0049	(0.04-0.08)
Polyethylene (low density)	35.3-48.5	(16-22)	0.032-0.045	(0.53-0.74)
Polystyrene (general)	33	(15)	0.035	(0.59)
PVC	52.9-63.9	(24-29)	0.063-0.086	(1.04-1.41)
Nylon	192-278	(87-126)	0.220-0.302	(3.60-4.95)
METALS*				
Aluminium SAE 309	55.1	(25)	0.147	(2.41)
Steel, CR alloy strip	34.4	(15.6)	0.269	(4.40)
Brass, yellow	87.1	(39.5)	0.740	(12.13)
Stainless steel, 304 rod	110.2	(50)	0.873	(14.3)

*Source: Machine Design, December 12, 1968.

Topic 4/2

RESEARCH INTO THE COMPOSITION OF RESINS AND POLYPHENOLIC WOOD EXTRACTIVES OF *Pinus radiata* BARK

by W.E. Hillis and Y. Yazaki

South African work indicated that the resinous material in the bark was very hydrophobic and that it adhered strongly to wood. An examination of the resin showed that although the composition differs from the resin of sapwood and heartwood of this species the same components are present. However, there are in addition large amounts of behenic acid and small amounts of another fatty acid. On the basis of the composition it would be expected that the resin would not behave very differently from that of wood resin. Other physical studies in these Laboratories have been unable to support the claims of the South African workers (Christiensen and Hergt). The quality of the polyphenolic extractives of the bark varies according to the source, conditions of storage, etc. (Plomley pers.comm.). In view of the importance of this material as a base for adhesive, work has commenced on the characterisation of the polymeric components. A method being developed shows that separation of the polymeric materials appears possible. This work, together with the development of a rapid method for the estimation of the amount present will enable the assessment of barks from various areas.

PINUS RADIATA BARK EXTRACT AS AN ADHESIVE BASE

By K. F. PLOMLEY and R. E. PALMER

In Australia the use of adhesives based on commercial tannin for bonding plywood and particle board is now well established. Tannin adhesives based on wattle tannin were developed by Forest Products Laboratory for manufacture of exterior type plywood in 1957 and for particle in 1969. Both developments have been adopted successfully by industry.

Up to the present time all the tannin used for adhesives has been imported, but, with increasing cost of the imported extract and the availability of larger quantities of waste *Pinus radiata* bark, there has been greater interest in potential economic advantages of producing tannin for adhesives locally.

The adhesive properties of radiata bark tannin were first reported by Dalton in 1953. Later in the 1950's the Division of Wood Technology did much valuable work in surveys of the tannin content of bark from different radiata plantations in N.S.W. and in studies of the tanning and adhesive properties of the extract. Unfortunately this work did not result in commercial use of radiata tannin.

Following the development of wattle tannin adhesives for particle board in 1969 the Division undertook a re-examination of the technical problems involved in the utilization of radiata tannin for adhesives.

Tannin Content of Bark

Studies are being made of the tannin content of bark from the Mt. Gambier area. Hot water extraction of butt bark of mature trees has yielded up to 29 per cent of tannin as tannin-formaldehyde. The distribution of tannin throughout the tree is also being investigated.

The results obtained so far agree generally with those of the extensive surveys conducted by the Division of Wood Technology on pine forests in N.S.W.

In laboratory studies changes in solubility of tannin in milled, undried bark over a period of 3 to 7 days at 38°C indicate limited storage life under these conditions.

Extraction and Properties of Extracts

Tannin yields and properties have been studied in aqueous extracts prepared at ambient and elevated temperatures. Yields at 100°C were approximately twice those obtained at ambient temperature and further increase resulted from extraction of bark with dilute solutions of sodium hydroxide or certain sodium salts. The viscosities of concentrated tannin solutions tended to be high for some uses except when sodium sulphite was used for extraction or as an after treatment of hot aqueous extract.

Gelation of radiata tannin-formaldehyde was significantly faster than wattle tannin-formaldehyde at the same concentration and pH.

Storage tests conducted at 25°C over a period of 36 weeks indicate that relatively stable concentrated liquid extracts can be prepared.

Topic 4/3

Adhesive Formulation

Fast hot-setting adhesives have been formulated for particle board, plywood and timber laminating.

Particle board factory trials have been carried out using laboratory preparations of radiata bark extract as the bonding agent. Both extruded and flat pressed boards have been made and in both cases satisfactory board properties were obtained, confirming the results of earlier laboratory tests and indicating that radiata tannin can provide a satisfactory exterior type adhesive for particle board.

In plywood tests under laboratory conditions bonds complying with Type A of AS 087-1963, Exterior Plywood, have been obtained with coachwood and *Pinus radiata* veneers.

Under laboratory conditions with radio frequency heating adhesives based on radiata bark extract and on mixtures of radiata and wattle bark extracts have given bonds complying with AS 1328-1972, Glued-Laminated Structural Timber.

MOULDED PRODUCTS FROM THE BARK AND SAWDUST OF *PINUS RADIATA*

by A.J. Michell and W.E. Hillis

Mature *P. radiata* bark contains about 20% condensed tannins which can be extracted and used as a base for a valuable wood adhesive. The bark can be readily powdered and in this form it readily flows under heat and pressure. The possibility has been explored as to whether a mixture of wood particles, powdered bark and formaldehyde-producing compounds could be moulded into shapes such as channel sections and boards which could be formed in a continuous process. The capacity of the bark for flow indicated that internal or external re-inforcing could be used. If successful, the bark could be completely converted into products of significant value, its disposal problems greatly reduced and the tree more efficiently utilised.

In order to produce material suitable for laboratory testing, air-dried pine sawdust (12 - 24 mesh) and powdered bark (100 mesh) were mixed, then a calculated amount of water of ammonium chloride or alkali added according to the conditions required. Formaldehyde (2% on bark) in the form of paraformaldehyde or hexamine was added, the whole thoroughly mixed and hot pressed without delay, usually in the form of boards. Our results supported those findings about certain aspects that had previously been studied by the Wood Technology Division of the New South Wales Forestry Commission in 1950.

The influence of the moisture content of the bark-wood mixture was significant. The modulus of rupture reached a maximum when it was 17.5% and the water absorption a minimum for boards initially in the 17.5 - 22.5% moisture content range. At higher moisture contents the boards split with release of steam pressure. The pressing conditions used were 420 - 700 kg/cm^2 for 5 minutes and about 40 kg/cm^2 for 10 minutes at 160°C. A pH 8 seems the most suitable conditions for setting of the adhesive.

The properties of the composite boards are compared with those of hardboards and of woods in Table 1. As can be seen the composite boards are as dense as tempered hardboard and show similar crushing resistance and ability to absorb liquid water; their modulus of rupture, however, is comparable only to that of standard hardboard whilst their dimensional stability is inferior to both types of hardboard. There does not seem to be any correlation between the amount of water taken up during humidity cycling and the changes in linear dimensions nor between these results and those obtained from experiments with liquid water.

It appears that although the bark and sawdust particles are bonded by a water resistant adhesive this adhesive does not completely coat the particles leaving opportunities for the uptake of water. The linear hygroexpansivity of the boards would, therefore, be attributed to the uneven distribution in the board of materials capable of swelling when exposed to water vapour.

We have moulded some channel sections which from geometrical consideration might be expected to give a 50 percent increase in bending moment compared to a solid strip made from the same amount of material. However, with the problems encountered in distributing the pressure evenly throughout the material in the simple channel die available, the maximum bending moments obtained were only about 40 percent of that expected from calculations.

Attempts to extrude powdered bark and bark composite under a variety of conditions have had little success.

TABLE 1

Comparative Properties of Materials

Property	Composite Bark-Sawdust	Hardboards	Woods
Specific gravity	1.04 - 1.12	Medium 0.48 - 0.88 Standard 0.88 min Tempered 1.09	*E. regnans* 0.64 *P. radiata* 0.51
Modulus of rupture (kg/cm^2)	245 - 280	Medium 70 Standard 280 Tempered 420	*E. regnans* 1120 *P. radiata* 840
Crushing strength (MPa)	40	Standard 22 Tempered 40	*E. regnans* 60 *P. radiata* 40
Water absorption on soaking for 24 hr (%)	15 - 20	Medium 30 Standard 25 Tempered 18	Not measured
Linear variation with change from 47 - 90% RH (%)	0.8 - 1.0	Standard 0.21 Tempered 0.27	*E. regnans* ∿ 4 *P. radiata* ∿ 3

BIODEGRADATION OF RESIN ACIDS

By

R.W. Hemingway , H. Greaves , E.W.B. Da Costa , W.E. Hillis

Exotic conifers grown in Australia such as *Pinus radiata* contain fatty acids, resin acids and esters, with about 0.75 and 2.5 per cent resin acids in sapwood and heartwood respectively. Over the last 40 years, several overseas workers have pointed out that resin acid salts are toxic to fish and other aquatic life even at concentrations as low as 1 ppm, and that they are commonly present in effluent water from wood processing plants. Some pulping processes, fibreboard production and even debarking can produce effluents containing appreciable quantities of resin acids. With rapidly increasing utilization of conifers in Australia, much of it in association with inland waterways, it is important to assess the degree of environmental hazard. Although it is recognized that resin acids are fairly readily biodegradable, little was known as to the rate of degradation, the factors influencing it, the organisms responsible and whether they were present in our ecosystems. Research has therefore been carried out on these topics. A detailed account of the initial work will be published by Hemingway and Greaves in Tappi.

A mixture of the sodium salts of resin acids of *Pinus pinaster* wood was added to a mineral salt solution of pH 7.4, inoculated with small amounts of activated sludge from a sewage treatment plant and incubated in shake culture at 27°C. Samples were taken at frequent intervals and the various resin acids analysed quantitatively by gas chromatography. At the same time, the total numbers of viable bacteria in the culture were estimated by colony counts on dilution plates of nutrient agar.

Results showed that viable bacteria counts increased rapidly from 10^5/ml to 10^9/ml in 25 hours and that resin acid salt breakdown commenced after about 20 hours and was complete within about 30 hours. Inoculum obtained from the Yarra River at South Melbourne gave almost identical results. Inoculum obtained from the North Pine River at Petrie showed a slightly greater lag period before breakdown commenced but degradation was still complete in 40 hours. The tests were repeated at a temperature of 12°C as being more representative of natural environments. This resulted in greatly increased lag periods but degradation once commenced was almost as rapid and was complete in 105 hours with activated sludge, 125 hours with Yarra River and 165 hours with North Pine River inoculum. (See Figure 1). The addition of 10 per cent of spent liquor from bisulphite pulping of *Pinus radiata* to the culture medium had no substantial effect on resin acid salt degradation when the initial pH was raised to 7.4, but when it was adjusted to various levels down to pH 5.5., degradation occurred only after the pH had been raised to over 7 by bacterial action (see Figure 1). Tests using ^{14}C labelled resin acid salts from *Pinus radiata* showed that when a North Pine River inoculum was used at pH 7.5 and 27°C, 70 per cent of the ^{14}C was converted to $^{14}C\,O_2$ within 80 hours.

The ability of aquatic ecosystems to degrade resin acids would be expected to increase markedly after prolonged exposure to resin acid discharge, but might be completely absent in ecosystems where these resin acids do not occur naturally. Inoculum from the tidal North Pine River adjacent to discharge from a pulp and paper mill handling *Pinus* spp. gave complete degradation of resin acids in 4-5 days at 18°C, as did mill effluent itself, whereas inoculum from a similar tidal creek remote from the mill showed only slight degradation after 6 days, but complete degradation after 10 days. Inoculum from the fresh water portion of the North Pine River gave complete degradation after 4 days.

Topic 4/5

All aquatic ecosystems yet examined have therefore shown ability to degrade all types of resin acid salts, but at very different rates. More work is needed to assess the initial ability of aquatic ecosystems of more varied type to degrade resin acids, and whether rates of degradation are increased by periodic exposure to resin acids. It is also necessary to assess the minimum time required for resin acid breakdown in typical effluent water treatment systems of softwood processing plants, and precisely how this is affected by temperature, pH and added nutrients. It is also desirable to isolate and identify the organisms responsible for resin acid breakdown.

UTILIZATION OF BARK FROM CONIFEROUS PLANTATIONS

By D. GREVE

The conversion of conifers leaves large volumes of bark (up to 23% or more of log volume) for which, in most cases, there is very little present use here, except in limited quantity as fuel and landscaping mulch.

A review of the literature on possible uses for bark has recently been prepared for publication and should be available shortly from the Department of Forestry, Brisbane. The areas covered in this leaflet are:

1. horticultural uses,
2. bark as a fuel,
3. bark as a constituent of boards,
4. bark as a source of fibre,
5. chemical compounds from bark,
6. moulded bark products, and
7. bark as an effluent filter medium, as well as other minor uses.

Although no new ground is covered in this publication, it does show the potential for the successful utilization of bark in a surprisingly wide range of applications, not just as a waste product, but as a high-volume raw material with marketable properties in its own right.

It also highlights the need for research aimed at testing the value in likely higher volume applications of bark from Australian coniferous plantations.

Suggested areas include:-

(a) as a partial component of particle board;

(b) in higher proportions than currently used in hardboard, to improve stability as well as adding bulk in production;

(c) as a relatively low percentage admixture to wood chips in less exacting pulp products such as paperboard; and

(d) as an effluent filter medium for subsequent use as a soil conditioner.

SOME ASPECTS OF WOOD RESIDUE UTILIZATION

by R.M. Liversidge

The purpose of this short paper is to indicate some of the activities of the Division of Building Research in the general field related to the utilization of residue created in sawmilling and subsequent processing of timbers.

(a) Use of wood residue as a soil additive

While the use of bark, and even more recently sawdust and shavings, are gaining favour as mulch materials and, in the case of bark, as a decorative feature material, there would seem to be a need for further investigation of the use of sawdust and shavings as a soil amendment. Problems of "nitrogen drain" on the soil, to the detriment of plants, can occur when wood wastes are mixed directly into the soil without additives, but the provision of previously composted wood residue, perhaps enriched with nutrients, might offer a potential economic outlet for considerable quantities of residue if a suitable product can be developed and promoted.

To this end, work is currently being carried out by the Division in an endeavour to develop a suitable compost. To date, some 80 different mixtures of sawdust, shavings or bark, with chicken or goat manure added to provide a nitrogen source, have been placed under test, with the aim of composting in sealed polyethylene bags under anaerobic conditions. If successful, such a technique would obviously be a very convenient method for the timber producer.

A further series of tests is also underway to examine the composting of a number of wood residue mixtures under aerobic conditions in wooden bins.

These composting trials are, of course, fairly slow processes so results will not be available for some time.

An alternative method of using wood residues for soil conditioning without the composting operation would be to impregnate dry wood residue with a nitrogen and nutrient source before adding it directly into the soil. Tests on this aspect are also planned.

(b) Use of small particle wood residues as a food source or roughage for animals

Considerable attention has been given overseas to the possible use of wood residues as a food source for ruminants. In some cases, animals have been fed satisfactorily with this material and, in at least one case, the manufacture of animal food from wood residue is reported to have reached the commercial stage.

As a first step in assessing the potential of some Australian species as a food source, sawdust from a number of species is being collected and will be tested under laboratory conditions to determine the "in vitro" digestibilities. It is hoped that these tests will be carried out by the Victorian Department of Agriculture. Both untreated sawdust and sawdust which has had simple steaming treatment will be examined. If any of these tests prove encouraging, it is hoped to organize some feeding trials with animals.

It is difficult at present to see wood wastes being used economically as an animal feed in Australia under normal conditions although the development of such feed could possibly be of considerable value in times of severe drought.

The use of sawdust as the roughage component of prepared stock feed as distinct from a food is another possibility.

(c) Use of wood residue as an oil slick absorbent or oil filter medium

Overseas studies have shown bark to possess properties suitable for oil collection from a water surface and tests at the Forest Products Laboratory have confirmed this. These tests have, however, indicated that dry sawdust and shavings also have considerable potential for this use. They also have some practical advantages over bark because of their ready availability, lack of preparation and low cost.

The ratio of the weight of oil collected to the weight of the wood residue varied from approximately 2:1 to 6:1. While the highest ratio was obtained with milled bark from fibrous barked eucalypts, all of the residues tested were effective. Dry shavings also showed potential when used as a filter medium to separate oil from oil/water mixtures.

(d) Use of short offcuts, edgings etc.

A large quantity of sold wood with remanufacturing potential is wasted during normal recovery operations and a substantial economic gain may be possible by utilizing this material, particularly decorative woods, for specialty products which can command a premium price. Such outlets would include parquetry flooring and small exposed furniture items.

Another possibility is to develop a system whereby small section timber can be used to construct various items for indoor or outdoor use by marketing precision machined pieces which could be simply assembled into a number of items by the home handyman or woman. One such system, which has been developed at the Forest Products Laboratory, consists basically of a single standard block accurately drilled for dowelling at each end. By purchasing these blocks in packs and with the use of dowel, a number of attractive items such as room dividers, indoor garden boxes, outdoor garden fencing and trellising can be made. Besides the basic block, a number of other machined sections such as capping pieces and legs would need to be available. If a system such as this could be developed and become popular, it could possibly represent a worthwhile venture in a number of mills.

CHIPPING OF SAWMILL RESIDUES

by H.G. Higgins

The environmental effects of the Australian chip export industry are sometimes depicted by conservationists as totally unacceptable. Community concern for the consequences of industrial development is to be welcomed, but it is desirable that this should be based on balanced and factual assessment of the projects involved. Whatever view is taken of the effects on the bushland ecology of clear felling and other forest operations (see Topic 1/8), there is one quite important sector of the chipping industry which receives little publicity but which must be regarded as not only acceptable environmentally but as making a positive contribution to the struggle against pollution. This is the chipping of mill waste.

The burning of sawdust and bark can provide the heat required for the sawmill boilers, so that profitable utilization of the solid wood residues as pulpwood not only eliminates a large part of the pollution due to smoke but reduces the cost of residue disposal by incineration.

Problems involved in expanding wood chip operations associated with sawmilling have been discussed in the report of an economic study group set up to examine the Australian timber industry (1). Some of the most relevant economic factors are the minimum log intake, freight costs, distance from a pulp mill or an export chipping plant, and the degree of concentration of mill activity within a particular area.

An interesting development in which the CSIRO Forest Products Laboratory has been involved in an advisory capacity is the negotiation by Gippsland Pulp and Paper Ltd., a company formed by a group of sawmillers in the Orbost district of Victoria, of a contract with Harris Daishowa to supply 100,000 tonnes per year of eucalypt wood chips derived from sawmill waste to their chipping and ship loading installation at Twofold Bay, near Eden, N.S.W. The chips are transported by road over a distance of about 150 km.

Sawmill residues will consist largely of wings, some brittle heart and short off-cuts, and the higher proportion of sapwood would lead to the expectation that pulping properties, such as pulp yield and chemical requirements, would be rather more favourable than for whole old trees, although less satisfactory than for young trees. The work of Phillips, Bain and Watson (2) has shown that sawmill waste from karri (Eucalyptus diversicolor) and jarrah (E. marginata) is in fact inferior as pulpwood to 26-30 year old thinnings of these species. Under identical kraft pulping conditions the unscreened pulp yields (Y), in per cent, based on o.d. weight of wood and pulp, and Kappa numbers (K) were as follows:

	Thinnings		Sawmill Waste		Mature Wood
	Y	K	Y	K	Y
Karri	56.2	12.3	50.4	20.6	46.3
Jarrah	45.2	34.0	41.8‡	82.2	-

‡ Screened yield, with 1.3% screen rejects.

A higher Kappa number can be regarded, under these conditions, as indicating higher chemical requirements for pulping.

Species which have inherent defects and consequently give poor recoveries in sawmilling should be particularly suitable for integrated sawing and chipping operations. A more rigorous selection of material for sawn timber would be possible than in a pure sawmill and an optimum partition between timber and chips, from the point of view of economic returns, could be established.

The extension of chip production from sawmill residues would seem to be in the best interests of both the timber and paper industries, and in terms of reducing air pollution and development of exports from areas remote from pulp mills it would also be of direct national benefit. Steps which might be taken to encourage residue chipping could well be discussed by this Conference.

References

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TOTAL SAWMILL WASTE INCINERATION AND STEAM GENERATION

by L.S. Barker

Community attitudes to pollution of the environment by industrial activities have resulted in a dramatic change in the acceptable levels of pollutants which industry is permitted to disperse into the atmosphere and into drainage systems. This has led to a need for a completely new generation of incineration equipment for the forest conversion industries.

Industrial Factors Affecting Waste Disposal and Steam Generation

The increasing conversion of solid wastes to chips has led to a reduction in the total volume of waste material produced in relation to the input of logs, and also to changes in the relative proportions of each type of waste within that total volume. This trend has affected performance requirements of incineration equipment in relation to acceptable waste input composition, and ideally requires an incinerator which will initially burn all waste from a mill without chipping facilities, and will subsequently perform satisfactorily if and when chipping is undertaken, when both the type and total volume of waste will vary markedly from the initial conditions.

The agglomeration within the industry of smaller mills being absorbed into a lesser number of large mills raises a further desirable criteria for incinerator performance, in that an ideal unit would be able to perform satisfactorily over a wide range of hourly input volumes.

Along with this rationalization into larger sawmilling units, there is the consequential vertical integration of the timber industry, by the addition to sawmilling of the secondary processes of kiln drying, moulding operations, pre-cut house frames, furniture components, laminated beams and joinery, and these secondary processes require the generation of steam. It is therefore an obvious and accepted practice in the industry to use timber residues for steam production, and hopefully thereby also to reduce the cost of pure incineration equipment.

Factors Affecting Equipment Design

The major problems in designing a combined total waste incineration and steam generation system are to devise equipment which firstly will meet legal emission standards, and secondly will have the capacity for a widely variable waste input, in terms of both volume and variety, and at the same time produce steam at the differing rates at which it is required by the various steam-using processes in the timber-processing complex, all at a cost which is within the capacity of the production unit, and hopefully so that the equipment can be regarded as a profit-yielding investment rather than as a depreciating capital item from which no financial return is possible.

One of the difficulties in endeavouring to use a conventional water-tube waste-fired boiler both for total waste incineration and for steam generation is the basic limitation of a boiler system of this type to burn fuel at a rate greater than that required by the design capacity of the boiler. This limitation leads on excess firing not only to an excessive production of steam (with associated loss of often expensive or scarce boiler-quality water) but also to excessive and damaging temperatures within the combustion and water tube zones, and to the production of flue emissions which contain particulate matter and smoke at levels well beyond acceptable standards.

Since the rate of production of waste during the hours of production must be several times that of the average boiler fuel demand, and since peak surges may be several times the average production-hours production of waste, such a boiler system would be called on to accommodate extreme variations in fuel input. It is therefore apparent that a combined total waste incineration-steam generation system must have provision for widely variable short-term rates of consumption of waste, and at the same time only deliver heat to the steam generation section at the demand level dictated by the steam consumption at any particular time.

The thermal efficiency of the steam generator is also of considerable economic importance, despite the surplus of virtually no-cost fuel which is available. This efficiency directly affects the capacity of the fuel storage hopper which is required to carry fuel sufficient to maintain steam generation while production operations are at a standstill; this has to cover a minimum period of more than sixty hours over a two-day weekend, and preferably should have greater capacity than this. The cost of the hopper therefore varies inversely with the efficiency of the steam generator.

A second factor related to this efficiency is the type of waste which has to be stored; ideally, this should include only sawdust from the sawmill and shavings from the moulding mill, since both are easily transported, the dry shavings have a very high fuel value per pound, and neither requires hogging or other processing to make it suitable for storage and re-use. It so happens that in most integrated hardwood plants the available volume of these two waste products is of the order of that required to maintain steam generation over standard shut-downs, and efficient use of this stored waste can therefore make the difference between burning solid waste as it is produced (which is eminently desirable), or having to dock, hog, store and then re-call this solid waste for generation purposes.

Thermal efficiencies in steam generators are affected to a great degree by the input temperature of the combustion gases passing over the tubes in which the steam is produced. This temperature also affects the maximum pressure at which steam can be economically produced (in terms both of fuel consumption and equipment cost). It is therefore most desirable that the combustion system should produce gases at high temperatures, even when running at the relatively low level of waste consumption required for steam generation only. These factors indicate that the incineration system should preferably be of the high temperature type, with a minimum of excess air, and constructed probably of refractory or other high temperature material.

Future Systems

There have been a number of commercial systems combining total waste incineration with steam generation, but to date the capital cost of these has been relatively high, and the capacity to burn large quantities of waste surplus to steam requirements has been relatively low. It is suggested that further basic work must be done to develop a system directly aimed at the needs of the Australian forest conversion industries, as these industries become more stabilised in the variety of processes carried out in a typical production complex. When such a solution is found, it will not only be of great benefit to the community at large by virtue of its low pollution characteristics, but will also cause industry owners to speak with pleasure of their profit-making incinerator, instead of being forced to condemn the expenditures which are at present involved in loss-producing incineration equipment.

SOME ASPECTS OF PULPWOOD LOGGING IN MATURE EUCALYPT FORESTS

by B. CUMBERLAND

Summary

This paper presents the data obtained to date on some aspects relevant to utilizing a higher proportion of an over-mature native forest being logged to yield both pulpwood and sawlogs.

Approximately 70% of the "readily available" fibre was harvested.

A limited study on the proportion of bark and defect occurring in individual logs indicated that the combined weight of this material frequently exceeded 30% of the total weight of the log.

Logging Residues

Although it is generally recognised that considerable volumes of usable fibre remain in the forest after logging operations there appears to have been no attempt made to actually record the amount and in particular, to categorize the material into size and tree component. In line with the policy of maximum utilization, the Logging Research Section undertook a pilot study in the Naghi State Forest near Eden (N.S.W.) during 1971 to record the residues remaining after completion of a normal sawlog/pulpwood harvesting operation.

At that time some thought had already been given to the possibility of harvesting logging residues, but the absence of adequate information on the dimensions of the material precluded the formulation of a positive developmental programme. It was hoped that the pilot study would indicate a relationship between tree size and residue volume expressed as a percentage of the total fibre available. From this relationship it might be possible to refer to Forestry Commission mensurational data and compute the residue volume per acre for various site qualities. With this information it would then be possible, using simulation techniques, to examine the economic feasibility of various harvesting techniques. Unfortunately, due to a number of factors but mainly to inadequate sampling, no such relationship was established.

Three separate fallers were studied, each for one complete week. No special requirements were asked of the mean and they carried out a normal felling operation. The following measurements were recorded:-

1. log dimensions - length, mid-girth underbark, butt diameter under-bark
2. stump dimensions - length, m.g.u.b.
3. butt dimensions in the case of defect - length, m.g.u.b.
4. trunk dimensions where continuation of the stem into the lower canopy was obvious - length, m.g.u.b.
5. limb dimensions to a maximum of 4 feet in length and 4 inches diameter under-bark - length, m.d.u.b.

Log sizes for each cutter were similar with the majority within the range 15-35 inches diameter under bark at the butt. The residue volume expressed as a percentage of total available fibre ranged from 5-55%. Table 1 shows the mean residue percentage by species for the three cutters; unit standard deviation is also given.

Table 1

MEAN RESIDUE VOLUME AS PERCENTAGE OF TOTAL AVAILABLE FIBRE

	E. muellerana (yellow stringybark)		*E. sieberi* (coast ash)	
Cutter 1	28%	(± 9.1%)	25%	(± 11.2%)
Cutter 2	28%	(± 12.8%)	-	
Cutter 3	37%	(± 14%)	35%	(± 11.9%)

Table 2 shows the average residue volumes recorded by component, species and cutter.

Table 2

AVERAGE RESIDUE COMPONENT VALUE AS PERCENTAGE OF TOTAL AVAILABLE FIBRE

	E. muellerana			*E. sieberi*		
	Limbs	Stump	Butt & trunk	Limbs	Stump	Butt & trunk
Cutter 1	8.3%	5.0%	12.8%	13.5%	6.7%	8.1%
Cutter 2	11.6%	6.8%	12.5%			
Cutter 3	30.6%	7.6%	1.0%	24.4%	8.9%	1.9%

Although inconclusive the data from the pilot study suggests that in general only about 70% of the "readily" available fibre is harvested. (It is likely that an additional 5-10% of fibre is contained in the limbs below the minimum arbitrary limits set by the study). In other words, for every 100 tons of fibre harvested over 40 tons are left in the forest, generally with reasonably large dimensions. Follow-up work is required to enlarge on the data of the pilot study and to provide the information required for the development of a harvesting system suitable for handling logging residues.

Bark Measurements

In conjunction with the residue study a survey of the bark component of logging operations was conducted. The Research Section had commenced development of a mechanical debarker for fibrous barked eucalypts and realised that of the many factors influencing the decision as to where debarking should take place, the volume of bark was of prime importance. While it is reasonable to suggest that debarking at a central site would be least costly, the volume of bark involved would affect both transport costs and subsequent residue disposal.

An attempt was made to establish a relationship between tree size and bark thickness. Unfortunately the sample size was not sufficient to clearly indicate that such a relationship existed. Trees were felled and the butt diameter under bark recorded. At 10 foot intervals a one foot square segment of bark was taken from the tree and the girth under bark recorded. The sample was then weighed and its thickness recorded. The expected relationship between tree taper and bark thickness by tree size was not established and averaged results have been used for subsequent calculations.

Table 3 shows maximum and minimum bark thickness recorded at 0 and 40 feet for three species viz. *E. muellerana*, *E. sieberi* and *E. obliqua* (messmate).

Table 3

MAXIMUM AND MINIMUM BARK THICKNESS RECORDED AT 0 AND 40 FEET

	E. muellerana	*E. sieberi*	*E. obliqua*
Max. Bark Thickness at 0 feet	2.19 inches	3.28 inches	1.49 inches
Min. " " " 0 "	0.66	1.32	-
Max. Bark Thickness at 40 "	0.92	1.51	-
Min. " " " 40 "	0.50	0.65	-

Table 4 shows the maximum and minimum bark weight (green) per cubic foot at the same sampling points.

Table 4

BARK WEIGHT PER CUBIC FOOT AT 0 AND 40 FEET

	E. muellerana	*E. sieberi*	*E. obliqua*
Max. Bark Weight at 0 feet	59 lb.	66 lb.	47 lb.
Min. Bark Weight at 0 feet	51 lb.	45 lb.	
Max. Bark Weight at 40 feet	53 lb.	65 lb.	
Min. Bark Weight at 0 feet	51 lb.	52 lb.	

From the limited data it was not possible to determine either a relationship between bark thickness and position in tree or bark weight per cubic foot and positions in tree. However for individual trees it was possible to devise the ratio weight of bark/weight of wood. Table 5 shows some of the ratios determined, expressed as percentages, with the corresponding log sizes. It can be seen that the variation is considerable.

Table 5

RATIO OF $\frac{\text{WEIGHT OF BARK}}{\text{WEIGHT OF WOOD}}$ FOR A RANGE OF LOG SIZES

E. muellerana		*E. sieberi*		*E. obliqua*	
L x m.g.u.b.	ratio	L x m.g.u.b.	ratio	L x m.g.u.b.	ratio
32' x 3'2"	15%	45' x 2'7"	23%	35' x 8'3"	11%
32' x 4'1"	12%	55' x 5'2"	23%		
46' x 4'5"	12%	25' x 5'4"	25%		
40' x 5'2"	15%	45' x 3'3"	22%		
		35' x 5'	16%		
		46' x 3'11"	20%		
		48' x 5'1"	15%		
		29' x 5'2"	16%		
		42' x 6'8"	20%		

Transportation of logs with bark on to a central debarking site could be expected to increase transport costs. Further work is required to supplement the data of the initial survey, to give an acceptable measure of the proportion of bark.

Log Defect

In assessing the economic feasibility of hauling long length pulpwood from the Naghi State Forest to the mill it became evident that in addition to bark volume considerations an indication of the amount of defect present (both weight and volume) was required. The amount of defect affects:-

(a) the cost of solid wood delivered to the mill

(b) the cost of conversion at the mill

(c) the cost of defect disposal

A limited survey of the amount of defect present in both mill and pulpwood logs was carried out by the Research Section. Log and defect measurements were recorded at landings resulting in a figure for the percentage defect applicable to a given area. Defect was treated as a cylindrical pipe and measurements were taken from the logs as they were cut into 8 foot pulpwood billets or random length sawlogs. A defect column was excavated from a billet, placed in a plastic bag and weighed on a portable weight scale. The volume of the excavated column was derived using length and mid-diameter and this was then associated with the corresponding weight to give a density figure.

In measuring the defect distinction was made between:

(a) pulpwood and mill logs

(b) tree species

(c) defect due to wood rotting fungi and termites

Table 6 shows a summary of log defect by volume for pulpwood and mill logs by tree species.

Table 6

LOG DEFECT RECORDED IN ONE SAMPLE AREA

		Pulpwood		Mill Logs
E. muellerana		8.8%		0.4%
E. sieberi		6.9%		2.7%
E. cypellocarpa (mountain grey gum)		3.5%		0%
	mean defect	6.4%	mean defect	1%

The amount of log defect which was found within the wood sampled was not as great as was previously assumed. The mean percentage defect from the three surveys conducted was 8.5%, 5.7% and 6.4% by volume which is well below the often quoted figures of 15 to 30% by volume, although it is admitted that the survey has only covered a small area of the logging concession.

The two most important conclusions arising from the study are:-

(a) the amount of defect by weight is less than 10% and may be closer to 6%

(b) 50 to 97% of the defect can be attributed to termites.

TOPIC 5. WHOLE TREE - ANY TREE UTILIZATION

1. SOME ECONOMIC ASPECTS OF SMALL LOG UTILIZATION AS PULPWOOD

....

2. THE EFFECT OF STEM STRAIGHTNESS ON SAWN RECOVERY

....

3. DETERIORATION OF CHIP PILES

   (a) CONTROL OF WOOD CHIP DETERIORATION IN THE TROPICS; DOES COVERED STORAGE HAVE POTENTIAL?

4. MICROBIOLOGY OF CHIP AND PULP STORAGE

5. HIGH DENSITY EUCALYPTS AS PULPWOOD

6. PULPING OF MIXED TROPICAL HARDWOODS

....

7. ANATOMICAL CHARACTERISTICS OF THE BARK OF YOUNG SMOOTH-BARKED EUCALYPTS

8. GLUABILITY OF SPECIES

9. THE POTENTIAL FOR NAVAL STORES PRODUCTION IN AUSTRALIA

10. PLANT FRACTIONATION

11. WHAT IS THE POTENTIAL FOR RESIN PRODUCTION IN PAPUA NEW GUINEA?

SOME ECONOMIC ASPECTS OF SMALL LOG UTILIZATION AS PULPWOOD

By W. J. SMITH

It has been stated following a U.S.A. study (1) that the use of thinnings and topwood containing "juvenile wood" (in this case from material 12 years old) is not economical for loblolly pine (*Pinus taeda* L.) in south-eastern U.S.A. unless some type of row thinning is used in conjunction with specialized thinning equipment, despite some improved paper properties from such material for certain purposes. (In this connection, see also Topic 1/12).

The report states even small amounts cannot be used without higher costs of production.

Apart from slightly lower pulp yields (2%-3% on a dry weight basis), a 98% wood procurement cost increase per cord is claimed, with a total increase of 115% in wood cost per ton of pulp produced. Total cost, including chemicals, etc., of a ton of juvenile wood pulp was estimated to be 65% more for this 12 years old material than that from "mature" (i.e., 25 years or older) trees.

Attention is drawn to this article in order to caution readers that this need not provide Australian forest management nor pulp producers with cause for alarm, because of important differences on the two markets.

Average tree diameters breast high over bark for the 12 years old and 25 years - plus material would have been 5 inches and 7.5 inches respectively in the south-eastern U.S.A. In pulping fraction samples from Queensland grown loblolly, slash, Caribbean and hoop pine stands aged 11-15 and 25-27 years, the average d.b.h.o.b. was 6.65" for loblolly and slash, slightly less for hoop pine and higher for Caribbean pine and there was no real difference between the two age classes (2); this last is due to similar girth-class ranges for the pulping fraction of the two differently aged stands in Queensland.

The major factor limiting the economic use of younger material in the U.S.A. study was the higher cost of wood procurement (purchased in cords, bark-on, at rail or wood yard), due to its smaller size and lower solid wood content per cord. From the preceding paragraph, it can be seen that Queensland pulpwood from comparably aged young stands is appreciably larger than its U.S.A. counterpart and, in fact, closer in size and, presumably, economic pulpwood processing potential to the acceptable older U.S.A. cordwood. No doubt a similar situation prevails with fast-grown regenerated stock, regardless of species, elsewhere in Australia.

However, following the American work, it seems procurement costs for smaller - diameter thinnings and tops for pulpwood, especially where sold on a cord rather than a log volume basis, and particularly where selective thinning is practised, may merit closer attention in relation to the cost per unit of pulp produced.

References

(1) Kirk, D. G., Breeman, L. G., and Zobel, B. J. (1972) - Tappi 55 (11) : 1,600-1,604.

(2) Watson, A. J., Higgins, H. G., and Smith, W. J. (1971) - Div. For. Prod. Tech. Paper No. 61, CSIRO, Melbourne, 20 pp.

THE EFFECT OF STEM STRAIGHTNESS ON SAWN RECOVERY

By J. ALCOCK

In association with sawing studies on plantation softwood species at the Department's experimental sawmill at Rocklea, it is current practice to obtain straightness data on logs in the mill yard. This involves measurement and recording of deflection from the longitudinal axis in two planes at right angles for each log. In many cases the stems involved have already also been assessed for straightness in the standing tree, using a subjective scoring system from 1 (extremely bendy) to 10 (straight) adopted within the Department for use as an aid in the assessment of candidate stems for tree breeding selection.

It is hoped, ultimately, from the results of sawing studies on these logs, to be able to improve methods of field assessments of straightness in standing trees, mainly to determine whether a stem should be utilised as a sawlog or as pulp. The results of these studies will also have an important application in assessment of stems for tree-breeding and for other silvicultural purposes, e.g. selection for pruning.

To date, only limited statistical analysis of the data has been carried out, but there are indications that a statistically significant relationship between degree of stem straightness and sawn recovery exists in both slash and Caribbean pines (*P. elliottii* var. *elliottii* and *P. caribaea*). More detailed analysis to eliminate the probable masking effect of such factors as stem size and site quality will follow. There are preliminary indications in slash pine that an improvement in percentage recovery (on true volume) of the order of 4½% for each unit improvement in stem straightness may be feasible. This awaits verification on further stratification of the data.

Other sawing characteristics such as average board length, grade of output and degrade in seasoning will be taken into account as well as recovery in the final analysis, in an attempt to place a market value on stem form improvement.

DETERIORATION OF CHIP PILES

by F.H. Phillips

Outside storage of pulpwood chips has been used for many years in the northern hemisphere but it is only recently that this form of storage has become popular in Australia. Considerable work has been reported on the effect of outside chip storage on wood quality for coniferous species in a variety of locations, and on certain hardwood species in temperate zones. Prior to the recent studies undertaken in Papua New Guinea, and described below, little has been published on outside storage of hardwood chips in the tropics.

Chip storage is accepted as having certain advantages compared with log storage, but undesirable effects may cause wood substance loss, pulp yield loss, reduction in pulp strength properties and brightness and increased cooking and bleaching chemical requirements. Reports indicate that coniferous chips behave differently to hardwood chips on outside storage and also that the various hardwoods can show different results. It is apparent that each situation and its particular conditions require special study.

There are at least seven sites in Australia at which hardwood chips for subsequent pulp manufacture are stored in outside piles. The quantity of chips stored in these piles per annum would be ca. 3.6 million green tonnes made up from ca. 0.8 million green tonnes stored at three pulp mills in Victoria and Tasmania and ca. 2.8 million green tonnes stored at four chip export mills in Tasmania and New South Wales. The number of sites will probably increase in the next few years as further chip export operations are established or as additional pulp mills are built.

In Papua New Guinea the total forest area covers 32 to 36 million hectares of which 14.8 million hectares are estimated as economically exploitable and wood chip production for export, in conjunction with sawmilling and veneer production, is a likely outlet for considerable quantities of this timber. Any such projects will almost certainly store chips in outside piles and, in fact, the establishment of one industry is currently proceeding at Madang. Present plans for this mill are the production of ca. 60000 green tonnes of chips in 1973 rising to ca. 320,000 green tonnes by 1976.

As reported at the last Forest Products Research Conference, CSIRO has been engaged, with the Papua New Guinea Department of Forests, in pilot scale studies of hardwood chip storage in outside piles. The site of the project was Vanimo in the north-west of Papua New Guinea. Two conical chip piles were built, each 6 m high and of 12 m diameter at the base and maintained for 2 and 4 months respectively. The loss of wood substance did not appear to be excessive for either pile, being of the order of ca. 1 per cent per month, although high losses occurred in certain zones. (Harries et al. (1973)). Larger chip piles may be subject to a lower loss in wood substance because the outer zones of the pile, which constitute a greater proportion of the total volume in a smaller chip pile, are the most affected.

The pulping and papermaking properties of the chips after storage have also been studied (Phillips and Logan (1973)). The stored chips when pulped by the sulfate and NSSC processes gave slightly higher unscreened yields (expressed on the basis of the o.d. wood after storage), and higher

Kappa numbers than chips from freshly felled trees, indicating that the stored chips might have been marginally harder to cook. The loss of wood substance on storage did not cause any appreciable difference in pulp yield, as expressed on the basis of the original unstored o.d. wood, except in wet zones near the outer surfaces of the piles. It appears that the carbohydrates which are attacked during biodeterioration are also among the wood components which are easily lost on pulping. Thus the loss of wood substance is not serious economically over the whole range of chipping and pulping processes. However, in a chip export operation involving a sales transaction after storage but before pulping it could be of disadvantage to the seller and of advantage to the buyer unless the effect is recognized and proper account taken of it in fixing the contract price, which is usually on the basis of a given o.d. weight of wood at the point of sale.

The papermaking properties of unbleached sulphate and NSSC pulps from freshly prepared chips and from stored chips were similar. Bleached pulps from stored chips gave satisfactory strength properties and brightness results (84-85 Elrepho after a CEHD bleaching sequence). However, the loss of yield on bleaching appeared to be greater for the pulps from the stored chips and the brightness of pulps from the latter chips was slightly less than that from the freshly felled sample.

From these studies it would appear that the storage of mixed tropical hardwood chips in outside piles is quite feasible, contrary perhaps to what might have been expected, and that biodeterioration does not seriously affect the pulping, bleaching and papermaking properties. However, further work is required to investigate the effect of pile shape and size and the effect of disturbing the pile at various intervals. The last factor will be significant in chip production for export where the pile prepared after chipping is broken down for shipment and then rebuilt, possibly at the wharf site as well as at the pulp mill.

Because of the large volume of chips stored in Australia it would be advisable to investigate the deterioration in at least some of these piles. The type of hardwood chip material likely to be stored in piles in the future could be very different to that stored at present and even if the present losses can be tolerated future effects may be uneconomic. Pulping and papermaking studies should be regarded as an essential part of any subsequent investigations of this type but the recent work on hardwood chip storage in the tropics suggests that the effect of pulp yield will be more important economically than any changes in papermaking properties.

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CONTROL OF WOOD CHIP BIODETERIORATION IN THE TROPICS; DOES COVERED STORAGE HAVE POTENTIAL?

by C. Levy and E.D. Harries

1. Introduction

Biodeterioration of stored wood chips depends upon the existence of favourable conditions for the micro-organisms responsible by way of moisture, oxygen supply, temperature, substrate and storage period. Each one of these conditions can be altered singly to create conditions unfavourable for decay organisms. To date various degrees of protection have been afforded wood chips by limiting oxygen supply[1], altering the substrate[2] and limiting the period and/or season of storage[2].

The variables operating upon decay organisms within a chip pile are:-

(a) Susceptibility of substrate.
(b) Compaction.
(c) Oxygen/carbon dioxide status.
(d) Moisture.
(e) Temperature developed.

Of these all but (a) are interrelated.

In experimental chip piles in P.N.G.[3] significant biodeterioration has been restricted to the edges of the conical piles where low temperatures and high moisture contents prevailed. These high moisture contents probably resulted almost entirely from rain wetting. W.C. Feist et al have demonstrated[1] that by sealing a pile of fresh aspen chips, biodeterioration and heat development could be substantially reduced.

The high temperatures developed in the bulk of the experimental piles in P.N.G. are thought to be in the first instance the result of respiration and after the death of the cells, chemical oxidation which, by reducing the content of starches and other readily available carbohydrates will reduce the susceptibility of the chips to rapid deterioration when later stored in unprotected piles in Japan. Thus it is not necessarily beneficial to make chip piles in P.N.G. completely anaerobic because of the multiple handling and repiling to which they will be subjected.

A variety of approaches has been made to the control of biodeterioration in chip piles using chemicals, amongst which may be listed sprinkling with waste sulphite liquor, treatment with fungicides such a pentachlorophenol and treatment with compounds such as nickle sulphate. The latter are reported to be toxic to wood destroying and staining fungi but tolerated by or even stimulating to certain moulds which produce antibiotic substances which give further protection against wood destroying and staining fungi but do not themselves cause significant deterioration.

No tests have been carried out in the wet tropics as yet which can support the efficacy of one or other of these prophylactic treatments. On the other hand it has been demonstrated that in dip diffusion treatment of sawn timber at least 2% sodium pentachlorophenate[4] is necessary to protect timber from sapstain when stored under humid conditions for a three week

diffusion period in P.N.G. Lower concentration than this may in fact be worse than no treatment at all as this can result in proliferation of tolerant sap staining fungi free from competition from the less tolerant fungi.

As the surface area requiring protection in a chip pile is extremely large there is always a great risk that it will not be economically feasible to apply useful concentrations of prophylactics and that the above described situation will result.

In exposed chip piles, subject to the high rainfalls occurring in the wet tropics, it is difficult to see how, even if it were economic to do so, effective doses of prophylactics could be applied and maintained for any length of time in view of the combined effects of sun, rain and the tolerance of many micro-organisms to some prophylactic or other and their ability to detoxify prophylactics.

Therefore if a prophylactic treatment is applied it will be far more effective in a chip pile which is protected from the weather.

2. Economic Considerations

Before considering possible means of protecting chip piles from the weather I would like to consider some of the economic consequences of chip deterioration. Chips from P.N.G. are to be used for pulp manufacture in Japan in the first venture to get underway there are plans for 12 shipments annually of about 30,000 tons each, making a total of 360,000 tons per annum. The value of these chips entering the digestor in Japan is about $54 per bone dry ton, excluding the costs of handling and screening etc. at the pulp mill, making a total book value of chips of some $19,440,000 (Australian) per annum.

If there is a loss of 1% wood substance between chipping and pulping there will be the following consequences:-

	Value in $(Australian)
Loss of wood substance	194,000
Loss of production	388,800
Total	583,200

This figure is arrived at on the basis that the digestor capacity is based on volume,and wood substance loss is usually reckoned from loss of s.g. and on the assumption that pulping doubles the value of the chips.
This does not take into account the likely increased requirement for pulping chemicals per unit of chips pulped, bleaching chemicals and the lowering of the quality of the finished product which is often associated with decayed and/or stained wood chips.

Now it is often argued that our responsibility in P.N.G. will end when the chips are loaded onto the ship. However the price which is obtained for P.N.G. chips can only be reasonably arrived at from a consideration of their final value in paper and/or board products and anything which will lower this final value must have an effect on their value in P.N.G.

The likelihood of fairly high losses due to biodeterioration, physical and/or chemical degradation are, we beieve, taken into account by the Japanese in the chip price which has been negotiated. Anything which can reduce deterioration at an economic cost should therefore increase the value of the

chips in P.N.G. and create a favourable situation for negotiation of better prices.

