FRI/INDUSTRY RESEARCH COOPERATIVES

EUCALYPT BREEDING COOPERATIVE

FOREST RESEARCH INSTITUTE
PRIVATE BAG 3020
ROTORUA

INSIDE IN AUSTRALIA

PHIL CANNON

REPORT NO. 8 FEBRUARY 1993

INSIDE IN AUSTRALIA

PHIL CANNON

REPORT NO. 8 FEBRUARY 1993

INDEX

	PAGE
Introduction and Summary	1
Visit to the CRC for Hardwood Fibre and Paper science	3
Visit to Rubicon	12
The RWG1 Tree Breeding Meeting in Canberra	15
Visit to Forestry Labs at CSIRO, Yarralumla	21

APPENDICES

I	The Cooperative Centre for Hardwood Fibre and Paper Science	30
II	Tree Breeding Working Group Meeting: Programme	34
III	Extracts from Robert Evans report: Rapid Measurement of the Transverse Dimensions of Tracheids in Radial Wood Sections from *P. radiata*	38
IV	The CSIRO High Yield Pulping Group	45
V	Flow Charts for Making RFLP's and RAPD's	48

INSIDE IN AUSTRALIA : FEBRUARY, 1993

by

PHIL CANNON

INTRODUCTION AND SUMMARY

The author spent February 10-20, 1993 in Australia. A tremendous amount of information was gleaned with respect to wood properties and genetic improvement of eucalypts. Almost all of this information was collected inside laboratories or conference halls, hence the title of this report.

The activities of this trip can and will be divided up into four sections. A brief summary of each of the sections follows next. The bulk of the report simply expands on each of these sections.

1. VISIT TO THE CRC FOR HARDWOOD FIBRE AND PAPER SCIENCE

The CRC for eucalypt wood includes researchers from APPI (Australian Pulp and Paper Industries), the Forest Products sections of CSIRO, Monash University (Melbourne) and several Pulp and Paper Industries in Australia. The central focus of this CRC is to study the wood and fibre of eucalypts grown in Australian plantations and figure out how to make best use of it. The author interviewed 9 of this CRC's scientists to find out what had been learned to date.

2. VISIT TO THE RUBICON

About one-fourth of all *E. nitens* families come from the Rubicon area in the present N.Z. breeding population for this species. In past provenance/progeny tests and in current frosting trials, families from this area performed better than average overall, with some Rubicon families ranking much better than others. The opportunity to visit the different places from which *E. nitens* seed collections have been made in the Rubicon

VISIT TO THE CRC FOR HARDWOOD FIBRE AND PAPER SCIENCE

A good synopsis of the functions of the CRC for eucalypt wood, written by the Centre's director, Dr Geoff Gartside, and others, is presented in Appendix I. During this particular visit 9 scientists working for the centre were interviewed. A summary of information gained during each of these interviews follows:

Dr Robert Johnston

Dr Robert Johnston is director of APPI, a combination research institute for the pulp and paper companies of Australia and graduate school connected with Monash University. He briefly described how APPI exists to furnish Australian paper companies with better educated pulping and paper manufacture engineers, and set up interviews for the author with some of his staff.

Dr Ian Parker

Dr Ian Parker is a physicist studying wood fibres for APPI to learn how fibre characteristics and the milling processes which alter them influence the properties of the paper which they go into. Fibril angle, conformability, and the degree of crystallinity are three characteristics which are of particular importance to strength properties. Dr Parker manages the graduate school for APPI which offers about 200 hours of lectures on pulp and paper science.

Dr Loi Nguyen

Dr Loi Nguyen has been an important person on the Australian Pulp and Paper scene. Earlier in his career he supervised the installation of APM's pulp mill, and later he supervised its operation. In this later capacity he was forced to determine which types of adjustments were needed in order to make high value pulp from plantation grown pine and eucalypt and from regrowth and old-growth eucalypt as well.

Along the way he developed several criteria with respect to what constitutes a good wood for pulp. They are as follows:

1. The bark should be removed easily.
2. The density of the wood should be uniform throughout the tree.
3. The wood should be easy to chip (low energy requirement) and easy to chip uniformly.
4. There should be a low content of "reactive" lignin.
5. Optimal fibre dimensions, fibre strength and handsheet properties depend on the type of paper being produced.

Because of its fibre dimensions, the wood of eucalypts is most likely to end up in fine papers, such as xerox and writing papers. Low reactivity to heat is especially important in xerox papers, otherwise there will be a tendency for the fibres to change their dimensions and, as a consequence, for the paper to jam in the hot xerox machine. In terms of fibre uniformity, what this refers to is that the density of the fibrous sections of the wood should stay as constant as possible as shown in Figure 1.

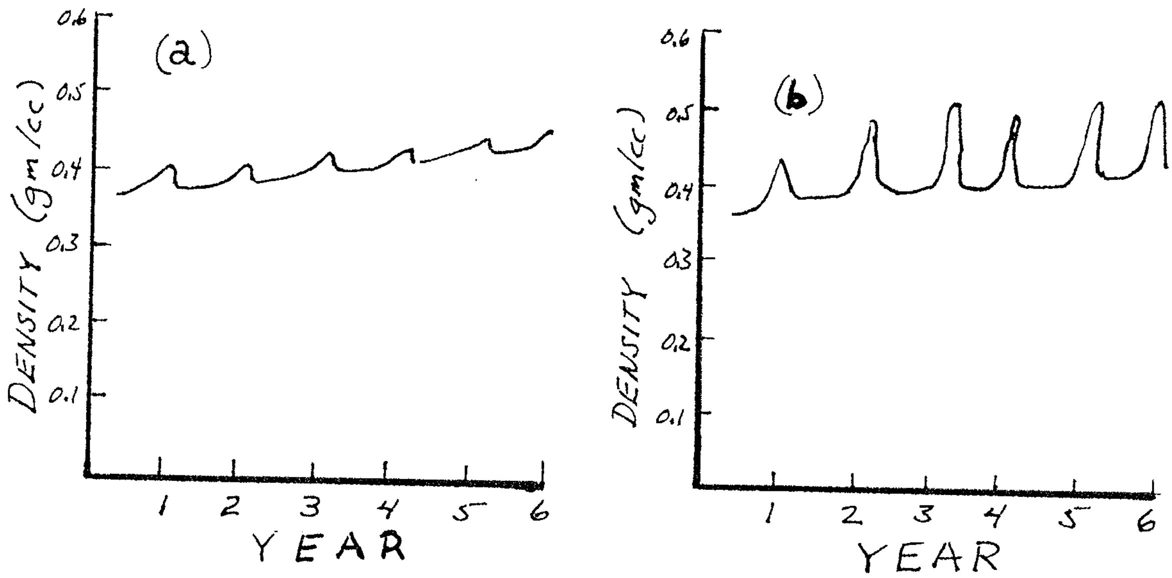


Figure 1: If the density differences (as recorded by image analysis of a radial core sample) are minimal from the core to the bark, as shown in (a) above, fibres will be more uniform than fibres from a sample with greater density differences (b, above).

Generally it is considered that fibres which conform well (i.e. have a low cell wall to lumen width ratio and so can be easily collapsed) are desirable for paper manufacture because they form a better bonded web on the fourdrinier and later stages of paper manufacture. But this notion is heavily influenced by the concept that fibres must bind well to give better strength at the wet end and that papers need strength in use. But Loi argues that eventually wet-end technology will probably get good enough so that binding strength does not have to be a consideration, and that most of the papers that eucalypt fibres will find use in have very low strength requirements as well.

What Loi sees as the big demand for hardwood fibre is fibre that can make a sheet of paper of given dimensions with a minimal number of fibres being required. In essence Loi thinks that if fibres could make a jungle-gym-like matrix with a large proportion of even-volumed-voids, that this would be ideal. The voids, could then be filled with a much cheaper, whiter, brighter and even more uniform and printable other material, such as kaolinite.

We concluded this conversation with a brief tour of APPI's miniature kraft pulp plant. Loi says that the scale of the kraft pulp plant does not matter when making tests for kraft pulping (it does with mechanical pulping). He also showed me a number of places in the plant where wood or fibre inside could be accessed to determine what impact each step in the pulping process was having on the transformation of the wood towards becoming a pulp fibre. As emphasised by both Ian Parker and Loi, the development of accurate kenetic models for every step in the pulping process is a major objective of APPI. With these in hand, they will then be able to predict, mathematically, the consequence of changing any input into the pulping process.

I asked Loi if there was any particular text book that he would recommend for someone wanting to get more familiar with pulping processes. Smook's[1] (1989) Handbook of Pulping was one of his strongest suggestions. He also indicated that there have been about 40 articles written on the pulping of eucalypts in Australasia. Almost all of these are in the APPITA Journal or in the proceedings of the Appita Conferences. These, in turn, are available either from the FRI library or from Phil Cannon.