We believe that covered storage can contribute substantially to a reduction in biodeterioration of chips stored in P.N.G. and that from the foregoing consideration of costs, that a capital outlay of one or even two million dollars would be justified if deterioration could be reduced by as little as 1%.

3. Proposed Experimental Work

It is proposed that this hypothesis be tested in the near future using small piles of chips from sawmill wastes at F.P.R.C.

We hope to demonstrate the potential value of protecting chip piles from the weather and perhaps investigate the effects of reducing the moisture content by dehumidification of the air surrounding (and within) an enclosed pile. However the upgrading of any system devised to commercial size is beyond our present resources and, should our initial trials prove successful, considerable assistance will be required to devise a means for practical application.

However, we would like to briefly consider possible means by which weather protection could be obtained. Some alternatives which come to mind are:-

(i) Permanent storage sheds of an A-frame construction or similar to bulk sugar or grain terminals.

(ii) Plastic tents supported during construction of the chip pile by air pressure and collapsed onto the chip pile when it is completed. Retrieval of chips could be achieved by reinflating the tent and extracting the chips with electrically driven coal mining type equipment.

(iii) Storage sheds with fixed sides and a plastic roof maintained in position as with (ii).

(iv) Storage sheds with fixed sides and on a permanent roof with a suspended elevated conveyor which would continuously spread the chips at an even rate over the full length of the shed. This would, I believe, result in virtually complete protection of the chips until the pile was completed as a result of the rapid development (in one or two days) of a high temperature (60°C or more) in chips covered to a depth of one foot or more. At the same time, the exposure of the chips which would occur during construction might help to significantly reduce moisture contents.

On completion of the pile, if prolonged storage was envisaged, the air surrounding and within the pile could be dehumidified. Considering the large expanse of exposed roof it may be feasible to use solar energy to help effect the reduction of the chip pile moisture content, which in addition to reducing the decay and staining hazard, will result in savings of fuel in shipment to Japan.

In the long term it is possible to envisage controlled partial delignification of wood chips stored in piles by the action of white rot fungi

developed specifically for the task. This will result in simpler and cheaper pulping processes and, in the present context, considerably increase the value of the chips, and lower the shipping costs to the purchasing country.

In conclusion the cost of any protective system for chip piles is very often said to be prohibitive because of the huge volumes of chips involved. It is expected that the unit cost of protective system will decrease with increasing volume. Thus,if it can be shown to be economically practical to protect small chip piles, it should be possible to achieve the same or better economic results with very large piles.

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Topic 5/4

MICROBIOLOGY OF WOOD CHIP AND PULP STORAGE

by E.W.B. Da Costa

Summary

Past research on outside storage of Papua New Guinea rain forest species has shown loss of wood substance in experimental piles to average 1% per month over four months. Microbial discoloration affected 57% of chips after four months, and current research is centred on the control of fungal staining by cheap chemical treatments or by antagonistic microorganisms. Storage of pine chips is increasing in Australia and because of the higher proportion of fast-grown sapwood, may show more fungal staining than conifer storage in the Northern Hemisphere. Storage of eucalypt chips has so far given few problems, but this may change as fast grown young plantation or reafforestation material replaces old mature trees. Attention is drawn to possible health hazards from inhalation of fungus spores in handling heavily moulded chips; to possible environmental pollution by continual percolation of extractives from piles near inland waterways or estuaries; and to the need for more knowledge of physical characteristics of commercial chip piles, such as temperature, air movement, water percolation and oxygen tension.

With the development of the export wood chip industry, the increased storage and transport of wood chips for domestic use, and with more interstate transport of wood pulp, a number of new microbiological problems have arisen. These problems vary with the type of wood involved and those of rain forest timbers, pines and eucalypts are strikingly different.

The research effort of the Preservation Section of the Division of Building Research so far has been directed mainly towards the rain forest timbers of Papua New Guinea, because of the potential importance of the wood chip industry to Papua New Guinea development. Early research by Dr. Greaves on experimental chip piles on the northern coast of Papua New Guinea has identified a large number of fungi, bacteria and actinomycetes, many of which have been shown to cause appreciable deterioration in wood in laboratory tests. Some of these organisms continued to operate even at the high temperatures of 60°-65°C found in the experimental piles and the rate of loss of wood substance was about 1% per month over the four months storage. In addition, 57% of chips stored for four months were affected by microbial discolouration, (together with a further 28% affected by non-microbial discolouration). (Greaves, 1973). This probably contributed to the slightly lower brightness of stored pulps when bleached under standard conditions. (Phillips and Logan (1973).

More recently, work has been concentrated on control of the discolouration caused by dematiaceous fungi. This is very resistant to bleaching and is likely to become more serious as the amount of inoculum builds up with prolonged use of the storage site. It is also likely to be more serious in chips re-mixed during loading to ships' holds and again on unloading in Japan. Fungistatic treatments normally used to control staining and mould growth in wood and wood products are likely to be too costly for chip protection because of the higher surface-volume ratio of chips and may also pose pollution hazards. Attention is therefore being paid to other chemical methods and to the possibility of biological control by antagonistic organisms. Screening of organisms isolated from the Vanimo piles has

identified a number of fungi capable of causing rapid and intense staining of Papua New Guinea woods and also some bacteria and actinomycetes which markedly inhibit growth of these staining organisms, not only in agar culture but also in wood. Tests under simulated field conditions will be arranged in collaboration with the Forest Products Research Centre in Papua New Guinea.

Storage of softwood chips has so far been on a relatively small scale in Australia and there appear to have been few problems, but this type of chip storage will probably increase greatly, with the growth of pine plantations and with more intensive utilization of sawmill residues. Most of this material will be fast-grown sapwood and may be far more susceptible to fungal staining in chip piles than Northern Hemisphere conifers.

Eucalypt chips have been stored in considerable quantities in Australia both for export and for local consumption and though few experimental data have been published, there appears to have been no serious loss of wood substance or microbial staining. However, wood utilized so far has been mainly from old trees, almost all mature heartwood and often of reasonably decay resistant species. In the future, there will be increasing quantities of very fast grown young eucalypts from plantations or from natural regeneration on clear-felled sites, and possibly very young trees or coppice growths. These will mainly be sapwood and far more subject to decay and to staining.

Attention should be drawn to some potential problems associated with chip storage. If large quantities of fungus-affected chips are being handled, e.g. in cleaning up a longer stored portion of the chip pile, the release of mould spores into the air could be a problem. Inhalation of mould spores is a serious health hazard and whilst it is not expected that the problem will be common, handling of mouldy chips by pneumatic conveyors into confined spaces such as a ship's hold may require stringent precautions. Secondly, there is the possibility that where chip storage has been carried on for some time at the same site, continual percolation of extractives from the chips into the soil and into nearby waterways will have undesirable effects on the environment. Resin acids and fatty acids from conifers and polyphenols from eucalypts may need watching, especially where the storage is near an inland waterway or an estuary with low tidal exchange of water.

Finally, some attention should be paid to the possibility of <u>desirable</u> microbiological changes in chip piles. Chip storage, especially for long periods, represents a form of "dry fermentation". Microbiological effects are inevitable, some of these will be beneficial, and there is a real possibility that some of the beneficial changes can be greatly increased. Examples are inactivation of resin and fatty acids in conifers, and of chromogenic polyphenols in eucalypts; destruction of non-cellulosic carbohydrates; and possibly easier defibration of the chips.

Research in control of microbiological processes in chip piles is hampered by lack of knowledge of physical parameters in typical piles, such as temperatures, percolation of rain water, air movement within the pile, packing density and so on. It is particularly important to know the variations in oxygen tension with time and with position in pile, and whether the temperatures reached are sufficiently high to kill all respiring sapwood cells and so prevent renewed heat build-up when the chips are removed to a ship's hold or another pile.

Topic 5/4

Storage and transport of wood pulp will require far more research attention in the future, especially if present plans for erection of pulp mills and export of pulp rather than chips are realized. Bacterial and fungal discolouration and degradation of this material can be extremely rapid, unless it is dried and kept dry, and many of the chemical control measures used for chip protection would be inadmissible. Rapid handling at low temperatures; sanitation to reduce inoculum potential; exclusion of oxygen, e.g. by tight packing; and use of leachable and non-polluting preservatives are possible control measures.

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HIGH DENSITY EUCALYPTS AS PULPWOOD

by J. Colley

Summary

Papers were made from bleached kraft pulps derived from Eucalyptus tetrodonta F. Muell. blended with either a mixture of low density eucalypt species or Pinus radiata D. Don. The tensile, bursting, tearing and folding strengths and also the stretch and bulk of the papers was measured. The drainage resistance of the pulp as indicated by the Canadian Standard Freeness value was also measured. In both types of papers certain properties could be predicted from a simple addition of the weighted proportions of the properties of the component pulps. Polynomial model mixture equations were fitted to the experimental data and used to examine the additivity of the properties and to produce surface response graphs of the various blends (1,2). The experiment illustrated the possibility of using species in the high basic density range for papers in which strength is not of paramount importance.

Most commercially produced papers contain more than one fibrous component and many also contain non-fibrous materials, e.g. clay and titanium oxide, to improve the properties given by the pulp furnish. The pulp blends are chosen such that the resultant pulp and paper properties are more acceptable when considered as a whole than those of the individual components.

In this paper the properties of pulp blends containing thick and thin-walled short fibres (i.e. less than 1.5 mm long) are studied along with pulp blends containing short thick-walled fibres and long thin-walled fibres. Fibres with a Runkel ratio (3) 2 w/l (w = cell wall thickness, l = lumen diameter) greater than 1.0 will be deemed thick-walled. Within the genus Eucalyptus there is sufficient correlation between Runkel ratio and wood basic density (4) that one may consider the fibres from high and low density species to be thin- and thick-walled respectively.

Short thin-walled fibre pulps are currently used for the manufacture of many varied grades of paper, and long thin-walled fibres have long been a traditional type of papermaking fibre. Short thick-walled fibres from the genus Eucalyptus have not been generally accepted because laboratory made papers from this type of fibre have relatively low strength (5,6,7) and since most of the previous work done on this material was in relation to high strength wrapping paper this source of pulpwood was concluded to be unsuitable for papermaking.

Thick-walled fibres have poor lateral conformability, and strength properties dependent on interfibre bonding are lower than those given by thin-walled conformable fibres. Tear factor, however, is often greater (6,8,9). As a result of the inability of the fibres to collapse when dried after beating (10), papers made from thick-walled fibres have high bulk, stiffness, and compressibility and in general high opacity than those utilizing thin-walled fibres. These assets have been appreciated for many years (14,15) but the relatively poor strength properties of the paper have been a deterrent to their use. Other factors include the location of many

high density species and the preferential use of softwoods which until recent years, have been in sufficient supply to satisfy the demands of the world's paper industry.

The possibilities of utilizing the intermediate and high basic density eucalypt species for the manufacture of paper have recently been under investigation (11,5,6,7,8,12,13). The interest shown by Japanese companies towards the importing of Australian wood chips has stimulated interest in a number of species which previously had not been considered suitable for paper manufacture.

The purpose of the investigations reported in detail elsewhere (1,2) was to show that by suitably blending thick-walled Eucalyptus species in the high basic density range with pulps which have been proven commercially, one may produce papers whose overall properties may be considered to be suitable for papers in which strength is not of paramount importance.

Experimental Methods and Results

The pulps chosen for blending were a pulp prepared from E. tetrodonta, one of the dominant species of the high density eucalypts growing in the Northern Territory, a commercial kraft pulp prepared from a mixture of low density eucalypts from the forests of the Gippsland region of Victoria, and a bleached kraft P. radiata pulp from New Zealand. The basic densities of the eucalypt pulpwood were respectively 0.87 and 0.55 g/cm^3 (54.5 and 34.6 lb/cu.ft.

Full details of the preparation of the pulps, their blending and subsequent testing, are given in references 1 and 2. Since the work involves the behaviour of two separate pulp furnishes it is appropriate to consider separately the results obtained for each type of furnish.

The addition of E. tetrodonta to the mixed eucalypt stock produced a monotonic reduction in strength. The freeness of the blended stock and bulk of the paper produced from it could be predicted quite satisfactorily from the weighted proportions of the component freeness and bulk values. None of the other properties measured behaved in such a predictable manner.

When E. tetrodonta was blended with P. radiata the predictability of the property of a blend was again evident but in this case the bulk, breaking strength and stretch were the most additive in behaviour. This is shown in Figure 1. Blends from various combinations of beating levels of the two pulps

Figure 1. Physical Properties of Four Blends of Bleached Kraft E. tetrodonta and P. radiata

gave property values which deviated from this simple relationship and thus demonstrated that caution must be applied when one uses such a simple relationship to predict paper properties. In both types of blend the most satisfactory predictions were given by the empirically derived mathematical model equations (1,2). It was shown that, for both types of furnish, in blends containing up to about 50 per cent E. tetrodonta the strength values did not fall below a level which would be considered unfit for making papers in which strength was not of paramount importance e.g. fine papers.

Conclusion

Species in the high basic density range of which *E. tetrodonta* may be considered an example may be regarded as a potential raw material for use in the furnishes of fine papers if they are suitably blended with commercially proven pulps of the types used in this study.

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PULPING OF MIXED TROPICAL HARDWOODS

By P. H. PHILLIPS, A. F. LOGAN, H. G. HIGGINS and V. BALODIS

Introduction

At the request of the Australian Government (Department of External Territories) and the Administration of Papua New Guinea (Department of Forests) the Division of Forest Products CSIRO commenced a study of the pulping and papermaking potential of the mixed tropical hardwoods in the Vanimo Timber Area (VTA). This forest resource covering an area of 292,000 hectares in the north west of New Guinea contains ca. 241,000 hectares considered suitable for logging operations and is divided into six blocks each containing two or three major forest types. Proposals have been made for the establishment of a wood chip industry as a source of raw material for overseas pulp mills, together with the establishment of facilities for the export of saw logs, sawn timber, plywood and veneer.

Because of the urgent need to determine the potential of wood resources from other forest areas in PNG which are now also available for utilisation the project has not been limited to the Vanimo timber area. Furthermore, aspects such as forest sampling, reforestation and chip storage have been included in the study which has been financed by means of a specific grant from Papua New Guinea.

The decision to carry out the studies in Australia depended largely on the experience and facilities available at the CSIRO Forest Products Laboratory for an assessment of raw materials for pulping. Useful results were available soon after commencement but the extent of work required on all aspects of the utilisation of mixed tropical hardwoods for pulping has required an extension of this project beyond the three years initially considered. Studies on these problems will now continue for a further three years.

Sampling Tropical Forests

The wide range of species in tropical forests, and the difficulties of access to the forest, create major problems in the collection of a representative wood sample. For example, it would be impossible to sample a sufficiently large number of trees so as to ensure that the wood sample contains each diameter class from each species in proportion to their occurrence in the forest, because economic factors usually impose an upper limit on the total number of trees that can be sampled in a given survey. To gain the maximum information from a restricted sample, the trees have to be classified according to forest type, diameter class, and if possible by species, and the strata sampled at random. An outline of the actual sampling procedure for the Vanimo Timber Area was presented at the 15th Forest Products Research Conference. In this area sampling was combined with an inventory survey carried out by the Department of Forests. The representative sample of the VTA contained disks from 2,400 trees.

Chips were cut from the pulpwood samples for the preparation of composite chip samples representing different blocks, forest types or possible utilization patterns considered feasible for the area. The chip mixtures contained the same volumetric proportion in each diameter class, for each major species and from each forest type as given by the inventory survey for the area under consideration.

From our experience in the VTA it is clear that more efficient sampling methods can be designed by using inventory survey information than by attempting to sample a forest of unknown composition. In view of this, an early start should be made in forest typing and in the preparation of inventories for any potential pulpwood source.

Assessment of Tropical Forest Resources - Using Simulated and Theoretical Samples

In making a technical assessment of a particular forest resource, the best information will of course be provided by pulping tests on a representative composite wood sample prepared according to the principles outlined above. However, where assessments have to be made rapidly or at minimum expense, various expedients may be adopted which will provide an approximate idea of the pulpwood potential of the resource.

One such approach is to prepare a simulated composite sample from the major species present in the area, as shown in the forest inventory. The individual wood samples used are not necessarily representative of the species used, nor do they necessarily come from the area under assessment. They may be chosen on the basis of an arbitrary criterion, e.g. all those species present in volumes greater than 1 per cent, or the species required to account for a predetermined volume percentage of the forest, say 75 per cent, in descending order of abundance. It has been found that usually about 30 species account for about three quarters of the total volume of a resource. Pulping tests are then carried out on this chip sample as for the representative composite wood sample.

Another method which has been used to obtain a rapid preliminary assessment of pulping quality of the mixture of species from a given area is to attempt to construct a "theoretical" sample from the results of measurements of basic density and pulping tests on samples of individual species. If standard pulping conditions are used for the individual species (in sulphate pulping: total alkali, sulphidity, liquor to wood ratio, time to temperature, cooking temperature, time at temperature), then the main assumptions involved are that the samples are representative of the species in the area, and that the presence of the other chip components of the mixture does not affect the cooking of an individual chip. If density or pulping results are not available on all species present in the forest area in appreciable amounts, an attempt can be made to obtain samples of at least the major species missing, and to carry out the required measurements and tests. Again, the samples need not necessarily come from the area under assessment. Calculations of the weighted mean basic density, pulp yield and pulp Kappa number are made knowing the percentage of each wood species present in the forest from inventory data for the area in question.

The three methods of assessment outlined above were applied to the Vanimo Timber Area, PNG, with the results shown in Table 1.

Table 1

COMPARISON OF METHODS OF ASSESSING RESOURCES - VANIMO TIMBER AREA
SULPHATE PULPING

Wood sample	Basic density ($kg\ m^{-3}$)	Total alkali as Na_2O* (%)	Unscreened pulp yield* (%)	Kappa number †
Composite representative sample	491	14	48.0	32.0 S
		15	(47.5)	(28.3)
		16	46.9	24.6 S
Simulated composite sample (major species)	475	14	48.6	33.8 US
		15	48.4	(31.3)
		16.5	46.9	27.6
"Theoretical" sample (individual species)	507	15	48.4	33.2 US

Interpolated values in brackets

US Unscreened

S Screened

* On o.d. wood

† On o.d. pulp

The higher density of the "theoretical" sample is probably the result of a bias in the laboratory density determinations towards samples derived from large trees felled in the course of sawmilling operations. Reasonable concordance can be observed between the results obtained by the various methods, but less reliance can be placed on the simulated sample than on the representative sample, and still less on the theoretical sample. However, the less exact methods have been found useful in certain situations such as preliminary discussions on development possibilities. The procedures outlined have been discussed in greater detail in the paper by Higgins et al. (1973).

Pulping Tests on Representative Composite Samples

The composite samples prepared to represent separate working areas, forest types or utilization patterns for the Vanimo Timber Area have been pulped by both chemical and semichemical processes and the pulps evaluated for suitability for bleached and unbleached paper production.

Unbleached sulphate pulps prepared from various composite samples using 16 per cent total alkali had Kappa numbers of 21 to 23 and the yields of screened pulp ranged from 45.1 to 46.9 per cent. With a lesser amount of cooking chemical (12 per cent total alkali) screened yields of ca 47 per cent were obtained at a Kappa number of 41. These pulps developed higher strength than the better cooked pulps, which is an advantage for some products.

Modifications to the representative composite sample from Block 6, VTA showed that the removal of 70 per cent of the large kwila and taun for sawmilling purposes, the exclusion of trees less than 92 cm (3 ft)

girth or the use of hill rainforest species only had no effect on the pulpability, the pulp yield or the papermaking properties of the mixture of tropical hardwood species. Furthermore, preliminary results obtained on a representative sample from an adjacent area (Block 2, VTA) which varied considerably in species, forest type and girth class composition were similar to those from Block 6. The strength values obtained show that these unbleached sulphate pulps should be satisfactory for use in a wide range of products including liner boards, multi-wall bag papers and wrapping papers.

Sulphate pulps prepared with 16 per cent total alkali and having Kappa numbers of 21 to 23, from each of the representative composite and modified samples, were used for the preparation of bleached pulps. A standard chlorine-alkali extraction-sodium hypochlorite-chlorine dioxide (CEHD) multi-stage bleaching sequence was used in all cases. All bleached pulps prepared using the CEHD sequence had similar properties. The yields on an unbleached pulp basis ranged from 91.6 to 92.9 per cent and from 41.3 to 43.5 per cent on the original wood basis. The brightness of all pulps was similar (85-86 per cent); such values for a standard CEHD bleach sequence are considered very satisfactory.

The papermaking properties of the bleached sulphate pulps are satisfactory for normal use, although tests to determine printability and surface characteristics are still being carried out. Consideration of such results will be necessary before a complete assessment can be made of the potential of the tropical hardwood mixtures for fine paper production.

Representative composite samples pulped by the neutral sulphite semi-chemical (NSSC) process gave pulps in high yield (ca 75 per cent) at Kappa number ca 145. When the chemical concentration and cooking time was increased the Kappa number pulp was lower by ca 30 units, but the pulp yield decreased by ca 10 per cent. Satisfactory NSSC pulps have been prepared from composite tropical chip mixtures and these should be suitable for utilization in a wide range of products including corrugating medium and other packaging materials.

Comparison with Pulps from Temperate Zone Eucalypts

The tropical hardwood chip mixtures required somewhat more chemical to produce sulphate pulps at a given Kappa number than mixed eucalypt species from certain areas in Australia. Generally the tropical pulps were produced in lower yield, were harder to beat, and had lower bonding strengths than the eucalypt pulps. Tearing strength was similar. The bleaching requirements, and the final optical properties and the strength reduction with bleaching for the tropical hardwood pulps were generally similar to the eucalypt pulps.

The properties of unbleached NSSC pulps from the tropical chip mixtures were slightly inferior to those from mixed eucalypts. When cooked under similar conditions, the tropical pulps had higher Kappa numbers, were harder to beat and the bonding strengths and the crush resistance of the handsheets were lower.

Additional Studies

(I) Pulping of Individual Species

The pulping of individual species gives valuable indications of the possibilities for mixed pulping, as discussed earlier, and can focus attention on difficulties which may arise from the density, structure or chemical composition of a particular wood species. Approximately fifty individual species have been pulped by the sulphate process and most gave satisfactory pulps. Any deficiencies so far encountered in the properties of individual species have not appreciably affected the quality of pulp from a mixture of the species.

(II) Within-Tree Variation of Pulp Yield for Tropical Wood Species

The variation of pulp yield and other properties both within and between trees has commenced. Three species, *Pimeleodendron amboinicum*, *Homalium foetidum*, and *Pometia pinnata* are being investigated, and the results will be used to assist in future sampling schemes of mixed tropical hardwood forests. Reliable information of this type is not readily available and this may be the first attempt to obtain such information for tropical hardwood species.

(III) Reforestation Species

Investigations will be commenced shortly to determine the most suitable species for future plantations, having regard to the needs of the pulp and paper industry, and of other forest industries, as well as silvicultural considerations. In particular, plantations of kamarere are available for examination and a detailed survey of the pulping and papermaking potential of trees from 3 to 20 years of age will be made in conjunction with morphological tests. These plantations have already been sampled and basic density determinations are being made at the Forest Products Research Centre, Papua New Guinea, prior to the commencement of pulping tests.

Reference

Higgins, H. G., Phillips, F. H., Logan, A. F. and Balodis, V. - "Pulping of Tropical Hardwoods: Individual and Mixed Species, Wood and Paper Properties, Resource Assessment." CSIRO Aust. Div. Appl. Chem., For. Prod. Lab. Technol. Paper. No. 70 (1973).

Topic 5/7

ANATOMICAL CHARACTERISTICS OF THE BARK OF YOUNG SMOOTH-BARKED EUCALYPTS

by W. E. HILLIS

The bark of young smooth-barked eucalypts has been examined to gain an indication of its potential as a source of fibrous material for pulp. So far we have examined barks from *E. globulus*, *E. stjohnii* and *E. regnans*.

The amount (dry weight basis) of bark on discs taken from a 2.7 year old *E. globulus* tree varied from about 24% for most of the tree to about 31% at the top. With the 6 and 7 year old samples it was about 35% at the bottom, 18-25% in the middle portion and 40-50% in the top. With a 10 year old *E. stjohnii* the amount steadily decreased from 41% to 18% at the top of the tree. The length of the bark fibres was significantly higher than that of the wood in almost all cases. The length was mainly in the region of 0.85 to 1.20 with *E. globulus* and 0.8 to 1.6 with *E. stjohnii*.

The basic density of the bark in the 2.7 year old *E. globulus* ranged from 0.34 to 0.46 g/cc and up to 0.62 g/cc in 6 and 7 year old trees. The density was 0.03-0.16 g/cc lighter than the wood portion of the disc. With a 10 year old *E. stjohnii* the basic density of the bark ranged from 0.32 g/cc to 0.48 g/cc. These values were 0.18 g/cc to 0.24 g/cc less than the wood portion of the disc.

The average length of bark fibres from a 2.7 year old *E. globulus* tree ranged from 0.99 to 1.10 mm in comparison with 0.62-0.67 for the wood fibres, for the 6 year old sample 0.97 to 1.13 compared with 0.66 to 0.81 and for the 7 year old 0.92 to 1.07 compared with 0.71 to 0.83 mm for the wood. With the *E. stjohnii* sample the average bark fibre length varied between 0.97 to 1.58 compared with 0.64 to 1.13 mm for the wood.

The bark from discs of *E. regnans* taken at different levels in a 4 year old tree have been examined to ascertain the ratio of fibres to other elements. Cross sections of inner, middle and outer bark were examined. The volume of the bark occupied by fibres (which were thick walled) varied between 23.8 to 28.4% and by the large thin walled parenchyma 50.7 to 55.5%. Sieve tubes, companion cells and rays each occupy a small volume usually less than 5%. The differentiating parenchyma at the base of the tree occupies between 17 and 12% but is lower at the top of the tree. The stone cells occupy less than 4% of the volume but the amounts increase towards the outer portions of the bark.

The average number of vessels per mm^2 of the wood and their average tangential diameter (µm) for *E. globulus* of different ages is as follows. For the 2.7 year old tree, 12 vessels with diameters between 75-80 µm, for the 6 year old tree 9 to 23 with diameters 77-84 µm, and for the 7 year old tree 13 to 23 with diameters 55-65 µm. For mature wood of *E. globulus* the values are 4 to 7 and 132-194 µm respectively. The 10 year old tree of *E. stjohnii* had an average number of vessels of 5-15 per mm^2 with average diameters between 75-96 µm whereas with mature wood the values were 4 and 6 vessels and an average diameter between 94-166 µm.

GLUABILITY OF SPECIES

By K. F. PLOMLEY, W. E. HILLIS and K. HIRST

Although the concept of "any tree" utilization may hold good for the mechanical properties of Australian timbers, it is not generally true for the property of gluability. There is a significant number of valuable species which are difficult to bond reliably, especially when using phenol- and resorcinol-formaldehyde adhesives.

Both high density and the presence of extractives have been implicated in gluing difficulties of certain species. Permeability may play a secondary role. High density is the cause of the unsatisfactory bonding of a number of useful species In some instances, silvertop ash for example, the gluing difficulties experienced when using some commercial PF adhesives can be overcome by changing the adhesive formulation. In studies made at this Laboratory a few years ago, it was found that satisfactory bonds could be achieved with this species by increasing crosslinking in the adhesive and by adding a larger proportion of filler.

The same method has been used successfully to improve the bonding of some high density species with resorcinol adhesives.

However, with a number of high density species changes in adhesive formulation do not result in significant improvement in bond quality. Moreover, there is a significant number of species in the low to medium density range which is difficult to glue with phenolics. In these cases the problem is believed to result from the presence of certain kinds of extractives.

Studies have been initiated which aim to reveal the kind and amount of extractives present in problem species, the effect on bonding of crude extracts of the species and of their various components and how their effects might be overcome.

The first part of the work involves a study of the effect of the methanol extractives of different species on PF bonding. In order to minimize differences in bond quality which may arise from density differences or differences in grain, hoop pine veneers are dipped in solutions of the extracts under examination and conditioned to 12 per cent m.c. Three-ply veneer assemblies are bonded with a commercial hot press PF or other adhesive and again conditioned to 12% m.c. Finally the panels are tested dry and wet after 72-hour boil as specified in AS 090.2 - 1964.

This procedure makes it possible to study the effects of a variety of tannin extracts and their separate components and also to examine the effect of concentration.

The effect of concentration of dip solution was studied over a range of 1.5 per cent to 10 per cent for most extracts. Uptake of solutions by veneers varied to some extent, but was equivalent to a range of 2.1 g to 19.9 g (mean values) of dry solids per metre^2 of veneer surface.

The results of the tests on PF bonded panels show that veneers dipped in solutions of wattle and quebracho extracts, which are condensed tannins, gave bonds which were better than the controls. The hydrolysable tannins

which are the major components of the extract of *Eucalyptus delegatensis*, *E. regnans*, chestnut tannin and myrabolams, and "Myrtan", which is a mixed tannin and *E. sieberi* kino, which is a condensed tannin different in nature from the above condensed tannins, all gave low bond qualities in the boil test and in some instances also in the dry test.

Ellagic acid, a component of hydrolysable tannins, gave low bond quality especially in the boil test. However, gallic acid, which is present in the free form and is also a component of hydrolysable tannins, did not affect bonding. Pyrogallol, which contains the characteristic feature of gallic acid and the hydrolysable tannins, also did not affect bonding.

The effect of all the hydrolysable tannins and ellagic acid was very marked even at the lowest concentration of dip solution, which was equivalent to 5.7 g solids per metre^2 of veneer surface for *E. delegatensis* and 2.1 g for all others.

Work is now being carried out with the aim of discovering how the hydrolysable tannins affect the glue bond. Extractives of other species are being investigated, together with the effect on bonding of lower concentrations of extracts.

THE POTENTIAL FOR NAVAL STORES PRODUCTION IN AUSTRALIA

By W. J. SMITH

The cost of naval stores imports to Australia in the year 1971/72 in the form of gum rosin, crude and refined tall oil, spirits of turpentine, pine oil, resin acids and other derivatives of rosin was in excess of $3,300,000.

Quantities totalled nearly 10,000 tons and 490,000 gallons.

The cost of these imports has increased by about 65% since 1963/64.

Apart from the large demand in Australia, there is an apparently considerable export market, especially to Japan (1).

Exotic pine plantations in Australia constitute a more than adequate resource to meet our own needs and provide an excess for export, with Queensland having the highest naval stores productivity potential in its slash, loblolly and Caribbean pine plantations. These species provide much of the world market's needs.

The problem is economic production, but it is suggested this could present less difficulties than might otherwise be envisaged if considered in conjunction with the additional one of waste disposal and the desirable objective of whole-tree, any-tree utilization. It is suggested more serious thought should be given to the profitable removal of resinous extractives in the processing of resinous coniferous wood for pulp, and in investigating the economics of bark and wood waste disposal and utilization. If higher volumes of raw material are needed, these would be available at minimal cost, in some areas at least, in the form of pre-commercial thinnings. Highly resinous stumpwood is also processed in other countries.

Reference

(1) Allen, J. L. (1966) - The production, marketing and utilization of naval stores - Tropical Prods. Inst. Rept. No. G.24, London.

PLANT FRACTIONATION

By G. GARTSIDE

In an introductory paper Dr. Weiss has expounded the philosophy of the IPPI concept. Briefly the aim of IPPI is to derive the maximum economic benefit from our resources of land and solar energy at the same time satisfying social and environmental requirements. Thus an integrated agricultural or forestry enterprise would be optomised on the maximum use of photosynthetic energy for products of value to man commensurate with the maintenance of soil fertility.

As described earlier by Dr. Weiss one of the keys to such developments is the fractionation techniques to be used on plants. Naturally produced materials are usually a complex mixture of organic chemicals contained in a variety of cellular forms. The utilisation of such natural materials involves chemical treatment and/or physical processing. In our work we are initially interested in the separation of plant nutrients from the fibre and other insoluble carbohydrates. Two techniques used for this primary separation are due to Pirie and his co-workers at Rothamstead, U.K., and to Kohler and his co-workers for the U.S.D.A.

Pirie's work has concentrated on the production of protein for human feeding with particular attention to alleviating the protein deficiencies that exist in India. They have developed a hammer mill in which leaf and green stalk material can be reduced to a pulp without excessive heat generation. The milling is optomised to give the maximum amount of cell rupture whilst retaining sufficient fibre to allow drainage of the juices when squeezed. The pulp is passed through a belt press to extract the juice which contains amongst other things the soluble protein. The protein is heat coagulated and separated by filtration.

The work of the U.S.D.A. has concentrated on the optimum production of animal feedstocks from freshly harvested lucerne. Their technique involves the extraction of juices by sugar cane rollers to give a lucerne meal and a protein rich juice. The meal has a reduced protein concentration and is of value for both ruminant and non-ruminant feeding but what is of importance is its reduced water content. Thus the meal requires less energy to dehydrate than normal lucerne. From the juice, by heat coagulation, is produced a protein rich concentrate that has high xanthophyll and carotene content. This is of high value in the feeding of poultry and pigs.

In neither case has an attempt been made to utilise the fibre rich meal other than for animal feeding. The maximum amount of protein that can be economically extracted appears to be in the range 50-65%. Thus any meal will contain significant amounts of protein. This could provide adhesion for the fibrous material. The meal will also be biodegradeable. The possibilities of the use of the meal other than as a feedstock appear to lie in the exploitation of these two properties.

A collaborative project has been established with Animal Physiology on the primary fractionation of lucerne. Lucerne has been chosen because of its high protein yield, its high total biomass yield, the extensive production period, the extensive literature existing on its chemical composition, the existance of an industry which dehydrates lucerne for animal feedstocks, and the information available from the

U.S.D.A. on its fractionation. A cursory look at the stalk showed that the best fibre was about 3 mm in length and thus could be very useful in paper products.

Initially, physical processing only is being used. This involves breaking of the cellular material to release the protoplasm, followed by squeezing to separate the liquid from the solid. Studies are being undertaken to compare the efficiency of cell wall breaking by impact milling, shear milling, and pressure milling through rolls. Various forms of rolls are being looked at for the juice squeezing. A pilot plant has been established at Prospect to supply various fractions for feeding to animals i.e. protein concentrate, residual liquor, and fibrous residue or meal. Additionally some of the latter two fractions will be the subjects of further experimentation in Melbourne. Further fractionation of the residual liquor is possible by fermentation. Alternatively the solids content can be increased by distillation, membrane separation processes, flash drying etc. The economics of these further processing steps will be assessed. The fibrous residue is undergoing tests to find its suitability for fibre board and moulding. As mentioned previously other work will concentrate on the exploitation of the inbuilt protein adhesive and the biodegradeability of this plant fraction.

The pilot plant at Prospect will be used to fractionate other whole plants and plant residues. The plants to consider for this work will range from the grasses to trees. In order to reduce the number of plant species that have to be examined a screening process to be applied mainly to existing economic plants is being established. This screening process will consider such points as existing physical and chemical data, probable properties assessed from information on similar species, the economics of fractionation processes performed on the plant, a projected cost for new fractionation, market requirements and prices. Obviously plants that perform some fractionation during their life cycle e.g. cereals, grains, legumes, trees, are to be favoured, since the processing costs are predictably lower. Other considerations can be made such as in the coppicing of trees for fibre, where for instance trees with leaves which contain substantial protein, or good foraging characteristics could be favoured. Also the ability of plants to grow in shade could lead to the establishment of "double economy" farming of annual crops and trees. A long list of similar considerations will be used in the screening process. The aim is to produce before next spring a list of about ten plant species for intensive study.

Future work may involve detailed chemical studies of possible medicinal compounds, or the reaction of extracted alkaloids to preferred products. The vegetable oils could provide raw materials for polymerisation, if this is so some work will be needed on the fractionation of these oils by distillation, solvent extraction etc. Fractionation techniques such as grain and seed cleaning and decortication, solvent extraction and distillation of oils, separation of bast from wood fibres and leaves from stalks will be assessed, adapted and improved where necessary.

WHAT IS THE POTENTIAL FOR RESIN PRODUCTION IN PAPUA NEW GUINEA?

By J. ZIECK

In tropical regions with their heterogeneous rainforests containing a great wealth of species, a wide variety of resin producing plants can be expected. This is also the case in Papua New Guinea.

Though there are two main commercial resin types in P.N.G. at the moment, namely Manila Copal (from *Agathis* spp.) and damar (from *Vatica papuana*), several other tree species, chiefly belonging to the families of *Araucariaceae*, *Dipterocarpaceae* and *Burseraceae*, could yield worthwhile resinous products.

The bark of *Araucaria cunninghamii* and *A. hunsteinii* turns out a rather viscose gum-resin (a mixture of water soluble gums and true resins), of which chemical composition, physical properties, usability and saleability still have to be better investigated. Methods of tapping and collecting this gum-resin have to be found, although it is thought that a general utilization of bark waste materials in the *Araucaria* timber industry could result in a rather considerable production of resins, tannin and bark fibres.

Besides *Vatica papuana* from the *Dipterocarpaceae* family, (in particular) *Anisoptera polyandra* (and *A. kostermansiana* to a lesser extent) with a wide distribution and sometimes a dominant tree in several areas, could take part in an increased damar resin production in P.N.G. As with *Vatica* the best tapping method for a more regular yield not depending on collection of natural exudations, must still be investigated.

In the *Burseraceae* family, *Canarium* spp. especially are the sources of commercial "elemi", an oleoresin with a rather high percentage of essential oils to give it a soft consistency when fresh, getting harder with increased age. *Canarium indicum* is locally extensively planted more for the tasty nuts than for tapping elemi.

A true naval stores industry could arise in P.N.G. from non indigenous *Pinus* species (in particular *Pinus merkusii*) with a growing oleoresin (turpentine and resin after distillation) production potential in near future after extending village plantations, e.g. in Wau/Bulolo and other Highland regions.

Locally all resin species are used in small quantities for lighting purposes (torches), burning, caulking canoes and in certain artifacts. Exported resin species find their applications generally in the paint and varnish industries. Here the problems of competition with synthetic resins arises, synthetic commodities being of a more uniform and constant composition and cleanliness, easier to handle for the user than the natural resins which tend to have different degrees of impurities from day to day and an unpredictable output being dependant on rather primitive production conditions. The only way to defy competition from synthetics is by cheap production of natural resins, accompanied by more careful grading, sorting, cleaning and introducing a chemical purification process in a factory near the source, resulting in a uniform commodity. Combination of natural resin with the synthetic in fact already has given good results.

Topic 5/11

Resin from *Vatica papuana* (damar hiru, gum herrol, Sud-est gum)

Export of this damar species mainly from Sud-est Island (Tagula Isl) via Samarai, started in 1888. Statistics show an export of more than 2300 tons over 46 years - annual average 50 tons - with a value of $260,000. Australian paint factories are the main customers, though during some years several European countries too were in the market for this resin. F.O.B. value nowadays is $A215 - per ton for graded, scraped damar. The Australian market is rather restricted; higher production volumes would require outlets into other countries. This dipterocarp is only a small to medium sized rainforest tree. It is distinctly a gregarious tree, forming forest areas where it dominates up to 70% of the total tree numbers. Though forming rather pure stands, they are not easily recognisable from the air (unlike *Agathis*). It is found growing on flat swampy areas, high river banks and on dry ridges up to 1500 ft altitude, on usually infertile soils. *Vatica* finds its eastern limits of occurrence on the islands of the Louisiade Archipelago (Tagula Isl), westwards it is found all over New Guinea up to E. Borneo and N. Moluccas. The heaviest distribution is found in Western District of Papua from the border near Kiunga eastwards to Kerema (a distance of 350 miles), also in Milne Bay regions and some lower areas of the Sepik Districts. These extensive *Vatica* forests in P.N.G. are an indication of a very large resin potential.

Damar is collected exclusively in the native spheres. Nearly all traded resin originates from natural and spontaneous exudations and dead trees. The resin is formed in sapwood (not in the bark). Regular and definite tapping methods are not applied yet. Influence of fungi or insects are supposed to have stimulating effects on resin flow. Freshly tapped, damar *Vatica* is of yellow-reddish colour and transparent. Commercial damar *Vatica* is yellowish to amber coloured and usually not transparent. As it is fairly hard (old), with a rather high melting point (125-150°C), the commercial resin belongs to the semi-fossil or semi-recent class of "Pale East India Damars", rather than to the "Batavia A-E" or "Singapore" damar grades. In Indonesia, damar originates from 50-60 *Dipterocarpus* species; negotiated quantities often involve a mixture of several origins. (Damar export from Indonesia amounted to 6,491 tons in 1971). Up to now, New Guinea supplied only one commercial species of damar i.e. from *Vatica papuana*.

Damar *Vatica* dissolves in coal-tar hydrocarbons, is nearly insoluble in alcohol. It is harder than the so-called Batavia damars, with a melting point between 125-150°C, low acid number of 16-35. Essential oil contents are lower, the older the resin. Wax content is sometimes up to 25%, in negative sense important in lacquer manufacture as the resin has to be dewaxed first, increasing cost and loss factors, though the wax has commercial value itself. A local damar purification and dewaxing installation could solve this disadvantage in the competition with synthetic resins and increase future uses and applications of natural resins of the damar type.

Grading of damar takes place according to size of pieces and extent of impurities, which mainly accumulate in the dust fragments. Light colours (yellowish) are valued more than dark brown. Regular supervision in an extension service can do much to get a cleaner, better and higher priced product.

Resin from *Agathis* spp. (Manila Copal, Kauri gum)

From the 3 or 4 *Agathis* species known from Papua New Guinea, *Agathis labillardieri* seems to be the best resin producer. Exports between 1967-1970

amounted to a total of only 17.5 tons, mainly due to the rather difficult accessible kauri stands. As grading and sorting of this resin are not extensively practiced, the prices for these uncleaned quantities were low ($160 per ton). First grade quality of this valuable copal (PWS, Prime White Soft) on the contrary has a f.o.b. value of $350 per ton. An extension service would need to teach the villagers tapping, cleaning and grading methods to get the best results. Copal export from Indonesia was 2,223 tons (1971); The Philippines exported about 1200 tons (1970).

Stands of *Agathis labillardieri* are mainly found in the West and East Sepik Districts along the middle reaches of nearly all southern Sepik tributaries, moreover in Bewani and Border Mountains from nearly sea level to 3000 ft altitude. The stands are clearly defined by gregariously occurring kauri dominating all other trees with maximum diameter of up to 6 ft and top lengths of 180 ft, belonging to the largest trees in P.N.G. Small stands contain several thousand trees, the biggest up to 50,000 mature ones. Total of tappable trees in these areas are estimated at about 2,000,000, representing approx. 400 million sq ft in terms of timber volume. From the air the stands are easily recognisable, facilitating assessment on good aerial photographs. Access can be obtained to a large extent along small navigable rivers.

For copal collecting only the bark (without wounding cambium tissue) is tapped by a simple means of bush knives or using the most efficient methods practised in the naval stores industry of the Southern States of the U.S.A. This involves barkhacks, acid stimulants, disposable kraft-paper-bags and staplers as already tried out on *Agathis* in the Philippines. Average copal yield per tree depending on regular tapping frequency (2 weekly) is 40 lbs per year (experiences of Dept. of Forestry in Irian Jaya). Taking a figure of 20-25 lbs for estimates, an annual potential of about 2000 tons is possible. Man/year production in a regular controlled and organized copal industry can reach gradually 2 tons. In primitive areas where copal production is only an "extra" in daily subsistence life, man/year output is much lower. One man could work about 100 trees.

Copal dissolves in alcohol, is insoluble in coal-tar hydrocarbons, turpentine. Colour is white, yellow to dark brown. Hardness varies with age from kneadable soft to the hardness of the semi-fossil grade. Melting point is 115 to 135°C; rather high acid number, 125-150; contains essential oils (mainly lemonene).

Copal is used in particular for oil and spirit varnishes, spirit type paints, lacquers, in combination with and competition from synthetic resins.

Indonesia as the main copal producer sets the example for general grading rules. PWS, WS, LAS, MA, MB, LOBA, BUA, etc. The demand for purest grades (PWS and LOBA categories) tends to grow relatively. The grades can be simplified as a regular controlled tapping and harvesting organisation get under way.

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Rayner, S.	FPRC	PNG	Topic 3/42
Reardon, G. F.	DBR	V	Topic 3/14
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Key: BAM W.Germ. = Bundesanstalt für Materialprüfung, Berlin, West Germany

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DBR, V = CSIRO, Division of Building Research, Melbourne

DF, Q = Department of Forestry, Queensland

DMS, V = Division of Mathematical Statistics, Forest Products Laboratory, Melbourne

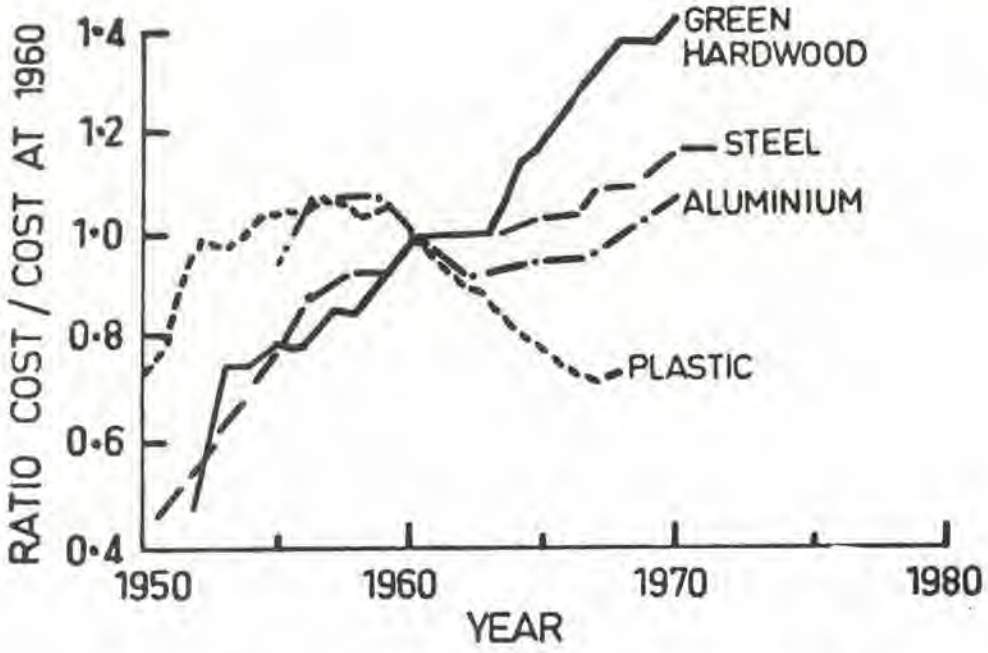
FC, NSW = Forestry Commission of N.S.W. , Wood Technology Division

FC, V = Forests Commission of Victoria

FRI, ACT = Department of Primary Industry, Forest Research Institute, A.C.T.