---

1 Smook, G.A. 1989. Handbook for pulp and paper technologists. TAPPI. Atlanta. 395p.

Geoff Gartside

Geoff Gartside is the director of the CSIRO Forest Products Laboratories. The article which he coauthored for APPITA (see Appendix I) does an excellent job of describing what CSIRO's role is in the present CRC for hardwood fibre. Geoff, arranged interviews with several of his staff and was obviously very excited about the developments in "image analysis". The image analysis work itself will be described in the next section, however it will be said here that the author set up a tentative invitation for Geoff Gartside and Rob Evans to present their image analysis process to GTI and interested NZ companies during an interval in the upcoming APPITA meetings to be held in Rotorua April 19-23. This invitation (or note to the contrary) must be confirmed by a letter to Geoff Gartside from Mike Carson.

Rob Evans

Rob Evans has set up a prototype machine which can quickly measure and analyze all features of pine fibres using x-ray densitometry and image analysis as a core sample is automatically moved beneath x-ray beams from the bark to the pith end of the sample. Besides getting first class images along the transverse (or cross) section of the stem, this machine also uses another x-ray beam to focus on the lateral surface of the sample. In this way, all dimensional measurements on a given fibre (length, transverse dimensions and fibril angle) can be made at the same time and determinations of tracheid coarseness (mass per unit length) and tracheid wall thickness are easily determined. This method is explained in greater detail in an article written by Rob Evans (Appendix III).

At present, Rob is in the process of trying to develop robots so that several (he says six) core samples can be analyzed simultaneously. He also has a mandate (since he is working for the CRC for hardwood fibre and paper science) to adapt this technique so that it will work for eucalypts. There are some difficulties in this respect, however. Eucalypt fibres are about 0.5% the volume of pine fibres, this means that the resolution for the densitometry and image analysis scanning must improve to accommodate these smaller volume fibres. Also, eucalypt wood is considerably more complicated than pine wood mainly because it has large and irregularly dispersed vessels; this is a particularly difficult situation for the densitometers to cope with. Still, Rob's team is motivated to find a solution.

I repeat, Geoff Gartside and Rob Evans will be in Rotorua on April 19-23. Interested persons may like to catch their show at APPITA displays in the Sports Drome, attend their talks during the APPITA meetings, or join the GTI group when it discusses possible usages of this technique in genetic improvement work.

Tony Michell

Tony Michell has worked on several aspects of optimizing the usefulness of eucalypt fibres. One of the main ways is through bleaching of mechanical pulp with alkaline hydrogen peroxide. The main objective is to bleach a pulp to an acceptible level of brightness (whiteness) and then to enable the pulp to retain this brightness for a relatively long period of time. Eucalypts with light wood and low levels of heartwood (including *E. regnans, E. fastigata* and *E. nitens*) are easy enough to bleach to a suitable brightness (although a breeding program to reduce the heartwood to sapwood ratio in *E. nitens* might make sense), however, the maintenance of this brightness over time is still problematic. UV light tends to react with lignin causing "reverse-yellowing". An economic solution to this problem has still not been found.

Vilnus "Bill" Balodis

Vilnus "Bill" Balodis is one of those classic thinkers that contribute so well in the last years of their professional careers by trying to put their own and their colleagues research in perspective.

With respect to the pulping of eucalypts, Bill went right to his bottom line. What matters, he said, is money. And money is dependent largely on the following formula:

$$\$ = MAI \times BD \times PY$$

where:

MAI = mean annual increment of wood per hectare

BD = the bulk density of the wood

and

PY = the pulp yield of the wood.

Bill states that most of the effort in tree improvement should be focused on increasing the MAI because this is the independent variable with the largest variation. He indicated that eucalypt forests in Australia were growing between 1/3 m^3/ha/yr and 45m^3/ha/yr. Wood needs to be cheap as well since approximately 50% of the cost of pulp is the cost of the wood (only 3% of the cost is tied up in chemicals).

The next parameter to focus on in the equation is bulk density since this also has a large amount of variation. Over all eucalypt species and tree ages, the bulk density can vary from 300 to 900 kg/m^3. In some cases, kraft pulp of very high density eucalypt wood has given poor paper properties; the relationship of pulp properties and bulk density is shown in Figure 2.

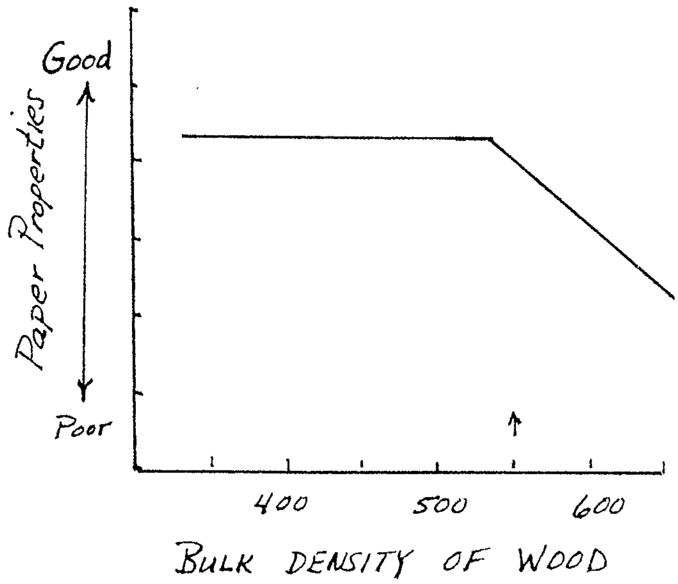


Figure 2: This is "Bill" Balodis' schematic representation of the effect of wood density on the properties of the paper which can be produced from that wood using the kraft pulping process.

However, most plantation grown temperate eucalypts can be expected to have bulk densities of between 350 and 550 so the objectionable properties associated with too high a bulk density should never be a problem in kraft pulping. This leads one to the conclusion that breeding for high (as in over 500 kg/m^3) bulk density wood makes good sense where kraft pulp is the intended product. Another reason for getting bulk density as high as possible is that the shipping lines carrying chips charge by volume, not weight; therefore use of the higher bulk density woods would effectively permit shipping more pulpable wood at the same cost.

Where mechanical pulp was the intended product, Bill thought that breeding for low density might be necessary since such wood generally requires less mechanical energy to be separated into fibres; approximately 80% of the cost during the mechanical pulping process is for electricity consumption during refining. The colour of the wood and the ratio of heartwood to sapwood are also factors that Bill thought might be worth breeding for where mechanical pulp was the anticipated end product because extractives are difficult to remove and are hard to bleach with this process.

According to Bill, there is no point in breeding for fibre length since fibres of all eucalypts have the same external dimensions.

The price of old growth eucalypt wood is $A80 per green ton FOB. Plantation grown wood may be worth less because it occupies more space per unit weight on ship. However, if the pulp yield of the wood is documented to be high, the buyer may be willing to pay more.

In terms of pulp yield, there is very little to play with. Bill suggests that a typical pulp yield for a eucalypt species might be 50% ± 2%, and only a part of this ± 2% variation is heritable. As a result Bill strongly advocates spending the first stages of tree improvement largely focused on increasing volume and bulk density.

Max Williams

Provided a thorough tour of both the pilot-sized mechanical pulp plant and the pulp assessment laboratory at CSIRO. A complete description of the mechanical pulping facility and services is given in Appendix IV. One problem with this facility is that it cannot give an accurate estimation of the energy that would be required to run a large scale (commercial) batch of the same wood. However, it can run on much smaller batches of wood and so samples can be tested very cheaply compared with PAPRO. Max is collaborating heavily with ANM (a sister company of Fletchers) in Maydena to try and establish a means of making the conversion. He would also like to collaborate with PAPRO, and will try to establish some nexus with the PAPRO crew at the upcoming APPITA meeting in Rotorua. He would also be willing to contract out his (and CSIRO's) services if the Eucalypt Breeding Cooperative might require such a facility. We need to figure out whch tests of our breeding and/or production populations might be worth doing with Max.

Alex McKenzie who ran the CSIRO pulp testing laboratory for 20(?) years, added several comments when Max took me through the laboratory section of CSIRO.

Andrew Rozsa

Andrew Rozsa is the only person that I had time to visit in the solid-wood section of CSIRO's forest products laboratory. He gave a good description of the reason why eucalypt woods are so difficult to dry. Basically they dry quickly along a longitudinal axis, but are fairly impervious to water movement in tangential and radial directions. This inability of water to move laterally in the wood of eucalypts is the main cause of checking. Cells on the outside of a wooden structure dry relatively fast and as a result tend to shrink in size, but the cells on the inside still have their original water contents and volumes; under these circumstances, the cells on the outside have no option but to split apart from each other.

A large proportion of CSIRO's solid wood products research is aimed at figuring out ways of drying eucalypt boards without having collapse take place. Basically, as eucalypt wood is dried down to 30% moisture content

~~(the fibre saturation point) quite quickly, but as drying moves wood moisture content from 30% down to 6% (the equilibrium point for m.c. in the interior of buildings in Australia~~) it is important that the relative humidity of the air outside of the boards be kept extremely high. This could be done with steam and, in fact, I was shown a couple of kilns where this is being done experimentally. It can also be done in a totally enclosed warehouse at room temperature. In this situation, the wood is simply stacked with only very thin stringers between layers. Initially the air humidity will be nearly 100%. As the wood gradually dries down, the warehouse is slowly but progressively opened up until finally, six-months later, the relative humidity inside and outside the warehouse is the same. The whole idea is to prevent the moisture content of the air near the outside of a piece of wood to be very much different from the inside of the piece of wood.

In terms of breeding to avoid checking, it seems possible and may be worthwhile. Kay Nixon (in South Africa) showed that some eucalypt species and some individuals within a given species were much more prone to split than others. She used a disk approach to evaluating splitting. This could be attempted at the between and within family level in New Zealand and correlations between the degree of splitting in these disks and the propensity to check could be established. Likewise correlations may be found between the propensity to split and certain (as yet unknown) anatomical features of the wood.

On quizzing Andrew with respect to the market for eucalypt wood, he suggested that eucalypts would most likely be going to the "pale-plastic" wood markets (which can be stained and manipulated if desirable) which prevail in Japan rather than into the character wood market (which is much smaller in extent); thus, here too, a low heartwood to sapwood ratio may be desirable.

VISIT TO THE RUBICON

Chris O'Connor collects *Eucalyptus nitens* seeds from throughout the range of the species. He operates out of Melbourne. One of the areas for *E. nitens* collection which is of particular interest to the Eucalypt Breeding Cooperative is the Rubicon provenance; seedlings from trees in this area on average grow better than most other sources of *E. nitens* in New Zealand and show measurably better frost resistance. (There is speculation that increased frost resistance is necessary because the Rubicon is cut off from the modifying influence of the Bass Straight by the presence of the Great Divide). However, there are large differences between families from Rubicon in both rankings for growth rate and rankings for frost resistance and there is only a very rough relationship between the elevation which the seed came from and frost tolerance.

In order to better understand why some families may have more frost tolerance than others, it was decided to visit almost all of the stands in the Rubicon area from which collections of *E. nitens* seed have made. Chris generously agreed to provide both guide service and a tough 4-wheel-drive vehicle for the trip. (I would realize just how generous this would be the next day when coming down a particularly steep stretch, Chris ended up parking the rig on its radiator grill).

The Rubicon area is represented schematically in Figure 3. *E. nitens*, wherever it occurs, occurs in patches (usually one to one hundred hectares in size) and these can be picked up on easily from colour aerial photographs (*E. nitens* shows up as light green). Sometimes it occurs on flatter ridge tops (Quartz Link and Tweed Spur), sometimes midway down slopes (Barnswall) and sometimes there are long stretches of *E. nitens* following a river (Snobs Creek, Rubicon River and especially Royston River). Generally, it might be thought that stands found in valley bottoms might be on warmer sites, but this is not true, in fact at the very bottom of the river basins and in areas that extend up to approximately 10 meters in elevation above the river, conditions are extremely frosty as evidenced by the presence of a heather species and as evidenced by the scant, scroungy, twisted, frost-tortured *E. nitens* that have managed to survive the frost. Just a few more meters up from the valley bottom, but out of the frost pocket, other *E. nitens* are growing magnificently; in fact this is where the largest and best looking *E. nitens* are found.

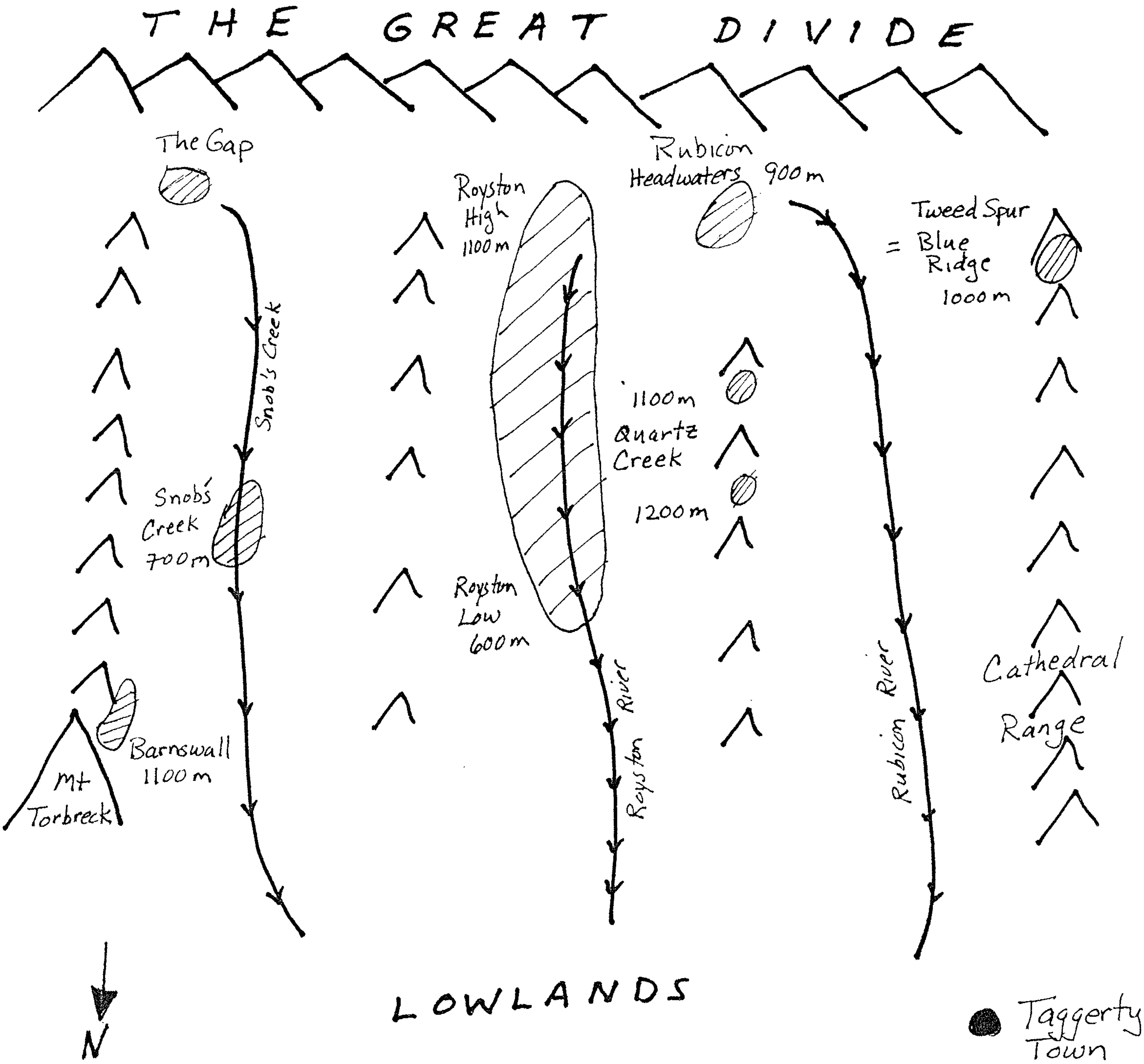


Figure 3: Schematic representation of the location of major *Eucalyptus nitens* stands ( ) in the Rubicon area. Geographical features shown are mountain ranges ( ) and rivers ( ). North is towards the bottom of this drawing and Melbourne is about 200 km to the southwest of Taggerty.

It may be worth interrupting briefly here to mention that the 1939 fire which razed the forests of Central Victoria killed almost all eucalypts in the Rubicon area. Thus almost all large *E. nitens* in the Rubicon are contemporaries and measurements of their size (especially height) can provide a decent estimate of the relative site quality that they have grown on.

The Royston River is an area which also deserves special attention. *E. nitens* is distributed along this river from a low of 600 masl (below the dam) to a high of 1,000 masl, thus it is important to know not only the position of the tree relative to the river (i.e. is it in the rivers frost pocket) but also the tree's position relative to the sea level (masl).

Barnswall Plains by all means should be in one of the coldest areas because of its high elevation, but this may be countered to a considerable degree by the slope (approximately 20% where the *E. nitens* stand has become established; cold air would tend to run off such an area) and by the fact that it is exposed to the northeast so that it could get sunshine before evening.