FPRC, PNG = Forest Products Research Centre, Papua New Guinea

Borrower	Date	Date Due	Reserve

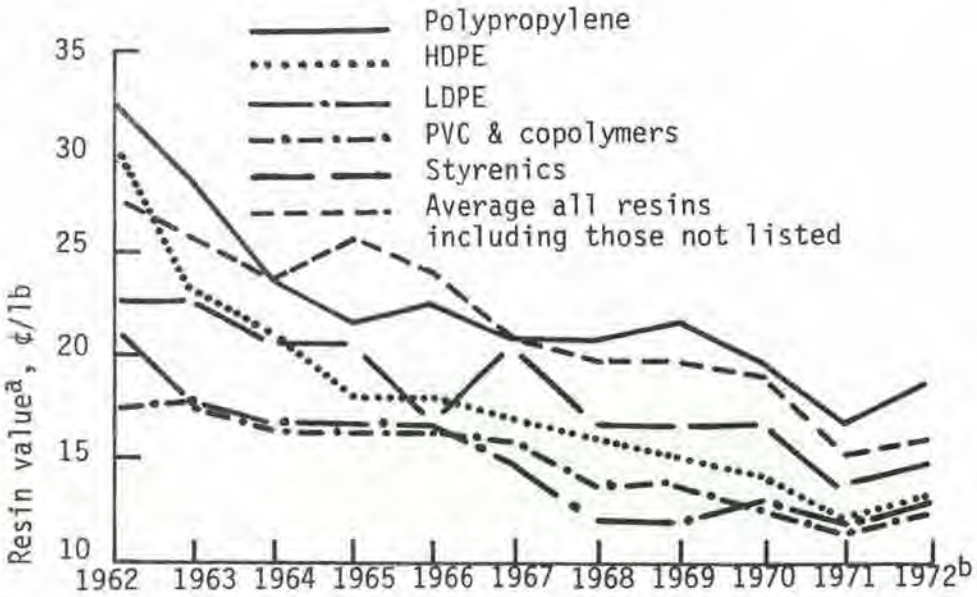


Relative price changes—Base year 1960.

Source: The Australian Timber Journal, November 1971, p.59.

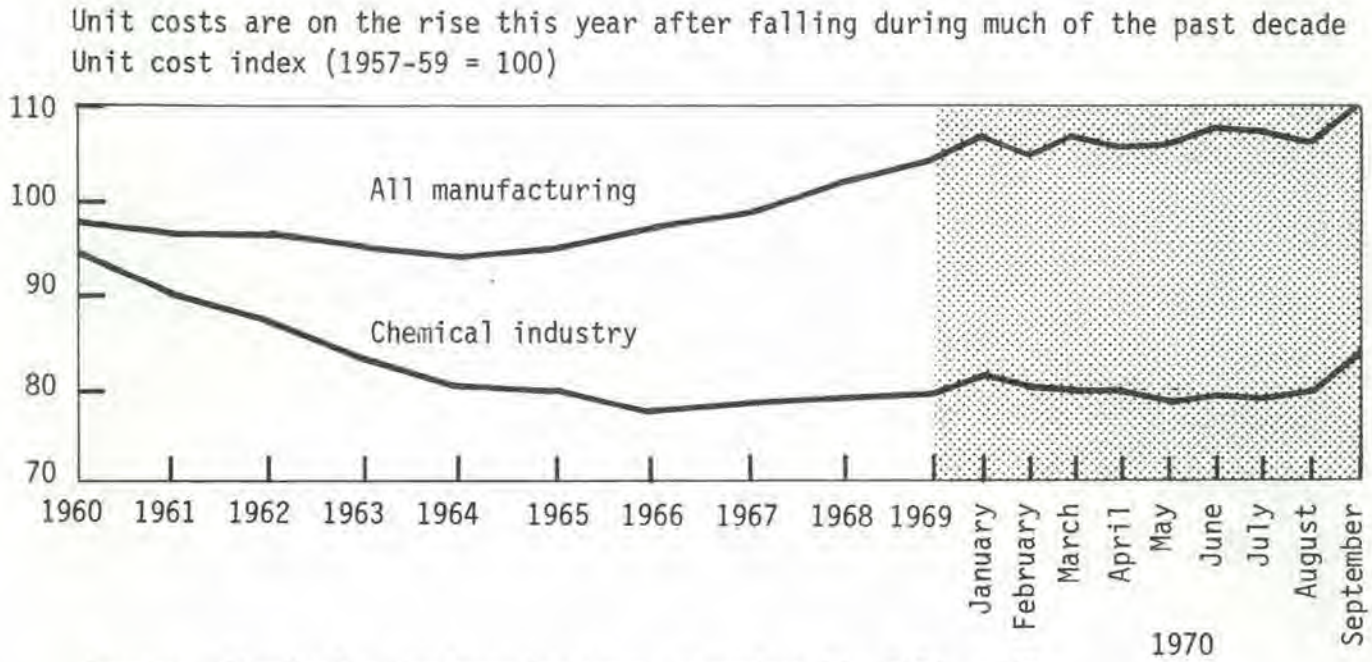
FIGURE 1

Here's what's happened in resin pricing since 1962



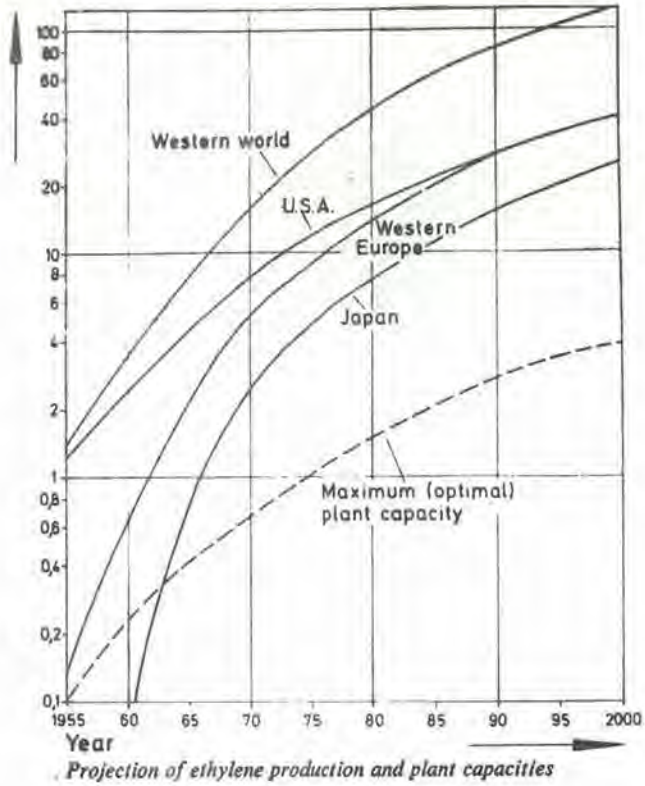
Source: US Tariff Commission reports and industry sources.
a - Price values are average for all grades in each resin family.
b - Projected.

FIGURE 3



Source: Chemical & Engineering News, November 30, 1970, p.17.

FIGURE 2

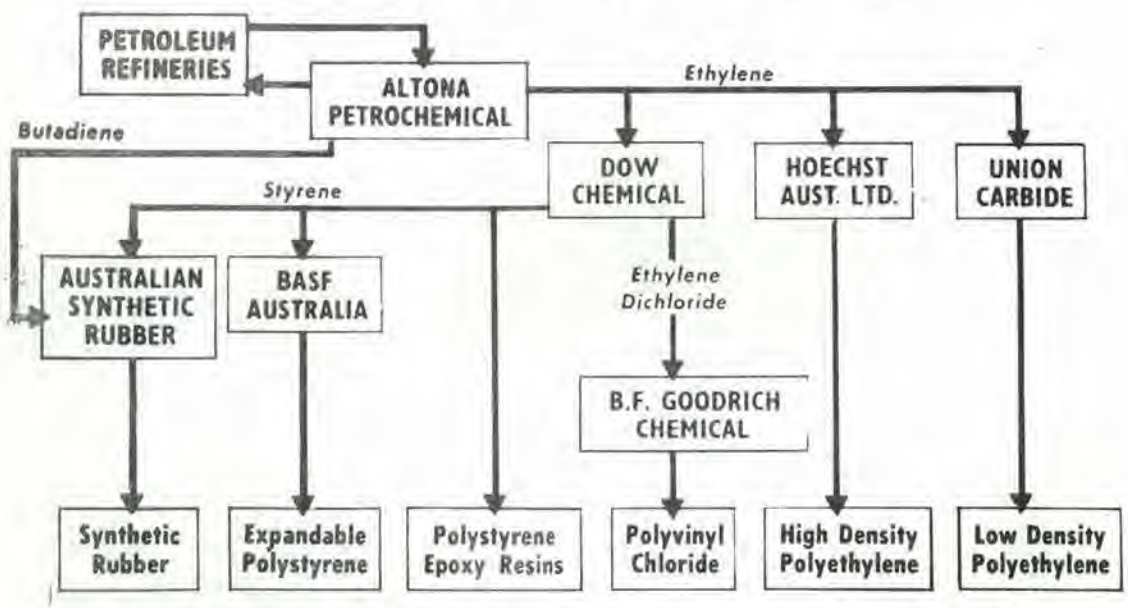


Projection of ethylene production and plant capacities

Source: Chemistry and Industry, 17 April 1971, p.419.

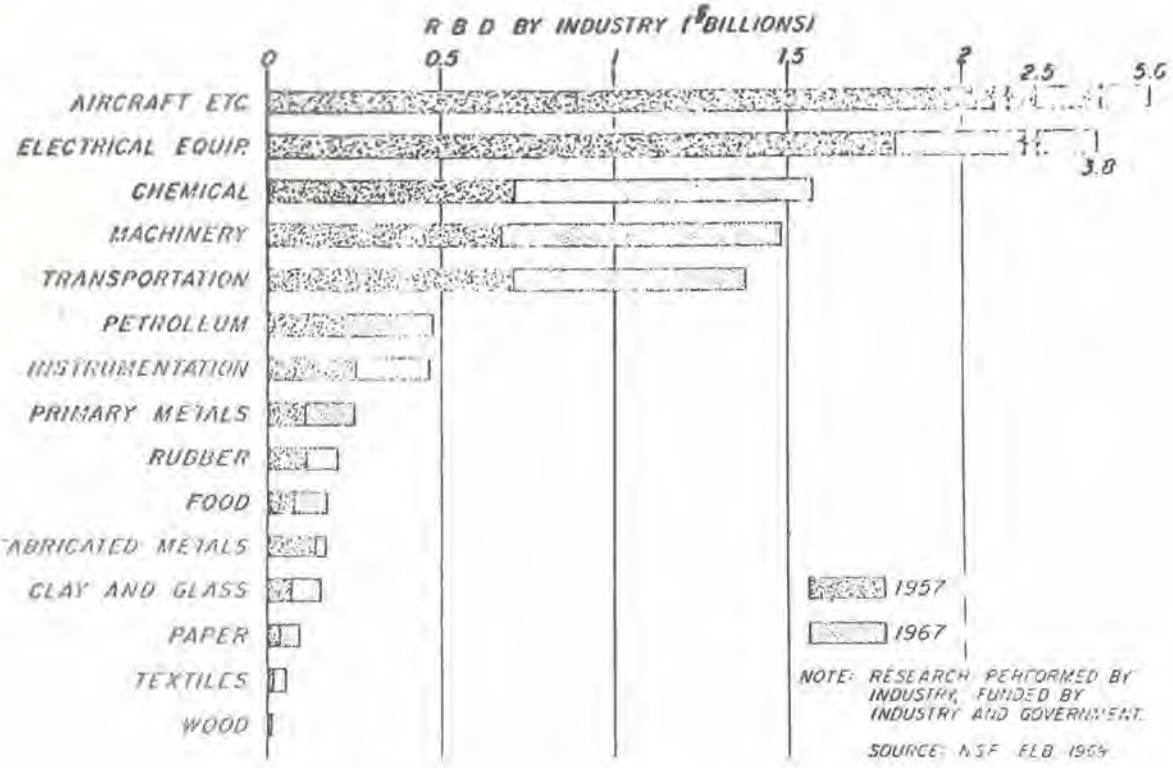
FIGURE 4

PETROCHEMICAL COMPLEX, ALTONA, VIC.



Source: Journal Department Trade and Industry, July 24, 1970.

FIGURE 5



Sources: The Wood Resource and the Environment - Some National Options and Alternatives, by Jerome F Saeman, Associate Director, Forest Products Laboratory, US Department of Agriculture. Paper presented at the 35th Yale Industrial Forestry Seminar, Madison, Wis, October 5-9, 1970.

FIGURE 6

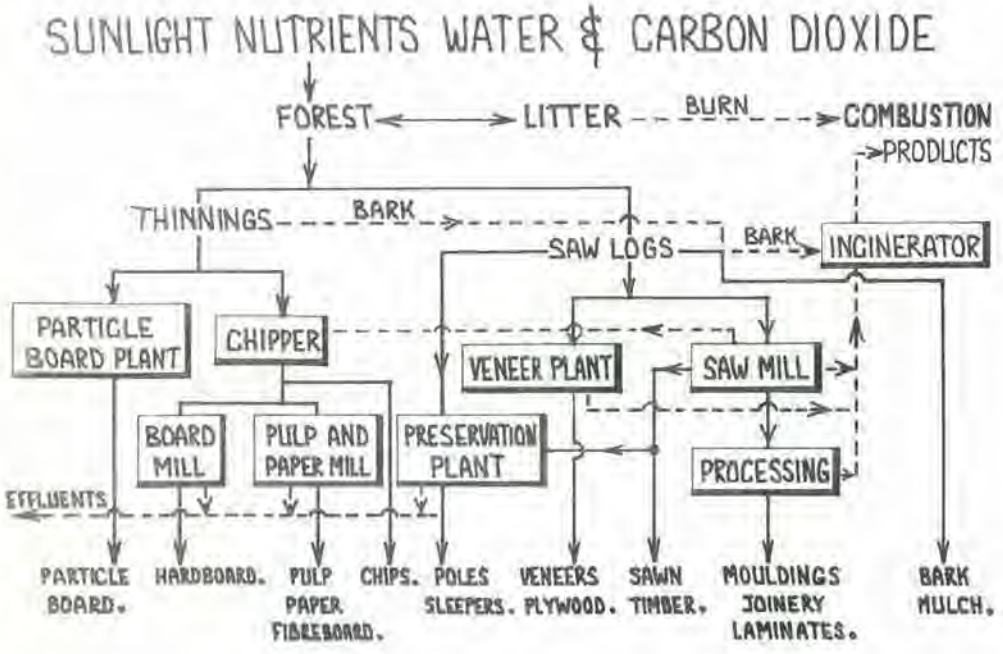
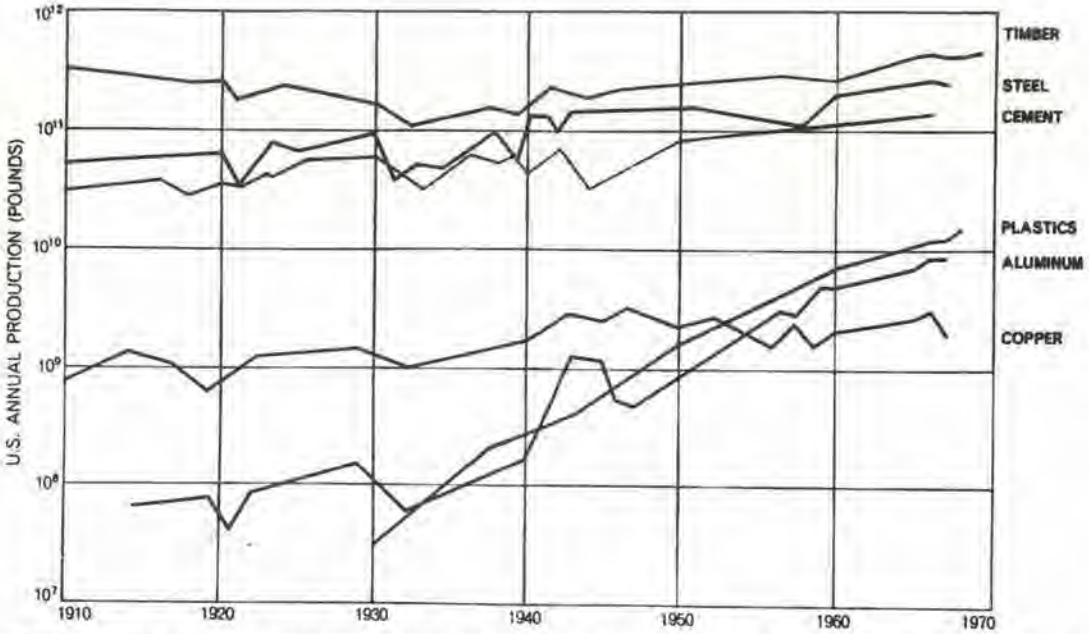


FIGURE 7



TREND IN CONSUMPTION of key materials is traced. The production of timber is usually reckoned in terms of board feet or cubic feet. For purposes of comparability it has been stated here in pounds, assuming an average density of 35 pounds per cubic foot.

Source: Scientific American, 223, 1970, p.200.

FIGURE 8

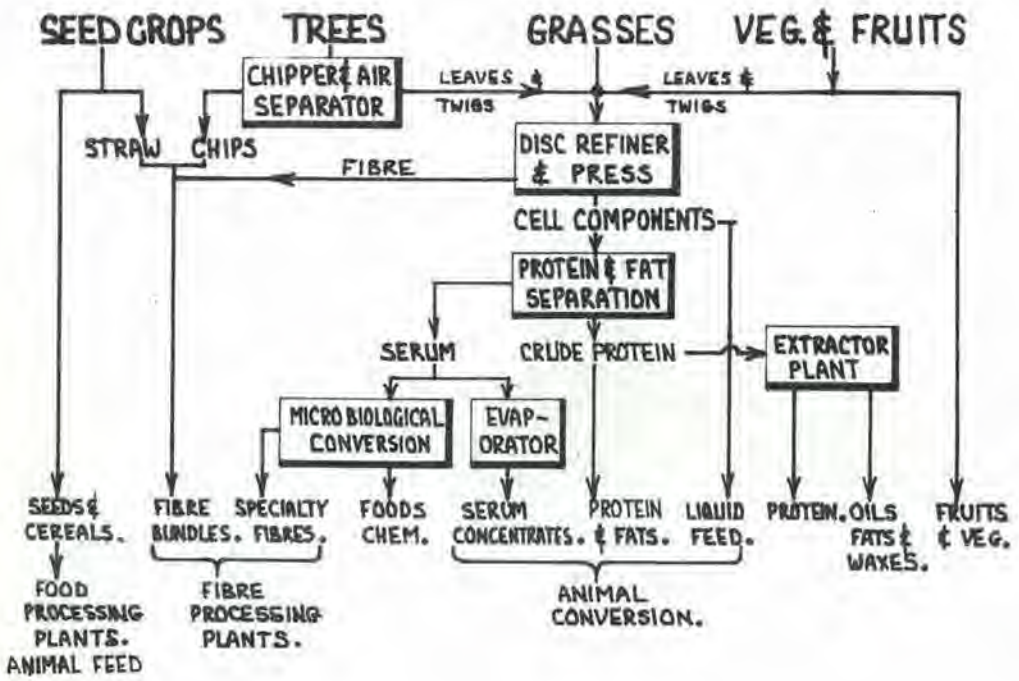
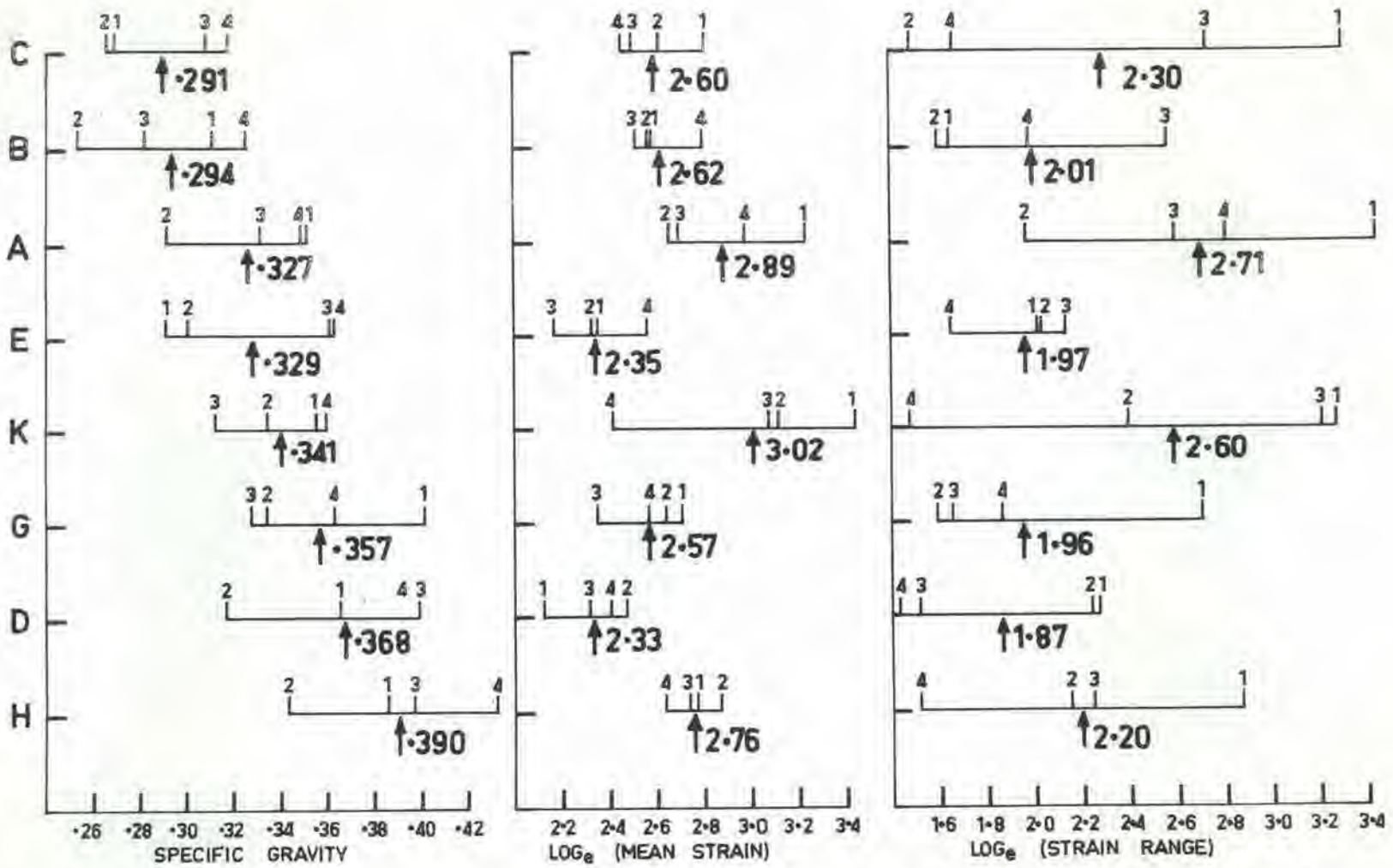


FIGURE 9

Figure 1a

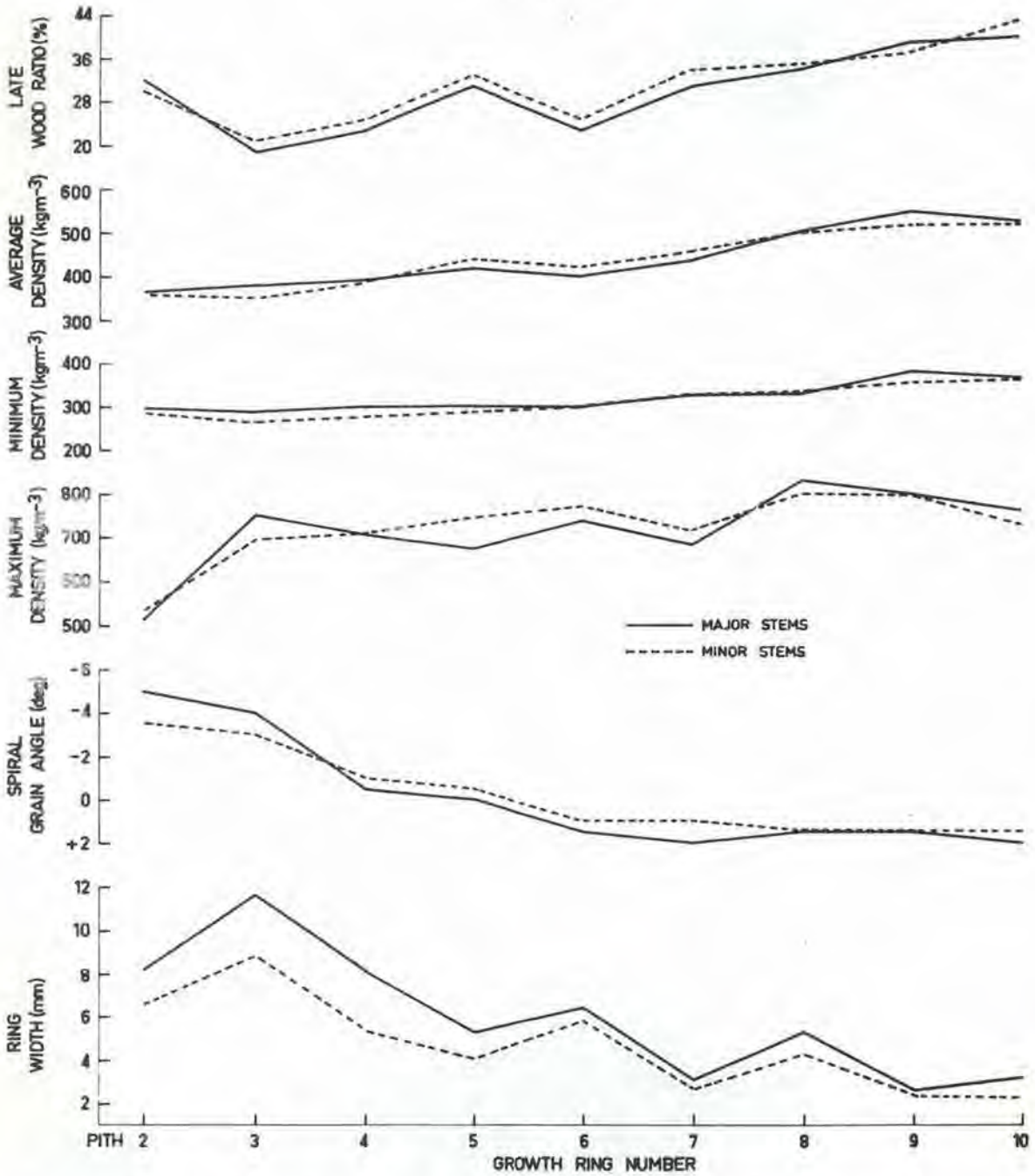
Figure 1b

Figure 1c



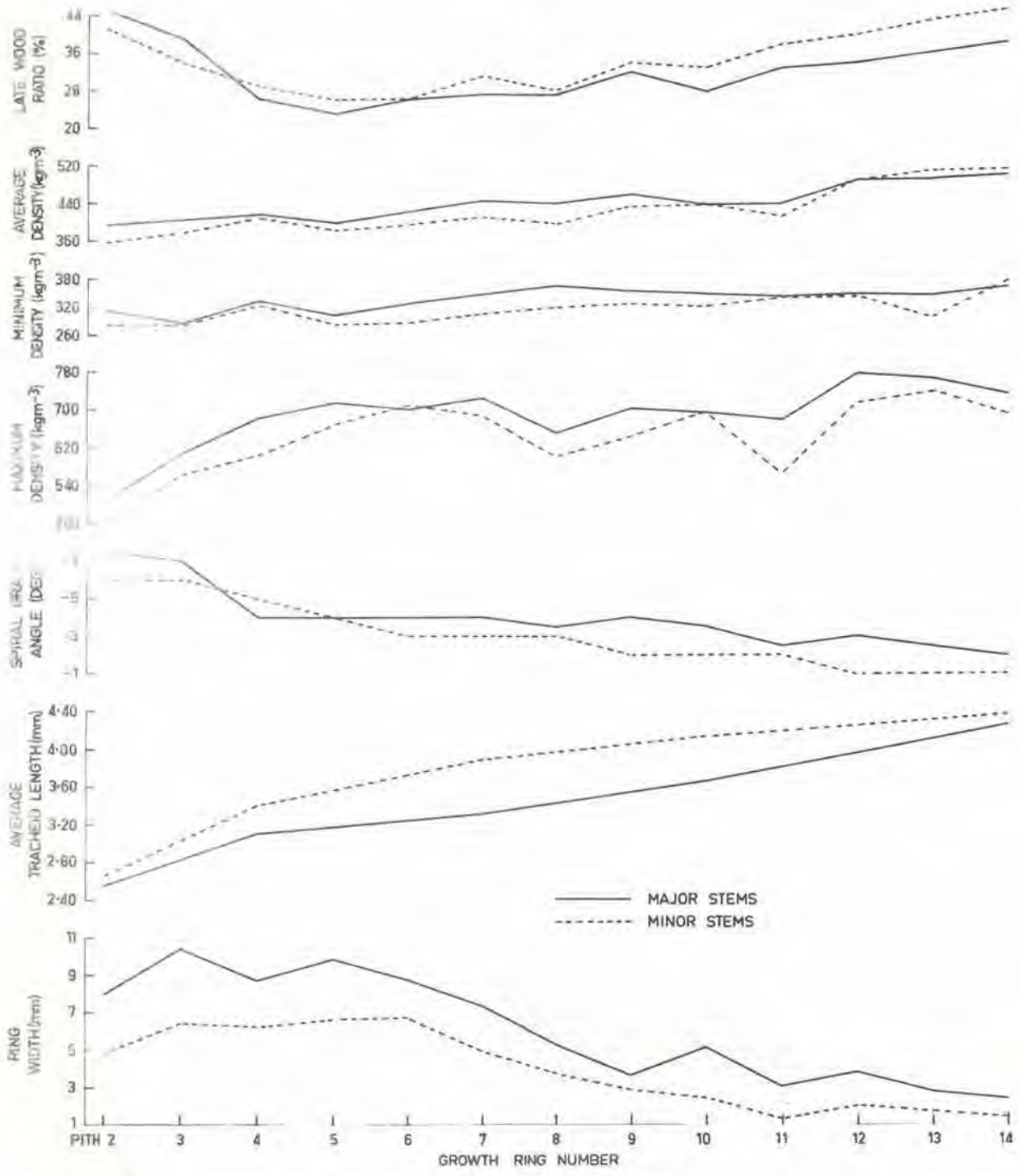
Poplar clones arranged in descending order of specific gravity (Fig. 1a) showing the unrelated nature of growth stress parameters when placed in the same order (Figs. 1b and 1c). Results are based on measurements on three ramets of each clone on each locality. Fig. 1b displays the mean within-stem longitudinal strain due to the release of growth stresses, while Fig. 1c displays the mean of the range of strain measurements for each ramet. The arrow indicates clone averages, the differences are essentially genetic. The vertical line shows differences between localities which are essentially environmental.

Figure 1



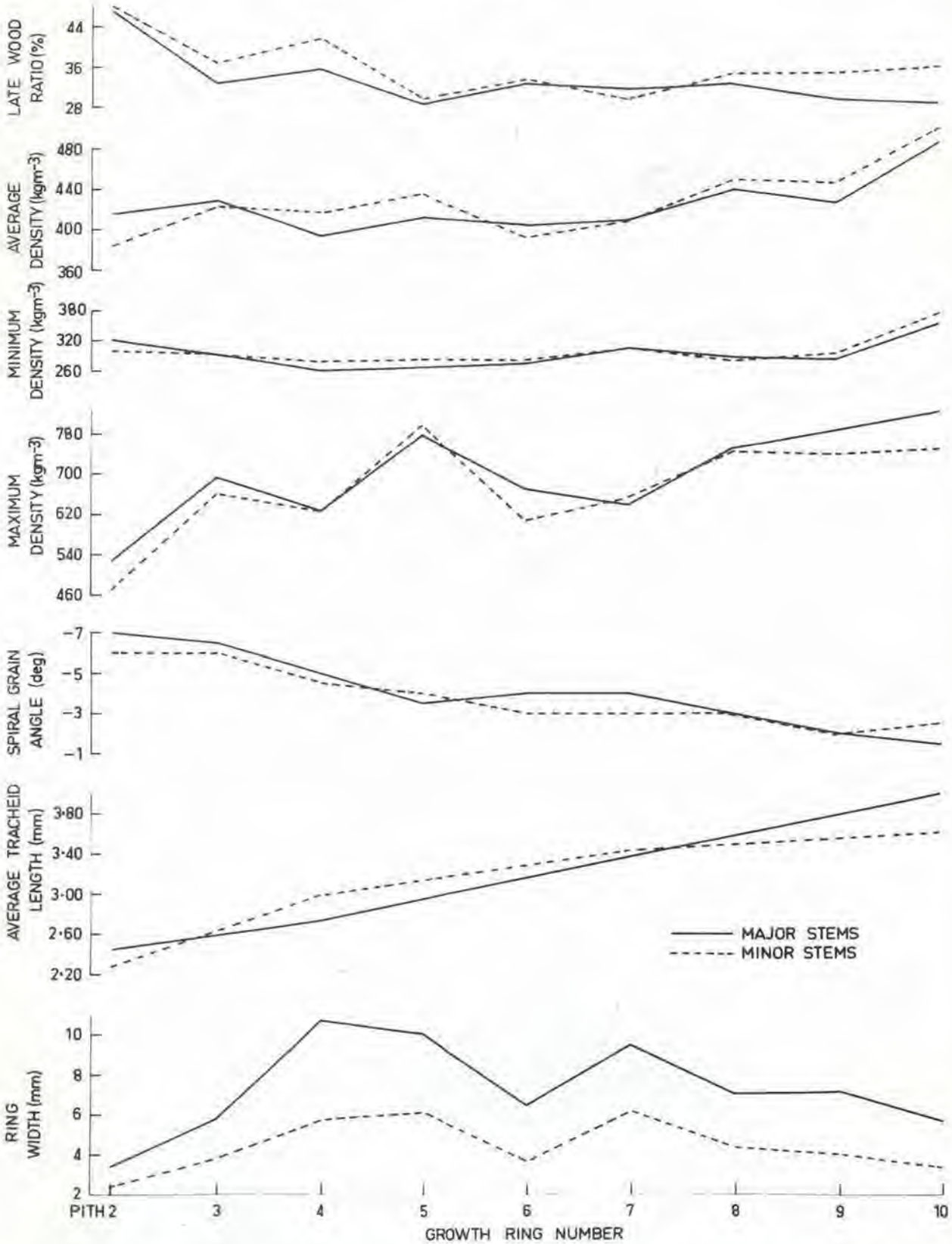
The variation through successive growth rings from the pith of the mean of ring width, spiral grain angle, maximum, minimum and average density and late wood ratio for breast high specimens from the major and minor stems of three double leader trees from Vanities Crossing plantation, A.C.T.

Figure 2



The variation through successive growth rings from the pith of the mean of ring width, average tracheid length, spiral grain angle, maximum, minimum and average density and late wood ratio for breast high specimens from the major and minor stems of three double leader trees from Kowen planation, A.C.T.

Figure 3



The variation through successive growth rings from the pith of the mean of ring width, average tracheid length, spiral grain angle, maximum, minimim and average density and late wood ratio for breast high specimens from the major and minor stems of three double leader trees from Blue Range plantation, A.C.T.

VOLUME DISTRIBUTION BY SIZE CLASSES

Fig 1

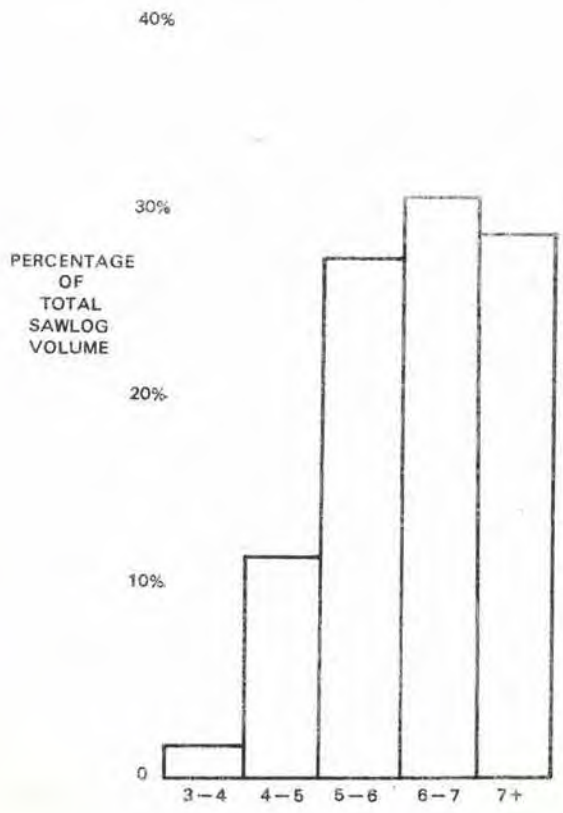
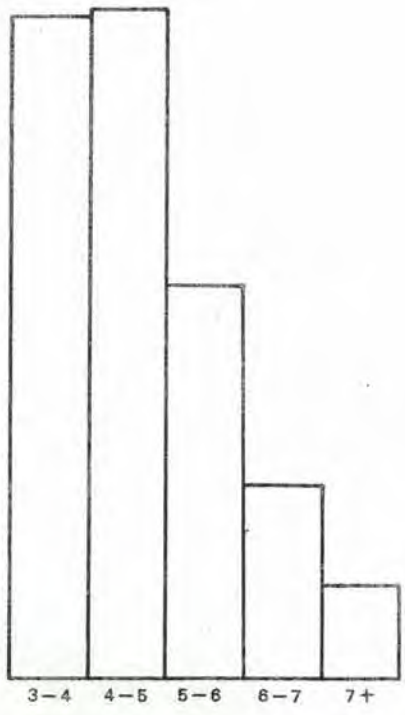


Fig 2



C.G.U.B. (FT) FOR 30 FT LENGTH SAWLOGS

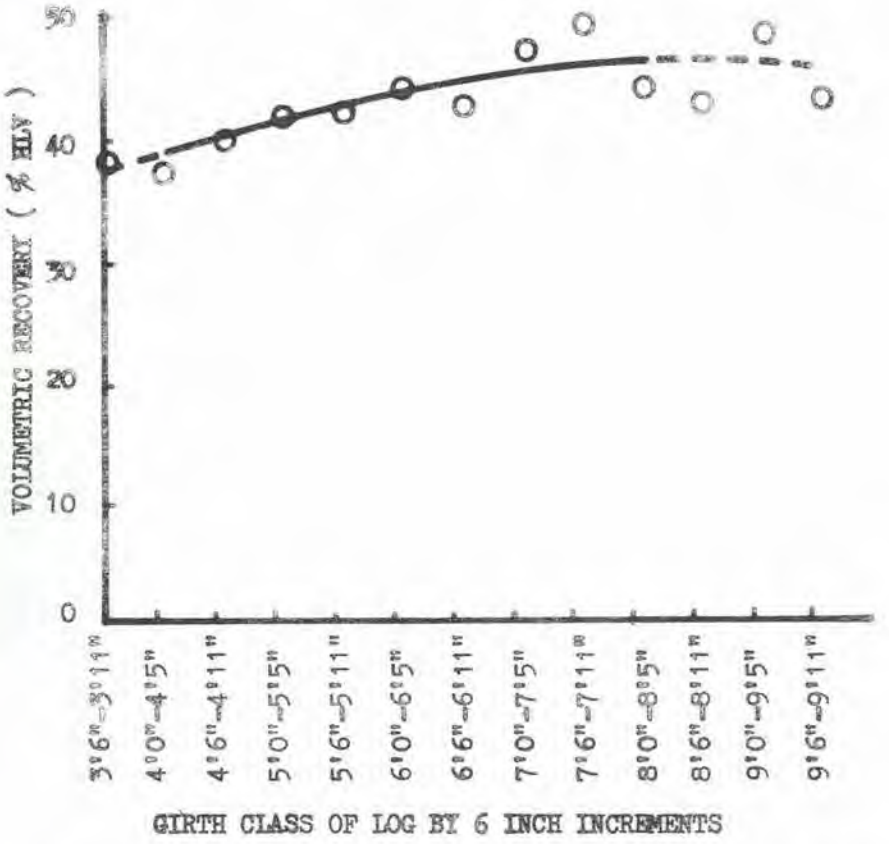


FIGURE 1 RELATION BETWEEN GIRTH CLASS AND VOLUMETRIC RECOVERY HLV WHEN MILLING JARRAH AT A WESTERN AUSTRALIA SAWMILL.

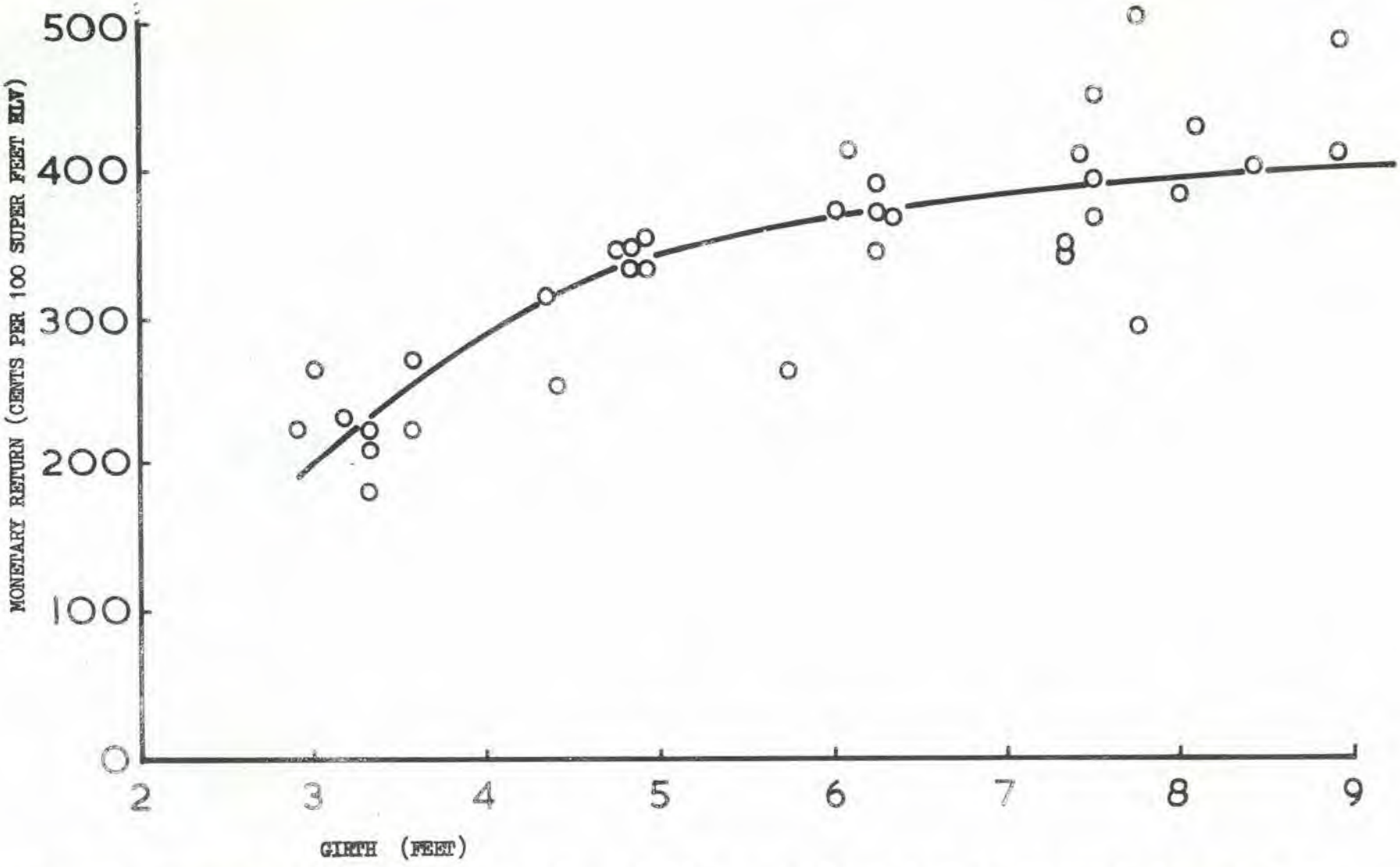


FIGURE 2 SHOWING RELATION BETWEEN MONETARY RETURN AND LOG GIRTH FOR *Eucalyptus obliqua* SAWN AT A TASMANIAN MILL.

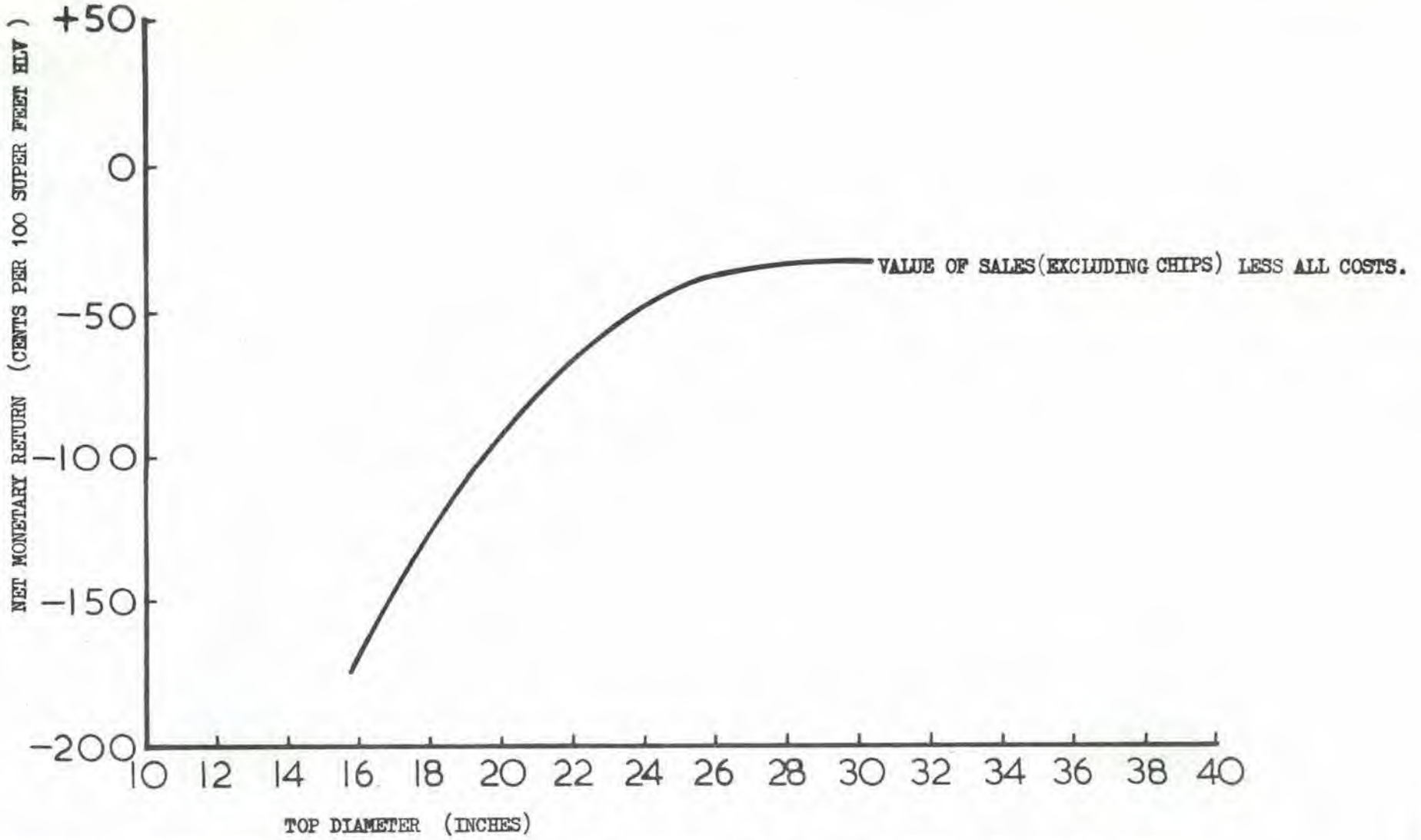


FIGURE 3. RELATIONSHIP BETWEEN NET MONETARY RETURN AND TOP DIAMETER FOR "MILL" QUALITY Eucalyptus obliqua.