This type of analysis could go on, but in fact, we do not know exactly where the trees are where the seed for our *E. nitens* came from, and there is not a good enough correlation between source of origin and frost tolerance to specify a collection point for frost-tolerant *E. nitens* (Beyond suggesting going to the highest stand possible on Mt Torbrect).

What would be excellent would be to position a max-min thermometer next to each of the 100 or so trees that have been collected from in the Rubicon area and find out what the minimum temperatures were during a few cold nights in winter. These results could then be compared to the performance of the offspring of these trees in a single-tree-plot progeny test or by use of the leaf-disc approach for testing for frost tolerance. Note: some modification of this approach would also be possible if a smaller experiment were desirable.

THE RWG1 TREE BREEDING MEETING IN CANBERRA

From the onset of this meeting, the New Zealand contingent of Tony Shelbourne, Paul Jefferson, Gerry Vincent, Fred Burger and myself was made to feel welcome. This was reinforced by Glen Kile's (Director of Forestry for CSIRO) opening address.

As a result of this situation, the business that developed outside the meeting was not focused on whether or not there should be collaboration between NZ and Australian tree breeding efforts, but rather where this collaboration would be most productive. Following is a brief description of each of the collaborative possibilities which cropped up (or was persued further) during the intervals of the meeting.

NEW ZEALAND'S JOINING OF RWG1

This topic is covered in detail by Gerry Vincent's account of the Canberra meeting. The essence is that if a government to government formal agreement takes place, NZ FRI will become a member of RWG1. If this does take place (and it seems likely), the next meeting of RWG1 will be in Rotorua.

ANM MAY JOIN THE NZ EUCALYPT BREEDING COOP.

Peter Volker and Sandra Hetherington indicated that ANM may well be willing to joint the NZ Eucalypt Breeding Coop. There would be a huge mutual advantage if this could come to pass. Both entities are working heavily on *E. nitens*. (ANM is about to establish Chris O'Connor's 600 family test) and *E. regnans* (they have a huge collection of fairly frost resistant families and all are different from those we are testing). If we can help them set up their tests so that they are complementary with ours, then both entities will have much, much larger breeding populations which can be drawn from to make future breeding populations and commercial seed orchards.

THE POSSIBILITIES OF THE NZ EUCALYPT BREEDING COOPERATIVE AND THE TASMANIAN COOPERATIVE RESEARCH CENTRE FOR TEMPERATE HARDWOOD FORESTRY HAVING MUTUAL OBSERVER STATUS

The CRC for temperate hardwood forestry only began in March of 1991, but it pulls together essentially all the eucalypt research talents in Tasmania regardless of whether they are from private or public institutes (see Table 1). The research achievements of this centre during its first two years of activities have been substantial and impressive. In terms of eucalypt genetic improvement, there are many research activities which are being run either parallel with those of the NZ Eucalypt Breeding Cooperative or which would be complementary to those of the NZ Eucalypt Breeding Cooperative. A quick glance at Tables 1 and 2, however, will quickly show that the Tasmanian CRC is supporting eucalypt genetic research to a much greater extent than is the NZ Eucalypt Breeding Cooperative. Therefore, it is logical to assume that an arrangement for mutual observer status might have to be regulated somehow so that there were fair exchanges of information and work load. If this is desirable for the NZ Eucalypt Breeding Cooperative, a letter should be written to Professor Jim Reid, the CRC's director.

EXCHANGES OF INFORMATION WITH CSIRO, YARRALUMLA

Although the CSIRO at the Yarralumla Campus has been heavily defused in the past few years, there is still a considerable amount of active research which is useful to the NZ Eucalypt Breeding Cooperative. This will be evident in the section of this paper titled CSIRO, Yarralumla.

POSSIBILITIES FOR COLLABORATION ON FROSTING TRIALS WITH WAYNE TIBBITS

Wayne Tibbits, acting director of APPM's forest research program, was quite interested in the results of our frosting trials. He was particularly relieved to find out that our field results showed that the various *E. nitens* provenances had the same relative degrees of frost tolerance as his leaf disc trials. Wayne suggested that we might want to rent the new machine which they have just built for testing leaf discs (although the actual price was not disclosed).

Table 1 - List of professional CRC staff by projects

Name	Designation	Organisation	Time Allocated (%)
Director			
J Reid (Programme Manager)	Professor	UNITAS	30
Deputy Director			
P West (Programme Manager)	Scientist	CSIRO	40
Genetic Improvement			
J Reid (Programme Manager)	Professor	UNITAS	20
V Gordon	Scientist	Forest Resources	50
J Gorst	Lecturer	UNITAS	10
V Hartney	Scientist	CSIRO	70
S Hetherington	Scientist	Forest Resources	25
P Kube	Scientist	FCT	20
R Menary	Reader	UNITAS	10
K Orme	Scientist	Forest Resources	60
B Potts	Lecturer	UNITAS	100
G Rasmussen	Scientist	APPM	40
C Raymond	Scientist	CSIRO	80
D Steane	Research Assistant	UNITAS	20
W. Tibbits	Scientist	APPM	30
R Vaillancourt	Scientist	UNITAS	100
P Volker	Scientist	ANM FM	40
A West	Lecturer	UNITAS	20
Support Staff Contributed (3.65)		ANM, APPM, CSIRO, UNITAS	
Support Staff CRC (1)			
Resource Protection			
J Madden (Programme Manager)	Reader	UNITAS	30
H Elliott	Scientist	FCT	10
A Greenern	Scientist	FCT	40

Name	Designation	Organisation	Time Allocated (%)
Resource Protection (Cont.)			
D de Little	Scientist	APPM	10
S Parsons	Scientist	FCT	40
C Raymond	Scientist	CSIRO	20
M Stoddart	Professor	UNITAS	20
Support Staff Contribuited (1.6)		UNITAS, FCT	20
Support Staff CRC (1)			
Soil and Stand Management			
P West (Programme Manager)	Scientist	CSIRO	30
C Beadle	Scientist	CSIRO	60
R. Cromer	Scientist	CSIRO	40
G Holz	Scientist	APPM	10
K Orme	Scientist	Forest Resources	10
P Sands	Scientist	CSIRO	100
P Smethurst	Scientist	CSIRO	100
C Turnbull	Scientist	CSIRO	70
Support staff Contributed (2.0)			
Support Staff CRC ( )			
Education and Communication			
N Davidson (Programme Manager)	Lecturer	CRC	100
J Beattie	Senior Lecturer	UNITAS	10
R Hill	Reader	UNITAS	20
J Reid	Professor	UNITAS	10
R Wiltshire	Lecturer	UNITAS	30
Support Staff Contributed (0)			
Support Staff CRC (0.5)			

Cont...

Table 2: – Summary of data from postgraduate student enrolments in CRC projects

I. Postgraduate Students		Number of Students
Full/Part Time:	Full time	13
	Part time	3
Degree:	BSc Honours	2
	Graduate Diploma with Honours	0
	MSc	3
	PhD	11
CRC Programme:	Genetics	6
	Soil & Stand Management	0
	Resource Protection	3
	Education	7
Supervisor:	Prof JB Reid	7
	Assoc Prof RS Hill	3
	Dr BM Potts	3
	Dr JL Madden	3
Funding:	CRC	2
	CRC & Univ. Research Scholarship	1
	CRC & APRA	2
	APRA	1
	APRA (Industry)	1
	IDP	1
	DPI (Forestry)	2
	Honours Scholarship	1
	Non, Employed in forest industry	3
	Non, Self-supporting	2
II.	Undergraduate Students	
Degree:	Forest Ecology	11
Short Courses:	Eucalypt Breeding	
	Resource Protection	
	Yield Prediction	

A major cost would be shipping as a bulky refrigeration unit would also have to be transported.

Wayne also indicated that he and Geoff Dean are on the brink of publishing the genetics studies which they have just completed to find out what the variation and heritabilities are for the kraft pulping properties of the wood of their nitens breeding population. I asked if he might like a reviewer for that paper, but only received a smile in reply.

Besides the arrangements persued on the periphery and intervals of the conference, there was also a tremendous amount of useful information on eucalypt breeding and improvement during the conference itself. The reader of this document is encouraged to scan Appendix II; all of the eucalypt presentations have been marked with an asterisk. Copies of any paper preprints may be obtained on request.

VISIT TO FORESTRY LABS AT CSIRO, YARRALUMLA

Five sections were visited at CSIRO

(a) The Australian Tree Seed Centre was visited on two occasions. During the first, Brian Gunn gave a step by step demonstration of what happens to seed from the time it is collected in the bush, through the extraction procedure, through the treatment with CO_2 gas (displacing oxygen with CO_2 to kill insects (very effective)) to labelling and storage (seedlots of almost all acacia seed are stored at room temperature inside cloth bags which in turn are stored in large air tight plastic bags and in turn are stored in 50-litre hermetically-sealable plastic drums).

The cards and computer system used for keeping track of seedlots was also explained.

During the second visit to the Tree Seed Centre, Tim Vercoe, director of the centre, and Craig Gardner, explained how the centre operates, what seed they collect and how they make the collections.

Ninety percent of the funding for the Australian Tree Seed Centre comes from outside Australia, basically the AID and ADB development groups and some private industry. To date the Centre has collected from 800 species including a large number of provenances of most of these (they try to get the entire spectrum of provenances). Their philosophy is that any woody species is essentially worth collecting from. They have collected from 400 provenances of *E. globulus.*

They usually leave at least 100 m between trees chosen for collection for coastal eucalypts. For the interior acacias, clumps of trees occur almost as local clones so the collection points need to be much wider. There is no focus on select trees as CSIRO is convinced that the form of the parent tree has little to do with the form of its progeny. (Note: I agree that seed from a poorly-formed roadside tree may develop into a fine tree, but if one had the chance of selecting a tree from out of an even-aged stand, such as after the 1939 fire which swept through Victoria, I am not sure that choosing a well-formed tree for seed would be a fruitless exercise).

Most of the family level collections are carried out by the staff at the centre. Commercial seed lot collections are usually carried out by contract. Trees are never climbed, but if seed are out of reach, rifles will be used to bring down limbs (an average of "5 rounds per limb").

The centre has 16 full-time staff and has developed seed orchards for five species which are in big demand in developing countries: namely, *Acacia mangium, A. auriculiformis, A. crassicocarpa, Eucalyptus pellita* and *E. urophylla*. The basic layout in the auriculiformis seed orchard, is 5 tree-row plots replicated 5 to 15 times. Garth Nikles and Colin Matheson are looking after the design of these orchards. I spoke with both of them as well as John Doran about designs for improving the seed of the acacias both in overseas development work (i.e. Mindanao) and in the Australian seed orchards. They all seemed quite intrigued by the idea of the Forward Selection Plot approach which we have developed at GTI for the breeding of eucalypts.

Of course the applicability of this approach depends on the reproductive biology of the species. Acacias have their flowers in polyads. Margaret Sedgely is the person who has done the most work on Acacia reproductive biology. I was not able to meet her on this trip, but I did buy several books from ACIAR in which she was one of the principle authors. (Hutchinson, Entomology FRI owns a book of hers as well).

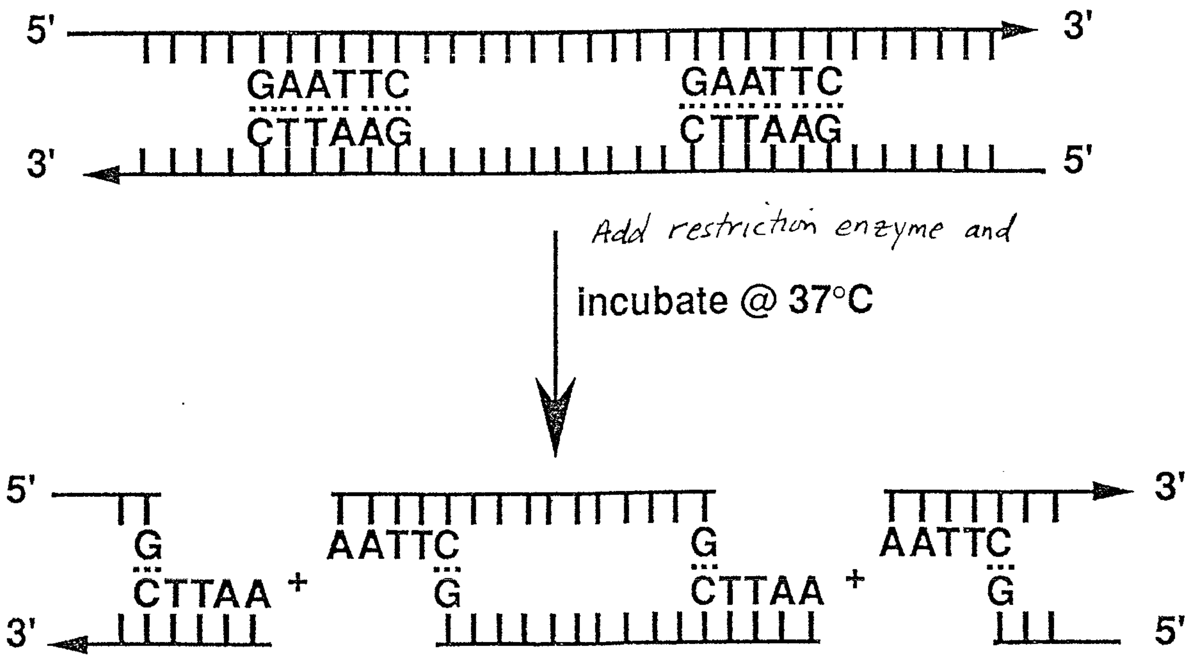
(b) The ACIAR section is in charge of advising on the use of and distributing Australian tree seed to the forestry projects in developing parts of the world. They also become quite involved with many aspects of tree improvement. It is a fairly high profile organization and is doing a lot of very useful and competent work. John Turnbull, Colin Matheson, John Doran and Garth Nikles are heavily involved in an advisory role. ACIAR has offices in Yarralumla, and downtown Canberra and has a classy book outlet on the ANU campus. To date they have had an important influence in a large number of countries in Asia and the Pacific Islands between Asia and Australia. In many ways, the net result of the joint activities between ACIAR and the seed centre is similar to that of CAMCORE for the central American pines.

(c) CSIRO, Yarralumla, also has a strong biotechnology centre. Some of the personnel from the centre who spoke to us were Gavin Moran, Mike Devey, Steve ??? , and Suzette Searle. They gave us a complete breakdown of the process for getting both RFLP's and RAPD's in their laboratory. The demonstration started with a very lucid flow-chart explanation of both of these processes. The flow charts, themselves, are shown in Appendix V. In the following paragraphs, the author will attempt to recapitulate Gavin Moran's explanation.

The first step for RFLP's is to get some DNA out of the tree's needles or leaves. About 50 mg of the young leaf tissue is ground up with a mortar and pestle in liquid so that about one mg of DNA can be extracted. (Note : a lot less DNA is needed for the RAPD technique). This DNA extract can be stored in the fridge indefinitely or it can be worked on. When working on the DNA, the first step is to separate the genomic DNA from the mitochondria and chloroplastic DNA. In the first step towards helping identify polymorphism's, the genomic DNA is put in a test tube and restriction enzymes are added.

Restriction enzymes work by cutting the genome only at points where certain base sequences are found. Figure 4 shows where a base sequence might be cut by a certain enzyme marker.

Figure 4: When a special restriction enzyme is added to genomic DNA (in this case an enzyme that cuts whereever G and C are opposite each other on the two opposing strands) the DNA strands become fragmented, as shown below.



This enzyme marker will cut at other points where this sequence occurs as well, leaving the genome "cut up" into many fragments. The "soup" containing these cut up fragments is then put in a small well at one end of an electrophoretic (agarose) gel along with a certain stain. "Soup" containing the cut up fragments of other genotypes (usually close relatives such as parents or siblings) is put into other wells at the base of the same gel. The current is then switched on and the fragments migrate across the gel. The shorter length fragments travel further across the gel in a given time span than do the longer ones.

After a fixed time, the current is switched off (and migration ceases). The fragments can then be transferred to a nylon membrane where they are fixed in what is called a "Southern (the name of a person not a hemisphere) transfer". This can be stored, or it can be used.

To identify the fragments on the nylon mesh, DNA probes can be used. These themselves are bits of DNA which have been formed as a result of similar cutting of the genome of DNA of other plants of the same species. Genetic probes can (and are) stored in the fridge. The genetic probe is used by adding it to the film (the nylon membrane). When it recognizes a homologue (a piece of DNA with the same base arrangement) it will react with this, and these homologues will be brought out on yet another gel. What one ends up identifying, as a result of this exercise, is the length of each of the sections that have been clipped out by the restriction enzymes. A "polymorphism" occurs when there is a difference in the length of the pieces which were cut out as a result of this process operating on two different but related individuals.

RAPD's have some similarities and some differences from RFLP's. Extraction of the DNA is similar, but only 0,01 of the amount is needed. After it is cut up by the restriction enzymes, the DNA fragments can be multiplied up many times using a system for synthesizing their formation. This system requires the presence of primers in a sort of soup (a primer is a sequence of bases, there are over 700 of these to date) which can combine with the extracted and sectioned up fragments of DNA to form multiples of these DNA fragments. To make this happen, one needs a hot plate type of apparatus. When the hot plate is turned off, the primers bind with the DNA bits forming fragments with identical sequences. When it is turned on, the original and the identical newly formed fragments separate. If this process is repeated many times (usually 40) the amount of a given fragment present in the soup will be approximately the same as with the RFLP approach.