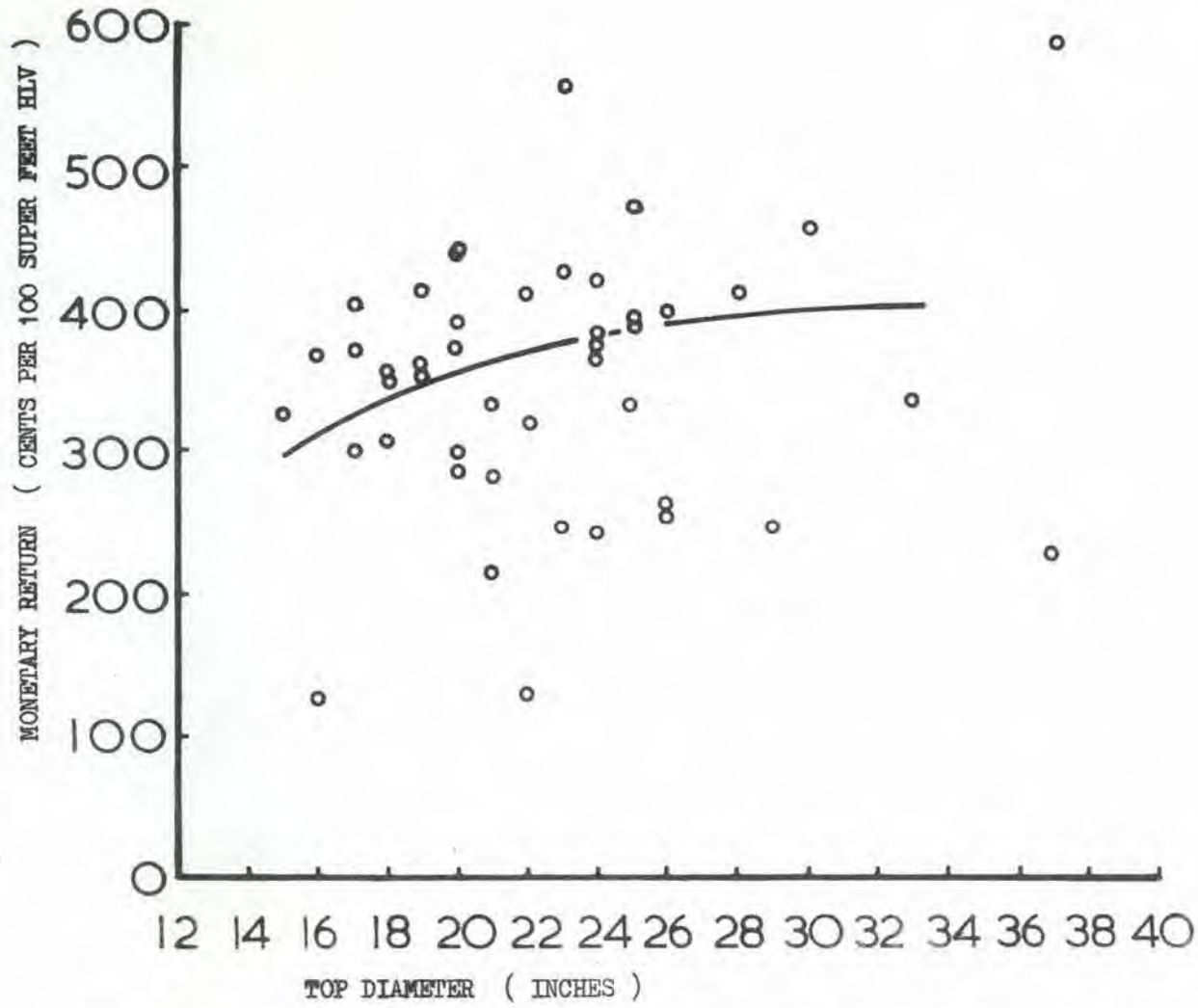


FIGURE 4. MONETARY RETURN PLOTTED AGAINST TOP DIAMETER FOR Eucalyptus obliqua, "MILL" QUALITY LOGS.

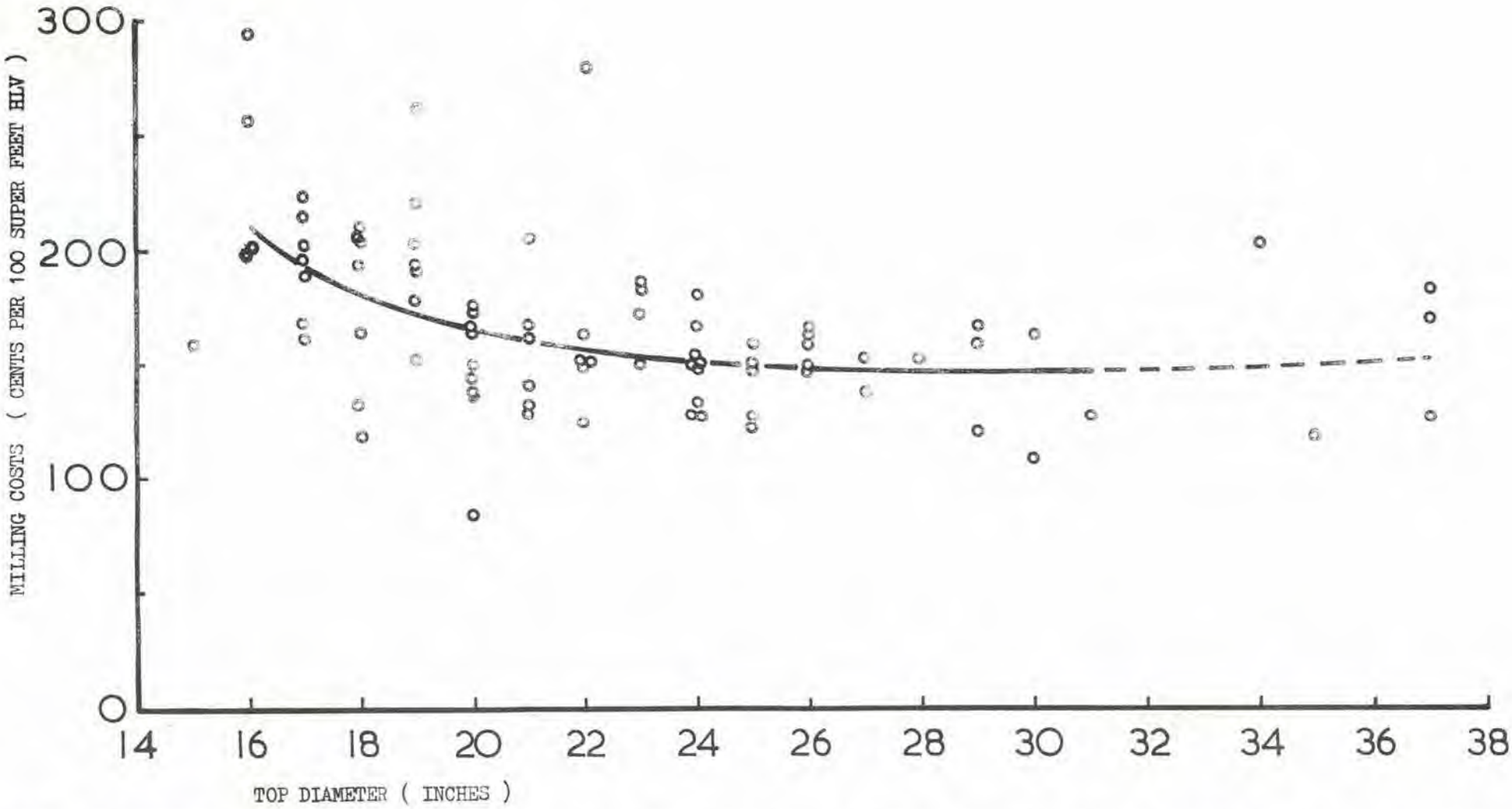


FIGURE 5. RELATION BETWEEN MILLING COST AND TOP DIAMETER FOR SECOND TASMANIAN MILL (ALL SPECIES , MILL QUALITY LOGS)

Fig. 1 Relationship between mean stem volume and total stand volume.

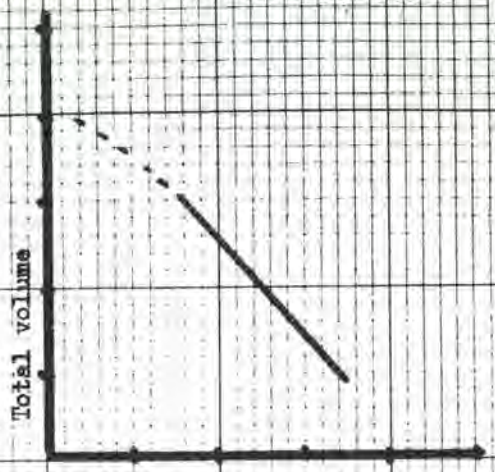


Fig. 2. Relationship between mean stem volume and growing costs.

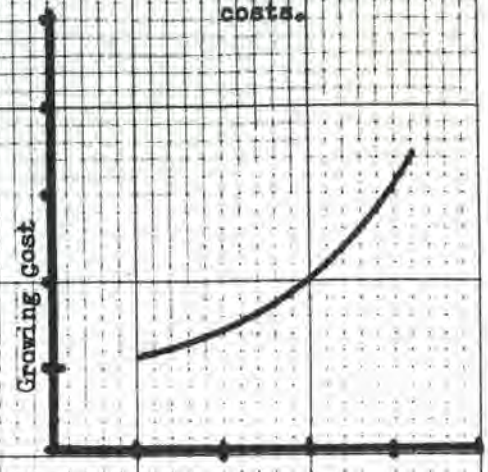


Fig. 3. Relationship between mean stem volume and harvesting costs

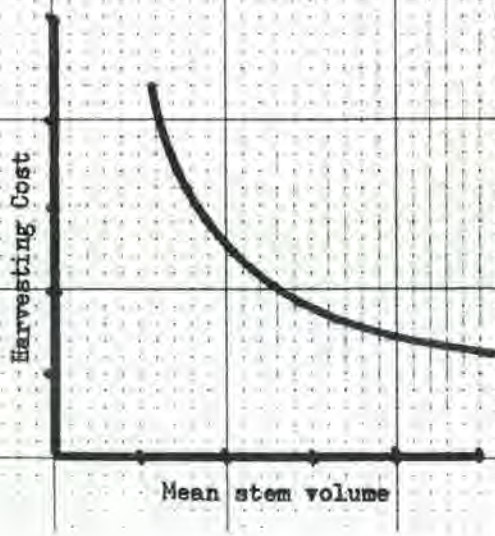


Fig. 4. Relationship between total costs and mean stem volume.

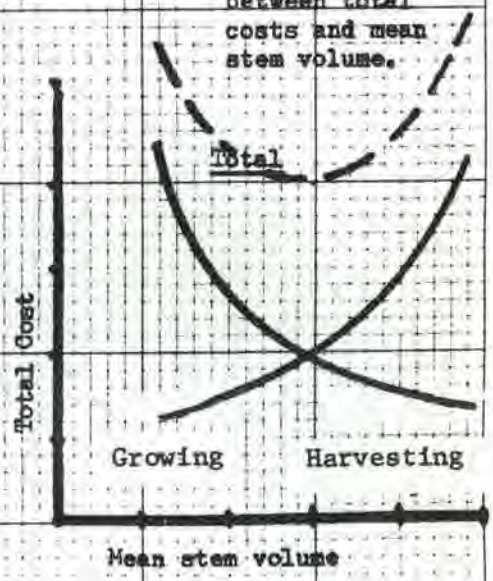


Fig. 5. Showing the influence of mean stem volume on costs for 3 types of processes.

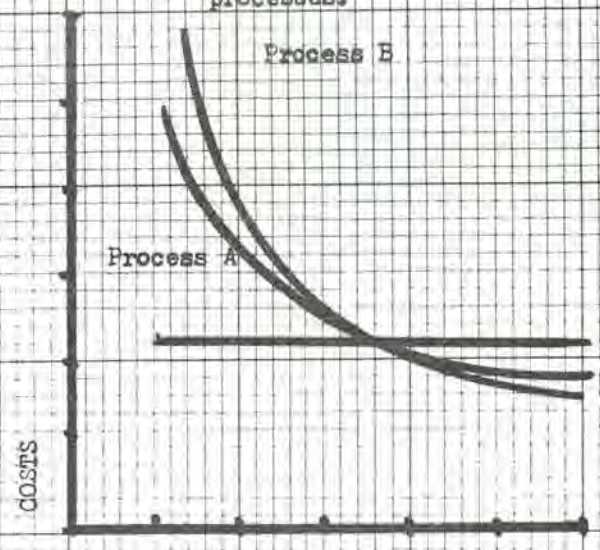
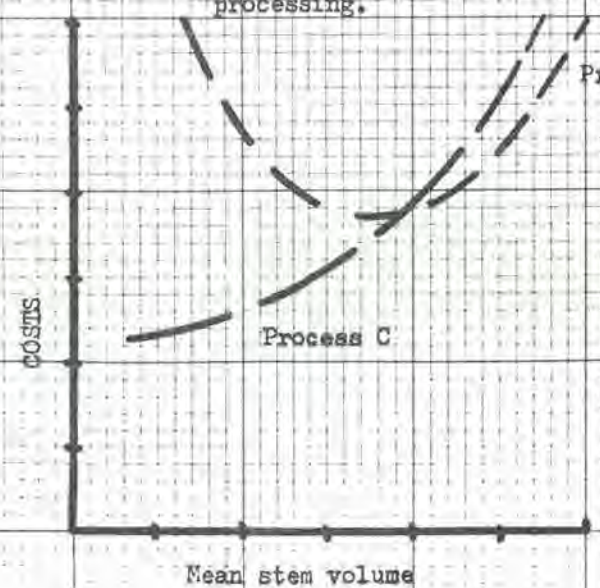


Fig. 6. Showing the influence of mean stem volume on total costs for 2 types of processing.



A well constructed house in a rural area making excellent use of untreated round poles.

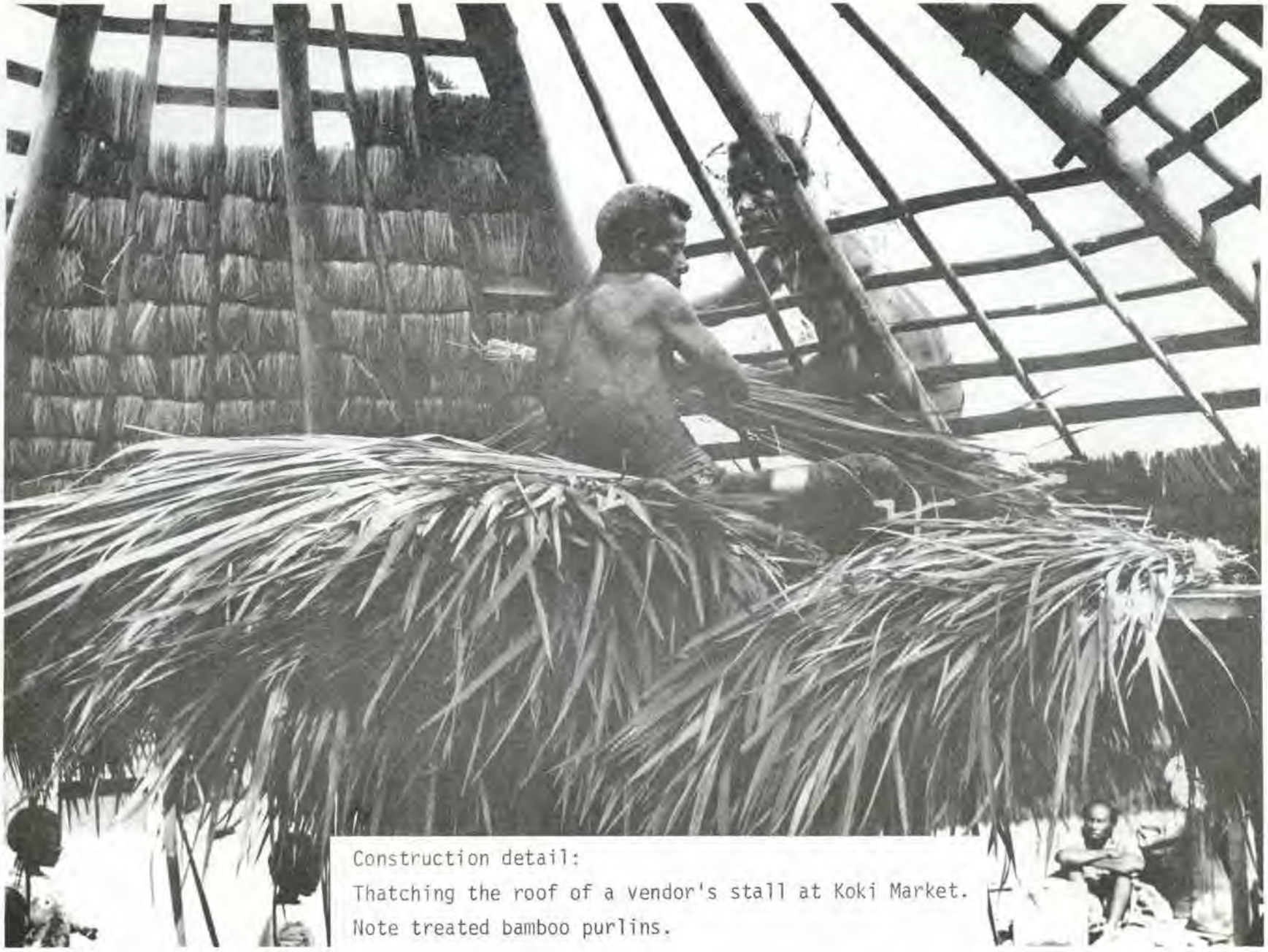
A bus shelter using treated teak poles at the University of Papua New Guinea.

A market stall using treated teak poles at Koki Market, Port Moresby; built from one of our standard designs.

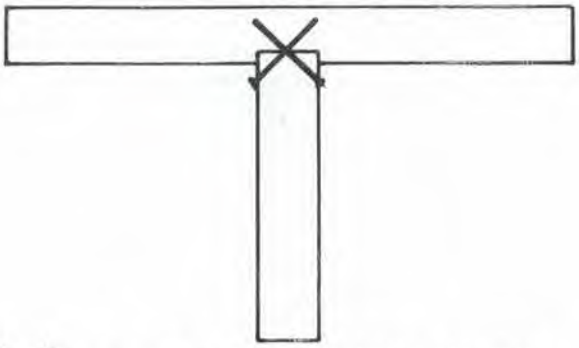
A market pavilion under construction
at Waigani Market.

Construction detail:
A rafter wired to a column with a purlin nailed on top.

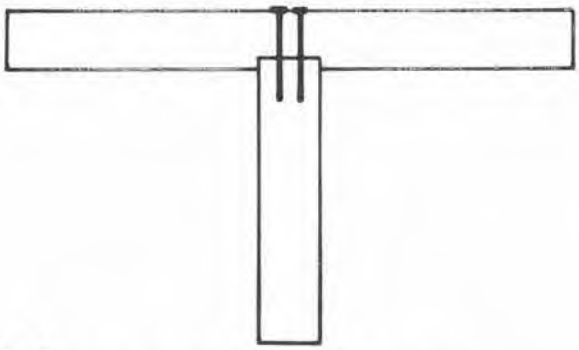
Construction detail:
A pole for displaying produce fastened to a column.



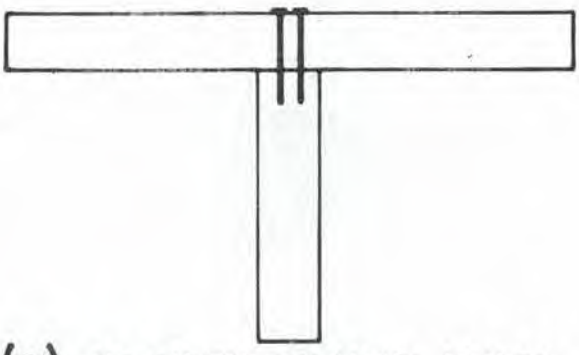
Construction detail:
Thatching the roof of a vendor's stall at Koki Market.
Note treated bamboo purlins.



(a) 6 mm CHECK SKEW NAILED



(b) 6 mm CHECK STRAIGHT NAILED

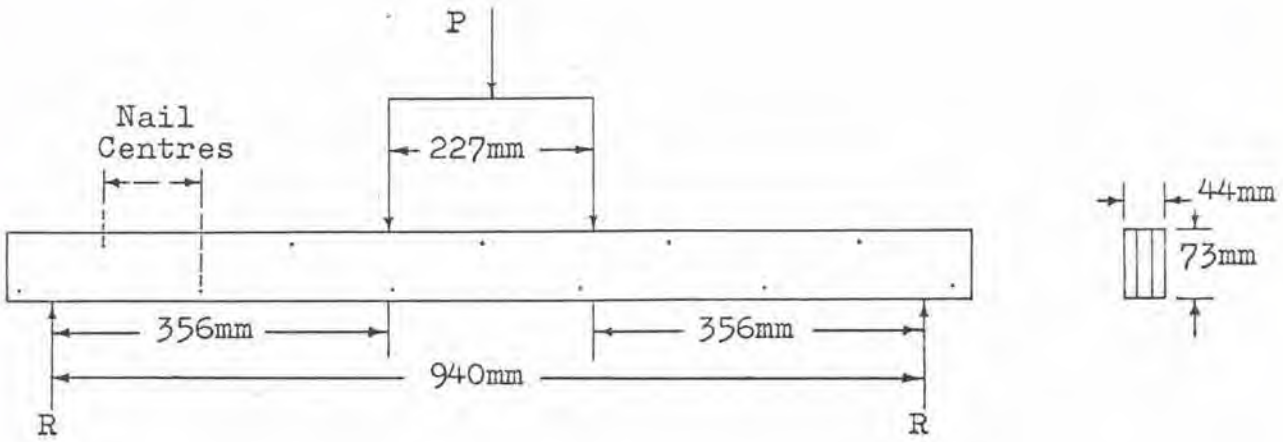


(c) NO CHECK STRAIGHT NAILED

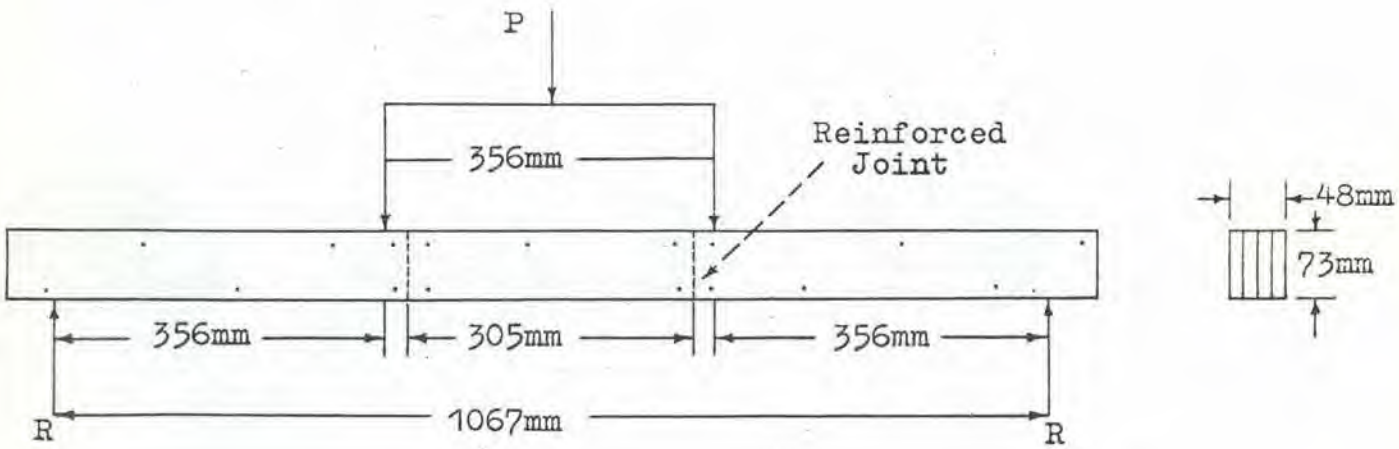
FIG. 1 NAILING PATTERNS

FIGURE 1. LOADING ARRANGEMENT

SERIES 1



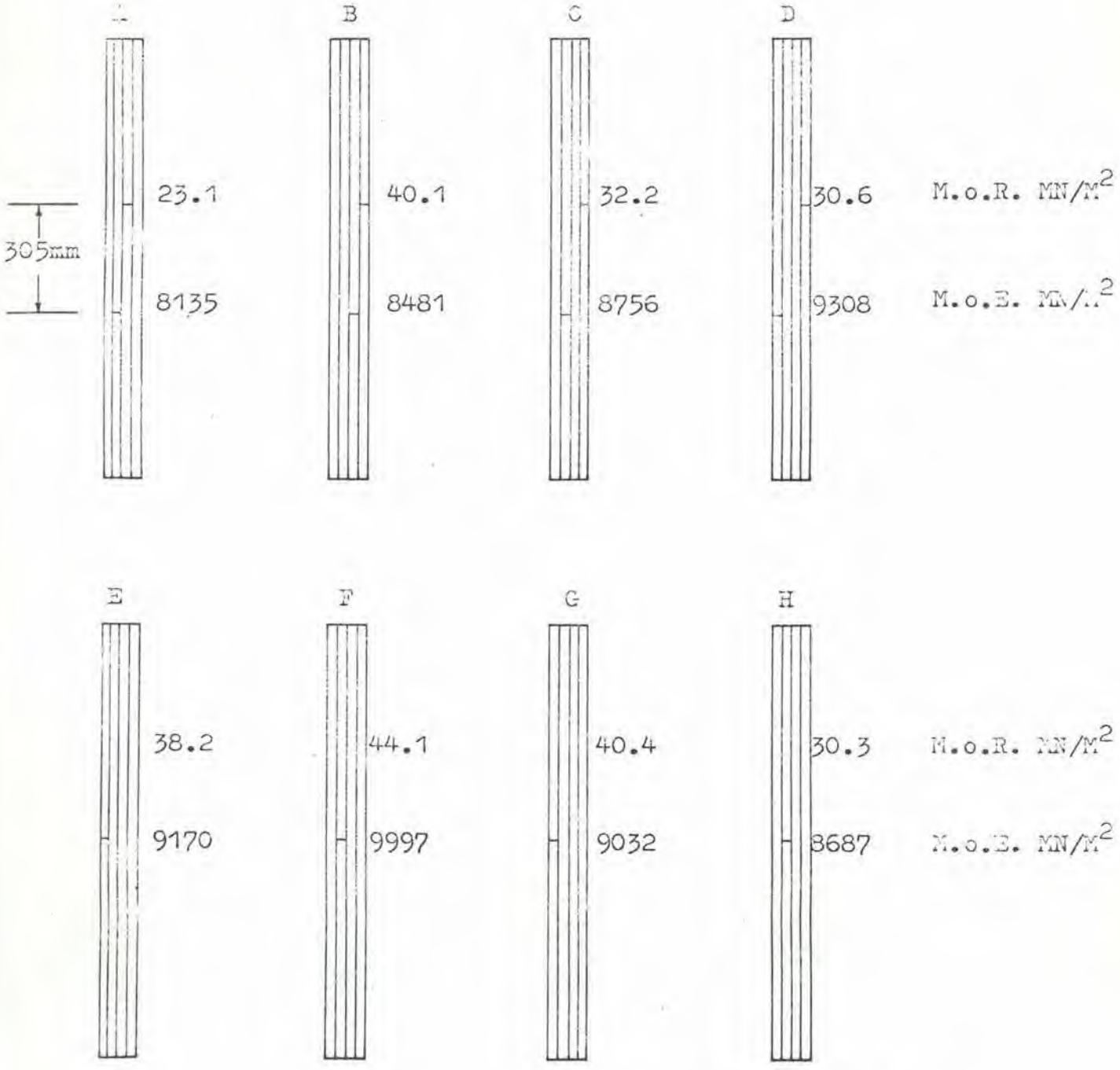
SERIES 2



P — Load

R — Reaction Points

FIGURE 2 SERIES 2 RESULTS



G & H, joints not reinforced.

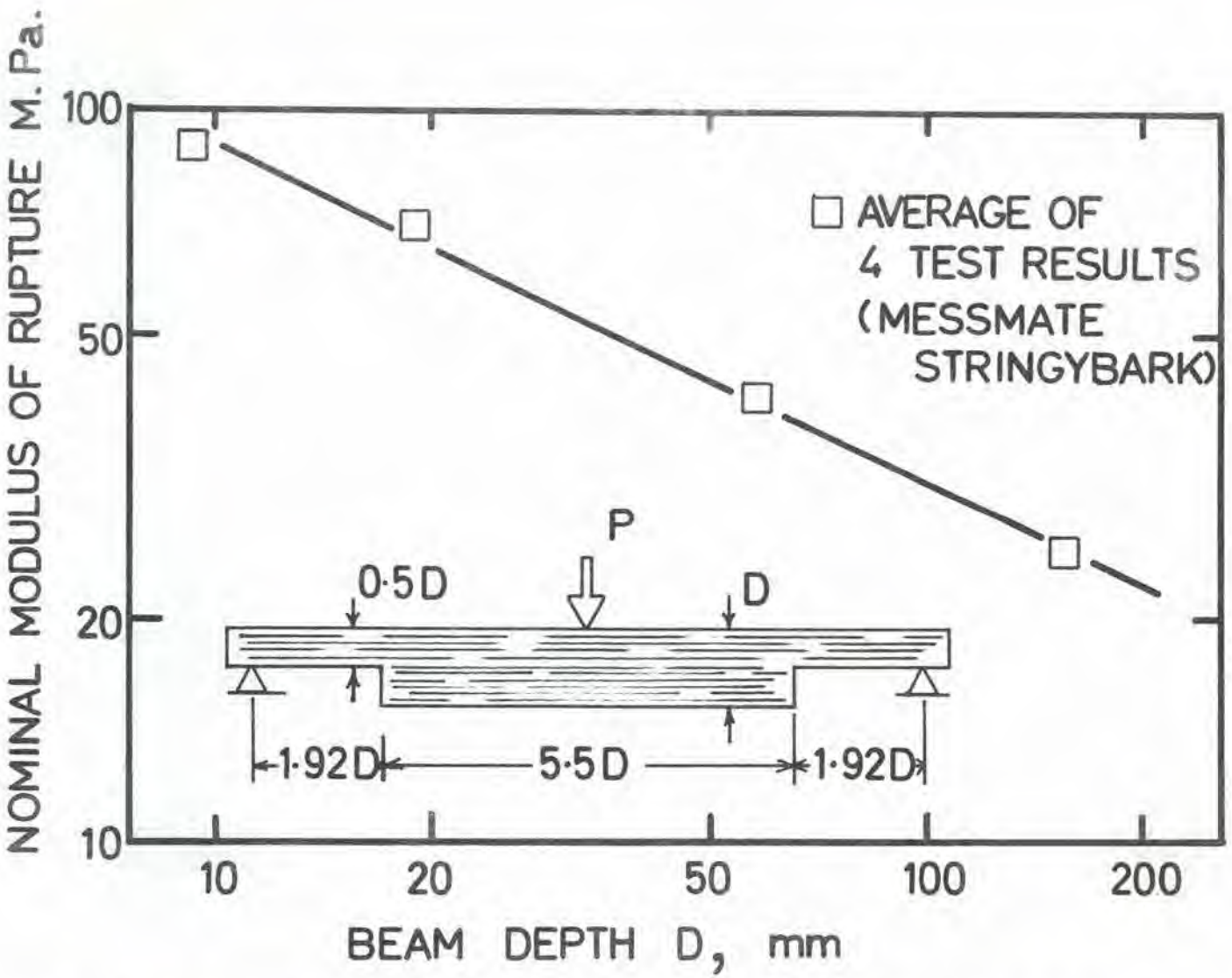


FIG 1. EFFECT OF SIZE ON STRENGTH OF NOTCHED BEAMS

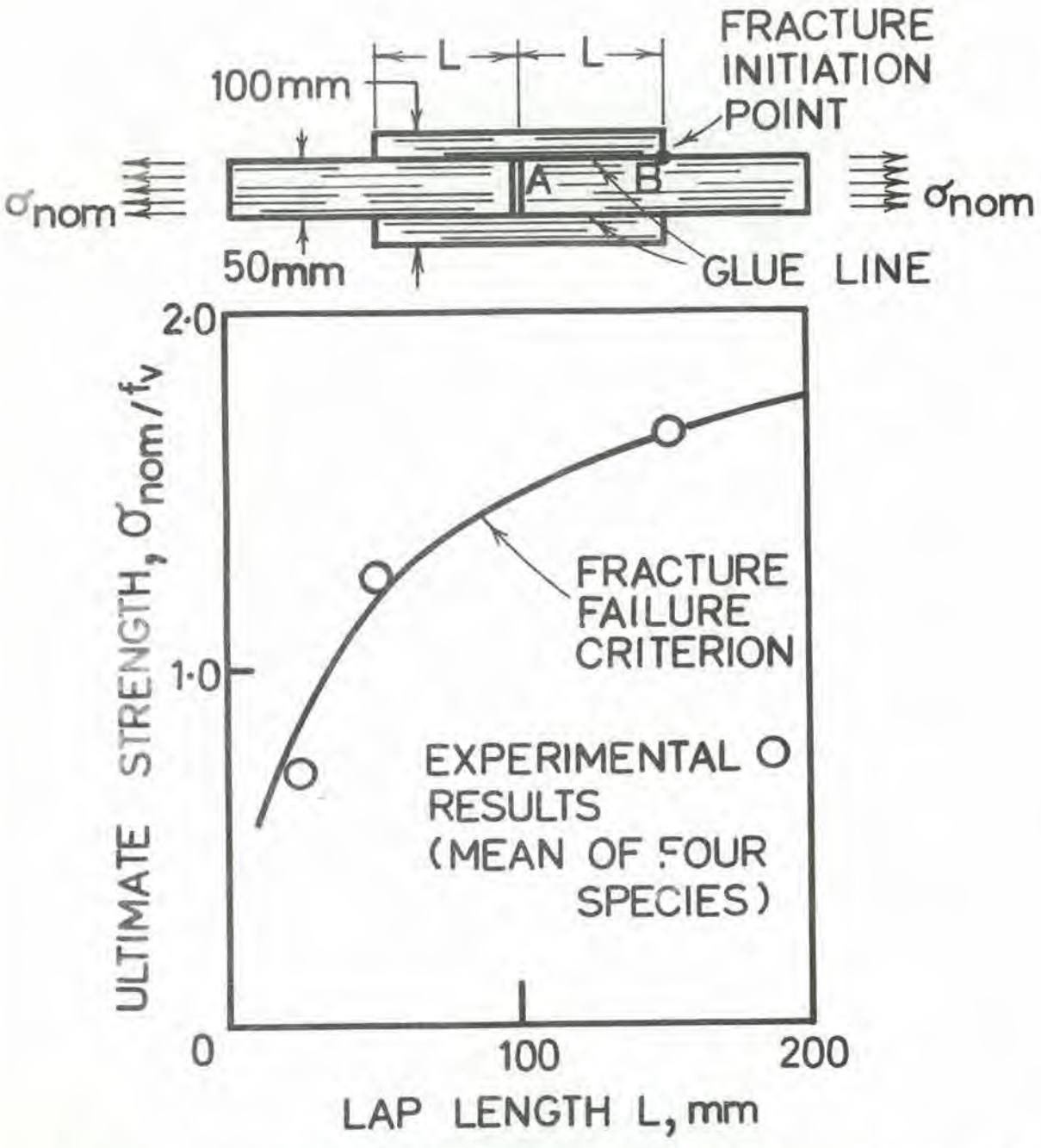


FIG 2. EFFECT OF LAP LENGTH ON STRENGTH OF GLUED JOINTS

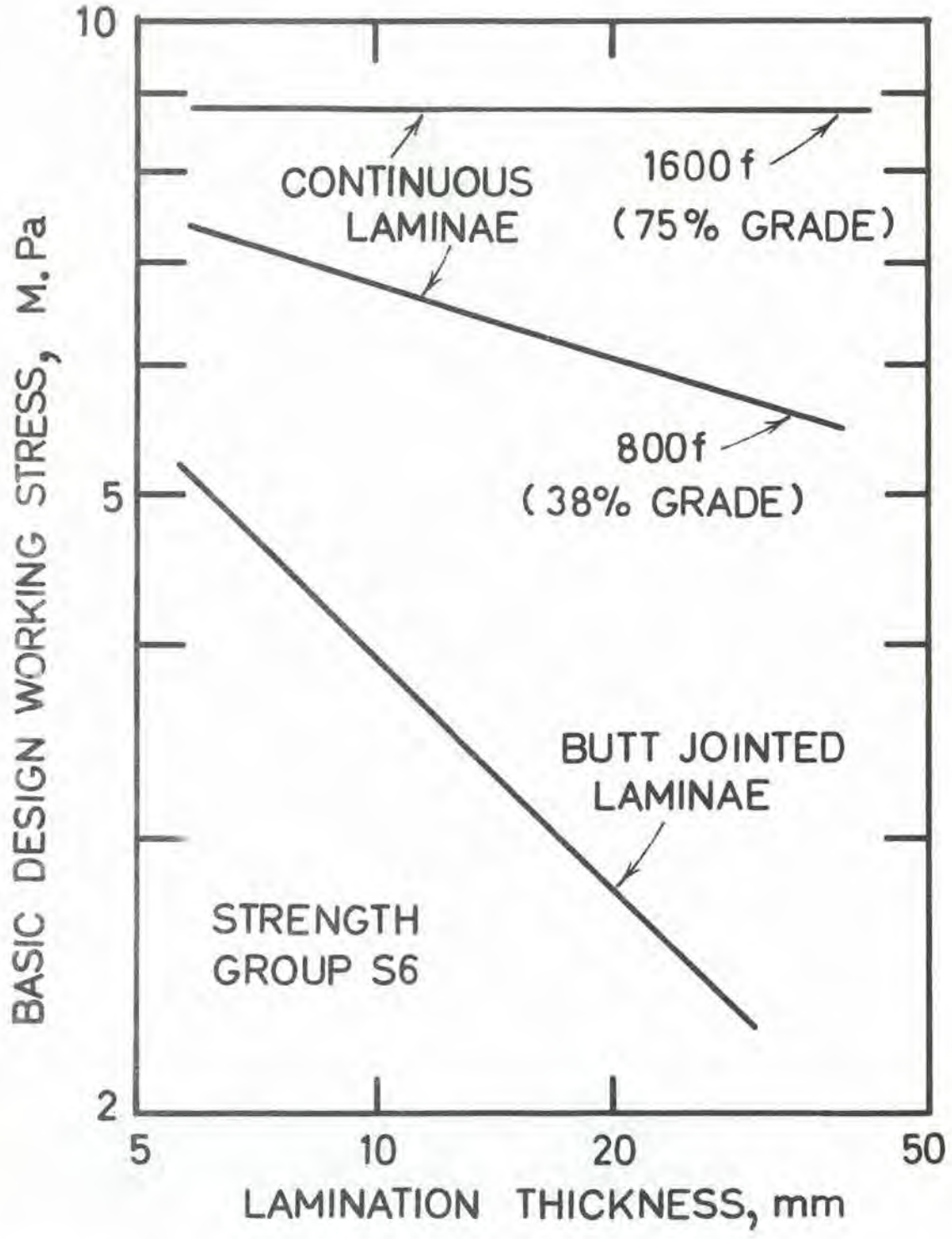


FIG 3. TENSION STRENGTH OF GLULAM

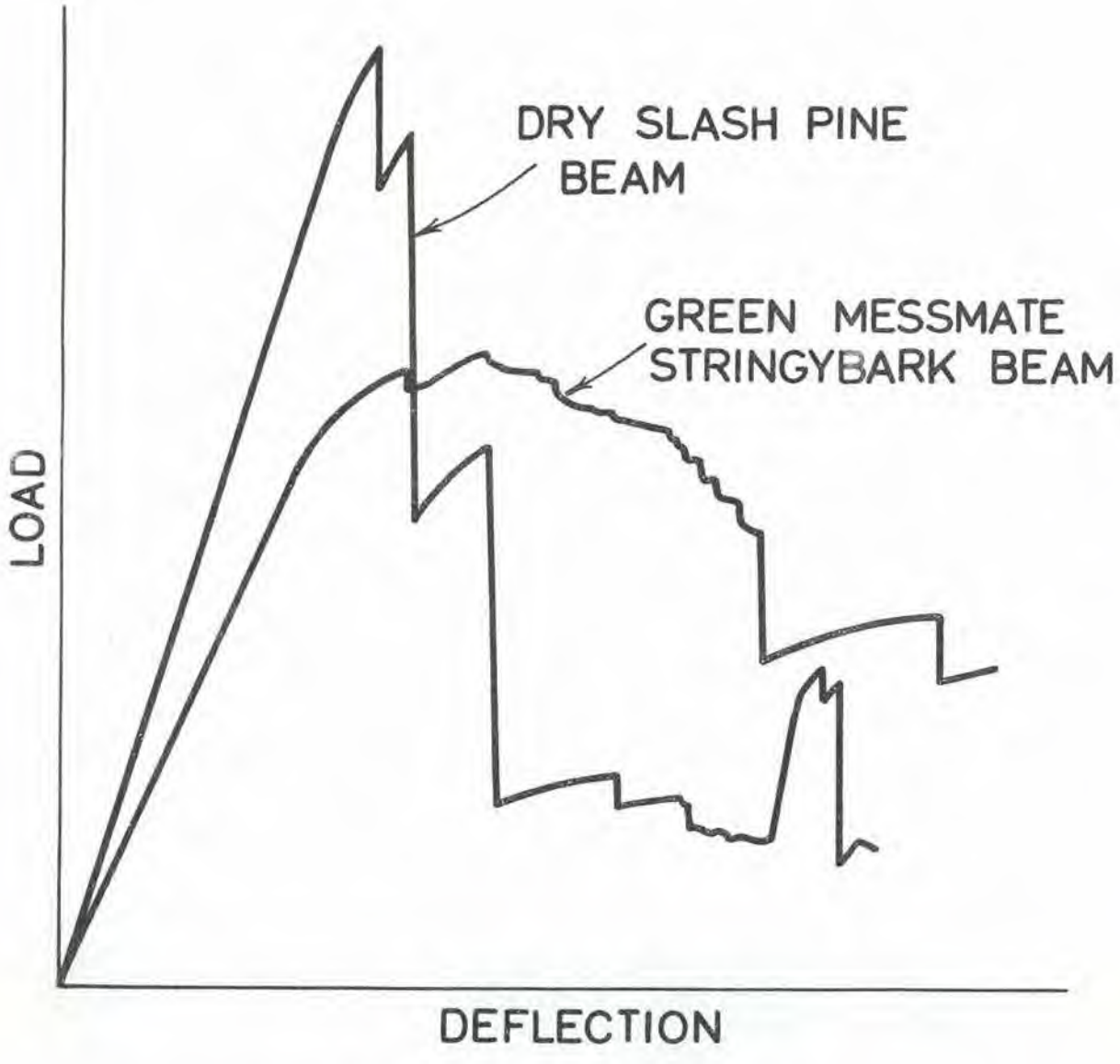


FIG 1. TYPICAL LOAD DEFORMATION CURVES FOR TIMBER SCANTLING.