RAPD's can function with little material and take little time (1 day versus 1 week for RFLP's). One of their disadvantages, however, is that they can only work with homozygous (megagametophyte) material. This implies that bud tissue is required when pines are in the "birdcage" (recently germinated) stage or when eucalypts are in the "first-leaf-pair" state.

In order to make a genetic map, what is needed is about 300 grandchildren wherein both parents and grandparents are of known pedigree. Usually the grandparents should be extreme for a character of interest. To identify those polymorphism associated with frost resistance, for example, a pedigree as shown in Figure 5 would be desirable.

Figure 5: An ideal pedigree arrangement over three generations to permit the identification of polymorphisms associated with frost tolerance.

Frost Resistant	X	Frost Susceptible	Frost Resistant	X	Frost Susceptible
		↘	↙		
	Intermediate	X	Intermediate		
		↓			
		300 progeny			

The CSIRO biotechnology group is making considerable progress in their effort to identify polymorphisms. By the end of 1993, they expect to have :

200 RFLP's
and 100 RAPD's for *Pinus radiata*
and 250 polymorphisms identified for *Eucalyptus nitens*

One additional point that they made was that their centre was one of the few working with RFLP's.

(d) A lot of research at CSIRO, Yarralumla, has been centred on increasing the amount of flowering, advancing the onset of flowering, and shortening the period between pollination and seed maturity for *Eucalyptus nitens*. This work was begun by Rod Griffin in about 1986 and has continued up until present; in recent years Mike Moncur has taken over this area of research and gave the "show" during our visit.

Paclobutrazol application is the best technique for increasing the amount of flowering. The best effects are achieved when this chemical is applied using Cultar as a basal drench in about 5 litres of water. The dose of Cultar should be 0.2 a.i. of paclobutrazol per cm circumference of the tree. (Note: equivalent dosages of paclobutrazol with stem-injected Clipper did not produce as great or as long-lasting an effect).

The time to apply Cultar is in March; this can be done within one year after grafting; flower buds should show up by the end of November of that same year.

Mike Moncur and Co. are also trying to shorten the elapsed time from flowering to seed set. Their main approach is to keep the grafts in large (100 litre) plastic planting pots which can be moved in (in winter) and out (in summer) of greenhouses. Some irrigation manipulation is also practised. To date they have been able to reduce the period from bud formation to flowering from one year to 8 months and the period from flowering to seed maturity from one year to 4 months. Thus they can cut down on the period to turn over a breeding generation significantly.

They also had developed an "espalier" orchard for their nitens orchards. Basically this means pruning the *E. nitens* grafted clones so that they resemble the vines in a kiwifruit orchard. My own guess is that they could just prune the side of the grafts with the kind of vertical mower which is commonly used in maintaining windbreaks in N.Z.

So far all work with paclobutrazol has been on grafts; the next stage will be to make seedlings flower earlier.

(e) A few years back, CSIRO took on a big project to see how the wood of genotypes of *Pinus radiata* from both controlled crosses and from certain clones would perform when it was mechanically pulped. The methods and results of this study were well presented by Colin Matheson during the RWG1 meeting and a full write up on this study is available from the author of this present manuscript, on request.

In a nutshell, it was decided to make composites of *P. radiata* trees which had one of the following characteristics.

(1) high density, short fibre wood

(2) high density, long fibre wood

(3) low density, short fibre wood

and (4) low density, long fibre wood.

Some of these composites gave very different kinds of pulp and had different energy requirements than did others.

In order to get a better feel for how the composite samples were made, I accompanied David Spencer to the site where he had first sampled individual trees and then pulled together the composite samples. We should be able to do something very similar with *E. nitens* although the fibres of all eucalypts are reputedly the same length (according to "Bill" Balodis) so possibly we would only want to divide up the wood by specific gravity.

David Spencer also took me, and Angus Carnegie[1], to visit one of three *Eucalyptus species* trials in the A.C.T. area. This was at Kowen, a very dry site (450-500 mm of rainfall per annum) with badly eroded soils which had evolved from sandstone and greywacke. Needless to say, none of the eucalypts had grown well enough to be a commercial proposition. Their poor growth had been aggravated by a very high level of insect foraging on their foliage.

1 Angus is one of Peter Ades' graduate students. He promised to end me a copy of his thesis on provenance variation with respect to *E. nitens* susceptibility to *Mycosphaerella.*

(f) Ken Elderidge

Has just, finally, almost finished his book titled "Eucalypts". It is in the galley-proof stage. I had a brief scan through it and it indeed looks comprehensive. I unearthed a previous conversation that we had had with Ken concerning the possibility of his coming to New Zealand. The reasons given previously for this visit were that he could present his book to our Eucalypt Breeding Cooperative and that he could provide a good external review of the breeding program and of the eucalypt research program in general. He is still quite keen to do this and has indicated that he is willing to make the trip if only his costs are covered.

An additional reason for having Ken come at this time is that he is secretary of an Australian task force to determine where all future government-funded agricultural research should be spent. This present capacity, plus Ken's long-time experience with eucalypt research, might provide some useful perspectives for getting our own research programmes better orientated and financed.

A QUANTUM LEAP IN UNDERSTANDING:

THE COOPERATIVE CENTRE FOR HARDWOOD FIBRE AND PAPER SCIENCE.

R. Evans*, G. Gartside*, A.J. Michell*, P.F. Nelson#, I.H. Parker#, R. Sands".

* CSIRO Division of Forest Products, Private Bag 10, Clayton, Vic.3168, Australia.

\# Australian Pulp and Paper Institute, Monash University, Clayton, Vic. 3168 Australia.

" School of Forestry, University of Melbourne, Creswick, Vic. 3363 Australia.

THE AUSTRALIAN INDUSTRY

The Australian pulp and paper industry employs about 10,000 people and produces about 2 million tonnes of product per year, with a value of about $2.2 billion, sold almost entirely on the local market. Imports of paper are about $1.4-1.5 billion per year, while exports total a mere $0.1 billion, resulting in a severe adverse balance of payments for these products. Available Australian wood resources are sufficient to replace these imports and to generate a substantial export income in addition.

Achieving success in today's highly competitive markets is no easy task, especially considering the cost advantages of some developing countries with low wage and tax levels and limited environmental constraints. On the other hand, we in Australia have advantages which could contribute to the development of export markets for eucalypt pulp and eucalypt-based paper. These include a very large eucalypt genetic resource and an unparalleled knowledge of the genus. Success in developing export markets will depend on the technological and scientific resources which we devote to exploiting these advantages and the level of skill, technology and scientific understanding available to our industry.

$12 M from Gov't over 7 yrs

$60 M from Ind., CSIRO, Univ.
($ & in kind Research)

The pulp and paper industries of most successful exporting countries enjoy the support, usually with strong cooperation from the central government, of cooperative research and graduate education programs focussed on the materials, operations and systems unique to the industry. These efforts are critical in providing the industry with an assured pool of well-trained scientific and technical talent not usually forthcoming from the mainstream of higher education.

THE CENTRE

The Centre for Hardwood Fibre and Paper Science has been established with Commonwealth Government assistance in order to improve our scientific understanding of those aspects of eucalypts relevant to papermaking. The Centre is a cooperative effort between CSIRO, Monash University, Melbourne University and the Pulp and Paper Manufacturers' Federation of Australia (PPMFA), designed to make available to the local industry the best scientific and technical expertise.

The aims of the Centre are:

(a) to identify those properties of hardwood fibres which are critical to the performance of pulp and paper products and extend our fundamental understanding of the relationships between fibre and product properties

(b) to develop rapid methods for evaluating pulpwood fibre properties and apply them to the assessment of wood resources from silvicultural and tree improvement trials

(c) to extend our understanding of the response of fibres to pulping and papermaking processes, including recycling

(d) to provide advice and assistance to foresters in their efforts to improve wood quality through genetic and silvicultural research on plantation and regrowth eucalypts

(e) to utilise the results of this research in developing advanced dynamic simulations of, and control sensors for, pulping and papermaking processes

(f) to provide technologists with directions for improving processes and product quality.

The Centre brings together the skills in:

* cambial physiology, silviculture and post-graduate education in forestry of the University of Melbourne

* fibre science and wood chemistry and physics of the CSIRO Division of Forest Products

* pulp and paper process engineering, paper physics and technology and post-graduate education of the Australian Pulp and Paper Institute (APPI), Monash University

* tree breeding and pulp and papermaking technology of the leading Australian pulp and paper companies through The Pulp and Paper Manufacturers' Federation of Australia (PPMFA).