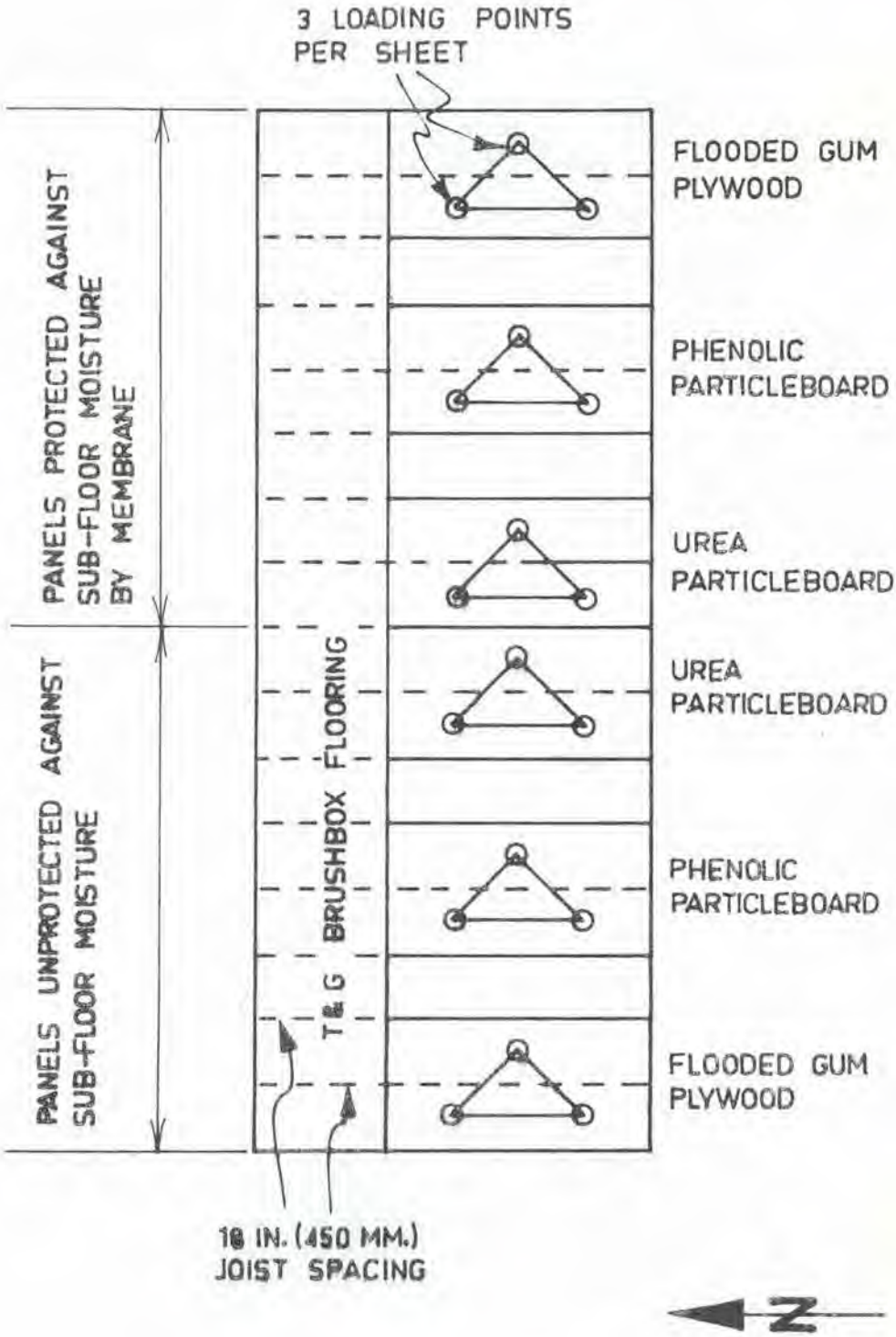


FIG. 1 FLOOR PLAN OF BUILDING

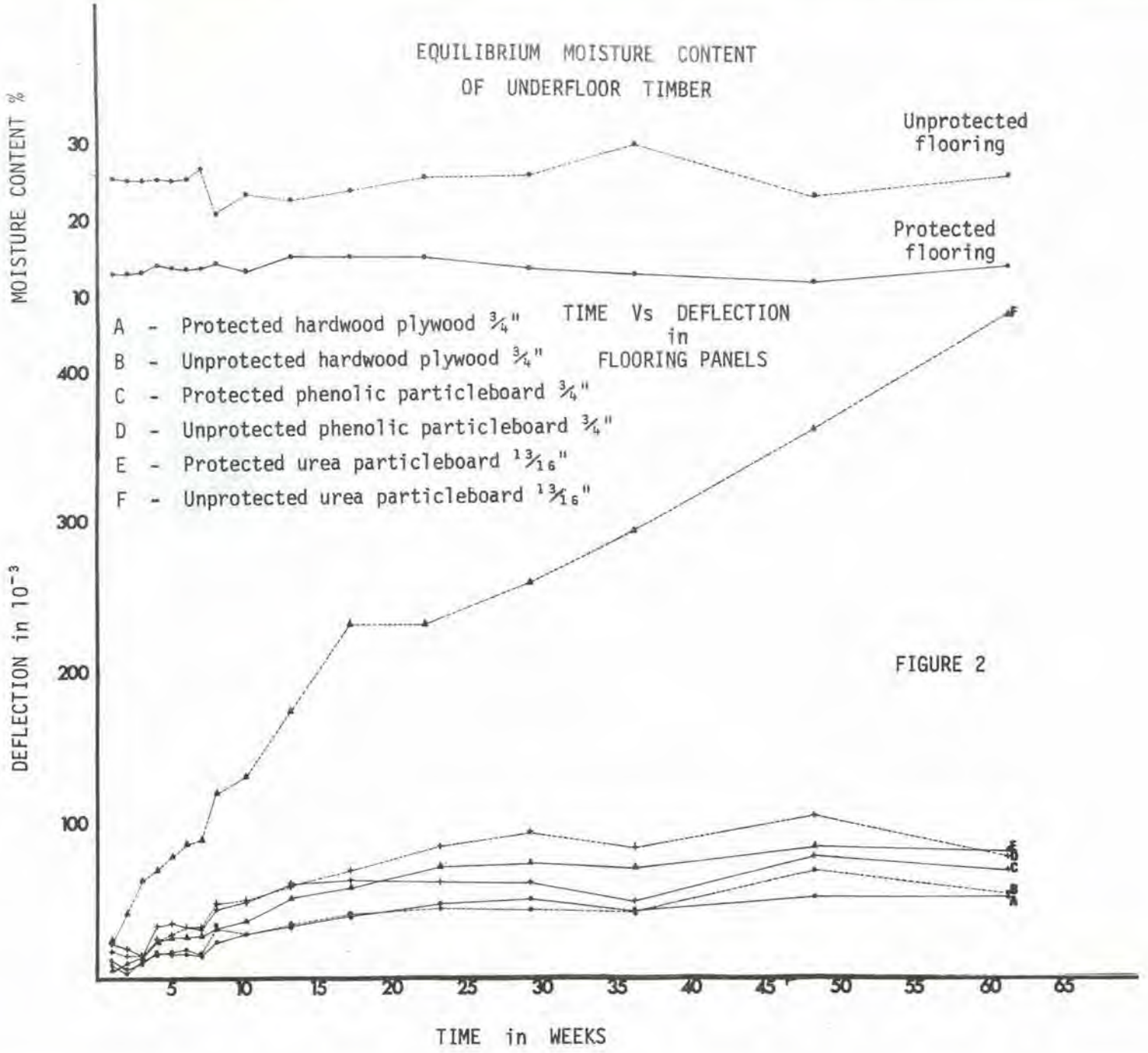

EQUILIBRIUM MOISTURE CONTENT
OF UNDERFLOOR TIMBER
MOISTURE CONTENT %
30
20
10
Unprotected flooring
Protected flooring
A - Protected hardwood plywood ¾"
B - Unprotected hardwood plywood ¾"
C - Protected phenolic particleboard ¾"
D - Unprotected phenolic particleboard ¾"
E - Protected urea particleboard 13/16"
F - Unprotected urea particleboard 13/16"
TIME Vs DEFLECTION in FLOORING PANELS
DEFLECTION in 10^{-3}
400
300
200
100
F
5
10
15
20
25
30
35
40
45
50
55
60
65
TIME in WEEKS

FIGURE 2

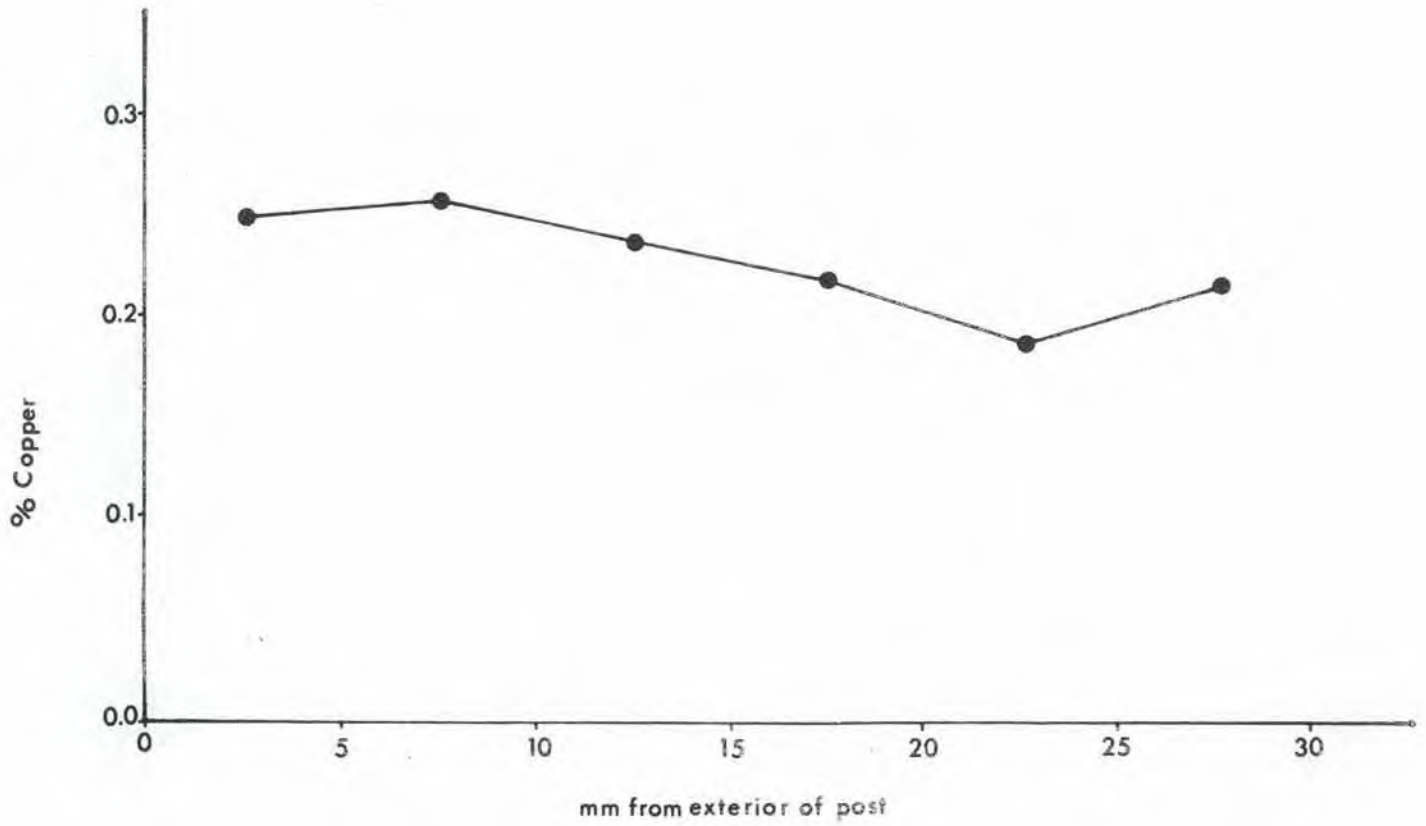


Fig. 1 Gradient of copper from the outer face of one *E. maculata* post (above groundline).

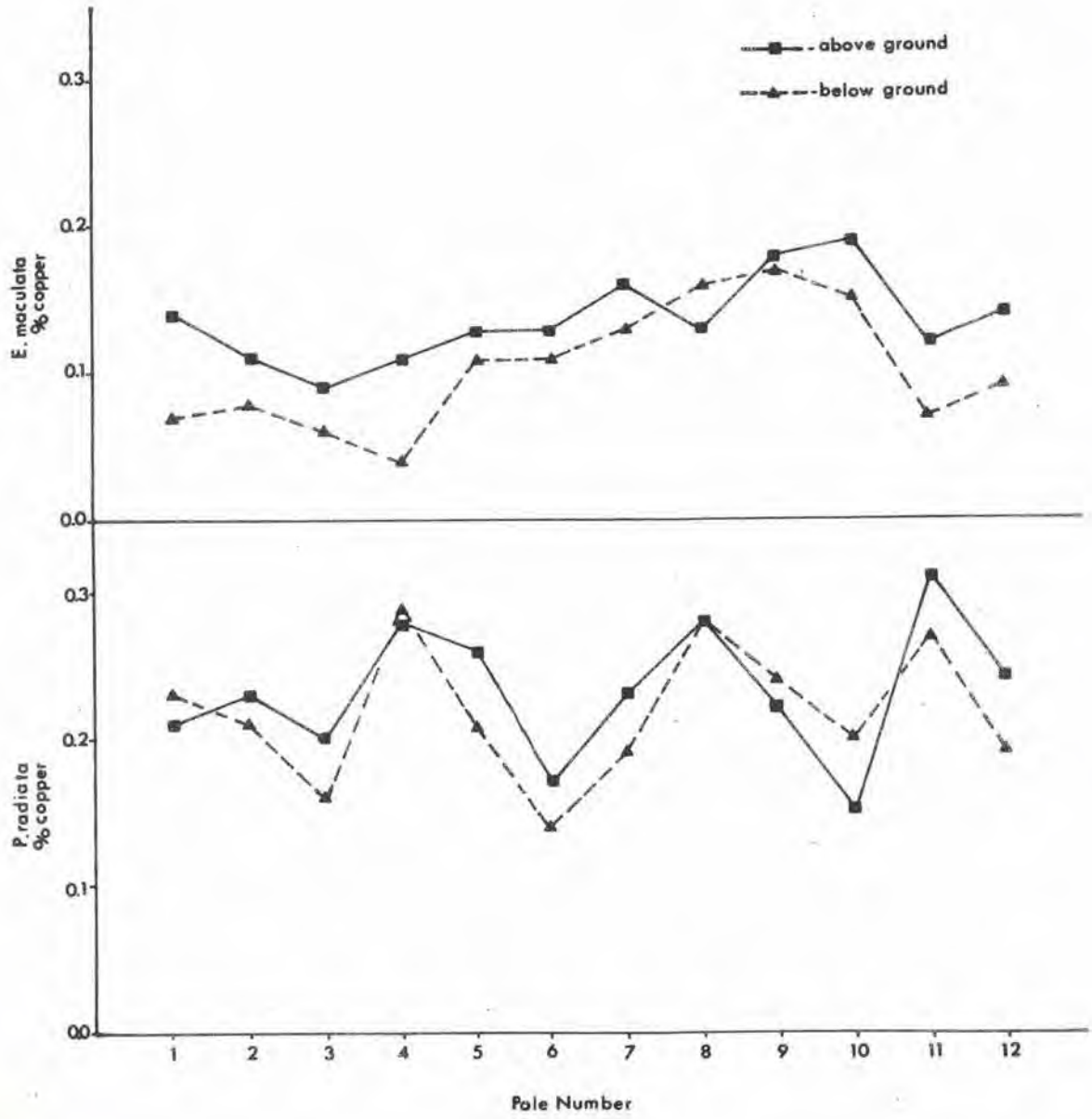


Fig. 2 Copper in *E. maculata* and *P. radiata* posts above and below groundline.

TABLE 2 SMALL SPECIMEN TEST DECAY SCORES - MEAN & (RANGE) AFTER 6-8 YEARS

Preservative	Timber	4 Northern Sites		4 Southern Sites	
		8 lb/cu.ft.	16 lb/cu.ft.	8 lb/cu.ft.	16 lb/cu.ft.
K.55 creosote	P	88 (76-92)	94 (88-97)	100	100
British creosote	"	88 (76-97)	99 (96-100)	100	100
AWPA creosote	"	82 (68-95)	90 (82-97)	100	100
Furnace oil alone	"	74 (49-95)	84 (72-100)	100	100
K.55 creo:furnace oil (1:1)	"	84 (69-97)	97 (95-100)	100	100
K.55 creo:furance oil (3:1)	"	89 (80-97)	94 (90-100)	100	100
5% PCP in furnace oil	"	87 (76-95)	99 (96-100)	100	100
2½% PCP in furnace oil	"	76 (62-90)	93 (87-97)	100	100
5% PCP in diesel fuel oil	"	73 (56-82)	90 (81-100)	97 (95-100)	100
K.55 creosote	S.E	74 (64-82)	-	96 (92-97)	-
Furnace oil alone	"	64 (54-70)	-	95 (92-97)	-
K.55 creo:furnace oil (1:1)	"	70 (57-85)	-	92 (82-97)	-
K.55 creo:furnace oil (3:1)	"	75 (67-85)	-	97 (92-100)	-
5% PCP in furnace oil	"	78 (72-85)	-	98 (97-100)	-
K.55 creo:vert. Tar (1:1)	"	74 (64-85)	-	99 (97-100)	-
K.55 creosote	R.E	28 (16-42)	79 (61-92)	75 (60-92)	89 (77-100)
5% PCP in furnace oil	"	68 (62-77)	79 (64-87)	95 (82-100)	96 (90-100)
5% PCP in diesel fuel oil	"	56 (41-77)	-	92 (77-100)	95 (85-100)
		0.75 lb/cu.ft.	1.2 lb/cu.ft.	0.75 lb/cu.ft.	1.2 lb/cu.ft.
Boliden K.33	P	95 (86-100)	-	97 (95-100)	-
Celcure A	"	94 (81-100)	-	100	-
Tanalith C	"	92 (80-100)	96 (91-100)	99 (97-100)	100
Boliden S.25	"	83 (66-97	91 (79-95)	98 (97-100)	100
Boliden K.33	S.E	53 (9-75)	-	90 (72-100)	-
Celcure A	"	66 (62-70)	-	93 (82-100)	-
Tanalith C	"	76 (65-87)	-	94 (82-100)	-
Boliden S.25	"	55 (22-75)	-	92 (80-100)	-
Boliden K.33	R.E	74 (71-80)	-	94 (82-100)	-
Celcure A	"	73 (56-87)	-	92 (80-100)	-
Tanalith C	"	71 (61-77)	-	93 (82-100)	-
Boliden S.25	"	61 (35-75)	-	87 (72-97)	-

P = radiata pine sapwood; R.E. = round *E. regnans*; S.E. = sawn *E. regnans*.

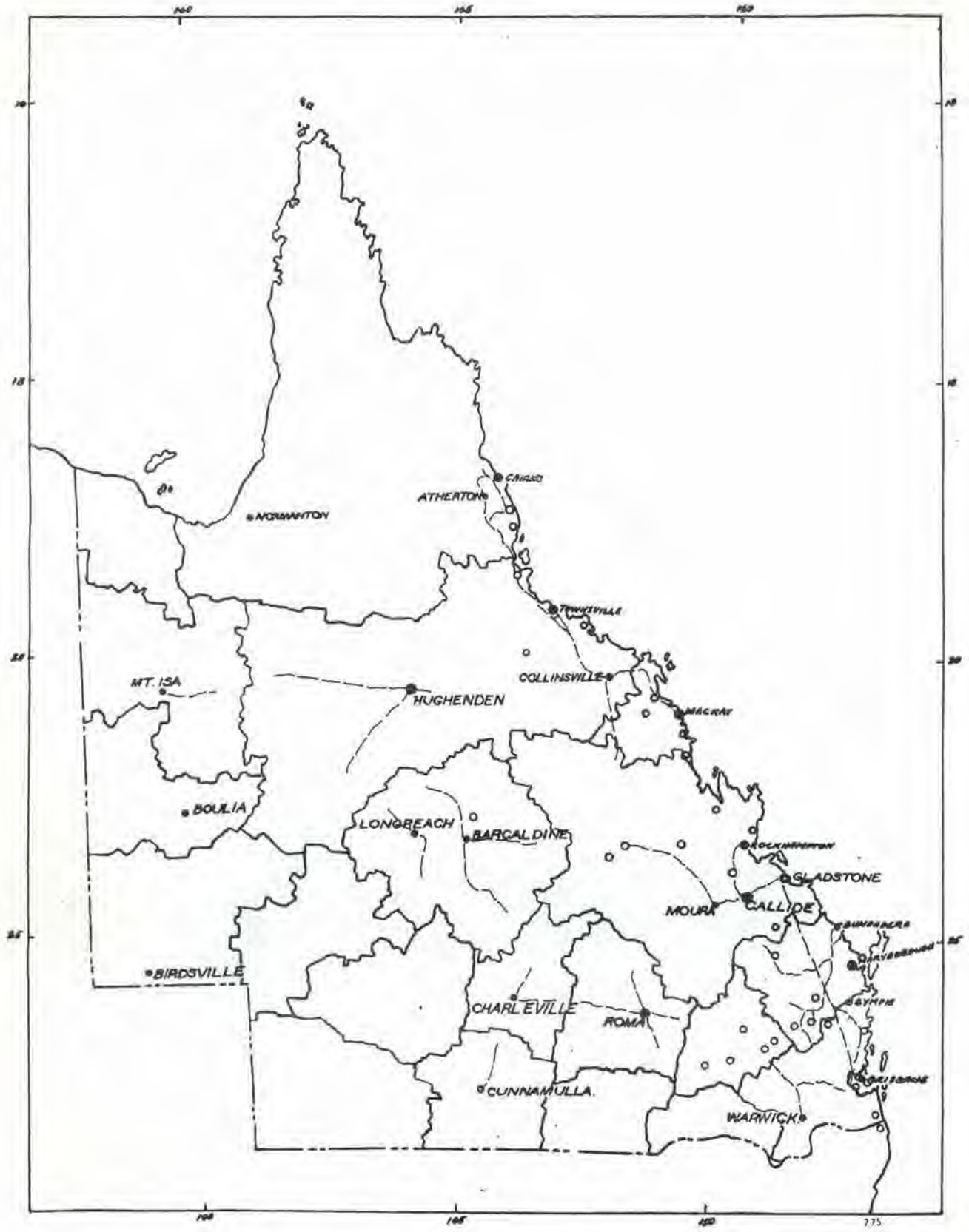
Northern sites are in Papua-New Guinea and North Queensland (Keravat, Brown River, Innisfail & Millaroo)

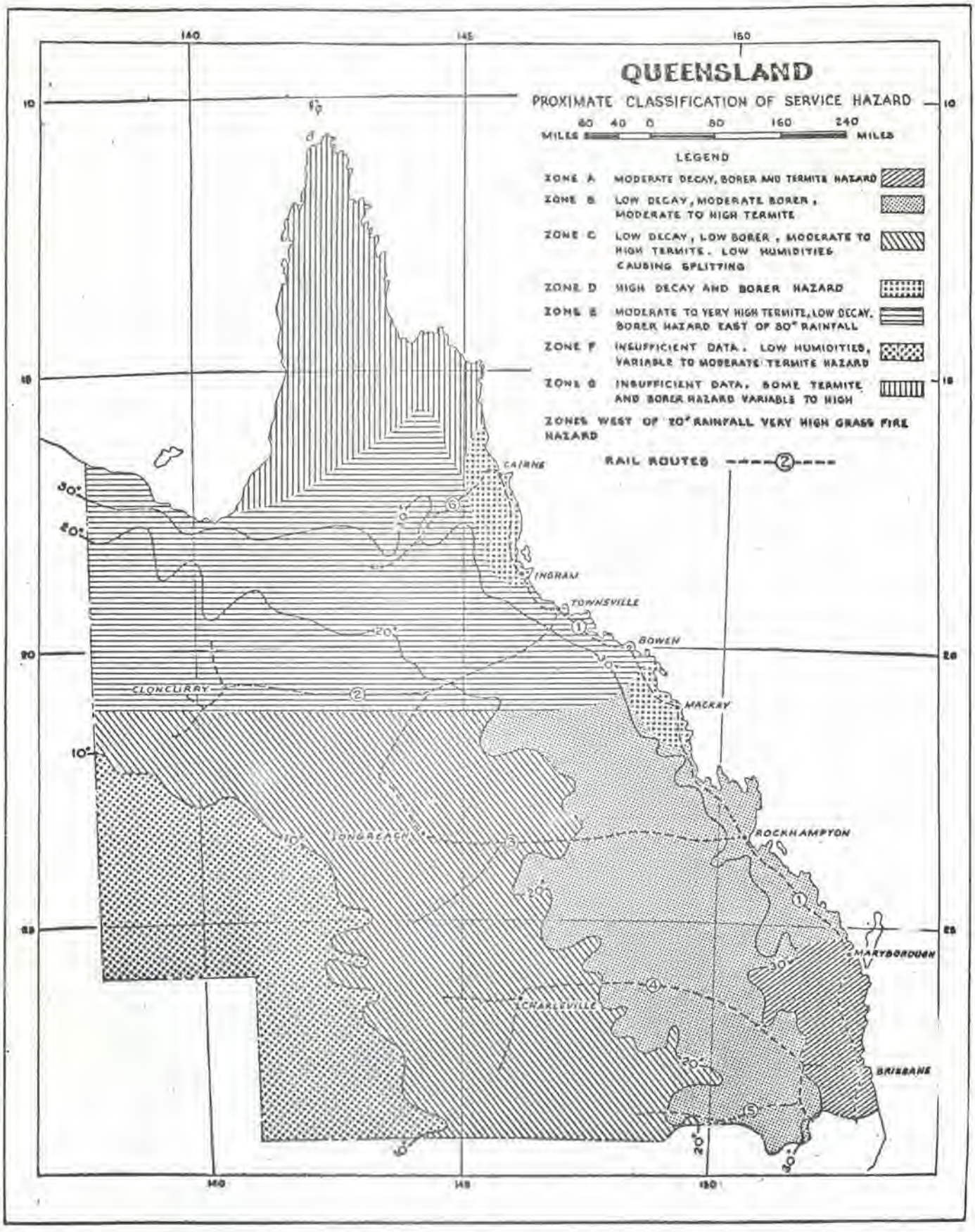
Southern sites are in N.S.W. and Victoria (Manning River, Pennant Hills, O'Shanassy & Walpeup).

MAJOR POWER LINES SHOWN BROKEN BLUE - - - -

AFFECTED POWER POLES SHOWN RED ○

ELECTRICAL REGION BOUNDARIES SHOWN BLACK




QUEENSLAND
PROXIMATE CLASSIFICATION OF SERVICE HAZARD
80 40 0 80 160 240
MILES MILES
LEGEND
ZONE A MODERATE DECAY, BORER AND TERMITE HAZARD
ZONE B LOW DECAY, MODERATE BORER, MODERATE TO HIGH TERMITE
ZONE C LOW DECAY, LOW BORER, MODERATE TO HIGH TERMITE. LOW HUMIDITIES CAUSING SPLITTING
ZONE D HIGH DECAY AND BORER HAZARD
ZONE E MODERATE TO VERY HIGH TERMITE, LOW DECAY. BORER HAZARD EAST OF 30" RAINFALL
ZONE F INSUFFICIENT DATA. LOW HUMIDITIES, VARIABLE TO MODERATE TERMITE HAZARD
ZONE G INSUFFICIENT DATA. SOME TERMITE AND BORER HAZARD VARIABLE TO HIGH
ZONES WEST OF 20" RAINFALL VERY HIGH GRASS FIRE HAZARD
RAIL ROUTES
140
145
150
10
15
20
25
30"
20"
10"
CAIRNS
INGHAM
TOWNSVILLE
BOWEN
CLONCURRY
MACKAY
LONGREACH
ROCKHAMPTON
MARYBOROUGH
CHARLEVILLE
BRISBANE

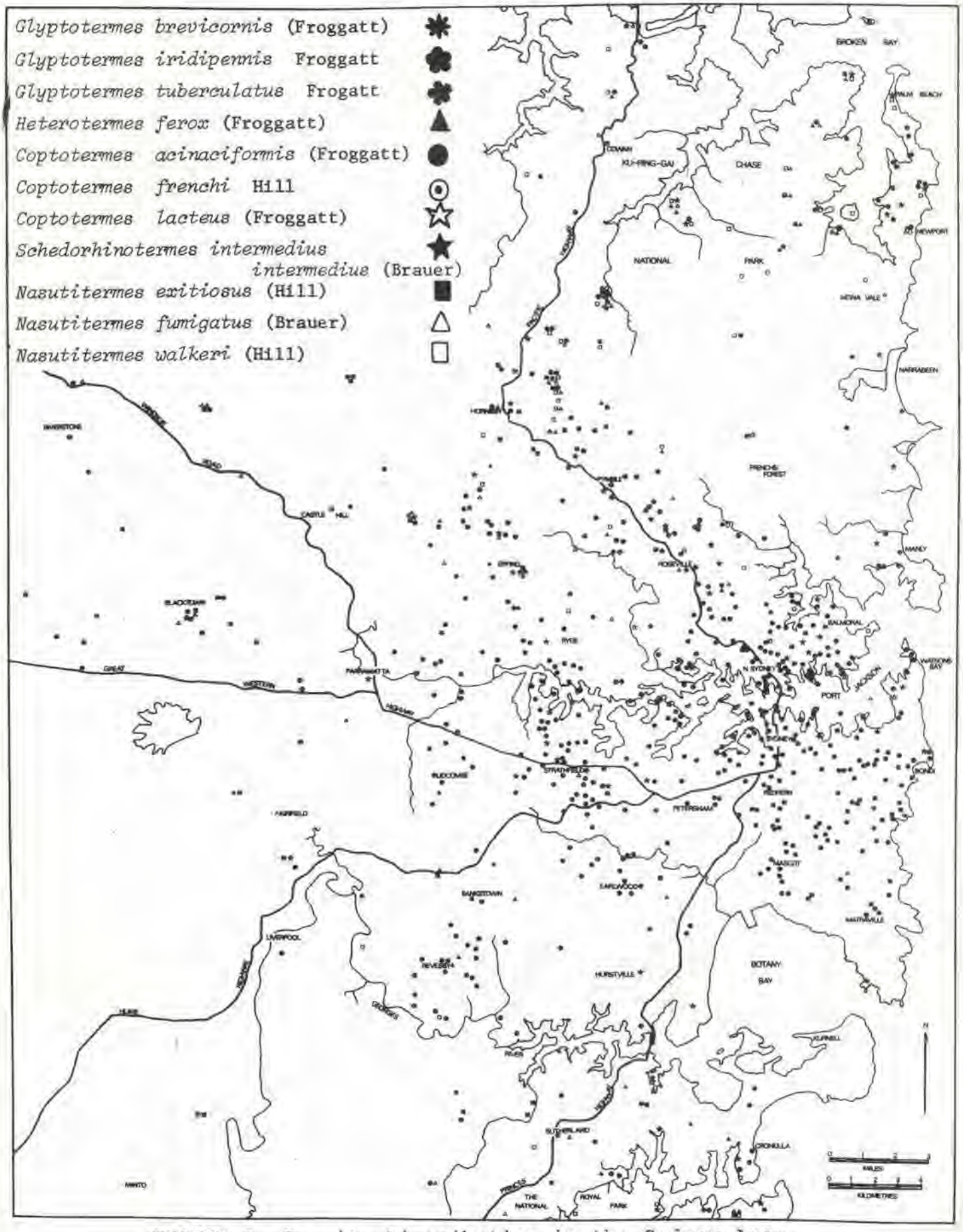


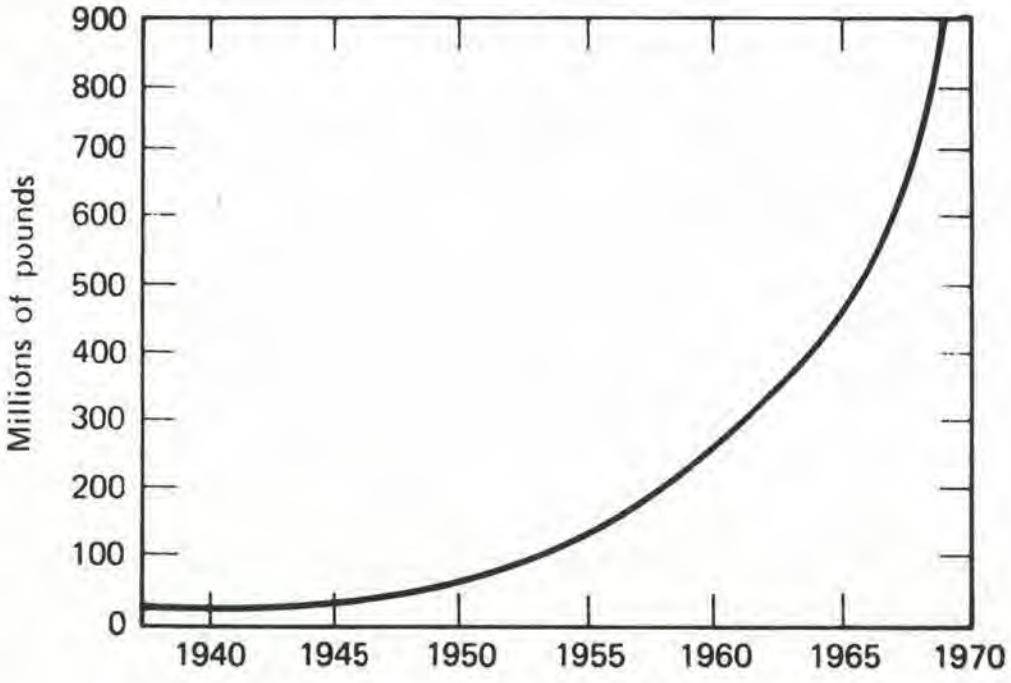
FIGURE I Termite Distribution in the Sydney Area

FIGURE 1

The four assemblies described in this paper:

A. Standard Australian
B. With separate specimen box
C. With separate specimen jar
D. Including specimens in jar on petri dish.

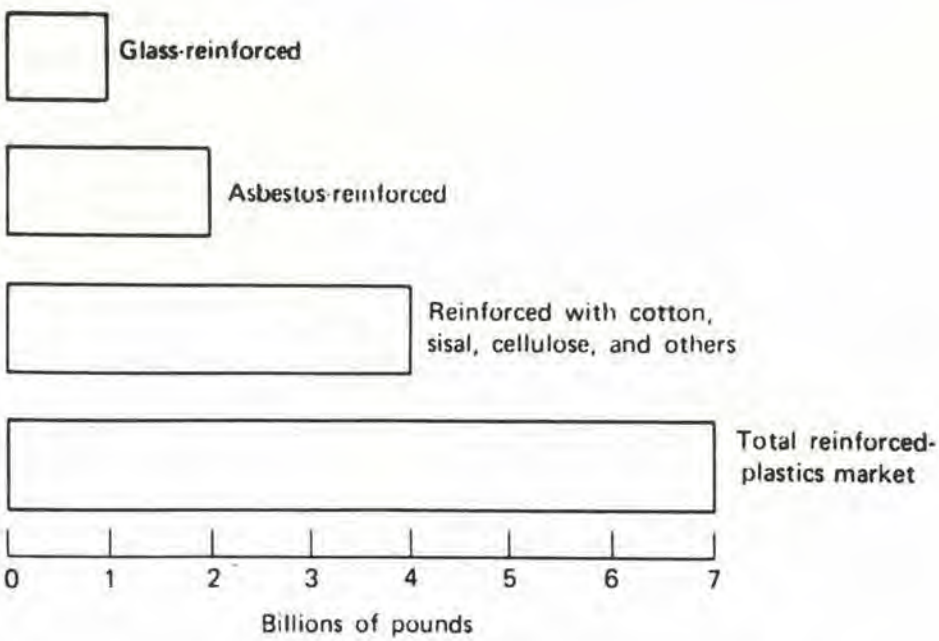
FIGURE 1



Consumption of glass-fiber-reinforced polyester.

Source: Encyclopedia of Polymer Science and Technology, Vol 12, p.29.

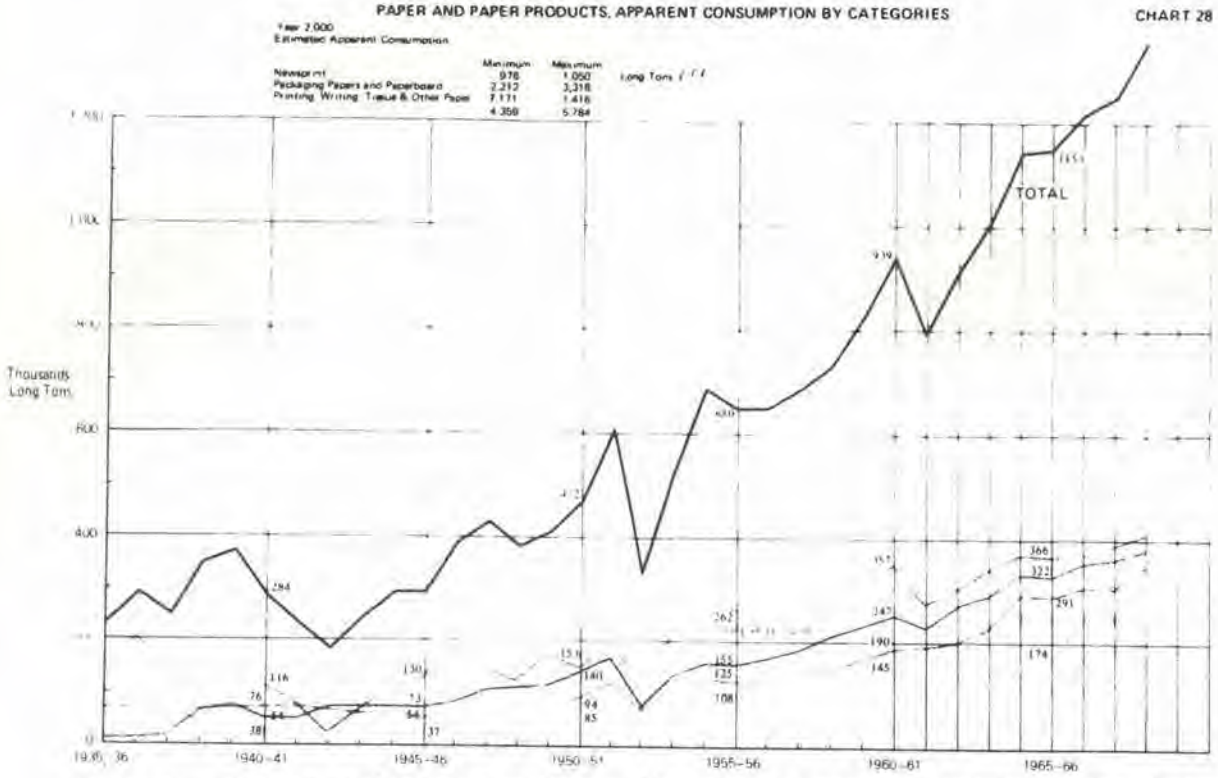
FIGURE 1



Production of reinforced plastics in 1969.

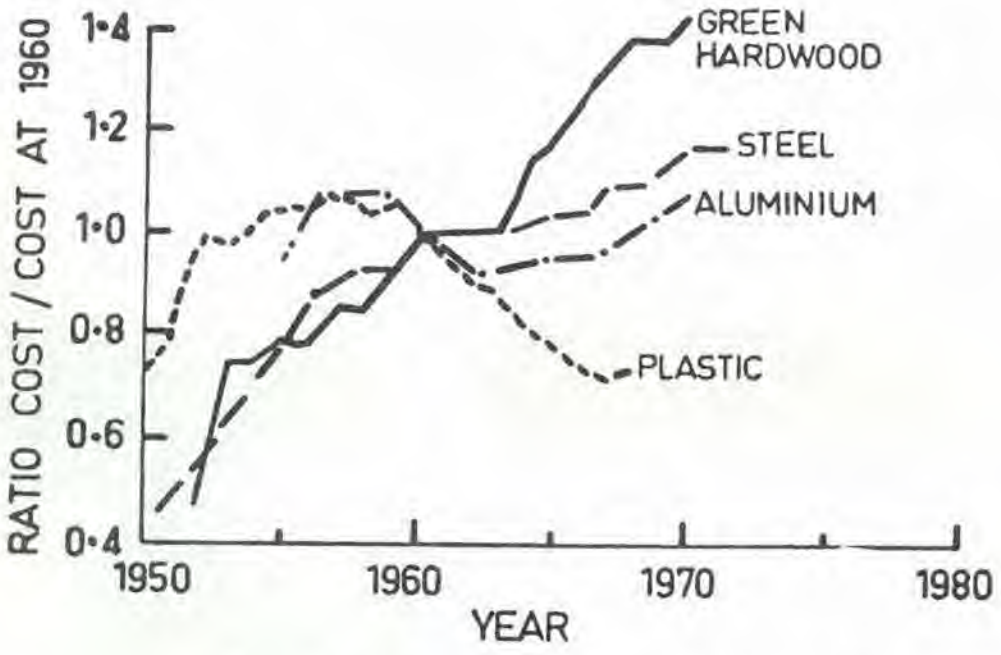
Source: Encyclopedia of Polymer Science and Technology, Vol 12, p.28.

FIGURE 2



Source: Forest Industry Graphs, p.28. Department of National Development, Forestry and Timber Bureau, Canberra 1970.

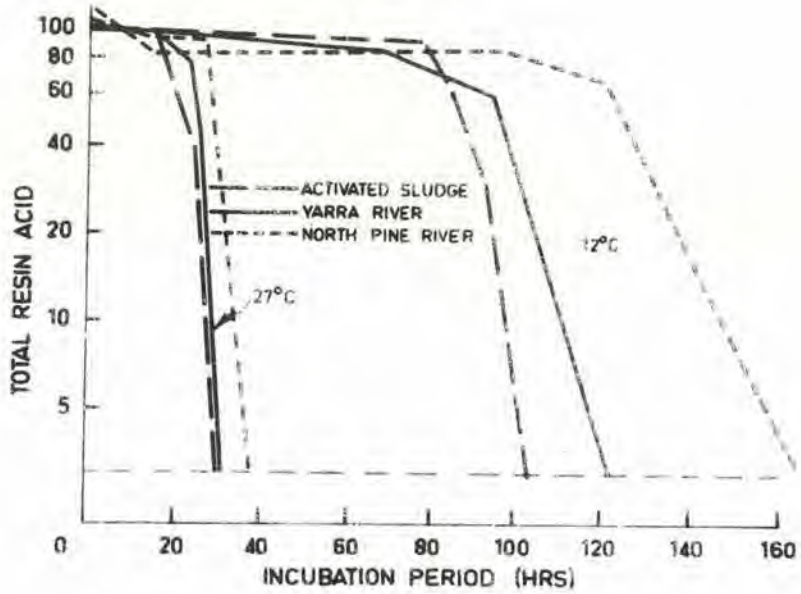
FIGURE 3



Relative price changes—Base year 1960.

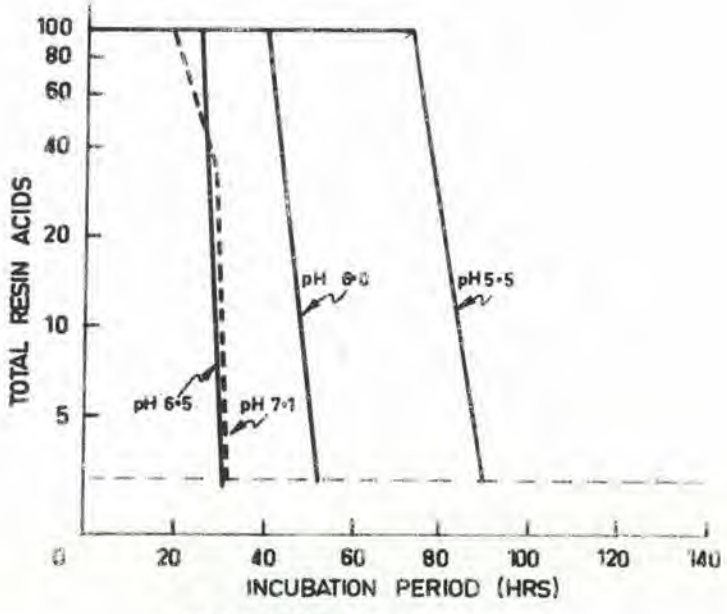
Source: The Australian Timber Journal, November 1971, p.59.

FIGURE 4



EFFECT OF TEMPERATURE AND SOURCE OF MICROFLORA ON RATE OF RESIN ACID SALT DEGRADATION

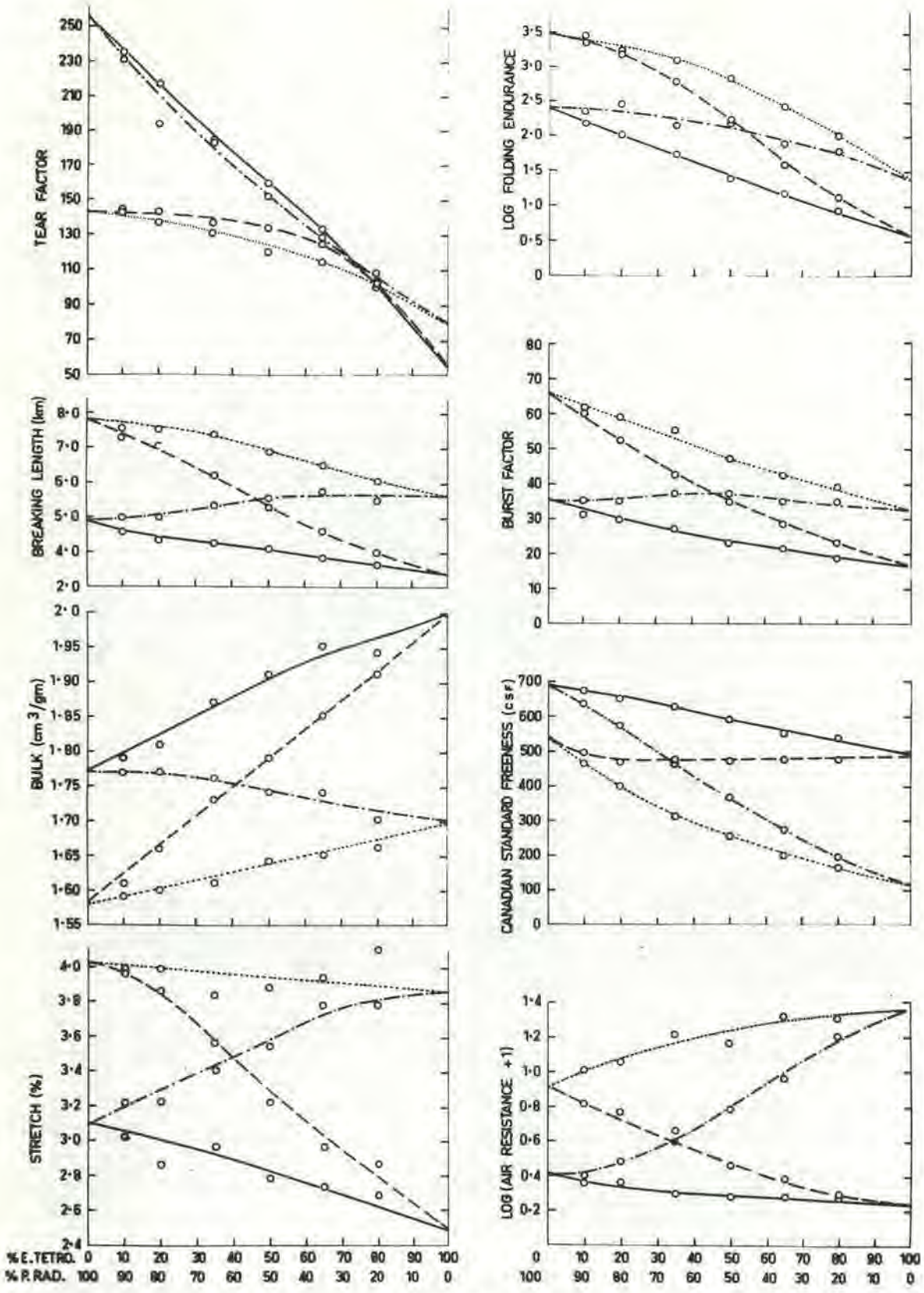
FIG. 1a.



EFFECT OF INITIAL pH ON THE RATE OF RESIN ACID SALT DEGRADATION

FIG. 1b.

FIGURE 1.



LEGEND

	E. tetrodonta Beating revs	(Csf freeness)	P. radiata Beating revs	(Csf freeness)
.....	9000	(114)	3000	(540)
– · – · –	9000	(114)	600	(688)
– – – –	2000	(485)	3000	(540)
———	2000	(485)	600	(688)

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FOREWORD

The Organizing Committee for the 16th Forest Products Research Conference wishes to explain that no attempt has been made to record in detail all discussions which took place during the conference. The object has been rather to record the main conclusions and recommendations for future work. Summaries by topic leaders have been included. As all presented papers are available in Volume I, summaries are not included here except in those cases where authors wished to present additional material.

Organizing Committee: C.D. Howick
D.E. Bland
E. Bolza
J.E. Nicholson

AGENDA

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	ASPECTS OF WORK IN PROGRESS AND PROGRAM CHANGES IN THE DIVISION OF APPLIED CHEMISTRY	D.E. Weiss
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	WOOD TECHNOLOGY DIVISION, FORESTRY COMMISSION OF N.S.W.	L.H. Bryant
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6.	GROWTH STRESS AND ANATOMICAL CHARACTERISTICS IN *E. REGNANS*	J.E. Nicholson, W.E. Hillis & N. Ditchburne
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	(c) WOOD CHARACTERISTICS OF COLCHICINE-TREATED *PINUS RADIATA*	J.W.P. Nicholls & A.G. Brown
	(d) THE ORTET RAMET RELATIONSHIP IN PINES	J.W.P. Nicholls & A.G. Brown
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22.	FACTORS AFFECTING RAIL SLEEPER UTILIZATION	W.J. Smith
23.	(PAPER WITHDRAWN)	

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36.	ASSESSMENT OF DECAY HAZARD APPLYING TO VARIOUS STRUCTURAL TIMBER COMPONENTS	K.V. Cokley
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REPRESENTATION

Australian Forest Industries Journal N.S.W.	-	C.A. Lembke
Australian National University Department of Forestry A.C.T.	-	D.M. Stodart
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Key:

BAM W.Germ.	=	Bundesanstalt für Materialprüfung, Berlin, West Germany
DAC, V	=	CSIRO, Division of Applied Chemistry, Melbourne
DBR, V	=	CSIRO, Division of Building Research, Melbourne
DF, Q	=	Department of Forestry, Queensland
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FC, V	=	Forests Commission of Victoria
FRI, ACT	=	Department of Primary Industry, Forest Research Institute, A.C.T.
FPRC, PNG	=	Forest Products Research Centre, Papua New Guinea
USDA, USA	=	Department of Agriculture, Pineville, Louisiana, U.S.A.

Key (cont'd)

UK Lex. USA	=	University of Kentucky, Lexington, Kentucky, U.S.A.
W & FD, SA	=	Woods and Forests Department, South Australia
*	=	Currently visiting scientist at BAM
**	=	Currently visiting scientist with DBR
***	=	On loan to FPRC from the Department of Public Works, PNG.

OPENING SESSION

In opening the Conference, Dr. R.W.R. Muncey said that he was welcoming the delegates to a conference of a different format to previous ones in that two Divisions now constituting the Forest Products Laboratory, the Division of Applied Chemistry and Division of Building Research, were concerned. A joint committee of the two Divisions had organized the conference and prepared the volume of papers. These papers should be regarded as a springboard to the future, rather than a pattern for forthcoming research programmes. The challenge for the conference to see how research could inject new and stimulating ideas into the timber industry was now greater than ever before.

INTRODUCTORY PAPERS

CHAIRMAN: R.W.R. MUNCEY

INTRODUCTORY PAPER 1(a)
THE NEW LOOK OF FOREST PRODUCTS RESEARCH
by Walter G. Kauman

Australia's forest products industry today is confronting a challenge as crucial and as exciting as the one it confronted in the late 20's.

Then, the problem was to promote the acceptance of Australian timbers by improving the technology of conversion and processing so that the resultant product would be of a quality comparable with or better than that of imported timbers. A forward-looking Government set up the Division of Forest Products as one of the first Divisions of the new CSIR to help industry face this challenge, and the Division of Forest Products has been singularly successful in solving many of the problems for which it was created.

Today, the problem is to transform the timber industry from its past condition of being essentially a cottage industry with small enterprises using the basic techniques largely developed during the last century or even prior to the industrial revolution, to a manufacturing industry that can supply the market with engineered products competitive with those manufactured by the large-scale production complexes that have grown up in related areas such as steel, concrete and in the chemical industry.

The Executive of CSIRO recognized that this new challenge required new tools and a new strategy, and this recognition found its expression in the re-organization of forest products research two years ago. From being a discipline devoted essentially to research on a raw material, forest products research must now be an activity directed towards applications and market needs, and must therefore be integrated with research on the industries that supply the two major markets of wood: Building and Pulp and Paper.

The paper before you attempts to present a provisional balance sheet of the first two years of operation of the new Division of Building Research. I shall not try to summarize it, but rather I want to draw your attention to the main features of what I consider the "New Look" of forest products research.

First of all, let me emphasize that there has been no break in continuity. The number of persons working on wood, and the amount of money spent on this research, is roughly the same as before. No research topic has been suddenly discontinued, and all services provided to the industry by the old Division of Forest Products are still going on.

The new look, and this is by no means confined to wood science, means that we regard forest products research as a consumer-directed activity, our

consumers being the industry and the users of wood. Our first concern is what our work contributes to the welfare of the community.

In this concern, we are in step with world-wide present-day thinking. In the recent World Forestry Congress in Buenos Aires, Professor Giordano, one of the most distinguished wood scientists, said that "Wood was not created for the academic exercises of researchers, but to serve the needs of industry and of the community", and Jack Westoby of FAO included in the final congress declaration with the statement that "Foresters are not concerned with trees, but with how trees can serve people".

Over forty years, the Division of Forest Products built up an unrivalled store of knowledge on the properties and behaviour of wood. Without this work our present contribution would not be possible. But now we have this knowledge, and whilst there are areas remaining that need to be further explored - and we are doing this - we can shift an appreciable percentage of our effort to applying this knowledge to research on production processes and on the use of wood and its products. This is reflected in the different names of our Groups: from Wood Structure, Wood Chemistry, Timber Physics, Timber Mechanics, Timber Seasoning, we have gone to Forest Conversion Science, Forest Conversion Engineering, Timber Structures, and of course Paper Science and Wood and Forest Science in Applied Chemistry - only Preservation is unchanged in name. The paper before you gives an outline of what our various groups are doing.

Naturally, the transformation is a gradual one and started already during the last six or seven years in the old Division of Forest Products. In implementing it now, we are happy to note the new look also in the Wood Technology Division and we look forward to even closer cooperation with our friends in Sydney.

In the Division of Building Research, as I have said in the paper, we are now transforming our research pattern in recognition of the growing community concern for better resource management, for the environment and for a greater direct contribution by science to better living. If we acknowledge that the problems of the 70's and 80's cannot be solved by the methods - good as they were - of the 39's, 40's and 50's, and if we continue our excellent partnership between the researchers and the industry, I believe we can help timber to remain a widely preferred building material.

I hope that in the next few days we shall be able to show you how we are going about working towards this goal, I believe we are on the right road, and we look forward to your criticisms and comment to promote our common endeavour.

INTRODUCTORY PAPER 1(b)

ASPECTS OF WORK IN PROGRESS AND PROGRAM CHANGES
IN THE DIVISION OF APPLIED CHEMISTRY
by D.E. Weiss

The incorporation of the former Division of Forest Products into the Division of Applied Chemistry has strengthened the Division's program relating to renewable resources, environmental matters, and polymer science with which it has had long association.

It will permit attention to be given to polymer coatings for paper and wood and the development of composites, for use as structural materials, containing a large amount of lignocellulose within a continuous, synthetic polymer matrix. Such composites would be competitors to other reinforced plastics rather than wood products. They would also provide a use for sawmill residues. Work is also beginning on the production of paper products by dry forming.

While we are striking out into completely new areas we are continuing much work concerned with wood quality assessment, and environmental influences on wood quality, but with increasing emphasis being given to the complete utilization of mechanically harvested young wood. Our work on the wood chip industry, pulp and paper manufacture and paperboard conversion is also continuing.

INTRODUCTORY PAPER 1(c)
SOME THOUGHTS ON FOREST PRODUCTS RESEARCH IN PAPUA NEW GUINEA
by S.J. Colwell

I appreciate the opportunity of being with you again. I ask myself why I wrote this paper - sometimes I think the explanation is one of empire building. I think it's an answer to John Beesley's which I saw prior to writing my own. If I had to write it again then I'd write it somewhat differently.

In PNG where "research" has become a dirty word, there is a possibility as I point out in the paper that research, and particularly forest products research, may come to an end in the next twelve or so months. I think, and I've tried to point out in the paper, we have achieved something in the short time we've been working there.

PNG is facing a major change as most people know, with self-government this year, independence next year without much doubt, and thereafter the country is on its own. I wonder what will happen to research in the Territory? I wonder if research is actually needed? John Beesley in his paper draws some conclusions on this uncertainty. He asks whether the luxury of research can in fact be justified in a developing country. I don't agree with this. I do say that in most cases the research needs are supplied from the more developed countries and that all a developing country requires is the expertise to apply it, and adjust to the demands of the developing country. But the trend is that

developing countries and developed countries are getting further apart. There's not much doubt about this.

Investment to develop nearly always comes into developing countries from developed countries. Gross National Products rise in developing countries, but the rub-off to the country itself is never very great, so although it is possible to say that most research needs can be transplanted, there is a growing need for enough basic research, enough applied research, enough people who can speak the language of research, in order to control the results of foreign investment in developing countries so that the maximum rub-off in financial terms can be achieved.

I would suggest in conclusion that I feel and I think my colleagues feel, and anybody else who has had any experience in developing countries feels, that the developed countries do have a major responsibility to places like PNG, regardless of politics, and I would like this body to give some thought as to where that responsibility lies.

INTRODUCTORY PAPER 1(d)
WOOD TECHNOLOGY DIVISION, FORESTRY COMMISSION OF N.S.W. -
A BRIEF REPORT ON WORK IN PROGRESS
by L.H. Bryant

The Wood Technology Division was established in 1936 to provide a technical basis for the Commission's aim of increasing the value of the forest crop in New South Wales. In the intervening years a well trained staff has built up a large amount of information on most aspects of timber and forest products usage, and regularly contributes articles to relevant scientific and technical journals.

In 1972 the Division moved from its original location in Harrington Street, Sydney to new laboratories in the Cumberland State Forest at West Pennant Hills.

At Putney on the Parramatta River it also has seasoning facilities plus a workshop, timber store and sawmill. It maintains three main test sites for durability trials of timber and other forest products in different parts of the State.

In addition to its work on the timber crop the Division also carries out research on the quality of forest soils and the nutrition of the main plantation species, as well as forest pathology and weed control.

The Division consists of four major technical groups and its organisational structure is set out below.

The Biology Group

The work of this Group can be considered under the following broad headings:

Forest Pathology. This covers the study of pathogenic fungi, bacteria, and nematodes in nursery and forest soils, and in the living tree; the early

detection of new pathogens; and the development of suitable control measures.

Soil Microbiology. With particular emphasis on the role of mycorrhiza in the uptake of nutrients from the soil by the tree.

Timber Microbiology. Which is concerned with the wood-rotting and staining fungi and bacteria, and their control. Of special interest here is the role of these organisms in wood chip storage piles.

Timber Entomology. Which covers termites, and wood destroying insects, and their control.

Preservative Testing. Laboratory facilities have been provided to permit the assessment of wood preservatives using recognized international standard tests against decay and attack. The Laboratories are approved by the National Association of Testing Authorities.

Wood Structure and Identification. This work covers the relations of the microscopic structure of wood and bark to a wide range of timber properties, e.g., the resistance to penetration by preservative solutions, elite tree selection and strength properties.

A timber identification service is provided backed by a collection of over 9,000 authentic wood specimens from many countries. This service is much used by industry, the police, research institutions and the public.

Photographic Services. A full range of photographic services is provided for Commission and Division needs.

The Building and Engineering Group

This Group has two main functions. One is concerned with the proper use of timber in the general building field and the better utilisation of forest products generally. The other is concerned with the engineering aspects of timber utilisation.

Building and Utilisation Aspects. A great deal of information is available on the properties not only of N.S.W. species but of commercial timbers of the world, in order to be able to advise the building and manufacturing industries on the best ways of using timber resources. Information is available on the specification, grading, processing and finishing of timber and other forest products such as hardboard, plywood and particle board and on the correction of such faults as may arise in service.

Investigations are made into the use of new species and grades of material that may be causing marketing problems. For example, current work involves the examination of the behaviour of young regrowth stands of blackbutt which when sawn undergo considerable distortion because of growth stresses in the timber.

Research is undertaken to develop improved building techniques to obtain better service from timber and extend its use. An important field of interest is the testing of all types of surface finishes in order to be able to give advice on products which will enhance the appearance and serviceability of wood products.

For a small charge, labelled samples of the State's main commercial species may be purchased.

Engineering Aspects. Research and development work is carried out on the grading of timber, the long term performance of stressed timber structures, the performance of structural plywood and particleboard, the evaluation of adhesives and the adaptation of glued-laminated methods of construction for local timbers. The laboratory is approved by the National Association of Testing Authorities for the testing of timber and other forest products.

The Group has developed a timber grading machine which is being manufactured locally for world-wide sale. Research continues in this field in an endeavour to achieve acceptance of the machine for everyday uses in industry and thus make timber a more truly engineered material for structures. The grading machine is being used as a laboratory tool in the preparation of more accurate visual grading rules for it permits a rapid non-destructive method of correlating appearance and strength.

The behaviour of timber under methods of construction and in such reconstituted form as hardboard and particleboard is studied under long term loads to determine the degree of deformation that may occur under a range of environmental conditions.

Some species cause difficulties when being bonded with adhesives. Increasing interest is being shown locally in glued-laminated construction and the laboratory is involved in the development and supervision of manufacturing methods relevant to local timbers.

A large volume of information on the physical and mechanical properties of the State's timber species has been built-up. This work is being extended to the various types and age classes of plantation-grown species.

The Chemistry Group

This Group undertakes most of the chemical testing work arising from the activities of industry and of other research groups within the Commission. This included such analyses as preservative and starch contents of wood and wood products, the estimation of minor constituents such as alkaloids, and investigations and research into extractives which interfere with manufacturing processes. In this group tannins and resins which affect gluing, machining and finishing have been a major source of interest. In addition to undertaking research and assisting with quality control in minor forest product industries, such as the rutin industry, the Group also plays its part in policing some aspects of the N.S.W. Timber Marketing Act by its analayses of samples from timber claimed to be preservative treated. Through the preservation unit within the Group it is responsible for technical approvals of preservatives and preservative loadings under the N.S.W. Timber Marketing Act and for the formulation and testing of preservatives generally.

Products used by the Commission in quantity, such as fertilisers and fire control wetting agents, are also evaluated.

Apart from its activities on the service side, the group undertakes a comprehensive programme of research into the soil and nutritional factors affecting the growth of the major timber species. Recommendations for fertiliser treatments come from this work which embraces a detailed knowledge of forest soils and the influence of minor and major elements of nutrition.

The group also co-ordinates field trials on the use of herbicides to control

unwanted vegetation and carries out research in the laboratory and glasshouse on the effects of such chemicals on the germination and development of seeds and tree seedlings.

The laboratory is approved by the National Association of Testing Authorities.

The Forest Conversion Engineering Group

The Group is carrying out research and extension work into all aspects of converting the growing tree into seasoned timber. The work covers logging and debarking methods, log storage, sawing, peeling, machining and chipping of wood and the drying of timber and problems arising in structures due to the loss or gain of moisture by wood.

Advice is given on air, kiln and special methods of drying timber, sawmill design and the improvement of saw and cutter blade performances. The Group can assist industry in overcoming problems of residue disposal so as to comply with the Clean Air Act and is also interested in the problem of noise in the forest conversion industries.

INTRODUCTORY PAPER 2
SUMMARY OF ACTIVITIES OF THE RESEARCH WORKING PARTY OF FORWOOD
by W.E. Hillis

A Working Party has been set up to investigate the Research into the Forestry and Wood-Based Industries. Its terms of reference comprised:

(a) Review current activities in research and define likely future needs.
(b) Consider and recommend desirable future patterns emphasising any changes that might be introduced.

The members of the Party are:

W.E. Hillis (Chairman), K.H. Bamber, A.G. Brown, L.H. Bryant, F.G. Craig, R.N. Cromer, B. Dexter, J.M. Gilbert, M. Goudie, P.J. Greig, E.R. Hopkins, J.B. Jack, C.M. Kerruish, W.M. McKenzie, J.E. Nicholson, D.G. Nibles, K.F. Plomley, B.L. Rumball, J.H. Warcup and A.J. Watson.

The activities were divided into the following areas of interest:

(1) Afforestation,
(2) Management of established stands,
(3) Forest protection,
(4) Forest operations research,
(5) Wood, bark and leaf characteristics,
(6) Conversion,
(7) Wood, bark and leaf products.

A questionnaire was sent to 78 organizations regarding their activities in these areas, and replies were received from 52. Information has been

obtained on the current research activities, and the research funding in 1971. With regard to the latter, it is noteworthy that the amount of total research effort in Australia represents less than 1% of the capitalised value of the forest products industry. Of this money, only 40% is spent directly on the forest products industry, and most of this is spent by the pulp and paper industry. Also, the likely future staff needs were considered, and future work needs.

Methods to co-ordinate research have been considered, and a number of recommendations have been made. Priorities for research were considered in the areas of:

(a) greater site productivity - by soil improvement, silvicultural practice, and control of product quality;

(b) better protection against fire, pollution, micro-organisms, insects, vertebrates and people; and

(c) better forest usage in the fields of environment protection, hydrology, social activities, and tree product utilisation.

The integration of these different areas of forest use will require increased research. All these aspects must be considered with more efficient product application from the fields of building, in pulp and paper and other forest products, but with recognition of the control of pollution in these areas.

INTRODUCTORY PAPER 3
INTEGRATED PHOTOSYNTHETIC PROCESS INDUSTRIES
by D.E. Weiss

The striking ability of the petrochemical industry to steadily reduce its costs over the last two decades when the costs of other commodities have been consistently rising can be attributed to the stability and flexibility inherent in its being attached to the very much larger petroleum fuel industry. Since unwanted hydrocarbon can always be sold in fuels there is virtually no waste of the primary raw material and processing streams can switch readily from one to another.

An exploratory program has begun, in collaboration with the Division of Animal Physiology, to see whether similar principles might be applied to the photosynthetic industries. A pilot plant has been erected to enable a variety of plant materials to be separated into a suspension and solution of cell components for the production of animal feeds, and fibres for conversion into building and paperboard materials; unwanted, or low-grade fibre components, can also be used for animal feeds. Initial studies will be concerned with lucerne, eucalypt leaves and pine needles.

By making better and fuller use of the plants that are already being grown future demands for new land resources, pesticides and fertilisers would be reduced and more efficient rural industries might be established which would relieve city population pressures. Thus the concept of integrated photosynthetic process industries has social and environmental, as well as economic, implications.

INTRODUCTORY PAPER 4(b)
REGIONAL CO-OPERATION IN FOREST CONVERSION
by M.W. Page

Our regional co-operation, while undoubtedly more involved with the Pacific Basin region, continues to be almost global, with perhaps a secondary predisposition towards both those countries converting tropical hardwoods and those who have extensively planted eucalypts; countries to whom our experiences and developed expertise could be of importance.

In Papua New Guinea our Preservation Group is working in co-operation with the Forest Products Research Centre on problems associated with expanding the utilization of the mixed species forests by increasing the service life of timber from species of low natural durability. Their programme ranges from field tests of specimens treated with various preservatives, studies of permeability and biodegradation to licensing of both the manufacture of dip diffusion salts and treatments by the dip diffusion process.

In the same area the Forest Conversion Engineering Group is investigating the suitability for veneer and plywood manufacture of a number of species and we have also been advising on the problems of producing sawn and processed wood, particularly for export. For Fiji and British Solomon Islands the assessment of a large number of species has been carried out as a co-operative project between the respective Forestry Departments, and the groups of Timber Engineering and Forest Conversion Engineering. The latter Group has also been investigating the potential of thinnings from Fijian *Pinus caribaea* plantations for the manufacture of blockboard.

In Malaysia the Conversion Engineering Group is acting as design consultants for the establishment of a government-owned forest converting complex, integrating sawmilling, drying, dressing and mouldings, veneer and plywood manufacture, blockboard production and the construction of prefabricated housing components. Also two members of the Division of Building Research joined a recent joint British-Australian Mission to advise on improving forest products research in Malaysia.

John Beesley of Preservation Group has just returned from a 2 year assignment in East Malaysia, assisting the F.P.L. at Kuching develop research programs.

A member of the Conversion Engineering Group recently visited Indonesia as a member of a Department of Overseas Trade Survey Mission to study the potential for the use of Australian forest industries equipment and the possibility of Australian-Indonesian joint ventures in the forest conversion field.

In addition to acting on various international committees concerned with a wide range of aspects of forest products research, staff members of the Division are from time to time invited to prepare background papers for international conferences.

In other regions of technical aid we have recently trained people from four developing countries, while one of our officers has just completed a three-year term advising in Ghana. Two other officers have spent short periods in South America and one of them is about to return to Paraguay for a one-year term.

INTRODUCTORY PAPER 5
RESEARCH IN THE TROPICAL ENVIRONMENT - SOME REVOLUTIONARY THOUGHTS
by J. Beesley

In his report on Forest Products Research in New Guinea, Mr. Colwell lists a number of short-comings from his experiences which apply equally well to my experiences in Sarawak. He mentions:

> 'Failure to learn by doing' - putting species to end-uses and adequately recording working properties of species used;
>
> 'Failure to appreciate that worthwhile results could be obtained without sophisticated equipment' - data on natural durability, susceptibility to Lyctus attack could be obtained from local knowledge; much effective preservation can be performed without a pressure cylinder; procedures for developing kiln-drying schedules are now well established.
>
> 'There is no mileage in carrying out work, obtaining answers unless the information so obtained is promulgated' - in Malaysia it was also necessary to find 'someone who wanted to know'. Industry (and Government) not always receptive of new ideas (i.e. 'new' with respect to traditional practices).

In looking to the future, he goes on to say that 'most technology required in developing country forest products industry is already available from the more developed areas'. This technology cannot be automatically 'transplanted', but the sort of people capable of adapting it to the environment of the developing country are likely to be quite different from those who developed the technology in the advanced country.

I agree that a research organization in the developing country needs to concentrate on adapting existing knowledge to local conditions and on spreading that knowledge amongst local designers, users and processors. Prof. Richardson also emphasizes this point.

Some of you will be familiar with the Malayan Grading Rules - in many ways an excellent document and one which is widely used in overseas trade with Malaysia. These rules are, in some respects quite impractical: the timber grader is required to certify to the <u>period</u> of air drying, he needs a mind like a computer to recognise 'clear cuttings' in boards and planks of assorted sizes; he must tally quantities as he goes, etc.etc.

A few days after preparing my paper, I was handed a local set of 'grading rules'. I will read a few extracts:

> "(A) <u>Select and Better</u>
>
> A grade designed for timber which is to be used for high class joinery or medium class furniture, where the finished product is to be clear finished.
>
> The market expects that all of the pieces will have one face with little or no defects. The other face may contain bright sapwood, pin holes, small sound knots, small seasoning checks.

(B) Standard and Better

A grade designed for timber which is to be used in products which are to be painted. As the grade includes all grades higher than Standard not less than 50% of the pieces should grade Select and Better.

(C) Merchantable

This is recognised as a resawing grade where long clear strips or short wide clear pieces can be recut from the supplied pieces.

EXPLANATION OF REASONS FOR GRADES

From the time timber is placed aboard ship at the sending port until it reaches a user's store in Australia, the value almost doubles. Any material which is not usable is thus costly waste.

The main areas in Australia which import timber have much lower humidity than the tropical areas in which the hardwoods grow - drying is thus much faster which causes pieces having heavy sapwood or large knots to distort badly rendering them unusable.

The main shrinkage in timber takes place from 25-30% downwards. Fully seasoned timber in Australia ranges between 10% and 14% hence large shrinkages occur. This requires that timber be full cut to allow for these shrinkages.

There is fear in Australia that insect holes may contain live insects. The Department of Agriculture has inspectors on the wharf to inspect the arrival of all shipments.

If an unduly large number of insect holes are present or if any live insects can be found, they Quarantine the whole parcel of timber, move it to a Quarantine area, cover it with air tight plastic covers, and fumigate it with Bromide gas."

To sum up, my thoughts are that countries like Australia, with a fairly well developed technology, can help developing countries in the harvesting and marketing of their forest products by practical advice - more by doing and showing, than telling; by a realistic approach to what is necessary and what are 'prestige' factors - in practice how often does one consider the mechanical properties of a timber species when making furniture? What are the general criteria for flooring timbers, which include jarrah, radiata pine, baltic pine, tallowwood etc.?

My friend the Importer has summed it all up nicely, "FIRST IMPRESSIONS ARE IMPORTANT, timber which arrives securely bound in neat parcels etc.". Diplomacy of a high order may be needed to persuade the Head of a Department in a developing country that what he needs is a good foreman (with an ability to impart knowledge) rather than the Director, or other leading research worker, from the Donor country's research centre! Often, it is a question of FACE rather than FACT.

TOPIC 1. WOOD QUALITY ASSESSMENT

CHAIRMAN: D.E. WEISS
TOPIC LEADER: W.E. HILLIS

TOPIC 1/1
WOOD QUALITY AND ITS ASSESSMENT
by W.E. Hillis

The meeting of IUFRO concerned with wood quality, and other aspects of forest products was held here in October 1965. That was the first time IUFRO held a meeting in the southern hemisphere. It resulted from the enthusiasm and initiation of Dr. Dadswell and the respect held for the high quality of his work and leadership, and also the work of others in this country. Dr. Boyd, as Acting Chief, brought the Conference to a very satisfactory conclusion under difficult circumstances and he continued to organise the wood quality aspects of IUFRO until IUFRO was reorganised in 1971.

The Wood Quality Subject Group is now under the leadership of Knigge of West Germany with Hillis of Australia as deputy. There are several working parties in this group and recently there was established formally a new party devoted to "Defects in Fast-grown Eucalypts". The other major Subject Groups in the Forest Products Division include wood engineering, processing, harvesting and wood utilisation, etc. Several of us in this country serve on several committees of IUFRO in different capacities, e.g. Mrs. Bolza, Dr. Boyd, Plomley, Nicholls, Edwards, Smith, myself and others. Other subject groups in other Divisions include Forest Fire Research led by Mr. McArthur, F.R.I.; Tree Breeding by Mr. Brown, F.R.I.; Economics and Harvesting by Mr. Kerruish, F.T.B., etc.

I make these points as:

1. Australia could synchronise its efforts with IUFRO with advantage
2. IUFRO is changing its emphases to meet current needs on a world basis.

I have written about these aspects more fully elsewhere.

The question at this stage is: Is Australia's work changing to meet its own specific needs in regard to wood quality?

I have tried to summarise how F.P.L. has changed its emphases in Topic 1/1. Topics 1/8 to 1/11 and 1/13 give further details. Amongst other aspects we are giving more attention to regrowth wood than to the study of mature and over-mature woods. A new set of properties are possessed by the regrowth wood and the necessity for this information is further brought out by Mr. Smith in Topic 1/3. Nevertheless some of the high density eucalypt forests have not been utilised to any extent for pulping and fundamental studies aimed to achieve their utilisation is given in Topic 1/9 and this will also be discussed in Topic 5.

One important area requiring attention is the need to predict the quality of wood in a forest. A forest inventory goes only part of the way in providing information on the amount of usable resources. One aspect of this is the prediction of the amount of heartwood in conifers of different ages and on different sites. This is reported in Topic 1/13. There is much to be done in assessing the amount of decay, kino, reaction wood etc. in our eucalypt forests.

Are we giving enough attention to the end-use of the product of certain forests? To do this satisfactorily we will have to concentrate our attention on the most versatile and plentiful species for different regions in this country. What is the short list of these species? From a forestry viewpoint they should have fast growth, tolerance to site quality, adaptability in respect to genetic improvement and genotype-environment interaction. However foresters should also bring into strong consideration the knowledge of wood scientists and technologists in the selection of the minimum number of species so that we will obtain the maximum quality of useable material from the forest whether it be for the pulping, preservation, the fibre board, particle board, laminated and solid wood industries. This joint approach will assist the future production of the maximum amount of optimum quality wood from these species.

The next point to be considered is the use of different forest practices on the quality of the wood from existing and future forests.

Nicholls and co-workers, in Topics 1/10 and 1/11 have shown the value of densitometric studies in assessing certain wood quality aspects after different silvicultural treatments. It is a worthwhile exercise to consider how far silvicultural work to improve wood quality is economically justified, although there will always be a need for high quality premium grade timber. However, there will be increasing consumption of low quality timber, smaller parts of the tree and bark in order to obtain sufficient raw material.

Information is needed on the effect of timing of thinning schedules on reaction wood and kino formation and the effect of weedicides on kino formation. "Tordon" used in jarrah forests several years had a pronounced effect in this regard. Fortunately our current information indicates that controlled burning has little effect on the quality of the wood.

Attention will need to be given to the wood quality of fast-grown trees; to growth stresses, the effect on fibre properties, discoloration, decay, kino vein formation, etc. Nicholson and co-workers have considered the aspects of growth stresses in Topics 1/5 and 1/6 and Gary Waugh in Topic 1/7. A fuller understanding of these aspects will show the extent they can be overcome by tree breeding and by silvicultural practices.

We have collected information that slip planes or broken fibres are found in the interior of an appreciable percentage of young fast-grown eucalypts. We have looked at specimens (E. grandis) from Zambia and this is reported in Topic 1/4 (Vol. 2).

Nelson and Heather have reported significant amounts of decay in young E. grandis from Coffs Harbour and decay has been observed in samples of this and other species in other countries. Further comments on these aspects are given in Topics 1/15 and 1/16. It is possible the decay in these fast-grown eucalypts is due to insufficient formation of toxic

polyphenols owing to the growth rate. This aspect has been studied in this laboratory by Hart, Yazaki and Hillis. Shigo and Hillis have reviewed pathological aspects of discoloration and decay.

What of the Future

One major aim of forestry work should be to reduce the variation of quality wood as far as possible. The increasing use of forests for several purposes, in particular that for recreation, will necessitate increasing attention to the quality of the wood in the living tree. There will be more damage with discoloration and decay and disease transmittance and it will be important to be able to assess the extent of alteration of wood quality at an early stage to see that it is kept under control.

More work will need to be given to eucalypt coppice growth, its wood and bark quality and the optimum eucalypt species for coppice growth and quality and the optimum tree age for wood quality in coppice and young seedling trees.

Quality Requirements for End Use Needs

What are our gaps in basic knowledge that are hindering more efficient wood and forest utilisation?

More attention needs to be given to non-destructive testing at various stages so that different grades can be produced enabling the most efficient use of forest products. Firstly we need to be able to assess the extent of defect in the standing tree so that the log can be directed to the end use giving maximum utilisation. This is a major problem with the large number of species that we have. Developments have been made enabling discoloration and decay in the standing tree to be detected by electrical means so that a check can be kept on the spread of disease or damage. More knowledge of anatomical and other features responsible for certain defects in the log may enable the development of rapid physical testing methods and assist the maintenance of standards and improvement of efficiency of integrated utilisation.

This information certainly must be obtained and applied rapidly during processing of the material. This means computerisation, for example, in our sawmilling and pulping industries in deciding the best methods of processing logs so that the greatest recovery is obtained.

We need more use of quality assessment of the sawn timber and in the past this country has been well to the fore in stress-grade application. There are other means of non-destructive testing, such as ultra-sonics, which could be studied in greater detail. More work is required on the chemical and anatomical features affecting adhesion along the lines that Plomley, Hillis and others are pursuing. The dangers of high temperature drying need attention. More assessment of the factors controlling liquid penetration and their variability in the tree is needed. Attention to these aspects should enable a higher yield of a more uniform, fixed quality produced to become more readily available. Attention is needed in the quality assessment of residues such as the barks of pines and smooth barked eucalypts, off-cut, reject and other materials and to the extent these products can be utilised in the most efficient way to convert them to building materials, pulp and other products. More about this aspect will be treated in other topics.

TOPIC 1/4
THE OCCURRANCE OF BRITTLE HEART IN *EUCALYPTUS GRANDIS* GROWN IN ZAMBIA

by W.E. Hillis*, A.D.K. Hardie+ and Y. Ilic*

An examination of *E. grandis* wood from Zambia revealed that slip planes were frequently present in log cross-sections from trees which showed a brash fracture on impact testing. Slip planes were not observed in log cross-sections from the tree showing a normal fracture. Where tension wood was present in a radius of a cross-section, slip planes were found on the pith side. The slip planes observed in tension wood fibre-tracheids were of a different nature.

No connection was found between the amount of slip planes and the cell wall thickness of fibre-tracheids which varied considerably in all specimens.

It is considered more likely that a brash fracture will result in timber under load if the spread of slip planes is extensive than if the slip planes are concentrated in a small area. An examination of *E. regnans* with known external stress figures showed a relationship with stress and the ratio of slip planes.

This study showed that attention should be given in future work to the selection of radii of log cross-section in relation to growth stresses in the standing tree.

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TOPIC 1/7
BETWEEN TREE VARIATION OF SELECTED GROWTH AND WOOD CHARACTERISTICS IN PLANTATION GROWN HARDWOODS

by G. Waugh

Notes in Volume I discuss the background to recent work in this field as well as introducing the objectives and basic experimental design of these studies. The primary aim has been to investigate selected growth and wood characteristics in standing *Eucalyptus regnans*. This study has been confined to looking at population variances with respect to the following characteristics:

1. diameter breast height increment
2. incidence of gum veins
3. growth stress
4. specific gravity.

I will have to be deliberately vague about some of the results; firstly as

the analysis is not yet complete, and secondly, John Doran from the Forest Research Institute, Canberra, has been using the same field trials in order to carry out an intensive investigation into specific gravity variations in *E. regnans*. Despite the fact that we have adopted completely different techniques, measured different aspects of the same properties, and in many cases sampled different genetic material, our preliminary results are so similar that I feel I would be stealing his thunder by disclosing results at this time.

Probably the most significant finding is the poor correlation between diameter increment and growth stress (or should I say the peripheral longitudinal strain resulting from the release of growth stress). Growth stress can be defined as stresses resulting from the maturation of peripheral xylem cells. For 399 degrees of freedom a correlation coefficient of 0.04 was obtained. This finding does not support the long standing belief of many foresters that the fastest grown trees are subjected to the highest growth stresses, although I do believe that certain silvicultural practices that will lead to an accelerated growth rate on individual stem can also promote higher growth stresses. This was evident in preliminary work on poplars.

Preliminary work developing measurement and analytical technique was carried out on poplars, investigating the cause of the problem of bent match splints. Initial investigations showed that high growth stress in poplars was related to tension wood formation. Samples containing a high proportion of gelatinous cells may be subjected to growth stresses up to seven times greater than the growth stress level in normal wood. However it was observed that high growth stress and the degree of distortion in match splints were not necessarily related.

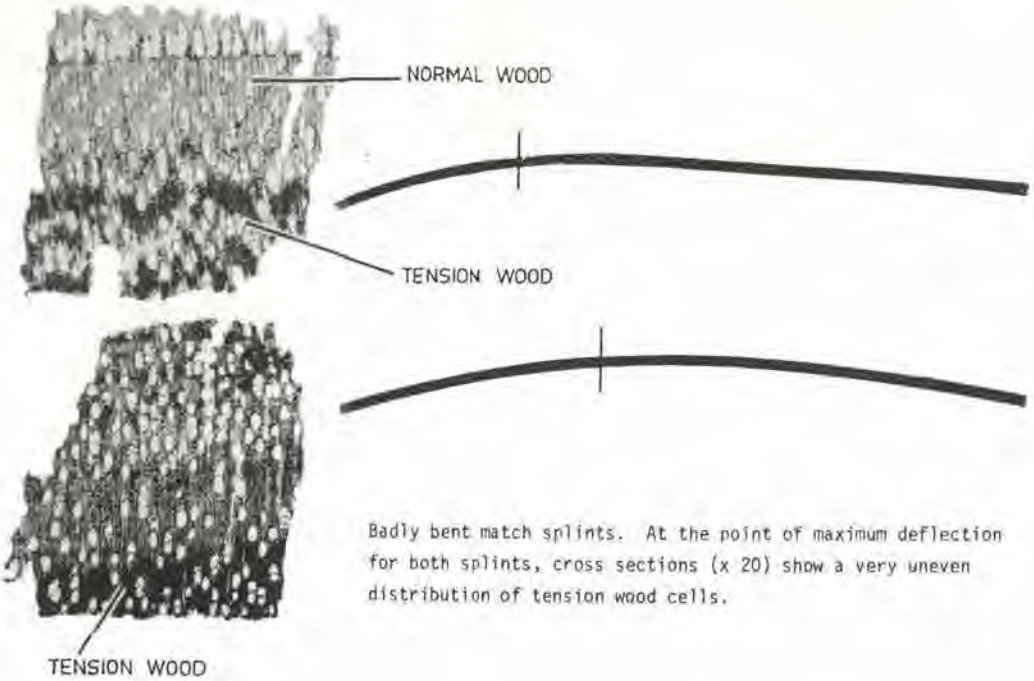
Figure 1 shows that the worst distortion occurred when there was a considerable change in the relative number of gelatinous cells across the match splint cross section, and that distortion was largely due to a high longitudinal shrinkage differential caused by gelatinous cells during seasoning. Microscopic cross sections of samples taken from trees which later produced a high proportion of distorted match splints also showed tension wood (gelatinous cells) occurring in narrow bands often only 1 to 2 mm in width. These narrow bands of gelatinous cells were much more pronounced in localities subjected to the greatest variations in wind conditions, and there again much more pronounced in the American black poplars than in the Euramerican hybrids. Trials at Tumut have shown a significant 50% increase in growth stress at one year after thinning, along with a threefold increase in the number of gelatinous cells.

The point which I am attempting to show is that poplars are very sensitive to environmental conditions, and fluctuations in these conditions can have a marked growth response. The result is a final product which not only fails to meet specifications, but also which if not graded out, disrupts the whole processing operation.

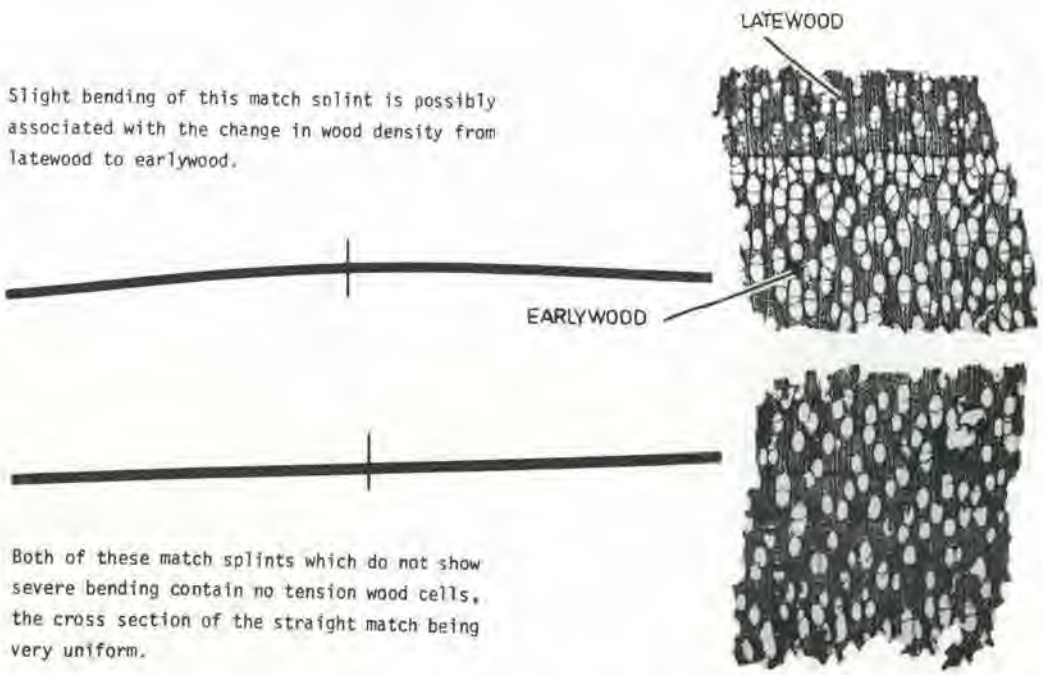
Poplar clones have been introduced into Australia and silvicultural systems evolved which give prime consideration to growth rate, (disease resistance now being of considerable interest).

Thus fast growing American black poplar clones have been introduced and subjected to frequent very heavy thinnings and pruning, leaving the remaining plantation open to fluctuating environmental factors such as wind and sunlight.

The solution to the difficult problem of defining and producing wood of desirable characteristics lies in the integrated effort of the wood scientist, the geneticist and the forester. The forester must realize that the wood which he grows must on utilization yield products which will meet required end use specifications. He must look upon silviculture as being more than a tool which allows him to accelerate growth rate, but also as a means for controlling wood quality as well.



Badly bent match splints. At the point of maximum deflection for both splints, cross sections (x 20) show a very uneven distribution of tension wood cells.



Slight bending of this match splint is possibly associated with the change in wood density from latewood to earlywood.

Both of these match splints which do not show severe bending contain no tension wood cells, the cross section of the straight match being very uniform.

RELATIONSHIP BETWEEN BENDING IN MATCH SPLINTS AND TENSION WOOD DISTRIBUTION

TOPIC 2. UTILIZATION OF SMALL HARDWOOD LOGS

CHAIRMAN: F.R. MOULDS
TOPIC LEADER: G. GRIFFIN

Topic 2/1
UTILIZATION OF 1939 ASH REGROWTH IN AUSTRALIA
by G. Griffin & D.J. McKittrick

The problem facing the Victorian industry, both producer and user, is that of a rapidly diminishing mature ash resource, and its replacement by a regrowth resource which is of a very different age.

The disastrous 1939 bush fires in Victoria killed the ash forest over large areas of the Central Highlands.

After salvage of fire damaged timber was no longer possible, the cutting of the remaining mature ash resource had to be concentrated in the unburnt stands, and so has prevented an orderly progression of age classes being established. We are now approaching the time when cutting will have to commence in the regrowth stands.

The challenge which we face is to quickly develop techniques for continuing to supply the traditional market, and if possible to develop new markets for regrowth timber, which are at least as efficient in unit cost as those which have been developed over many years for the original mature crop.

There are several characteristics of the regrowth which immediately make this task more difficult.

The first, and most obvious one, is that of size. An attempt has been made to quantify the order of the size differences between the two resources in Figures 1 & 2 of the written paper.

It has been part of bush-lore since logging and sawmilling began that "big is good". Paper 3 of this topic, to be presented by McArthur and Page, quantifies this effect. Studies carried out more recently by Forests Commission officers have shown that the residual value of sawlogs increases dramatically over the range from 2 ft. cg. to 4 ft. cg., and then less rapidly with increase in log girth to an apparent maximum, or levelling off of value at about 7 ft.centre girth. The order of magnitude involved is an increase of approximately 500% in residual value between 3 ft. and 7 ft. centre girth, with over half of this increase occurring between 3 ft. and 4 ft. centre girth. The reason for this rapid change is due largely to the high fixed unit costs in log handling, both the bush and in the sawmill.

Another characteristic of the regrowth is the greater difference in sawn timber quality between the two main species, *Eucalyptus regnans* and *E. delegatensis*.

Regrowth alpine ash sampled to date has yielded a much clearer product than the

mountain ash regrowth. The difference between these species in the mature crop is not as apparent.

There is nothing which can be done about altering the quality characteristics of this crop of regrowth. However, an understanding of the quality variation likely to be experienced, and any means of predicting the likely out-turn from a given log will assist in the most efficient conversion processes. Work is proceeding in the Forests Commission along the lines indicated in the paper.

The steep stress gradients encountered in small logs is another problem which must be overcome in the conversion of regrowth logs. This subject is under study in several areas, and is discussed to some extent in the paper by Mr. Bootle. The problem is one which should be overcome by a greater understanding of the mechanics of "spring", and also by a variety of conversion techniques, such as backsawing and/or multiple saw arrangements.

Because of the need to commence cutting regrowth for the requirements of the market on a large scale within the next few years, the traditional "trial and error" approach to the solving of problems will not be good enough. Answers will be required quickly, and they will have to be the right answers, as wrong answers are likely to be expensive. Such a situation is one where the scientific and technological approach to problem solving should be able to provide quick and accurate answers.

TOPIC 2/3
THE ECONOMICS OF MILLING SMALL HARDWOOD LOGS
by Ean McArthur and Mervyn W. Page

In Topic 2/1 (Utilization of 1939 Ash Regrowth in Victoria) the log volume distributions by girth classes are extremely interesting. Approximately 60% of the present Victorian sawlog volume exceeds 6 ft. centre girth and almost 30% of this is above 7 ft. centre girth for a 30 ft. sawlog.

By contrast in the first stage of regrowth utilization only approximately 15% of the regrowth forest volume will exceed 6 ft. girth and only 5% of this will exceed 7 ft. girth. These proportions will increase to 30% under 5 ft. c.g.u.b., 39% between 5 ft. and 6 ft. c.g.u.b. and 30% over 6 ft. c.g.u.b. at the end of the first liquidation period.

A clear felling operation in the early stages of regrowth utilisation would produce 85% of log volume below 6 ft. girth, and all the indications are that traditional hardwood mills are hopelessly inefficient in handling these small logs.

The paper previously referred to comments that utilisation techniques for the regrowth resource must be at least as efficient in terms of costs and product recovery as those which have traditionally been employed. This is a rather formidable aim but presumably products from regrowth utilisation must compete effectively with timber from other sources.

Referring to our own paper (Topic 2/3), the most recent CSIRO mill study in

Tasmania reinforces the view that it is extremely difficult to maintain recovery of traditional products from small logs at economic levels, and to do so would require logs of very high quality. In addition it was shown that a reduction in log girth can increase milling costs in traditional-type mills.

In this study the economics of milling Eucalypt logs of various girths were studied and amongst these were 36 mill quality logs below 6 ft. centre girth. Under the cost conditions studied only one log out of this 36 was profitable.

Species:	*E. obliqua*	- 47%
	E. delegatensis	- 33%
	E. regnans	- 8%
	Other species	- 12%

Average log length	- 14.8 ft.
Average volume	- 312 s.ft. HLV
Average milling cost	- $1.89 per 199 su.ft. HLV
Average sawn recovery	- 31% (0-47%)
Average loss	- $1.66 per 100 su.ft. HLV
Average centre girth	- 63.6 in.

In this type of mill study, logs are sawn at random without segregating girth sizes and there is probably a tendency to under-estimate milling cost of small logs, as long delay times resulting from a run of small logs are avoided. Even so, milling costs per 100 su.ft. HLV increased by approximately 30% compared with larger logs.

Many studies have shown that, below 6 ft. girth, milling costs increase sharply with decreasing girth. This is similar to the trend for harvesting costs (Topic 2/4) (Fig.4). Thus all costs,except cost of log transport and the cost of growing the trees, increase rapdily with decreasing girth and this makes the aim of maintaining product recovery and holding costs rather ambitious and for traditional methods of harvesting and milling, almost impossible.

Recovery is of paramount importance. Indications are that log costs at the mill often represent approximately 60% and milling costs approximately 40% of the cost of green timber in a hardwood mill. Reducing these costs is important but good recovery is probably more important. An increase in recovery from 30% to 40% while maintaining grade will mean that 33% more timber is produced for the same log and milling costs.

Obviously many of the answers on regrowth sawmilling are still uncertain. The volume required and the sawmilling equipment necessary to constitute an economically viable small-log sawmill will,to some extent, be influenced by the characteristics of each particular species. The Forest Conversion Engineering Group is carrying out further investigations to establish answers to these questions for a range of species.

TOPIC 3. TIMBER FOR CONSTRUCTION

SUB-TOPIC A - STRUCTURES

CHAIRMAN: F.A. BLAKEY

TOPIC LEADER: A.P. WYMOND

TOPIC 3/1
THE MARKET FOR TIMBER CONSTRUCTION
by A.P. Wymond

The work which I have reported very briefly in the paper before you was initiated, as Dr. Kauman said in his paper yesterday, to provide information on the market for timber and timber components; also to uncover problem areas in relation to timber, particularly in the building industry.

In a total of just on 300 interviews, a volume of opinion has already been obtained on which may be based some fairly definite findings, the major areas of which I have listed, and you will see that I have commented on timber grading, framing and structural timber, Glulam, roof trusses, flooring and window joinery.

This is an unfortunate time to be doing a survey of this nature, for the current boom in housing throughout Australia has resulted in a seller's market in timber as well as many other building materials and components. However, it is also unfortunate that at times like this the Timber Industry is the first and maybe the only industry to relax its standards in order to meet the demand. If the industry is not careful, the result is going to be a repetition of what happened in the 1950's, when the Timber Industry earned a bad name in exactly the same way.

Whilst there may be good reasons, and indeed it may even be desirable, for the decline in grade supplied to builders as evidenced in Bill Clifford's paper, builders do not see it this way, and they may face irate owners or critical architects who take them to task for the quality of timber used in their job. Once again the builder is the meat in the sandwich and understandably he doesn't like it - he vents his feelings on the Timber Industry as a whole.

There are two papers in this session dealing with particle board for flooring. The use of sheet flooring is presently an area of considerable interest in the building industry. Many architects and builders are convinced that this represents an area of possible savings in on-site labour, which is becoming a critical factor today. However, they are suspicious of the material and are very hesitant. Their caution is reinforced by the refusal of many lending authorities and councils to approve the material in view of limited knowledge of its long-term capabilities. Furthermore, in N.S.W. one of the conditions for builder

registration is that they provide a 7 year guarantee in relation to the integrity of the structure. It is understandable that they would like to see a lot more field experience with particle board before they consider its more extensive use.

The Light Timber Framing Code is presently causing much discussion in the building industry. It is probably fair to say it is being regarded with a mixture of interest, suspicion and cynicism. These problems with local government inspectors, with lending authorities, are due to the sub-contract system where a builder pays for frame erection on the basis of squarage, the only saving possible is in the lesser volume of timber used. Whilst this is of great importance to some of the very high volume builders, many of those in the lower volume area feel that saving $50 or $100 on a house is not worth the disruption it causes to the trades, as any changes in routine could lose them sub-contractors, in this period of critical labour shortage that could put a builder out of business. In addition many builders are cynical of the Timber Industry's capacity to provide the stress graded timber required by the Code. They feel again that they will have to bear the brunt of arguments with councils and lending authority inspectors.