We believe that this combination of expertise has the potential to secure Australia's place as the world leader in eucalypt fibre technology.

Current Knowledge

Since paper is a web of self-bonded cellulosic fibres, its properties depend on those of the constituent fibres, their orientation in the sheet, their capacity to bond to each other and the effects of additives. In order to make paper of the highest quality, it is important to start with fibres having the right properties. It is also important to produce them at the lowest possible cost, i.e. to grow the best fibres as efficiently as possible. Achievement of these goals requires collaboration between pulp and paper technologists and foresters to establish the key fibre properties and to apply this information in growing superior trees.

It should be noted that some key fibre properties are already known. Most of the work done on fibre properties overseas has been concerned with softwoods. However, earlier research done in CSIRO and the Australian industry has established significant basic relationships between paper properties and eucalypt fibre dimensions e.g. length, diameter, wall thickness and certain ratios of these dimensions. In most cases the paper properties considered have been traditional strength indices such as tensile and tear index.

The achievement of this understanding was a major step forward, especially for wrapping and packing materials which may be subjected to severe stresses in service. Nevertheless, these indices are still insufficient to characterise adequately performance in processing and end use, e.g. the relationship of fibre properties to compression behaviour of boxes under certain conditions. In the case of printing papers the inadequacy of our understanding is even more apparent. For properties such as dimensional stability under changing relative humidity and others influencing printing quality, understanding in terms of fibre characteristics is far from adequate. Furthermore, many previous investigations of the interrelationship of fibre and paper properties have established empirical correlations rather than fundamental understanding.

In the same way, much tree breeding work has been aimed essentially at achieving high growth rates and improved form, both admittedly very worthy objectives, rather than at producing an understanding of the mechanisms by which these aims are achieved and still less at producing trees with improved fibre properties.

In our opinion, traditional methods of correlating fibre properties and product performance are approaching the limits of their usefulness and are becoming less capable of responding to the increasing rate of development of new products and processes. Design of tomorrow's products will require more versatile and robust relationships based upon fundamental understanding of the physical and chemical mechanisms by which fibre properties influence product performance.

ASSESSING THE TREES

A large number of trees will need to be assessed with respect to their fibre properties. Traditional methods involving pulping trials are lengthy, expensive and require felling of the trees concerned. CSIRO workers are developing a range of physical and chemical techniques for the rapid examination of small specimens taken from test trees. The extent of silvicultural and genetic influences on key fibre properties will be assessed in collaboration with foresters from PPMFA member companies and the Centre for Temperate Hardwood Forestry at Hobart, Tasmania. At the University of Melbourne, emphasis will be on developing an understanding of the processes involved at the cellular level.

ASSESSING PROCESSED FIBRES

Fibres are modified by pulping and papermaking processes. New, rapid measurement techniques will be developed to enhance our understanding of separated fibres and the ways in which they are modified by processing. New insights will be provided into the effects of recycling on fibre properties. The new measurement techniques will be developed into sensors for process control in pulping and papermaking. Improved understanding of the relationship between fibre properties, processes and paper quality will facilitate the development of dynamic simulations, leading to improved understanding and process control. Such simulation procedures will also be valuable in design and teaching.

COOPERATION IS THE KEY

Close cooperation already exists between the members of the Centre. The setting up of APPI at Monash University was a PPMFA initiative and staff of both CSIRO and the PPMFA member companies are heavily involved in the APPI MEngSc course. The industry has been closely associated with CSIRO research through the Wood Fibre Research Advisory Group of the Division of Forest Products, especially with the development of the Tree Improvement Program which will become part of the Centre's research activities. The University of Melbourne Forestry School has been a major source of forestry graduates for industry and its relationship with PPMFA members has been long and fruitful. Based as it is on developing and applying advanced methods of assessing fibre properties, the work of the Centre is clearly complementary to that of the Hobart Centre and the formal collaborative links established will lead to inter-Centre research projects.

BENEFITS TO EDUCATION

Establishment of the APPI MEngSc course involving one year of intensive course work plus a minor thesis on an applied research project was, as noted above, a PPMFA initiative. The course is now in its fourth year and its graduates have been well received. It has already attracted a number of students from overseas. Master's degrees by research are about to commence and a PhD research program has started in collaboration with CSIRO. Similarly, joint supervision of postgraduate research by staff of CSIRO and the School of Agriculture and Forestry at the University of Melbourne has existed since 1986. The establishment of the Centre will greatly strengthen these activities, with the added benefit to the research students of bringing them into close contact with industry. There will be complementary benefits to industry through closer contact with university research. These interactions can be expected to produce appreciable synergy.

In addition to the research itself, the Centre's educational program will involve a continuing series of research seminars and specialist lectures. These will be open to a wide audience and it is expected that they will attract a number of technical people from industry, CSIRO and government educational institutions. We believe that this complex of interactions will act as a substantial stimulus to technical progress and an interest in science and technology, not only in the pulp and paper industry but in the wider community.

OUTCOMES

The economic value of a research project such as that described above is very difficult to calculate with any accuracy. However, an attempt is made below to provide order of magnitude estimates.

(a) Market share

Increasing emphasis on pulp quality is evident among overseas producers of bleached eucalypt kraft pulp. If the discount for inferior quality were $25-50 per tonne, this would represent a loss of around $10 million per year for a 500,000 tonne per day mill producing the lower quality pulp. Market penetration and share for an

Australian export mill will depend on the maintenance of high quality. Loss of 10% of sales for a mill of this size would represent a loss in revenue of the order of $30 million per year.

(b) Pulp substitution

Improved quality of local eucalypt pulp is estimated to hold the potential for a saving in foreign exchange of several million dollars by replacement of imports. Such a quality increase might also allow increased use of clay, with a further potential saving of similar magnitude.

(c) Productivity gains

The Tree Improvement Program referred to above is expected to result in an improvement in pulp yield giving it a value of the order of some hundreds of millions of dollars over a five year period. The development of advanced control systems, envisaged in the Centre's program, should also result in significantly reduced production costs.

CONCLUSION

The setting up of the Centre represents a milestone in the history of the Australian pulp and paper industry. Never before has such a body of expertise, involving a leading research organisation and two leading universities been brought to bear on its technical problems in a collaborative effort. The Centre's aims are nothing less than to secure the Australian industry's competitive commercial position and its reputation as the world leader in eucalypt fibre science and technology.

APPENDIX II

Tree Breeding Working Group Meeting: Programme

* = deals with eucalypts

Monday Feb 15th

1.30 -1.45	Slee		Introduction
1.45 - 2.00	Kile		Welcome
2.00 - 2.45	Libby	UC Berkeley	Review of Bordeaux meeting -discussion of practical implications
2.45 - 3.00	Coffee		
	BIOTECHNOLOGY		Chairman - Haines Moderator - Vaillancourt
3.00 - 4.00	Moran	* For - CSIRO	Genetic mapping and marker aided selection in tree breeding
	Byrne	* For - CSIRO	Construction of a genetic linkage map in Eucalyptus nitens
	Devey	For - CSIRO	Preliminary linkage map for radiata pine based on RFLPs
	Teasdale	Griffith Uni	Progress in biotechnology of pines - gene mapping, developmental biology and propagation
	Chandler	* Calgene Pac	Use of Agrobacterium rhizogenes to enhance rooting of micropropagated Eucalyptus
	Devey	For - CSIRO	Identification of RAPD markers linked to a gene for resistance to white pine blister rust in sugar pine
4.00 - 4.30	Discussion		
	R&D CORPORATION		
4.30 -5.00	Barlow	UWS	Role and operations of RIRDC
5.15			Happy hour