Many builders are concurrently taking more interest in the possibility of using steel or aluminium frames. Over the past few months many more aluminium frames have been erected, whilst a very large Sydney builder is erecting two steel frames for evaluation and serious consideration. It is perhaps fortunate that at the present time steel and aluminium are possibly almost as hard to get as timber, otherwise the swing could be more pronounced While builders are wary of new materials and methods, once changed they may be hard to win back.

The question of window joinery is also becoming critical. By excellent promotion, imaginative design and comprehensive service, some of the larger joinery firms have very largely pushed aluminium out of the market. However they have relied very heavily on an imported timber, western red cedar, which is now not only in very short supply, but its price has risen from about $40 to over $70 in the past 6 months. Whilst 1 or 2 of the largest firms carry big stocks, the position generally is worsening, and many builders are moving back to aluminium rather than risk substitute timbers, having become used to western red cedar.

There is a clear need for a substitute for this paragon of timbers, and the possibility of combining suitably treated radiata pine with a local durable species should be investigated. However, the preservative treatments needs to be more than we have at present, for the timber so treated needs to be not only resistant to biological degrade, but must also be stainable, paintable, and have some degree of improved stability.

TOPIC 3/5
PRODUCTION AND USE OF FINGER-JOINTED SCANTLING
by A. Anton

(a) There appears to be a significant difference in emphasis between the two Australian Standards for finger-jointed framing timber. Australian Standard 098 for S.E. Australian hardwoods refers to framing studs, plates and nogging, applications where one might normally expect in use a high degree of load sharing; Australian Standard 0123 for radiata pine refers, in addition, to structural engineering applications which surely infers a greater potential stress. A clarification of aims seems to be needed.

(b) The position in regard to the adhesives to be used seems rather confused. It appears to be common commercial practice to use products which are not classified as waterproof but which seem to behave satisfactorily in practice. As an example, laboratory tests carried out on joints made with fortified ureas (e.g. Grasp 62),but with rather poor production control, showed no sign of failure after 30 cycles of 24 hour soakage in cold water followed by 72 hours air drying. Such adhesives are much more tolerant of temperature conditions etc. at time of application than, say, resorcinol. There is no merit in a truly waterproof adhesive if the conditions for proper adhesion to the wood are not secured in practice.

The time seems ripe for a much closer look at what minimum qualities an adhesive must have for use in structural non-laminated finger-jointed members.

TOPIC 3/12(b)
IMPROVEMENTS IN TIMBER FRAMED HOUSING
by R.N. Bournon

This paper is a report of the background, aims and reasoning behind a project to improve the structural reliability of the timber framed, site built house. The work has been in hand for some time and some of you may have seen the original test frame in the structure laboratory where the final one can be examined. A 14 square demonstration house is being built in the open at Highett and part of it will be completely finished as a feasibility and cost study.

The aims of this work include the following:-

For the Timber Industry: A drastic reduction in the number of sizes required - to 2 only. To promote the use of mixed hardwoods, air dried, graded to 1250f straightened and gauged to width - hopefully to improve the image of timber as a building material.

For the Builder and Owner: To reduce the cost of the carcass and to improve its reliability against:

1. cracking of plaster and brickwork
2. opening of joints between gable and eaves lining and brickwork
3. distortion of door and window openings

4. loss of alignment of floors, walls and roof,
5. the occasional major damage caused by high winds.

The main features of the new system are:

1. A new type of foundation consisting of timber piles driven 5-10 ft. and up to 12 ft apart with low cost equipment. The main weight of the house is carried on prestressed concrete beams spanning between the piles. This form of foundation has a predictable performance in any soil and is particularly suitable for filled or swampy sites.

2. A new framing system which uses 45% of the quantity of timber, with 65% of the value and 35% of the weight of that currently used in a similar frame. The outer load-bearing walls are positively attached to the floor and roof frames and a much improved wind bracing system is used to resist the very high wind forces that sometimes demolish houses and in my opinion more frequently cause minor damage. The roof system is supported only on the outer walls and is adaptable to hips or gables and to any outline in plan.

3. On my present estimates the cost of foundations and frame for a 14 square house should be reduced by 33%, i.e. about $800.

SUB-TOPIC B - WOOD PRESERVATION

CHAIRMAN: L.H. BRYANT

TOPIC LEADER: N. TAMBLYN

TOPIC 3/24
REPORT OF THE WOOD PRESERVATION COMMITTEE
by N. Tamblyn

For the benefit of members of this Conference who may not know the history and purpose of the Wood Preservation Committee, perhaps I should explain that some years ago items on wood preservation began to overload Conference Agendas until at the 1961 Conference there were about 34 items listed for discussion. It was then decided that a Preservation Committee should be formed so that many of these matters could be discussed in more depth without inflicting the full detail on all Conference members.

The Wood Preservation Committee as formed in 1961 comprised only 3 members representing the Queensland and New South Wales Forest Services and the then Division of Forest Products. It soon gained a 4th member from the Victorian Forests Commission and at the last Conference (1971) it was decided to further increase its numbers to include representatives from the Timber Preservers' Association and from the Department of Forests, Papua-New Guinea. It now has 8 members: Messrs. Clifford, Cokley, Johnston and Levy, representing the TPAA Technical Committee and myself (as convenor) representing the Division of Building Research.

The Committee meets at least once and sometimes twice a year and now that it has been strengthened by our industry colleagues from the TPAA, I believe it is servicing a wider and more important function than was originally expected. At a typical meeting lasting 2 or 3 days we have some 20 to 30 items listed for discussion. These relate to research work in progress, to problems requiring future research, to matters arising in legislative control of wood preservation in Queensland and New South Wales and to areas in which industry. as represented by the TPAA, would benefit from knowing our collective opinions. Our purpose is not to make decisions which are binding on one another, but rather to ensure that we are all as well informed as possible on current topics and that we see and understand different points of view so that as individuals we can then act as wisely as our responsibilities and restrictions of office permit.

The report submitted to you was prepared by myself too late for it to be circulated and approved by other members of the Committee. I apologize to them for this, but absence in Malaysia left me no time to do better. They are free to expand some part of it, criticise or contradict it, and you may wish to ask questions concerning some of the 25 topics listed. I cannot guarantee to remember "off the cuff" all the details of several days discussion but other members of the Committee can no doubt help in this.

TOPIC 3/25(a)
PERMEABILITY OF RADIATA PINE AND SERAYA
by R.K. Bamber

To provide some guidelines on the penetration of dip-type solutions the author has examined samples of radiata pine and seraya dipped in specially stained mineral turpentine for 5 minutes.

The penetration by the turpentine seemed to be confined to the following areas:-

(a) In radiata pine sapwood - very shallow penetration to the cavities of the surface tracheids but deep penetration along the rays and along both the radial and the axial resin canals.

(b) In radiata pine heartwood - similar shallow penetration of the surface tracheids but only rarely was there deep penetration along the rays and resin canals.

(c) In seraya sapwood - very shallow penetration into the surface fibres and parenchyma, but deep penetration along the vessels and the radial resin canals.

(d) In seraya heartwood - similar very shallow penetration with the surface fibres and parenchyma but rare penetration of vessels and radial resin canals.

In both species the penetration of the mineral turpentine was confined to those cells or spaces connected to the surface of the wood. The amount of movement from cell to cell through pit membranes was undetected by microscopic examination.

It was found that in seraya heartwood the radial resin canals became blocked with callus growth apparently derived from thin-walled epithelial cells, a growth which has apparently not been described before. The following photographs might be of interest.

It is apparent that dip solutions which will in practice be considerably more viscose than mineral turpentine will have little chance of penetrating in any great volume into the wood.

Fig. 1. TLS of Shorea sp., red serayah heartwood. Unembedded, sectioned at 15 m, x 700 brightfield. Canal occluded with callus growth apparently derived from the thin-walled epithelial cells.

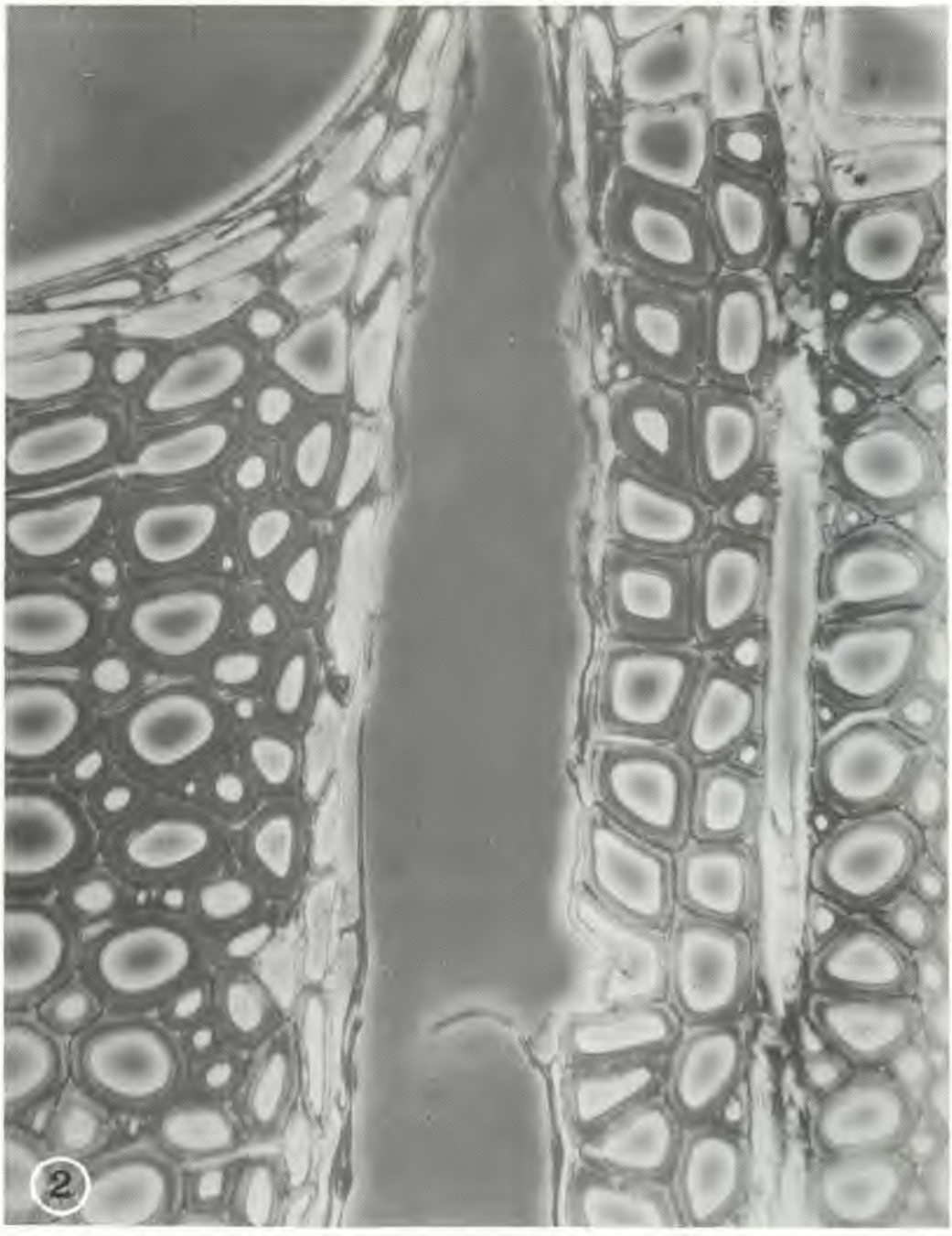


Fig. 2. TS of Shorea sp., red serayah sapwood. Embedded with Spurr's epoxy, sectioned at 1-2 m, x 600 phase contrast. Radial resin canal with remnants of thin-walled epithelial cells.

TOPIC 3/25(b)
DIP TREATMENTS WITH WATER REPELLENTS
by K.R. Bootle

Good quality joinery timber suitable for window manufacture is becoming very difficult to obtain. In a recent survey of the seven leading N.S.W. window manufacturers, who supply 80% of the wood windows being sold, they all agreed that the demand for wood windows has improved but they were frustrated by the shortage of suitable timber.

Radiata pine and S.E. Asian (including Papua New Guinea) timbers of rather low durability will no doubt be called upon. My short note describes 7 years success for water repellent dipped radiata pine. The test pieces are subject to quite severe exposure and the untreated controls have almost all failed.

Mr. Bamber's paper indicates the limited nature of the penetration by dip treatments so one must wonder just how long these joints will remain free of decay.

It appears that dip treatments have made considerable headway in South Australia but this position does not apply in N.S.W. Of the seven manufacturers mentioned earlier only two have made much use of dip treatments and even these have now abandoned the use of products containing pentachlorphenol because employees complained about its burning effect on their skin.

It does appear that there are a number of serious obstacles to the general acceptance of dip treatments, yet there is an urgent need for relatively cheap preservative methods to up-grade potentially suitable wood. In the case of radiata pine we also need a treatment that will help to discourage the splitting, both radial and tangential, to which this species is all too prone. Because of this latter factor an oil treatment rather than a waterborne treatment could have merit.

I might mention that I have recently been comparing the splitting susceptibilities of quarter-cut as well as back-cut untreated radiata pine. The quarter-cut material has behaved as poorly as that which was back-cut and deteriorated within a period of just a few months.

TOPIC 3/26
ORGANIC SOLVENT PRESERVATIVES
by N. Tamblyn

It is now apparent that waterborne preservative treatments are far from ideal for exterior decorative woodwork because of degrade from splitting and checking which begins during redrying and continues during service unless the wood is kept well painted. Waterborne preservatives are also not ideal for timbers which are machined after treatment because treated wood is wasted and the protective envelope reduced or removed in

timbers which cannot be completely penetrated. Bob Cowan and Frank Dale make these same points in their papers and since the problem applies with particular force to radiata pine, it is one which we must regard as urgently requiring solution.

As we see it at present, the best approach to this problem lies in the pressure treatment of pre-machined timber with an organic solvent preservative in which the components are dissolved in a light mineral oil or other solvent which can be readily volatilized from the wood. For exterior decorative woodwork the preservative would contain water repellents (wax and resin) to give the weather resistance necessary for satisfactory use of flat oil coating.

For non-durable permeable timbers such as radiata pine we would expect the same or better penetration than is obtained at present in CCA treatments, but for more impermeable timbers such as meranti, Douglas fir or ash eucalypts an envelope treatment with good end grain penetration would meet most requirements provided the timber was fully prefabricated before treatment. There is no doubt that with most timbers a satisfactory envelope treatment could be obtained at pressures of 100-200 p.s.i.

For these treatments we have the choice of using two types of preservative. These are:-

1. A preservative based on a cheap petroleum solvent such as mineral turpentine which would be applied by a Rueping treatment to give deep penetration but low solvent retention in the wood when removed from the cylinder. For radiata pine solvent retentions of about 3 lb/cu.ft. are quite practicable. After treatment it would probably be necessary to strip out for a few days to volatilize the solvent before the wood would be marketed.

2. A preservative based on a more costly, non-inflammable and more volatile solvent such as methylene chloride. In this case, it would be necessary to recover the solvent before removal of the wood from the cylinder. This would be a more sophisticated process involving heating of the wood and vacuum distillation and condensation of the solvent.

Both processes have advantages and disadvantages and will require considerable developmental work by industry or ourselves before they are ready for commercial use. The paper discusses the treatment with a mineral turpentine based preservative in considerable detail but does not develop the case for a methylene chloride based preservative because we have not yet done sufficient experimental work with it to present the necessary facts.

We believe the development of one or other of these treatments is a necessry step in Australia and would appreciate a full discussion on them in the working group stage of this Conference.

SUB-TOPIC C - BIO-DETERIORATION

CHAIRMAN: L.H. BRYANT

TOPIC LEADER: E.W.B. DA COSTA

INTRODUCTORY REMARKS
by E.W.B. Da Costa

This sub-topic is concerned mainly with the types and agencies of bio-deterioration of wood, and in introducing it I would like to call your attention to the radical changes which have taken place in research in this field, in Australia and elsewhere. You can see this by comparing the papers for this Conference with the Proceedings of previous Conferences, even that held two years ago.

The most obvious change is the sudden increase in interest in soft rot in hardwood timbers in ground contact, the subject of the first four papers in this session, and of several in the previous one. Soft rot in preservative treated eucalypt sapwood, especially in the tropics, has proven far more severe than expected, and none of our current recommendations for preservative treatment will give adequate control. The problem of failure of CCA, and other preservatives, in eucalypt poles is peculiar to (or at least more important in) Australia,and we are unlikely to get much help from other developed countries, as they do not use eucalypt poles. We know from our own research that not all CCA-treated hardwoods are as susceptible as eucalypts, and the data in C. Levy's paper suggest that teak may not offer such a severe problem.

It is clear that we need much more information, both from field data and from laboratory research, on the whole process of decay in wood, on the associatative effects of organisms and the effect of micro-organisms on preservatives, on the effect of timber substrate and on the effect of micro-climatic factors such as CO_2 accumulation. This applies not only to soft rot in poles but also to decay in external joinery, deterioration in chip piles, and heart rots in living trees. For much of this work we need to develop better techniques of identifying the causal organisms and better laboratory bio-assay techniques.

Similarly in entomological research, there is a need for more rapid and reproducible bio-assay techniques using termites and other insects, for more knowledge of the physiology and behaviour of the organisms concerned, and for more detailed knowledge of their distribution. All these aspects are discussed in the entomological papers in this session.

If we understand more fully the way in which each destructive organism operates, we have far more chance of reducing the damage by selective control measures which do not involve chemicals having widespread effects on natural ecosystems. This is preferable to the present"shot-gun" approach of total annihilation by chemicals, which is now being abandoned in the agricultural pest field, not only because of side effects on the environment but because, in the long run, it just is not working.

TOPIC 3/31
ARE CHLORINATED HYDROCARBON COMPOUNDS SAFE TO USE IN WOOD PROTECTION?
by R. Johanson

The object of this communication is to remind all concerned of a probable health hazard that may be associated with the chlorinated hydrocarbons commonly used in protection of timber against destructive organisms.

Some chlorinated compounds are relatively tolerable and others extremely dangerous. It is the chemical structure with often quite subtle differences in molecular arrangements of the atoms that produces profound biological effects. The difference between aldrin and dieldrin consists of one extra oxygen atom but it is an epoxy oxygen, and it endows dieldrin with an extra physiological activity.

A hydroxyl radical in pentachlorophenol molecule enables formation of very potent dioxin compounds, with teratogenic properties. (Abnormalities such as those produced by Thalidomide, the chemical allegedly well tested and found safe for humans as professed by the Makers.) Benzene hexachloride lacks this property but there are indications that it may contribute to liver cancer. In general, all chlorinated hydrocarbons are 'nerve-type' poisons for insects and a broad-spectrum poison for other living organisms - they all possess extreme range of biological activity, chemical stability, mobility and affinity for living systems.

The usual measure of toxicity of a compound, the LD_{50} in mg/kg is not adequate to give even an indication of various deleterious effects which an insecticide may have on mammals and environment. Recently in a report it was described how a mg quantity of dieldrin in pregnant mice produced mentally retarded offspring, although these were indistinguishable in other respects from the control litters used in the tests. In another report, dietary dieldrin effected phenylalanine metabolism in rainbow trout and produced the well known phenylketonuria syndrone which affects brain enzymes with accompanying mental disorder.

The use of particularly dangerous chlorinated compounds, in a situation however safe it may appear, should be made with the utmost caution and with the knowledge that such a use may be fraught with risk to an environment including an unborn child. It is worth remembering the warnings and stoical defence of thalidomide and finally the tragedy brought about by this compound.

TOPIC 3/34
SOFT ROT IN TREATED WOOD
by N. Tamblyn

In this paper I want to draw your attention to some important conclusions which are now apparent from our small stake test of wood preservatives in 8 sites ranging from Papua-New Guinea, Queensland, N.S.W. and Victoria.

These conclusions refer to decay resistance only and you should not try to

read into them any correlation with termite resistance.

In the paper I have drawn 8 conclusions which may be summarized more briefly,and perhaps somewhat differently, as follows:-

1. The decay resistance of all preservatives is lower in the 4 northern sites (Papua-New Guinea and North Queensland) than in the 4 southern sites (New South Wales and Victoria).

2. This difference between the northern and the southern sites is due to attack by soft rot which appears to be more directly related to temperature than to rainfall. The higher the temperature the more rapid is the attack by soft rot.

3. The broad picture is as follows, after 6-8 years in ground contact:

   Eucalypt sapwood - No preservative is really satisfactory. CCA preservatives and 5% PCP in furnace oil are the best of a poor bunch and creosote oil is by far the worst.

   Radiata pine sapwood - CCA is good and creosote and 5% PCP are satisfactory. There is really no problem in treating pine for tropical use.

   Eucalypt heartwood - Results are rather variable and barely satisfactory. The preservative oils (creosote and 5% PCP) appear to be slightly better than CCA.

4. The most important conclusion is that in our stake test we do not have a really satisfactory preservative for eucalypt sapwood under tropical conditons. We do not know to what extent this applies to other hardwoods and we do not know whether the poor performance obtained with preservative oils in short stakes is applicable to poles where we now believe there is some replenishment in the butt in service due to downward movement of oil under gravity.

TOPIC 3/37
DECAY AND DISCOLORATION IN NEW AND OLD STRUCTURES
by N.E.M. Walters and E.W.B. Da Costa

An extract from "Australian House Fungi", a D.B.R. Technical Note by N.E.M. Walters now in the press, is reproduced to assist those prepared to suply information for future revisions:

"The following data would be relevant (in addition to samples of decay and fungus tissues, sufficient to describe and identify the fungus):

Climatic data

Place and dates of attack. The local climate: seasonal rainfalls and temperatures, altitude, winds, frost and dew incidence, etc.

Site data as it effects climatic data.

Climate modification by shrubberies, cliffs, fences, direction and steepness of slope, soil type and shade. Excavation under the floor, floor clearance and wetness of site. Drainage.

House data (preferably with a block plan)

Effective through-draught routes under the house, and external and internal obstacles to it. Shape and size of house. General construction data (brick, wooden stumps, flat roof etc.). Ventilation types, size and spacing. The use of waterproof barriers over soil, on wooden suspended floors, within or lining (e.g. tiles) walls and roofs. Priming behind weatherboards. Damp proof course data. Recent building extensions, especially if on new concrete floors. Aeration of rooms.

Attack data

Location of attack (floor, walls, higher or low, SE, NW, bathroom etc.). Timbers attacked, hardwoods or softwoods and whether treated. Building flaws that are found to be contributory to the attack. The extent of attack and time taken. Any spore dust deposits or odour."

TOPIC 3/43
NEW CONCEPTS AND STRATEGIES IN PEST CONTROL
by J.R.J. French

The topic to be discussed will be the main problems and ecological consequences of present pest control practices and the offering of alternatives as future strategies. Inherent problems in the present forest products pest control strategies, viz:-

(a) plant quarantine,
(b) chemical pest control practices,
(c) community attitudes.

Suggestions for future strategies

1. Alternatives are needed to replace the chlorinated hydrocarbons, and if possible, organophosphates and carbamates. Third generation insecticides, or insect growth regulators, suggest a new approach. Analogues, mimics and antagonists of these compounds such as Juvenile Hormone (JH) (homosesquiterpenic esters) and ecdysone (steroids) may provide the basis for a new approach.

   Application (orally or topically) of these biodegradable compounds will hopefully replace the presently used compounds which have unwanted ecological effects. Currently, we are investigating the effects of several JHA on pests in this laboratory.

2. Use of micro-organisms as attractants and pathogens. Again, we are investigating this line of approach.

3. Governments should encourage and help in the development of new candidate pesticides which limit ecological deterioration.

4. Bio-assaying pesticides on target and non-target organisms.

5. Internalizing the effects of the pest control industry at all levels of the community.

6. Introduction of environmental impact statements as a built-in safeguard to governments and society - and placing a 'legal freeze' on technology.

7. Need for effective systems approach in the practice of of pest control (or management) and the introduction of integrated pest control (basically, control with occasional small scale use of pesticides).

8. Co-operation by governments at the international and local levels in the field of pest management.

TOPIC 4. RESIDUE DISPOSAL AND UTILIZATION

CHAIRMAN: W.G. KAUMAN

TOPIC LEADER: D.E. WEISS

TOPIC 4/1
WOOD FIBRE-PLASTIC COMPOSITES
by D.E. Weiss

As part of the program following from the establishment of a Wood Waste Committee within the Forest Products Laboratory, the Division of Applied Chemistry has begun a long term program aimed at preparing composites containing a high proportion of lignocellulose fibres within a small amount of a continuous polymeric matrix. The fibres could be prepared from sawmill residues.

One product has been made from a mixture of *Pinus radiata* sawdust and bark. Tannins within the bark are polymerised by reaction with formaldehyde to form a polymer matrix which binds the sawdust together. The composite has properties comparable with those of a hardboard.

Another type of composite is being studied in which the continuous polymer matrix is a thermoplastic.

TOPIC 4/4
MOULDED PRODUCTS FROM THE BARK AND SAWDUST OF *PINUS RADIATA*
by A.J. Michell and W.E. Hillis

Mature *P. radiata* bark contains about 20% condensed tannins which can be extracted and used as a base for a valuable wood adhesive. The bark can be readily powdered and in this form it readily flows under heat and pressure. The possibility has been explored as to whether a mixture of wood particles, powdered bark and formaldehyde-producing compounds could be moulded into shapes such as channel sections and boards which could be formed in a continuous process. The capacity of the bark for flow indicated that internal or external reinforcing could be used. If successful, the bark could be completely converted into products of significant value, its disposal problems greatly reduced and the tree more efficiently utilised.

In order to produce material suitable for laboratory testing, air-dried pine sawdust (12-24 mesh) and powdered bark (100 mesh) were mixed, then a calculated amount of water and ammonium chloride or alkali added according to the conditions required. Formaldehyde (2% on bark) in the form of paraformaldehyde or hexamine was added, the whole thoroughly mixed and hot pressed without delay, usually in the form of boards.

It soon became apparent, in agreement with earlier work by Bryant, Humphreys and their colleagues at the Wood Technology Division of the New South Wales Forestry Commission, that the production of strong boards required a minimum initial moisture content. It also became clear that boards made from mixtures having excessive moisture contents suffered from the destructive release of steam when the external pressure was released. No significant improvement was effected by using a wire gauge similar to that used in the production of wet process hardboard nor did the substitution of bark from which the wax had been removed by extraction appear to have much effect. It was found that the steam release was best controlled by pressing for five minutes at the higher pressure (4.2 - 7.0 MPa) and then for ten minutes at a pressure (0.4 MPa) just below that of the steam in the board.

The properties of the composite boards are compared with those of hardboards and of woods in Table 1. As can be seen the composite boards are as dense as tempered hardboard and show similar crushing resistance and ability to absorb liquid water; their modulus of rupture, however, is comparable only to that of standard hardboard whilst their dimensional stability is inferior to both types of hardboard. There does not seem to be any correlation between the amount of water taken up during humidity cycling and the changes in linear dimensions nor between these results and those obtained from experiments with liquid water. It appears that although the bark and sawdust particles are bonded by a water resistant adhesive this adhesive does not completely coat the particles leaving opportunities for the uptake of water. The linear hygroexpansivity of the boards would, therefore, be attributed to the uneven distribution in the board of materials capable of swelling when exposed to water vapour.

Dry processed hardboards pressed at higher temperatures are known to show better dimensional stability than those pressed at lower temperatures. Some experiments have been carried out in which the boards have been pressed at temperatures up to 225°C (cf. 160°C used normally). The dimensional stabilities of these boards showed only marginal improvement. We have not yet attempted to improve the water resistance of the boards by the addition of waxes. However, one of the advantages of such a composite material is the possibility of improvement of properties by the use of additives. As well as waxes, fire retardents could be added as might glass fibres or various meshes as reinforcement.

We have moulded some channel sections which from geometrical consideration might be expected to give a 50% increase in bending moment compared to a solid strip made from the same amount of material. However, with the problems encountered in distributing the pressure evenly throughout the material in the simple channel die available, the maximum bending moments obtained were only about 40% of that expected from calculations.

Attempts have also been made to extrude the powdered bark and sawdust. Because of the need for the material to be heated for flow and cure most experiments were made with screw extruders. By using a non-compressive screw short lengths of extruded material of simple cross-section were obtained. However, breaks soon occurred accompanied by puffs of steam indicating the need for a vented barrel. The possibility of using a ram extruder was also investigated. However, experiments in which the tannin was squeezed out onto the sawdust by cold pressing and the mixture then heated indicated that an aftercure could not be obtained simply by heating.

TABLE 1

Comparative Properties of Materials

Property	Composite Bark-Sawdust	Hardboards		Woods	
Density (gcm^{-3})	1.04 - 1.12	Medium Standard Tempered	0.48 - 0.88 0.88 min. 1.09	*E.regnans* *P.radiata*	0.64 0.51
Modulus of rupture (MPa)	24 - 28	Medium Standard Tempered	7 28 42	*E.regnans* *P.radiata*	112 84
Crushing strength (MPa)	40	Standard Tempered	22 40	*E.regnans* *P.radiata*	60 40
Water absorption on soaking for 24 hr (%)	15 - 20	Medium Standard Tempered	30 25 18	Not measured	
Linear variation with change from 47-90% RH (%)	0.8 - 1.0	Standard Tempered	0.21 0.27	*E.regnans* *P.radiata*	∿ 4 ∿ 3

TOPIC 4/9
TOTAL SAWMILL WASTE INCINERATION AND STEAM GENERATION
by L.S. Barker

Unlike the basic philosophy behind the other papers presented this morning, it is to be hoped that the subject matter of this paper will be of relatively short term importance, and that the long term beneficial use of waste materials will ultimately eliminate much of the need for incineration. However, there is an immediate and pressing need for improved incineration equipment, and it is to this end that this paper is directed. As a comment relating the two fields of waste utilization and waste destruction several of the previous utilization papers have indicated major energy input requirements for the proposed processes, and it could be that some waste components could meet these energy requirements to process the balance in utilization systems.

The major proposition which I have endeavoured to put forward in this paper is that there is to date no readily acceptable economical answer to the incineration of wood wastes, even when this incineration is coupled with a heat utilization system. Thus, there is a need for investigation and design aimed at developing an incineration system which will meet industry's need for widely variable waste input volume, will meet Clean Air Act emission levels, will be relatively less expensive in relation to capacity than existing equipment, and will be suitable for utilization as a heat source for steam generation.

Traditionally, the design and construction of incinerators, boilers and other types of heat exchangers has tended to be carried out by separate organizations which specialize in one of these three fields, but rarely cover the scope of all three. The purpose of this discussion is to suggest that the time has arrived when these various aspects of combustion engineering should be considered as one subject, in the context of the particular conditions which apply in the timber industries. The developing attitudes to atmospheric pollution are forcing industry to make a complete re-assessment of the economics of incineration and steam generation, with particular reference to the opposing needs for high capacity variable input of the incineration system during the hours of production, and the more or less steady lower level heat demand on a twenty-four hour basis.

The problems are not only those of combustion engineering, but are also those related to material handling techniques, since the transport, storage and subsequent recall of wastes for fuel usage or for controlled-rate incineration pose questions of at least equal complexity and importance as those of the combustion processes themselves.

The Division has designed a high temperature incinerator, the prototype of which is approaching completion, and it is possible (but by no means certain) that this may give a lead to further work on the subject, in that it is aimed at the incineration of waste at a variable input, and to yield high temperature flue gases hopefully suitable for utilization in a waste heat boiler or other heat exchanger. However, even if this design is found to have some measure of success, a great deal of work will remain to be done both in emission control and in heat utilization. It is to be hoped that industry itself will take a more direct part in this work in the future, and that a co-ordinated effort from research bodies and industry will produce an answer which will also be feasible on economic grounds.

TOPIC 5. WHOLE TREE - ANY TREE UTILIZATION

CHAIRMAN: F.R. MOULDS
TOPIC LEADER: J. SMART

INTRODUCTORY REMARKS
by J. Smart

These topics were closely inter-related and introduced two main areas which appeared to merit specific attention in research:-

1. Utilization of small logs
2. Behaviour and control of chip stockpiles.

Re (1), it was recognized that the situation is dependent not only on actual log size but also on tree age and species characteristics.

It is also influenced by the scale of operations and on the particular management practices which are to be employed since these can determine, for example whether the design of any new milling unit is required to cater only for a restricted size range or for a mixed size input, as under a selective logging regime.

There is therefore a need for work to be done to establish the most economic scale and type of conversion operation possible within the particular constraints applying in both the high volume, even-age situation, and also in the selective cutting type of operation involving relatively low yields of small sized material admixed with larger logs.

There is also a need to study the log characteristics in both young and old small-sized material to develop log grading requirements.

Re (2), it was felt that the initial work done in T.P.N.G. should be extended to the mainland where the chip and environmental conditions are so markedly different.

It was recognized that, with the magnitude of operations involved, even relatively small losses in quality in chip piles may well have significant economic consequences.

There exists a need to look at possible changes in chip behaviour which might occur as the nature of the operation shifts from mature wood to regrowth material.

It was felt that the very interesting and promising biological control work such as the use of bacterial solutions, should be continued and extended, bearing in mind its possible potential extension into the fields of controlling degrade of logs and sawn timber in storage.

TOPIC 5/2
THE EFFECT OF STEM STRAIGHTNESS ON SAWN RECOVERY
by W.J. Smith

In presentation, the following was substituted for the third paragraph:-

"Analysis of the data is still not complete but some results of interest are available.

It has been stated elsewhere that, in *Pinus radiata*, variation in stem straightness had no significant effect on percent recovery of sawn material.

In our trials of 18-19 years old *P. caribaea* and *P. elliottii* from matched plots over three site index classes at one location in south-east Queensland, a low-level but statistically significant positive linear relationship was shown to exist between tree straightness score and percent sawn recovery on true volume for both species (0.313*, n=41 for *P. caribaea*; 0.268*, n=62 for *P. elliottii*), when data from the three sites was pooled.

Variation in average log size between sizes had an effect on recovery, as shown by the also low-level but significant relationship exhibited between stem basal area and percent recovery for the pooled data (0.542* for *P. caribaea*, 0.328* for *P. elliottii*).

When the pooled data from the three sites was stratified to test the percent recovery/stem straightness relationship within only one site index, the correlation coefficients for two of the four *P. caribaea* plots and one of the four *P. elliottii* plots (r=0.7105* to 0.8462**) were more meaningful (the remainder were non-significant).

It would appear from the data there is an overall relationship between percent sawn recovery and stem straightness, but that percent recovery depends on the combination of a number of stem, stand and locality factors, and studies are continuing to investigate this further.

The significant stratified relationships indicated that, for each unit improvement in stem straightness over the 4-8 range of a 0-10 subjective rating scale, sawn board recovery on true merchantable volume increased by from 4½% to 5½% in these samples of slash and Caribbean pines."

TOPIC 5/10
PLANT FRACTIONATION
by G. Gartside

The plant fractionation programme results from the I.P.P.I. philosophy. In this we are interested in a total design system that eliminates waste from the processing of plant materials rather than in the conventional waste utilisation schemes.

A study of existing plant fractionation techniques is being made in order to provide data for preliminary economic assessments which will indicate the probable areas for the development of the concepts and to indicate the key technical and economic areas that require further investigation.

Primary fractionation equipment has already been established at the Division of Animal Physiology in Sydney, thus facilitating the animal feeding trials. The equipment consists of a Pirie Pulper, sample scale sugar cane rolls, and a roll press. The pine pulper is a hammer mill with multiple rows of cylindrical pins placed around the rotor. This has been developed in the U.K. for maximum protein extraction from leaf material. The sample sugar cane rolls are designed for a throughput of 500 kgs/hr green material. The milling here is done by shear due to differential movement between interlocked grooved rolls. The roll press has been designed by us to squeeze juices out of the milled material. The design is based on experiences with small scale textile squeeze rolls. In addition to these there is the extensive processing equipment located here at the Forest Products Laboratory for use in work on the fibrous fraction.

As we now see it the primary fractionation techniques will yield three components, viz:-

1. the green juices containing water soluble nutrients, i.e. sugars, proteins, some fats and carbohydrates, etc.; this fraction will be of value for animal and human feedstuffs.

2. the fibrous fraction for possible uses in the existing paper technology but more likely of use in the new areas of dry forming and high fibre content plastic composites.

3. a cellulose and nutrient fraction that will contain the residual material after the extraction of components (1) & (2) and this should also be of value in animal feeding.

The aim is to achieve the highest purity levels of components (1) and (2) consistent with acceptable costs.

We are looking at three areas of plant species. Firstly the plants with a high percentage of soluble nutrients, e.g. lucerne, pasture grasses. The second is of plants with possible high grade fibre as well as large amounts of nutrients. Here we have,for instance, the tropical grasses kenaf and napier grass. The third area is the high fibre plants that is trees. These plants have a separable nutrient component, the leaves and growing tips that are at the present little utilized.

The third area is of particular interest to this meeting and is one of the areas in which we feel there is a real chance of success for the concepts being pursued. Earlier speakers at this conference have talked about the 'whole tree' concept, and it is evident that economic development will depend in part on the utilization of leaf and small branch material. As part of our studies we will be experimenting with leaves from *Eucalyptus* and *Pinus* species. Here for instance we see the possibility of simultaneous extraction of proteins and essential oils leaving a residue suitable for mulching or animal feeding.

In conclusion, we have on one hand increased efficiency in agriculture coming from the utilization of integrated fibre and foodstuffs production by the use of novel techniques to provide packaging materials for farm products, and on the other hand an essential part of the 'whole tree' and coppicing concepts coming from the production of essential oils and animal foodstuffs. It seems to me that the application of plant fractionation techniques to further the integration of agricultural and forestry activities will lead to a more efficient use of one of Australia's natural resources, viz. photosynthetic energy.

DISCUSSIONS, CONCLUSIONS AND RECOMMENDATIONS

SUMMARY OF GENERAL DISCUSSION

CHAIRMAN - W.G. KAUMAN

In this Forest Products Research Conference we have in many ways made a new departure. As we emphasized in our first circulars, our intention was to concentrate largely on what we are going to do in the future rather than on reporting past work. We have continued our tradition established three or four Conferences ago of inviting the participation of industry through their associations and we feel that this practice should continue. Perhaps our principal innovation is that we are trying to streamline the process of presenting to the various Australian forest products laboratories, the recommendations of industry on work that they feel ought to be done. Whereas previously we relied on a final general session to prepare a list of recommendations which usually resulted in a long Christmas shopping, this time it is our intention to end up with a very brief list of problems that are genuinely urgent for the development of Australian forest products industries.

To achieve this we have decided to sub-divide the Conference into a number of working groups, each of which should elaborate their recommendations on one or sometimes two of the topics we discussed. I would like now to give to each of these groups a definite brief, as fore-shadowed by Dr. Weiss during the first session, that they should come back to the plenary session tomorrow morning with two, and not more than two, recommendations on research projects they feel should be undertaken. These research projects could be new work or could refer to a desirable extension of work that is already under way. Each should be directed towards a well defined definite project and we hope we will not receive blanket recommendations such as that more work should be done on seasoning or pulping.

If all the groups do their work properly we should have tomorrow morning a list of some ten recommendations on work that this Conference considers desirable. The plenary session should consider these and as far as possible make some judgement on relative priorities and recommendations made by different groups.

Following this, heads of Australian forest products laboratories and senior officers from the forests commissions will consider these recommendations and decide which of them can be accepted as the most suitable for projects to be undertaken during the next two years. I do not anticipate that all of the recommendations can be accepted but we will report back to the full Conference tomorrow afternoon with a definite programme saying which have been accepted.

It is my belief that we achieve more significant results if we have a commitment from the laboratories to undertake, say, five projects rather

than ending up with a list of fifty projects that probably will not be looked at until the next Conference.

We must remember that there are two facets in forest products research today, as was brought out during the Conference. There is the traditional aspect - seasoning, sawmilling existing materials - and we are active in improving these processes and helping industry with today's problems. Then there is the new field of what ligno-cellulose fibres can do for us in the future - maybe as the basis for new building materials - and Dr. Weiss's team is working on this aspect.

During our general discussion this morning I would like you to take up the major points that have come out during our discussions. I think the significant questions are those which appear rather provocative. Without attempting to be exhaustive I want to start off the discussion by repeating a few of the points that, to me, appear to be particularly significant.

When we discussed wood quality the question was asked by John Wright whether it was really so important to learn more about the scientific, physical and mechanical properties of wood and whether more attention should not be given to the macroscopic properties of the tree and log. I would be happy to hear some argument and opinion on this.

When we talked about timber for construction, Bill Keating asked whether one could justify the large amount of money spent on this research when the industry on the one hand and application on the other made so little use of it. He made some gloomy predictions about the failure of the timber industry to supply higher quality building material and I hope some of you might have an answer to this. It is a truism to say that quality must be adequate - let us not forget, however, that an over-designed product with quality that is greater than necessary, and increases cost, may be as detrimental to the industry as a poor quality product.

During the Bio-deterioration session we had strong views put forward by John French and J. Foxton about the impact of our work on the environment and this is a subject on which the Australian forest products community should have opinions. It would be good for the industry to which we all belong if we could agree among ourselves on the stands to be adopted before we go the general public.

The utilization of small hardwood logs brought out mainly economic factors and an interesting difference came out between the regrowth material in Victoria and the somewhat older small logs in Tasmania. Should we not give more attention to a more efficient utilization of the resource as was brought out by Frank Moulds from the Chair in his parable of the prodical son referring to Victoria's 1939 mountain ash regrowth?

Similarly on whole tree-any tree utilization, I would like to hear some expressions of opinion about the concept put forward by Dr. Weiss and Geoff Gartside on photosynthetic process industries and how one might look at the eventual future of the use of timber as a building material.

REPORTS FROM GROUP DISCUSSION LEADERS
CHAIRMAN - W.G. KAUMAN

TOPIC 1: WOOD QUALITY ASSESSMENT
Topic Leader - W.E. Hillis

HILLIS: Mr. Chairman, we have two recommendations. The first one reads:

"An investigation of the between-tree and between species variability of wood quality determinants such as growth stress gradients, basic density and fibre dimensions amongst shorter rotation eucalypts intended to be the subject of intensive regeneration programmes and tree improvement work."

As a rider to this, this Conference recommends that forest services place more emphasis on eucalypt tree improvement programmes.

Recommendation 2 concerns: "The origins, development and prospects of amelioration of defects of importance to the consumers."
The individual defects studied will depend on the species and the environment. Specific problems to be considered are associated with distortion potential, kino veins, surface deterioration, knots and stability.

TAMBLYN: Mr. Chairman, in that first resolution I note you make no suggestion that any work be directed to the permeability of these timbers to preservatives. I think that permeability is an important characteristic; in the more durable timbers we want impermeability and in the less durable timbers we want some preservative permeability and I wonder whether you could include in your recommendation that permeability be assessed.

HILLIS: We did consider permeability in this but we felt the recommendation was getting too omnibus.

KAUMAN: May I propose that any general resolution of recommendations to forest services and other bodies be embodied in resolutions of the conference which we will be discussing later and that we confine ourselves to specific recommendations for research working during the next two years during this session. We are not trying to make a list of subjects on which it would be desirable to do work; rather we are proposing subjects which may be the topic of a specific research project during the next two years.

DA COSTA: I think that permeability could be only one additional word in the recommendation and is very important. I have within the last few weeks arranged that when the Forest Research Institute is conducting intensive sampling of mountain ash near Traralgon they cut out some samples and send them down to us. Once the material is collected about 80% of the work required has been done. I intend to do preliminary work on this within the next six months. Its a very important field of current research and I think it definitely should be included in the resolution.

HILLIS: I also consider that permeability is a most important aspect. We did have before us very strongly to keep it down to something which could be accomplished within two years. I agree with you the collection is a very significant part of the project, and it would be a tragedy if permeability wasn't investigated.

KAUMAN: May I suggest then that we include it for the time being. We will discuss the matter,of course, with the Heads of Services in the later session this morning in the light of what facilities and what resources we have.

TOPICS 2 & 5: UTILIZATION OF SMALL HARDWOOD LOGS AND WHOLE TREE ANY TREE UTILIZATION
Topic Leader - J. Smart

SMART: I might say that the discussions were worthwhile and stimulating. The two main areas that the group considered merit specific attention to be received at this stage involved firstly the utilization of small hardwood logs, and secondly the behaviour and control of chip stockpiles.

In the first item, the small hardwood logs, it was recognized that the situation in this regard is dependent not only on log sizes and the tree age but also on species characteristics. It is also influenced by the scale of the operations which are envisaged and their management practices which will apply in the particular area involved. For example, the milling complexes should be built to handle restricted log size ranges, as compared with the situation which could apply in much of the rest of Australia where handling of mixed size inputs will be required; therefore the need for work to establish the most economic scales and type of operation possible within these particular constrants and also the need to study the log characteristics in both young and old small size material to develop log grading requirements.

With regard to chip stockpiles it was felt that the initial work that has been done in New Guinea should be extended to the mainland where chip and environmental characteristics are markedly different and it is recognized that with the magnitude of operations involved, even relatively small losses in quality of chip piles has very significant economic consequences. It is felt that the promising biological control work which has been initiated and has been commented on at this Conference should be extended into other fields such as controlling the degrade of logs and perhaps sawn timber.

So therefore the two recommendations the Group has put forward are, firstly:

"That, as matters vital to the successful conversion of small (less than 5 ft. centre girth under bark) hardwood sawlogs, investigations should be carried out into: (a) sawmill scale and process design, and (b) development of log grading requirements as related to specific end uses and management regimes.

The second recommendation is:

"That investigations be made into the changes occurring in woodchips in outside stockpiles in Australia. Such investigations do include aspects of biological control of chip degradation and also the possibility of their wider application within the timber industry.

TAMBLYN: What do you mean by "biological control in wood chip piles having wider application within the timber industry"?

SMART: It was mentioned briefly, but that's partly my own interpretation. The question is, has this sort of thing a possible application in the control of decay deterioration and staining, in logs or in sawn timber?

DA COSTA: Biological treatment, distinct from biological control, has got other possibilities apart from wood chips, particularly in things like biological incising of sapwoods for easy treatment as is done in Europe.

TOPIC 3A: STRUCTURES
Topic Leader - A.P. Wymond

WYMOND: The Structure Group had a wide area to cover. Although we have only one resolution, we have a number of comments we'd like to make to the Conference. The Group considered lamination to be of particular importance in view fo today's shortage of timber generally, and particularly in some of the structural uses as in house building. The Group wishes to stress that adequate information is already available on lamination of structural members as the result of work carried out already, but there is need for a document to promote this information. We had considerable discussion on this question of reconstituting wood, that is with or without additives, to produce pressed or extruded sections with uniform, constant properties for structural purposes. The group appreciated that this topic would be discussed, or we hoped would be discussed, at length by another group, but it felt that as it was of particular importance to our area of interest, we recommend to the Conference that high priority be given to any proposal for work on reconstituted wood for structural applications.

Mr. DaCosta presented us with a recommendation calling for "urgent evaluation of the parameters governing the incidence of condensation on wood and buildings". Whilst the Group readily agreed that this was a problem area, no value could be seen in any recommendation at this stage due in particular to the tremendous range of completely uncontrollable variables which must be faced in any such investigation.

Now, finally, considerable time was spent by this Group discussing the work on panel type construction and rationalized foundation and framing systems. Both of these projects were considered to have considerable merit. However, both projects appear to be of a stage necessitating a removal from research to development and the research team does not

necessarily have the expertise to take the project to that stage. We therefore wish to propose the following recommendation to the Conference:

"The work on panelized structures and rationalized frame is particularly endorsed and remaining work should be expedited, and that the CSIRO, D.B.R. set up a techno-economic development team to take these and other projects of a like nature to a total design stage once they are capable of assimilation by industry."

It was further recommended: "That industry should be approached for funds to finance this work".

DA COSTA: If we're going to do research work some of the efforts of the group would be better expended in attempting to develop the necessary expertise to solve the problem of condensation which is already affecting hundreds of thousands of houses in Australia.

This is a difficult problem, and this is an extra reason to try to get research done on it. I suggest that: (a) this is a problem of structural design, and (b) there hasn't been enough physical evaluation by physicists and engineers of the various parameters involved. We can: (a) suggest that in the meantime we should aim for a high standard of sub-floor ventilating, and (b) more importantly, we should make every effort to make use of soil cover common, perhaps we should even make it mandatory in certain circumstances.

WYMOND: I must say that the group was at a distinct disadvantage in not have somebody from the area of particular interest within our ranks. This question of ground cover was mentioned and in fact the group wondered whether there shouldn't be some mandatory clause in building regulations that the ground should be covered.

FOXTON: My comment is on the resolution itself and I'm interested in the move from research to development and I'm more particularly interested in the use of an expression like "techno-economic development team". I'd like to see some kind of direction on that kind of hearing either in this motion or indeed in all motions that have anything to do with the market, but does it imply carrying research through the development stage once it is known that the market really does exist?

BRYANT: I took the view concerning the sub-floor ventilation problem that a solution does exist in the use of a membrane. Its not a very costly one and in the light of the amount of work that one might have to do to get to the stage where a prediction can be made, this seems to be worthwhile.

DA COSTA: Could the resolution be read out.

WYMOND: This is the recommendation:

"This Conference recommends urgent evaluation using existing data and known physical relationships of the paramaters governing the incidence of condensation on wood in buildings with special reference to condensation on flooring and within the wall cavity of wood frame houses. This is required in selecting the critical parameters for future experiments or surveys and choosing among recommendations for ventilation in various situations."

TOPIC 3B: WOOD PRESERVATION
Topic Leader - N. Tamblyn

TAMBLYN: The Working Group for Topic 3B, Wood Preservation and 3C, Biodeterioration, was a large one with a broad field to discuss covered by twenty-three papers. I will summarize only the main areas of discussion and recommendations made to the wood preservation topic.

The group firstly discussed the need to develop new procedures and preservatives and problems of environmental toxicity. It was generally agreed that this was an area of vital concern with preservation but that at present we could work only with the tools in hand and might even be forced to use continued compounds such as "dieldrin" in relatively safe applications until the effectiveness of such agents was established. It was decided not to make a resolution on this.

The group then discussed into considerable length the need for an organic solvent preservative treatment to stabilize and improve the weather resistance of exterior building timbers and of other dressed timber without incurring the re-drying and degrade problems associated with the use of waterborne preservatives. In stressing the need for this development the point was clearly made that this was a special application and was in no way a condemnation of existing CCA treatments. A recommendation was made that this work be given high priority.

Discussion then centred around the need for more effective treatments of timber in marine use. It is considered to be an area of immediate importance if hardwood piling is continued to be used in warmer waters, and the group agreed that a recommendation on this should be submitted.

Although two papers on rail sleepers were included under Topic 3A, they did not specifically express the need for future work to improve rail sleeper fastenings. This was considered to be an essential development if maximum life is to be obtained from treated sleepers. A resolution was made on this drawing to the attention of Group 3A the need for suitable recommendations.

The two recommendations and the resolution are as follow:-

Recommendation 1:

"It is recommended that the D.B.R. and the State Forest Services should regard as urgent development of a stabilizing organic solvent preservative pressure treatment for exterior building timbers and pre-machined timbers and should cooperate closely with industry in this development."

Recommendation 2:

"It is recommended that the screening work on new preservatives and coatings for marine timbers which is already proceeding should be given high priority."

Resolution:

"In the event that no recommendation on the need for improved rail sleeper fastenings eliminates from Committee 3A, it is resolved that this matter should be given urgent attention in cooperation with railway authorities."

TOPIC 3C: BIODETERIORATION
Topic Leader - W. Da Costa

DA COSTA: The Working Group discussed at length the severe soft rot found in recent years in preservative-treated eucalypt sapwood in ground contact, especially in northern areas. This problem has been reported only from Australia, apart from some cases in New Zealand, and a very few abnormal cases in other hardwoods overseas. All eucalypts yet examined are severely affected but pines and some other hardwoods are not. At present no effective method of control is available. Several maintenance treatments are being tested on a large scale in Queensland and aspects of the problem are under investigation in several laboratories. More field research is urgently needed, including testing of various rain forest timbers in Queensland and Papua New Guinea, and assessment of the environmental factors governing severity of attack. It was agreed that more basic knowledge of the nature and the mechanisms of attack of the associations of fungi and bacteria involved was essential for the development of better treatments. We also need more detailed study of preservative distribution and of chemical fixation reactions in various timbers. The Working Group suggests the following recommendation by the Conference:-

"This Conference recommends urgent investigation on the problem of severe soft rot in treated eucalypts and other hardwoods, including: (a) biological research; (b) immediate evaluation of remedial treatments for infected poles; and (c) the development of more effective initial pole treatments."

The Group also discussed the centre rots found by the S.E.C. in Victoria in 5-10 percent of treated poles over 15 years old. These rots, occurring in poles with Class 3 durability heartwoods, could cause sudden collapse of a power pole and are a danger not only to linesmen, but also to the general public. The problem is complicated by lack of rapid reliable methods of detection of decay in its early stages and by the possibility that some of this attack may have been due to unsatisfactory control of treatments in the early days of pole preservation in Victoria. The Working Group suggests the following recommendation:-

"Recognizing the potential safety hazards of centre rots in treated transmission poles of durability class 3, this Conference recommends immediate surveys of the incidence of these defects, the development of methods for the treatment of standing poles, and the evaluation of the use of diffusible preservatives in the inital treatment of these poles."

The Group discussed our lack of knowledge of those aspects of the biology of organisms attacking timber in marine environments which would be relevant to their control, but decided that no members of the Conference would be in a position to investigate them.

It was felt that the several new wood-based materials described at this Conference (and new construction methods) should be assessed for their liability to deterioration and any need for preservative treatment considered at an early stage of development.

TOPIC 4: RESIDUE DISPOSAL AND UTILIZATION
Topic Leader - D.E. Weiss

WEISS: We are all aware and agreed on the urgency of the current research on incineration, but since this has been progressive to the stage where field trials are about to commence it was felt that little further could be done other than to ensure as rapid a conclusion of those trials as possible and to ensure that full resources were available to assess the air pollution aspects of it. It was agreed that we in Applied Chemistry would look into the possible application of a relevant instrumental technique which we have been devising for other purposes.

The two recommendations in order of priority which were agreed upon are as follow:-

"F.P.L. Should make in cooperation with the appropriate industry organizations, Forest Services and State Departments a more detailed survey of location, quantities and type of forest products residue with the objective of offering advice on the most appropriate method for their utilization. Such a survey would provide useful outlets for current F.P.L. research on residue utilization."

It was felt that really one has to get down to specific location, specific situations, to make effective use of the extensive research that is in progress in the laboratory.

The second recommendation is as follows:-

"F.P.L., and particularly the D.A.C., should give high priority and devote substantial effort to developing useful composites from mill residues in the short term and from primary resources in the long term in order to maintain a place for wood-based materials in the markets in the future. Such a programme involves research in adhesives and adhesion, surface finishes and protection, comminution, dehydration and forming."

I think we all felt that in the short term the pressing problem was to meet the E.P.A. regulations relating to incineration, but in the long term a more satisfactory solution would need to be found. A long term answer is much more likely to come from production of composites and the like by taking advantages of particular local situations. We in our Division should pay particular attention to the processing, and of course Building Research would come increasingly involved in the assessment of the product as building materials.

GENERAL, OPEN DISCUSSION ON ALL TOPICS

CHAIRMAN - W.G. KAUMAN

KAUMAN: Our programme calls for a general discussion on all topics from 10.45 to 11.30 and this will be followed by the Policy Session. During this three-quarter hour session I want to report to you briefly on the previous conference, the 15th Conference, and also the Timber in Housing Conference. Before and during this meeting I have been asked by a number of people what has been done, if anything, on resolutions for previous conferences and I think this is useful background. Then we will go back to the resolutions and recommendations presented in the earlier sessions this morning and I would like to have some expressions of opinion whether this meeting considers some topics more important or more urgent than others, and then finally, I would like to have notice of any general resolutions that members wish to present this afternoon.

As the next item, let's discuss the 15th Forest Products Research Conference which was held in May 1971. There was a motion passed that these conferences should continue. It was agreed that the format should be in general terms the same as last time. We have discussed a number of selected topics, rather than having a discussion of all disciplines of forest products research and this seems to have worked out quite well. This afternoon there will be opportunity to discuss the future of these conferences. There were suggestions made during the last conference for new or extended research topics. In fact, thirty-one recommendations were made. I don't think it would serve any useful purpose if I read them out in detail. They are, of course, included in the proceedings of the last conference which all members have. They came under the headings: Conversion, Harvesting Preparation etc., Utilization General, Environmental Problems, Pulping of Chips, Wood Preservation, Surface Preparation etc. I don't claim absolute accuracy for this survey but I have gone through them and find that out of the 31 topics I can say reasonably truthfully that 9 have either been done or are under way. Another 11 I would say are being looked at, though I don't think they have been either completed or are the subject of any major work at present and the other 11, as far as I can see, have not been tackled although some people might have considered them. My figures on more detailed investigation might be a little bit out but I think they give general idea of the picture.

Before I ask for comment I also want to report on a conference that was held at this Laboratory in November 1971 and was the outcome of a suggestion made during the 15th Forest Products Research Conference, namely that a specialized meeting should be held on Timber in Housing becuase of the obvious importance of housing as a market for timber. It was very well attended, and continued for 3 days, and those who participated have received the proceedings. This meeting on Timber in Housing made a number of recommendations, 18 altogether. Of these I consider that 4 either have been done or are being done, 5 are being looked at, another 3 I don't think have been tackled at all, I'm not quite sure about 3, there were 2 where no action was required, and there is one which we have to discuss this afternoon. I'll read this out:

"The question of future conferences of this nature (that is specialized conferences on specific topics within forest products) should be considered at the next Forest Products Research Conference".

Consideration of any future meeting should also include the question of the desirability of other participants such as the housing authorities submitting items to the Agenda. I want to discuss this subject this afternoon when we talk about the future of this conference. There were also at the Timber in Housing meeting two resolutions; the first one was:

"This Conference endorses the proposal that integration and rationalization of standards and codes relating to the use of timber in building be pursued with all possible speed",

and the second one:-

"This Conference notes and endorses the move to reactivate the national paint committee".

I don't know whether anything has been done on this since November, 1971.

CLIFFORD: That committee has been reactivated and placed under the auspices of the ATPC.

KAUMAN: Is there any comment on the resolution that this conference endorses the proposal that integration and rationalization of standards and codes relating to the use of timber in building be pursued with all possible speed?

SUTHERLAND: Some work has been done in this field, Mr. Chairman. There has been a joint committee on radiata pine and slash pine, and a substantial degree of agreement has been reached but this has been deferred pending metrication and there has also been quite a lot of work, nearing completion as a matter of fact, on the integration of the three hardwood standards.

COKLEY: We still have the position where there are innumerable standards and still more coming out - innumerable building authority regulations and quite frankly I feel that unless we get that rationalized, the earlier the better, our industry is still going to be in trouble.

KAUMAN: I am glad we've had this comment because I believe we should have more continuity and that resolutions made at one conference should be discussed and the follow-up considered at the next conference.

SOUTH: There might have been much more comment had we revised those resolutions in the last day or so in our own minds. In actual fact the numbers that you have given us I wouldn't regard as making an impressive record as percentage of resolutions having received attention, but I don't think we can comment further without having re-brief sessions.

KAUMAN: The next item I have noted on here was a discussion of the resolutions and recommendations. Each group has decided within their particular field and their particular specialty on the priorities. I would like to know whether the Conference considers some topics are more urgent than others.

BRYANT: Mr. Chairman, I notice that there is no mention whatever in any of the resolutions of the importance of transportation. We did discuss this in some length in the conference and we agreed, I think, that logging and

handling of timber from forest to the sawmill and within the sawmill was very important and played a major role in the cost of many products and yet somehow or other we've decided that its not important enough to embody in the resolutions.

GARTSIDE: I think this was implied in the first resolution of Groups 2 & 5.

PAGE: We intended that "process design" cover the whole operation.

KAUMAN: Well would the group like to make amendment to this resolution? Does anybody of groups 2 & 5 object?

RUDLING: No, the recommendation was intended to cover the full range of the economic operation.

KAUMAN: WE now have three suggestions, "traffic", "transport" and "materials handling" - which is it to be? "Materials handling" - all in favour - CARRIED.

KERRUISH: Relating to the second point that was made - there are tentative arrangements for a logging conference to be held in approximately 12 months time which will cover the aspects referred to. The actual specific details have not yet been decided but probably it will be held approximately one year prior to the next Forest Industries Machinery Conference. The theme will be "men and machines" and we're particularly concerned with the operational and training problems being encountered in the industry as opposed to the straight technical problems. We feel that the real problems are, in fact, the lack of skills available to us from the work force,and it will be aimed at this particular point.

RUDLING: If the planned conference could be extended slightly then I think it would cover our requirements. I don't think it goes quite far enough as explained just now.

HARRIS: Mr. Chairman, we have talked about utilization of waste bark in a chemical sense, that is using the polyphenolic content of the bark, but no mention has been made of utilization of Kraft lignin. Now in New Zealand the oven dry production of bark from exotic species amounts to something like 200,000 tons dry weight per annum, whereas the actual amount of lignin produced amounts to something like 380,000 tons per annum. I know this is a very difficult subject and I know that the forest science generally takes the view that we simply can't compete with the petrochemicals. I believe we, as wood scientists, should be looking for the time when the permanently renewable resource can take over from the rapidly expendable resource, and yet I've heard no mention in composite wood structures of using phenolics derived from Krafts, lignins, or any other utilization of these substances, and I wondered: (a) whether this omission could be explained to me, and (b) whether it is in fact National policy to ignore it.

WEISS: Firstly, Adrian Wallis is looking at the chemistry of lignin in

the light of work going on in U.S.A. which has shown that you can reduce wood waste by reaction of carbon monoxide to produce hydrocarbons; we're looking into the chemistry of this, partly as a pulping agent and partly with a possibility, and let's be frank, its a slim possibility, that you might be able to produce liquid hydrocarbons, particularly ethyl benzene which is a source of styrene. The SO_2 pulping work we've been doing with the Division of Chemical Engineering has interesting possibilities in this context because it does produce dry lignin. However, there are difficulties, and I think the reason why lignin based polymers have never got off the ground is a question of quality control and meeting the tight specifications which are essential if you're going to use them in mass production.

KAUMAN: Does the meeting have any further thoughts on relative priorities, relative urgency of suggestions under the different topics?

GARDNER: I think you might have a problem here in that certain topics are very specific to certain areas such as soft rot in the tropical areas, and some might be general like condensation in housing.

KAUMAN: Are there any observations from the promotional organizations from industry? This is one of your opportunities to bring to the notice of research bodies topics that you consider of special importance among the recommendations which have been made.

SUTHERLAND: Would you say that the problems of sawmill waste disposal are acute?

MARTIN: The work of reconstituting wood by the chemical side of the CSIRO should be of number 1 priority so that the structural applications of these things can be brought up in a reasonably short period of time.

SMITH: From the other end of the scale, there's one that seemed to me to be of relatively less importance than the others. That was this question of rail sleeper fastenings since it was only a small element in relation to the total failure of sleepers.

TAMBLYN: Sleeper fastenings are only a minor part of the failure, but as we come down to species that are of low durability and timbers in strength class C, we have a very great real problem in holding the rail down on the sleeper and I think we want very much to use sleepers in these lower strength groups. My opinion is that we will never use these timbers satisfactorily unless we do a lot of work on fastening the rail down on to them.

FOXTON: We are not dealing with the sleeper in isolation. We are really dealing with a whole panel; unless the sleeper is fastened to the rail as part of the panel then the panel doesn't exist and tragedy or economic disruption tends to ensue. I would very strongly press for the inclusion of this most important item as the matter of great urgency.

SMITH: If we are going to consider the utilization of low strength materials then it does assume far greater significance.

KAUMAN: Now I have had guidance on urgencies - are there any other observations?

BRYANT: Recommendation 2 (topics 2 & 5):
"Such investigations to include aspects of biological control of chip degradation and also the possibility of their wider application within the timber industry."
The resolution looks as if its primarily concerned with biological control, but it seems to me that it will be quite a bit of work for other people than biologists because it is conceivable that you could have degradation which would perhaps made the pulp better although it would probably make it worse. Whatever work we do in this field that involves the D.B.R. seems to me also to involve the D.A.C.

WAUGH: I think the urgent problem of handling small logs and the large amount of waste that is going to arise during the harvesting and conversion of this kind of material should be viewed as being important.

KAUMAN: We have received some guidance on the urgency of these recommendations and this meeting agrees to presenting these recommendations to the Policy Session.

Participation in the Policy Session is by direct invitation and the people who are to come along have already been invited. They are the Heads of Laboratories and the Senior Representatives of each State Forest Service.

ADOPTION OF CONCLUSIONS AND RECOMMENDATIONS
ANNOUNCEMENT OF ALLOCATION OF PRIORITIES

CHAIRMAN - R.W.R. MUNCEY

MUNCEY: Under Topic 1, the first recommendation - the investigation of between-tree and between-species variability - both the D.A.C. and D.B.R. will be extending their activities in this area and the W.T.D. is certainly interested and will collaborate in activities, particularly as they relate to N.S.W.

In the recommendation number 2, I think everybody will appreciate that this is not an activity that will produce rapid results and D.A.C. and the W.T.D. will be consulting and thinking of the situations to some extent, especially for N.S.W. and at the next conference there may well be some comments to make as to what action there has been, but I think we clearly can't expect results at that stage.

Under Topics 2 & 5, the recommendation number 1 - D.B.R. accepts that some extension of activity in this area should be undertaken. No. 2 is an area which is active at the present time and will continue to be active, especially with respect to P.N.G. but certainly an eye will be kept on the situation if it relates to Australia.

Under Topic 3a, Structures, recommendation 1 - the Queensland Department of Forestry expects to undertake some survey activity in this area, and the D.B.R. has decided that a major discussion within the Division should be held on the matter. Mr. DaCosta will be convenor of that group.

Under recommendation 2 - the D.B.R. has promised that it will look at this matter; it is by no means satisfied at the present time that, in relation to this sort of thing, the techno-economic team as proposed is the right way of handling it. There is no question that further extension in this area needs to be considered.

Under Topic 3b, Wood Preservation, recommendation 1 - the D.B.R. is interested in this area and will extend its activities.

Recommendation 2 is an activity already proceeding within the D.B.R., and that will continue at the present level; we cannot promise extension.

In the matter of rail sleeper fastenings (un-numbered resolution), D.B.R. is interested in this area and probably will need some discussions in consultation before the best way to handle it can be decided. We have undertaken to convene these consultations.

Topic 3c, regarding Biodeterioration - the D.B.R. will be extending work in biological and bio-assay fields; the Queensland Department of Forestry will be doing some evaluations and D.A.C. may be called upon. We obviously need some co-operation here but we have not, by any means, completely covered the areas suggested under recommendation 1.

Under recommendation 2 - its understood that the most likely Group to be conducting quite largish surveys is the S.E.C. of Victoria and the D.B.R. has undertaken to communicate this point of view to that authority.

Under Topic 4, recommendation 1 – to quite an extent covers activities presently under way and many of you will know that there is a Wood Waste Committee of the D.A.C. and D.B.R. Depending on what is achieved and what the Government offers to CSIRO in the next few months, this activity will be extended or not. W.T.D. will be moving to the field and the D.A.C. has undertaken to convene the activity in this area.

Finally, recommendation 2 of Topic 4 - The D.A.C. is increasing their activity in the very broad area described under this recommendation and the D.B.R. you will note is already active in the field and will certainly continue, probably at around about the present level.

Another subject discussed between the Directors was the location of the next of these Forest Products Conferences. The general body of feeling in this area was that the next converence should be held in Melbourne. There was a suggestion that we should go to Canberra, but this was only supported by, shall I say, a minority of the people there. We didn't discuss a date but I don't think there's very much doubt that some time around May/June 1975 would be the date in people's minds and the exact location within this fair city that will be appropriate at that time depends on what transpires in between the two dates.

Mr. Foxton has a resolution he wishes to propose.

FOXTON: The motion has been read and you now have it in readable form in front of you. The principle that lies behind this is obviously to conserve research funds since it isn't always certain how much money various Government Authorities will have. Moreover, there is a desire in the industry, I believe, to try to have the maximum amount of research and development directed into those areas where the greatest need really applies. It is true that, especially in the field of preservation, the co-operation between the Governmental Authorities and the industry itself is, I think, at a high and increasing level, but it is often necessary for us to sit down and assess which is the most urgent thing to be done. That's why, in fact, so many resolutions come from this Group. In future, however, it occurs to me that it would be advantageous if we crossed over to some of the conventional ways of doing this. I would be the last to want to try to ham string a research scientist. This motion deals essentially with things which are of considerable commercial potential. As a broad generalization I'm going to have to leave it that way because obviously what is considerable and what is essential varies from topic to topic, so if you'll understand me in that broad sense I think we'll get along very well indeed. Then it is necessary to define really what we mean. Should there be potential it can be researched as a concept, it can be an idea before any research is done on it at all. You might, of course, read through the literature and see what has to be done with a particular idea, but before any further research it may be very desirable to go to industry and say "This is the idea that we have which we would like to do some work on. Now if it were successful what would be the likely size of the market; what would people be prepared to pay for it, would you be prepared to install whatever part could conceptually be necessary?" This, in fact, is merely doing a market research on what sometimes is referred to as 'concept market research'.

There's a second area and this is 'attitude research'. In effect I say that

Lon Wymond has been doing 'attitude research' discovering why people think certain things about certain products, then that will be enough to define that one.

Then the third aspect is where you already have done the preliminaries. Its got through the research stage and its had to go that far because the particular concept is not certain and research was necessary to determine just how far you could go. Now before you do any feasibility study or anything else like that, which is quite expensive, before you expend what for the purpose of this exercise I'm going to call development money, then market research would be a highly desirable thing to do, in order to conserve your funds, your time, your equipment; all of these things which are, let's face it, in very short supply, and particularly skilled manpower of the kind that is sitting around the table.

D.B.R., D.A.C. and W.T.D. are, as far as I know,not set up to do any of these kinds of market research. It is therefore desirable that the Divisions claim the assistance of industry, of industry associations who, from their own personnel, should be able to provide the information and if they cannot then they should be, provided that the project under discussion is attractive, prepared to provide some funds and perhaps the Divisions may find themselves in a position to make some sort of contribution towards this as well, so that professional assistance could be hired in order to determine the necessary facts associated with the proposed project. I do hope I've made that clear as quickly as I can - there are many, many aspects to it and I've by no means counted them all, but this is the kind of resolution which I think would help the Divisions in their work without restricting them, without restricting individuals even, and at the same time would be a much more efficient way and by bringing industry into the picture early in the piece.

KAUMAN: Mr. Chairman, I would like to say also that I think it is a very good motion. There is one half sentence at the end on the first reading of these that worries me a little. The second paragraph starts saying "It recognizes that the Divisions are not constituted to exercise this function.." then goes on to say that "..funds are to be provided together with contribution from the Divisions". There seems to be some contradiction in that and I think it might be a little bit difficult for us to accept this as a commitment or a promise that we could contribute when, as the motion itself says, we are not really constituted to exercise this function. If the motion stops after the words "by the provision of funds" then I will certainly be very happy to accept it.

MUNCEY: Having an eye on the clock, I wonder whether the Group generally would be willing to leave John Foxton, Walter Kauman and anyone else who likes to, to discuss the wording over the afternoon tea break and come back and read it to you. I feel that the resolution is acceptable generally but we need to get the words right.

CHAIRMAN: W.G. KAUMAN

KAUMAN: Ladies and Gentlemen, let us maintain our good records we have achieved during the week and run this last session also strictly to time-table. As I told you this morning we will now give an opportunity for the presentation of general resolutions, of which you received notice in this morning's session. We have already anticipated the first one and Mr. Foxton and Mr. Tamblyn and myself have agreed on the wording for this resolution.

TAMBLYN: I don't like the suggestion in this motion and it is essential that research work be vetted by industry before we proceed with it. I am quite sure in my own mind that many,many developments which are promising ones in the mind of the research worker would be knocked on the head straight-away in a market survey. I move that the words "each project" be removed from this motion. My proposed amendment would read as follows:

"That market research techniques be utilized where appropriate".

The amendment was carried.

KAUMAN: So the motion now with the amendment now becomes a motion and it reads "I'll just read out the appropriate sentence - the second last two lines of paragraph 1):

"....in projects involving forest products this Conference recommends that market research techniques be utilized where appropriate".

PAGE: Why are the research branches of the State Forest Services other than N.S.W. excluded? I propose that the words "Wood Technology Division" be replaced by "Forest Products Research Branches of State Services".

The amendment was carried.

KAUMAN: I put the motion as it now stands.

The amended motion as follows was carried:

"TO ASSIST THE DIVISIONS OF BUILDING RESEARCH, APPLIED CHEMISTRY AND FOREST PRODUCTS RESEARCH BRANCHES OF STATE SERVICES IN ASSESSING PRIORITIES, EXPENDITURE OF FUNDS AND THE DIRECTION OF RESEARCH, AND MORE ESPECIALLY DEVELOPMENT, IN PROJECTS INVOLVING FOREST PRODUCTS, THIS CONFERENCE RECOMMENDS THAT MARKET RESEARCH TECHNIQUES BE UTILIZED WHERE APPROPRIATE.

IT RECOGNIZES THAT THE DIVISIONS ARE NOT CONSTITUTED TO EXERCISE THIS FUNCTION AND CONSEQUENTLY ALSO RECOMMENDS THAT THE ASSISTANCE OF INDUSTRY AND INDUSTRY ASSOCIATIONS BE ENLISTED TO PROVIDE SUCH DATA EITHER FROM THEIR OWN ESTABLISHMENTS OR BY THE PROVISION OF FUNDS TO ENABLE COLLABORATION OF PROFESSIONAL PERSONNEL ATTACHED TO THE DIVISIONS FOR THIS PURPOSE."

KAUMAN: I have been handed a resolution by Dr. Higgins:

"In view of the environmental and economic benefits of chipping sawmill

residues, as outlined in Topic 4/8 of this Conference, it is recommended that Forest Departments and Governments should give consideration to encouraging the extension of chipping facilities at sawmills."

HIGGINS: I don't propose to outline the ways in which this might be done already mentioned this morning - I don't want to see the forest services waste more royalties but there are other possible methods which could be considered - tax relief, loans, subsidies and other economic devices which peopole much more qualified than I am are able to suggest. All I want to say is that if we're going to take this environmental question seriously we should give encouragement in those areas where excellent environmental operations exist. This is an outstanding one as far as I can see in the forest products industries, and I don't think a sawmiller should be penalised in any way because he takes the initiative in this respect and should be encouraged,and I would like to leave it to Forest Services that this motion is carried to explore ways in which this can be done, and make appropriate recommendations to our governments and maybe to the Commonwealth Government.

SMART: Could we add to "chipping", "and other methods of waste utilization"?

KAUMAN: If we say "In view of environmental and economical benefits of chipping or other forms of utilizing sawmill residues" - does that cover it?

SMART: Yes

WAUGH: I'd like to move an amendment that the word "economic" be removed from the motion. How can we recommend that an industry has to have some form of subsidization for an economic advantage to the industry?

PAGE: The amendment refers to the economics of the sawmill whereas I think the original proposer referred to National economics.

HIGGINS: I meant economics of everyone concerned. I see the point of the amendment and accept it.

KAUMAN: The motion now reads:

"IN VIEW OF THE ENVIRONMENTAL BENEFITS OF CHIPPING OR OTHER FORMS OF USING SMALL RESIDUES AS OUTLINED DURING THIS CONFERENCE IT IS RECOMMENDED THAT FOREST DEPARTMENTS AND GOVERNMENTS SHOULD GIVE CONSIDERATION TO ENCOURAGING THE EXTENSION OF APPROPRIATE FACILITIES AT SAWMILLS."

Carried unanimously.

SUTHERLAND: Mr. Chairman, I mentioned yesterday the communication gaps between industry and research workers working for the industry and I now wish to move:

"That having regard to the importance of establishing close contact between

research workers and industry this Conference requests all research organizations to establish a system whereby research personnel would be seconded to industry companies for periods of up to six months to work on specific problems referred by such companies through industry organizations to the research body concerned."

Mr. Chairman, I think this has two specific advantages. Firstly, that the research work he is doing would be much more closely related to the problem, and secondly that the commercial organization to which the offer was seconded would be much more likely to implement the research results rapidly than at present time.

Seconded: Foxton

SOUTH: I support the motion. I think what Bob has said - the two reasons for the motion, proposing this, are valid. I think that to have that provision there is good, but I also think that we should realize that this should not reach the state where the progress results of such research didn't become available to industry generally. I think its a good idea that would have to be watched.

MARTIN: My suggestion is that rather than that,industry be invited to send staff here for selected periods of time in the particular fields of training.

KAUMAN: This facility already exists. We have had in the old D.F.P. and also in D.B.R. people from industry for various periods of training. Also, we have seconded people from time to time, under conditions that I won't go into now, to industry to do work that was of mutual benefit. However, we do need approval of our Executive to do this. It depends very much on the particular conditions, whether for instance we agree to pay the man's salary or whether industry takes over the man's salary; all I can say is that it can be done and not make a commitment that every individual case will be necessarily approved

WEISS: I'd like to make one further variation on this. The question is whether or not the information the officer receives or gives has got to be confidential. If it is, then its a matter for Ministerial approval. We have a specific instance now where we particularly want, and we've had a request from industry, for a collaborative programme. We want to put one of our officers to work in this company's research laboratories but in order to do it under realistic arrangements we have to get Ministerial approval, and we're having great difficulty in this.

PAGE: I think the key phrase, Mr. Chairman, is that through industry associations this ensures that its an industry problem; they would nominate the plant they wanted the work done at and this would ensure that the information was available to the industry. I'd like to support the motion as it gets our people into industry and lets them understand the problem at the grass-roots.

KAUMAN: There is one slight change to that which I would suggest from the Chair - it says "to establish a system whereby research personnel would be" - I would suggest "could be seconded to industry".

KLOOT: I'd just like to point out, Mr. Chairman, that that type of operation is not necessarily appropriate in all fields of Building Research. In certain fields in which, say forest conversion people's work, it is quite appropriate; in the structural field it would be quite inappropriate.

KAUMAN: I think that is understood; I had said already that we would certainly not undertake to approve every individual case, every case would have to be considered on its merits. I shall read it again before I put it:

"THAT HAVING REGARD TO THE IMPORTANCE OF ESTABLISHING CLOSE CONTACT BETWEEN RESEARCH WORKERS AND INDUSTRY THIS CONFERENCE REQUESTS ALL RESEARCH ORGANIZATIONS TO ESTABLISH A SYSTEM WHEREBY RESEARCH PERSONNEL COULD BE SECONDED TO INDUSTRY COMPANIES TO WORK ON SPECIFIC PROBLEMS REFERRED BY SUCH COMPANIES THROUGH INDUSTRY ORGANIZATIONS TO THE RESEARCH BODY CONCERNED."

Carried.

TAMBLYN: I should like to move that:

"RECOMMENDATIONS FOR RESEARCH OR OTHER WORK ACCEPTED AT THE PREVIOUS CONFERENCE, SHOULD BE SUMMARIZED IN A PRE-PRINT TOGETHER WITH A BRIEF STATEMENT OF THE ACTION TAKEN."

Seconded - South.
Carried.

DaCOSTA: There are now working from this Conference two specific bodies - the Preservation Committee and the Fire Retardant Committee. Is it necessary to formally endorse their continued activities?

KAUMAN: This really belongs to the next item - format and organization of future conferences. Any further resolutions?

Mr. Martin, would you perhaps read out your motion?

MARTIN:

"THAT A STUDY OF THE EFFECTIVENESS OF EXISTING METHODS OF DISSEMINATING THE INFORMATION FROM RESEARCH BODIES BE UNDERTAKEN BY OFFICERS OF THE CSIRO, DIVISIONS OF BUILDING RESEARCH AND APPLIED CHEMISTRY, IN CONJUNCTION WITH INDUSTRY PROMOTIONAL BODIES AND REPRESENTATIVES OF INDUSTRIES GENERALLY."

Carried.

KAUMAN: I would like to move on to the next item which is format, location and organization of future conferences. I don't think that it is necessary to call for a motion at each conference that the Conference be continued. It was an appropriate time just after the re-organization of this research area in CSIRO. I would like an expression of opinion on the future of these conferences. From your silence I take it then the meeting feels the conferences should continue and as Dr. Muncey said at Heads of Services and Senior Officers Session it came out in favour of having the next one in

Melbourne, probably about two years from now. Are there any suggestions or any comments on the format of future conferences or criticisms of this conference regarding organization, performance, contents of papers, presentation or whatever?

DaCOSTA: Can consideration be given to the possibility of a small part of the conference time, a half-day or one day, be given to concurrent sessions of widely different areas of interest?

KAUMAN: Does anybody else have any thoughts on this?
I recognize that one often seems to finish up in a situation where the two sessions you want to go to are both at the same time.

HARRIS: I would like to suggest that presentation of papers be eliminated; that it be left to the discussion group leaders briefly to summarize papers. Conference members should do their homework properly beforehand. This would leave more time for discussion.

KAUMAN: I was going to make a suggestion that we have a moderator to summarize briefly groups of papers.

KERRUISH: I'd like to suggest that future conferences should have a spot that will let us cover current developments in the harvesting field. I think at the beginning of the session there were the various forest products research groups outlined their work and as a result during the conference we got an impression of the developments and the problems of the industry, but I do believe that from the number of enquiries and discussion we've had here that the overlap between these two areas are becoming more apparent. I suggest that in the next couple of years we're going to see a considerable increase in the amount of mechanized harvesting and the problems are going to occur in processing which you've never heard of today.

KAUMAN: Any comment on this harvesting question? The feeling seems to favour including it.

COKLEY: Could I make a suggestion, Mr. Chairman, that working groups be put forward earlier in the week.

KAUMAN: Any further on performance, organization?

HARRIS: Mr. Chairman, some of the papers that have been presented here have something of the appearance of being a little introspective as they tend to look into the industry or into the particular field of research. I'd like to see a reversal of form where more outward looking topics are chosen, more attempts to explain where research results could be used in industry. I merely commend this to the attention of the authors next time with perhaps a small group that edits the papers before they are accepted.

KAUMAN: This thought has been brought up by one or two people, including

Dr. Muncey in his introductory remarks on Monday. This is sort of a hard thing to achieve. I'd just like to read out a sentence from the first circular of the 14th September that I drafted myself. As you may recall, the format introduced last time concentrated the discussion on a few major topics and emphasis on the definition of problems and consideration of future action rather than reviews of work accomplished in the past. We have made this point a number of times; emphasis should be on future action, but of course this is not so easy to achieve. Should we have a Committee that has power to review papers to the extent that they may exclude papers that, according to some conditions we lay down, do not meet requirements?

SMART: I don't think its so important in future conferences if we follow this format of moderation that you propose. I think its a pity to discourage people from expressing their thoughts, even though they may or may not be strictly in accord with the theme advocated. With a moderator any loss of time or any problems in this regard are eliminated.

HIGGINS: I think in some sessions that some of the topics were only vaguely related. After a hammering by several papers on rather diverse topics and then a discussion you tended to forget what the earlier papers were about. I would like to have better grouping or more selected grouping of topics or perhaps even a short discussion after every paper.

BLAND: I'd like to say, Dr. Higgins, that if we adopt the format that we seem to be adopting by these previous resolutions, I think you point is covered. A topic leader or moderator will have worked on all the papers beforehand to summarize the relevant material presented.

KAUMAN: Obviously new ideas should be tried out where possible, but we are now trying to work out what can be approved. I'd like to ask Doug Howick as Chairman of the Organizing Committee to express his opinion because the Organizing Committee was responsible, of course, for the grouping of the papers.

HOWICK: I accept Huntley's statement - I can answer it by saying there are two ways of finding out what people want to discuss at a conference and what you saw was the result of both of these ways being used. One way is to send out a list of topic titles and say "Do you like these topic titles - if you don't will you suggest other ones and if you don't suggest other ones then we will take it that you do like these topic titles" and of course nobody suggests other ones and you're then stuck with topic titles. The other way to find out what people want to talk about is to ask people to submit papers. This difficulty in trying to do both of these things is to try to fit the papers into topic titles and it seemed to the organizers that as we had the larger number of papers we did on the subjects that we did, this is what people wanted to talk about. But we had previously committed ourselves to certain topic titles - I think it could be done a bit differently on another occasion.

BEESLEY: Perhaps a re-definition of the purpose of the Conference and the meetings that go with it could perhaps facilitate writing and act as a guide to the sort of papers wanted and what should be in them. I think that the purpose of this Forest Products Conference has probably changed over the

period of years, and possibly a re-statement of an objective might serve to bring things back into perspective. Could we perhaps leave that as a thought for the organizers of the next Conference.

The sort of things that come up obviously are: Is it an opportunity for those people in research to show what they're doing? Is it simply window dressing to convince industry that we're really working for their benefit? Is it an attempt to educate industry - in which case have we got the right people here to be educated and are we the right people to educate them, or just what is our function? Why are we gathered here - this group of people representing our diverse interests? What do we aim to get out of it?

KAUMAN: Thank you John for putting this before us. The purpose originally was co-ordination between the Forest Services and the D.F.P. It became more or less a scientific conference for presentation of scientific results in the days when communication was not as good as it is now as regards trains and telephones and what have you. It has now gone, hopefully, into a co-ordination conference but forward looking, in the sense that we try to have two way flow of information from us to the industry and vice versa. I can't expand on this because of the time but this will be given very careful thought between now and the next conference.

TAMBLYN: I feel that this restriction of papers to topics is wrong. Each of us has an urge to tell the rest of the people what he is doing or to ask their help in some areas that he's in doubt about and he pens down four or five or six topics and wonders how the heck he's going to fit something in. Some papers don't get written and the person writes a paper that he wouldn't have otherwise done. I think its essential that we give everyone free rein to present the papers they want to present and the Organizing Committee sorts them out afterwards, and I just want to make the point that I am against being presented with 4 or 5 topics and asked to write a paper - I want more liberty than that to decide what I think I ought to talk to the Conference about. I wonder whether others feel the same.

KAUMAN: This is a reversal of the opinions expressed by the last two Conferences - don't forget that this idea was proposed by the Conferences and the last Conference carried the motion saying this format would be retained for this present Conference. I think the reason why it was introduced was that simply it got out of hand; there was such a diversity of subjects that it became impossible for one to classify them, and also one tries to talk around topics that are of importance in the context of the day when you are holding the Conference, but there is no vested interest in any particular format.

RUDLING: Mr. Chairman, could I ask Doug whether he got much reaction from industry when he circulated and asked for topics?

HOWICK: I thought I made the point clear that it wasn't I who circulated and asked for topic titles - this was done before the Committee was formed - the Committee inherited the titles - then asked for papers.

RUDLING: Did in fact industry respond much to the original circular? I'm personally not happy with the performance of industry in this Conference. Maybe they are not entering into it to the extent that they

could or should because of a feeling that it is in fact sort of a close circuit session - rather family affair amongst the scientists. Perhaps the Organizing Committee must do a little selling on the industry side of the meeting.

BEESLEY: Is it a lack of definition of purpose and therefore industry hasn't understood the purpose of the Conference?

RUDLING: Admittedly, when industry was first invited, they were invited as observers. I don't think that was the intention of this Conference.

KAUMAN: I think at this stage of the afternoon we can only note these thoughts. I would like to say that the format and the titles were, of course, a follow-up from the last conference where it was said, as I have told you already, the format was considered satisfactory. It was generally agreed that selected topics rather than areas of research should constitute the main agenda headings. The format was considered satisfactory; we suggested topics but we did not get much reaction or much suggestion of other topics. I would like to suggest to those of you who expressed a desire to continue these conferences, you let us know your proposals for definition of the purpose of the Conference. We will consider all these and perhaps arrive at a better definition. I do not feel we have enough time this afternoon to decide on such a definition.

BRYANT: I notice that these documents are no confidential any more; we used to say they were, but I think this present format is extremely useful because a lot of people I would like to give copies to so that they can read the scope of our discussion. I think this will be helpful in itself and I assume that this will be possible.

KAUMAN: Are there any objections to considering this material that has been presented in the Conference as freely available for distribution? Then we take it the Conference agrees that material presented here is not in any way restricted or confidential. We would like to hear from organizations represented here, their thoughts about the purpose of the Conference excepting that they all feel that these Conferences should continue. The consensus seems to be (subject to whatever is suggested later) that we should reduce or eliminate presentation of papers by authors and should have them summarized by moderators so that we can have longer discussions. We should not have concurrent working sessions but we should have the working groups earlier and I interpret this as meaning that we might have two sessions of the working groups. We should have a slot for harvesting, and feeling was not in favour of vetting papers.

RECOMMENDATIONS ADOPTED BY THE CONFERENCE

TOPIC 1:

RECOMMENDATION 1:

An investigation of the between tree and between species variability of wood quality determinants such as growth stress gradients, basic density, fibre dimensions and permeability amongst shorter rotation eucalypts intended to be the subject of intensive regeneration programs and tree improvement work.

RECOMMENDATION 2:

Research on the origins, development and prospects of amelioration of defects of importance to the consumers. The individual defects studied will depend on the species and the environment. Specific problems to be considered are associated with distortion potential, kino veins, surface deterioration, knots and stability.

TOPICS 2 AND 5:

RECOMMENDATION 1:

That, as matters vital to the successful conversion of small (i.e. 5 ft e.g. ub) hardwood sawlogs, investigations be carried out into:-

(a) sawmill scale and process design, materials handling, and

(b) development of log grading requirements as related to specific end uses and management rejimes.

RECOMMENDATION 2:

That investigations be made into changes occurring in wood chips in outside mills in Australia. Such investigations to include aspects of biological control of chip degradation and also the possibility of their wider application within the timber industry.

TOPIC 3A:

RECOMMENDATION 1:

This Conference recommends urgent evaluation, using existing data and known physical relationships, of the parameters governing the incidence of condensation on wood in buildings, with special reference to condensation on flooring and within the wall cavity of wood framed houses. This is required in selecting the critical parameters for future experiments or surveys, and in choosing among recommendations for ventilation in various situations.

RECOMMENDATION 2:

That the CSIRO Division of Building Research set up a Techno-Economic Development team to take these and other projects of a like nature to a total design stage whence they are capable of ready assimilation by industry. It was further recommended that industry should be approached for funds to finance this work.

TOPIC 3B:

RECOMMENDATION 1:

It is recommended that the Division of Building Research and the State Forest Services should regard as urgent the development of a stabilizing organic solvent preservative pressure treatment for exterior building timbers and pre-machined timbers and should cooperate closely with industry in this development.

RECOMMENDATION 2:

It is recommended that the screening work on new preservatives and coatings for marine timbers which is already proceeding, should be given high priority on the widest possible basis.

RESOLUTION:

In view of the significance of rail sleeper fastenings on the service life of wooden sleepers, it is resolved that this matter should be given urgent attention in cooperation with railway authorities.

TOPIC 3C:

RECOMMENDATION 1:

This Conference recommends urgent investigations on the problem of severe soft rot in treated eucalypts and other hardwoods, including: (a) biological and chemical research; (b) immediate evaluation of remedial treatments for infected poles; and (c) the development of more effective initial pole treatments.

RECOMMENDATION 2:

Recognizing the potential hazards of centre rots in treated transmission poles of durability class 3, this Conference recommends immediate surveys of the incidence of these defects, the development of methods for the treatment of standing poles, and the evaluation of the use of diffusible preservatives in the initial treatment of these poles.

TOPIC 4:

RECOMMENDATION 1:

F.P.L. should make, in collaboration with the appropriate industry organizations, forest services and State departments, a more detailed survey of the location, quantities and type of forest product residues with the objective of offering advice on the most appropriate method for their utilization. Such a survey would provide useful outlets for current F.P.L. research on residue utilization.

RECOMMENDATION 2:

F.P.L., and particularly the Division of Applied Chemistry, should give high priority, and devote substantial effort to developing useful composites from mill residues in the short term, and from primary resources in the long term in order to maintain a place for wood-based materials in the markets of the future. Such a program involves research in adhesives and adhesion, surface finishes and protection, comminution, defibration and the role of particle geometry.

CLOSING SESSION TO DISCUSS FUTURE CONFERENCES, FORWOOD, ETC.
CHAIRMAN - W.G. KAUMAN

SMART: Mr. Chairman, I would like to say how much we do appreciate the excellence of the arrangement that both Divisions have made for this conference and the facilities that have been offered to us, including the preparation of this bound volume of all papers.

PAGE: Mr. Chairman, at the 1969 Conference of AUS.T.I.S. at Lismore the Research Priorities Sub-Committee was formed to draw up a list of research projects and nominate the priorities for a presentation to CSIRO and to the other established Forest Products Research Laboratories. The responsibility for that Research Priorities Sub-Committee has now moved from AUS.T.I.S. to the Timber Producers' Council and I believe its a serious omission that that priority list didn't appear on the Agenda of this Conference. Between this Conference and the next Conference that Research Priorities Sub-Committee will be meeting to up-date this list of priorities - might I suggest that that list be an Agenda item for the next Conference.

BOOTLE: Mr. Chairman, there's one topic which seems to be becoming of more and more interest and that is small logs. I wonder if perhaps there's enough effort put into the coordination of the various works that have been carried on throughout Australia on this topic. I think there is some sort of an informal committee on small logs and I wonder if perhaps this Conference could give some impetus.

PAGE: The last Conference established a small log sub-committee. Unfortunately that committee as yet has not had the opportunity to meet.

KAUMAN: My colleagues and I would be very happy indeed to hear any suggestions regarding the material presented to this Conference, the format in which it was presented, the selection of topics, for which incidentally Don Weiss and I take responsibility. I think this Conference has served a very useful purpose just as the previous ones have. It brings together the forest products community in Australia. Under the forest products community I mean the whole spread of interest from the growers of trees to those who sell the product made from trees, and those who promote the sale. It has led to an exchange of information which perhaps was not entirely new but which was useful to discuss.

I believe that this Conference has the potential every two years to define where we are going, what are the requirements to make the best use of our forest resource to keep the industry profitable and to present to the consumer products that are genuinely required and that also fit in with the new concept of the environment. We have made a new departure in the working groups and these have been successful. We would now like in succeeding conferences to be able to report the results of work done at the suggestion of the previous one. I hope that this will mean that in the meantime we will keep very much more in touch.

Finally, it is my particular pleasure on behalf of Don Weiss and myself to thank our Organizing Committee. We have had many conferences, they have

all been very well run and have all been very successful, and I would like to pay tribute on this occasion to the very unselfish and efficient work done on many conferences by Lon Wymond. This time we changed the format of organization and I would like to thank Doug Howick, Dave Bland, Nora Bolza, and Jim Nicholson very much for this very excellent and rather onerous work they have done in making this conference a success.

I hope to see many of you again in two years time.