Tree Breeding Working Group Meeting 15 - 19 Feb 1993- Program

Tuesday 16 Feb 93

	SEED ORCHARD MANAGEMENT			Chairman - Boomsma Moderator - Hetherington
8.30 -9.45	Bail		CNR Vic	A study of background pollen levels and implications for seed orchard strategy
	Eriksson		FRI Sweden	Large scale controlled crosses in scots pine
	Butcher		CALM WA	HAPSO development in WA for mass production of full-sibling seed
	Moncur	*	For - CSIRO	Effect of paclobutrazol on flower bud production in E. nitens
	Bail		CNR Vic	Application of liquid pollination in radiata pine breeding
9.45 -10.00	Discussion			
	CLONAL FORESTRY			Chairman - Whiteman Moderator - Spencer
10.00 -10.30	Johnson		NSW	Growth and form of seedlings and cuttings of radiata pine on ex-pasture sites
	Slee/Kartiko		ANU	Phase change in P. radiata
	Haines/Walker		QldFRI	Vegetative propagation for the capture of genetic gain with pine hybids in Queensland.
10.45 -11.00	Wilhelmsson		FRI Sweden	Clonal forestry with picea abies
11.00 - 11.15	Discussion			Role of vegetative propagation in breeding program
	PROVENANCE VARIATION			Chairman - Tibbets Moderator - Wentworth
11.15 -12.30	Johnson		NSW	Provenances of E. agglomerata in NSW
	Benyon	*	MMBW	Species and provenance performance on irrigated sites at Werribee
	Spencer	*	For - CSIRO	Variation in E. globulus on an effluent irrigated site.
	Pederick	*	DCE	Genetic variation in E.delegatensis in natural populations around Mt Stirling Vic.
	Butcher/Bell/Moran		ANU	Variation in Tea Tree oil production
	Ades		Uni Melb	Genotype x site interaction in P radiata provenances
	Kube	*	Tas FC	Variation in E. nitens
I	PLANT VARIETY RIGHTS			
2.00-3.00	Thearle			PVR
	ORGANIZATIONS REPORTS			Chairman - Boardman Moderator - O'Connor
3.15 - 4.15	Status reports			
	Cannon	*	FRI NZ	Update NZ Eucalypt Breeding co-operative
	Eriksson		FRI Sweden	
	Libby		UC Berkeley	
	Vincent		FRI NZ	Effect of commercialization and changes in funding oin New Zealand tree breeding
	Shelbourne	*	FRI NZ	A tree breeding co-operative for South Africs
	DATABASES			Chairman - Volker Moderator - Clarke
4.30 - 5.00	Butcher		CALM WA	TBIMS - A database management system for tree improvement systems.
	Jefferson		NZFRI	Database development in New Zealand

Wed 17 th Feb 93

	DEFINITION / QUANTIFICATION OF GAINS		Chairman - Nikles Moderator - Johnson
8.30 - 9.00	Wilhelmsson	FRI Sweden	Estimation of gains by combining selective harvesting, flower stimulation, nutrition and SMP
9.00 - 9.45	Whiteman / Lieshout / Came	APM	Realized gains for Pinus radiata from breeding and silvicultural developments introduced in the 1970s
	Whiteman / Cameron	APM	Performance of genetically improved Pinus radiata and eucalypts over time
	Wentworth/Matheson/Eldridg	APM/CSIRO	Growth of Pinus radiata provenances across three contrasting sites in Gipsland
9.45 - 10.30	Discussion		
	METHODS FOR SPEEDING OPERATIONS		Chairman - Dutkowski Moderator - Burger
11.00 - 12.00	Whiteman	APM	Rapid assessment techniques
	Potts *	UTas	Variation and heritability of early growth traits in a base population trial of Eucalyptus globulus
	Butcher *	CALM WA	Early selection in Euclyptus globulus for breeding
	Potts *	UTas	A reassessment of morphological patterns in E globulus complex
	HYBRIDIZATION		Chairman - Pederick Moderator - Benyon
1.30 - 2.00	Shelbourne	NZFRI	Inter specific hybrids
2.00 - 3.00	Nikles	FRI Qld	Breeding and propagation strategies for the development of superior hybrid in Qld.
	Volker *	ANM	Progress report CSIRO Eucalypt hybrid trials
	Nikles / Powell (MP to prese	FRI Qld	General and specific hybridising abilites (GHA's and SHA's) in population hybrids.
	Potts *	UTas	The inheritance of growth traits in some inter specific hybrids of Eucalyptus
	Nikles	FRI Qld	Qld hybrids - Provenance A. cunninghamii, P caribaea.- P tech x Prad/Pcar (hond)
	Discussion		
	RESISTANCE / SPECIAL BREEDING		Chairman - Kube Moderator - Bail
3.15 - 3.45	Butcher	CALM WA	Pinus radiata/phytophthora cinnammoni resistance breeding
	Ades/Carnegie *	UMelb	Resistance of E.globulus to mycosphaerella leaf diseases
	Discussion		
3.45 - 4.30	Nyakuengama	ANU	Breeding for wood quality
	Matheson/Spencer	For - CSIRO	Breeding for pulp quality
	FOREST GENETICS EDUCATION		Chairman - Potts Moderator - Bail
4.30 - 5.00	Ades	UMelb	Forest Genetics Education - Role of Quantitative genetics in tree breeding
	Slee	ANU	Forest Genetics Education - other needs
	Discussion		

36

Thus 18th Feb 1993

8.30-12.30 Business Meeting

1.30- Field trip
(nb departure will be brought forward if the meeting finishes early)

Fri 19 th Feb 1993

9.00 - Choice of visits to -

1 Biotechnology Lab Forestry CSIRO and
Australian Tree Seed Centre - Yarralumla
2 Biotechnology Lab PI CSIRO
3 Wood Structure Lab ANU

37

APPENDIX III

DRAFT 38

Rapid Measurement of the Transverse Dimensions of Tracheids in Radial Wood Sections from *P.radiata**

By Robert Evans

CSIRO Division of Forest Products, Private Bag 10, Clayton 3168, Victoria, Australia

Summary

A new analytical instrument has been developed for rapid measurement of the transverse dimensions of tracheids in Australian plantation grown *P.radiata*. The instrument combines scanning x-ray microdensitometry and image analysis to produce radial profiles of tracheid diameter, wall thickness, coarseness and other wood morphological characteristics. All measurements are performed automatically on polished radial wood sections cut from increment cores. Corrections are made for the unavoidable deviations from radial alignment. The initial purpose of the instrument is to provide comprehensive information for tree breeding and silvicultural programs with particular emphasis on pulp and papermaking characteristics.

Keywords

Coarseness, Density, Diameter, Distributions, Image analysis, *Pinus radiata*, Tracheids, Wall thickness, X-ray densitometry

Introduction

The papermaking properties of wood are greatly influenced by the morphology of the constituent fibres. Characteristics such as length, transverse dimensions and fibril angle have long been recognised as controlling factors in pulp fibre quality and paper performance.

Length distributions of separated fibres can be estimated rapidly using commercial instruments and a method for the rapid estimation of fibril angle in wood sections

* Note, only a portion of this report is reproduced here. For the full copy, contact Phil Cannon

has been published (El-osta *et al.* 1973), although not widely used, perhaps because of the complex calculations involved.

Traditionally, density has been used as the major criterion for pulpwood quality, even though wood density is a composite property that depends on fibre wall thickness and fibre diameter. These more fundamental morphological characteristics of wood have not been measured routinely because of the slowness and labour-intensive nature of quantitative microscopy. This has prevented general application to tree breeding and silvicultural programs. The thousands of samples generated demand rapid and efficient characterisation methods. These methods should use small wood samples such as increment cores and should involve minimal sample preparation and automatic data acquisition and analysis.

This report describes the first automated system capable of meeting these criteria. Although the instrument was designed to evaluate increment cores from Australian plantation grown *P.radiata*, the methods are suitable for all similar softwoods. The instrument, which uses a novel illumination system and novel image analysis methods, has been in routine service since early 1992. We are currently extending the methods and constructing new systems to assist in the much more difficult assessment of wood from plantation grown eucalypts.

* Based on a presentation to the 1992 Appita General Conference in Launceston, Tasmania.

Experimental

Sample preparation

Resins are removed by acetone extraction and the core is reconditioned. All samples are conditioned to 22°C and 50% RH before and after trimming, and during measurement.

The radial increment cores are cut with an automated twin-blade saw to give slices 5-7 mm in the longitudinal direction and 2.00 mm in the tangential direction. Thickness standard deviations, as measured by a micrometer, are less than 20 μm. The dimensions and weights of the cut samples are used to calculate average conditioned densities.

Our preferred surface preparation technique for both softwoods and hardwoods is a modification of one described in the literature (Britt 1966, Schnell and Sell 1989). One transverse surface is hand polished with a series of fine abrasive sheets (to 12000 grit if necessary) on a hard flat surface. The use of a power sander was not found to be necessary. Application of 1200-2400 grit abrasive for a few minutes is often sufficient for *P.radiata*

weighted distributions of the measured properties
pith position
annual ring pattern
mean annual increments
various minima, maxima and means

Accurate cross-matching of the density and tracheid area profiles is necessary for estimating coarseness and wall thickness profiles. Small positioning and measurement errors are greatly amplified in the coarseness calculation near strong gradients in the profiles (e.g., at ring boundaries). Misregistration of the profiles can vary because image analysis is not done using the same plane as that scanned by the x-ray beam. During the analysis of the results, the operator fine-tunes this alignment process to allow for small variations in the relative positions of features.

Results and Discussion

Typical images of *P.radiata* in reflected and transmitted light are shown in Figure 2.

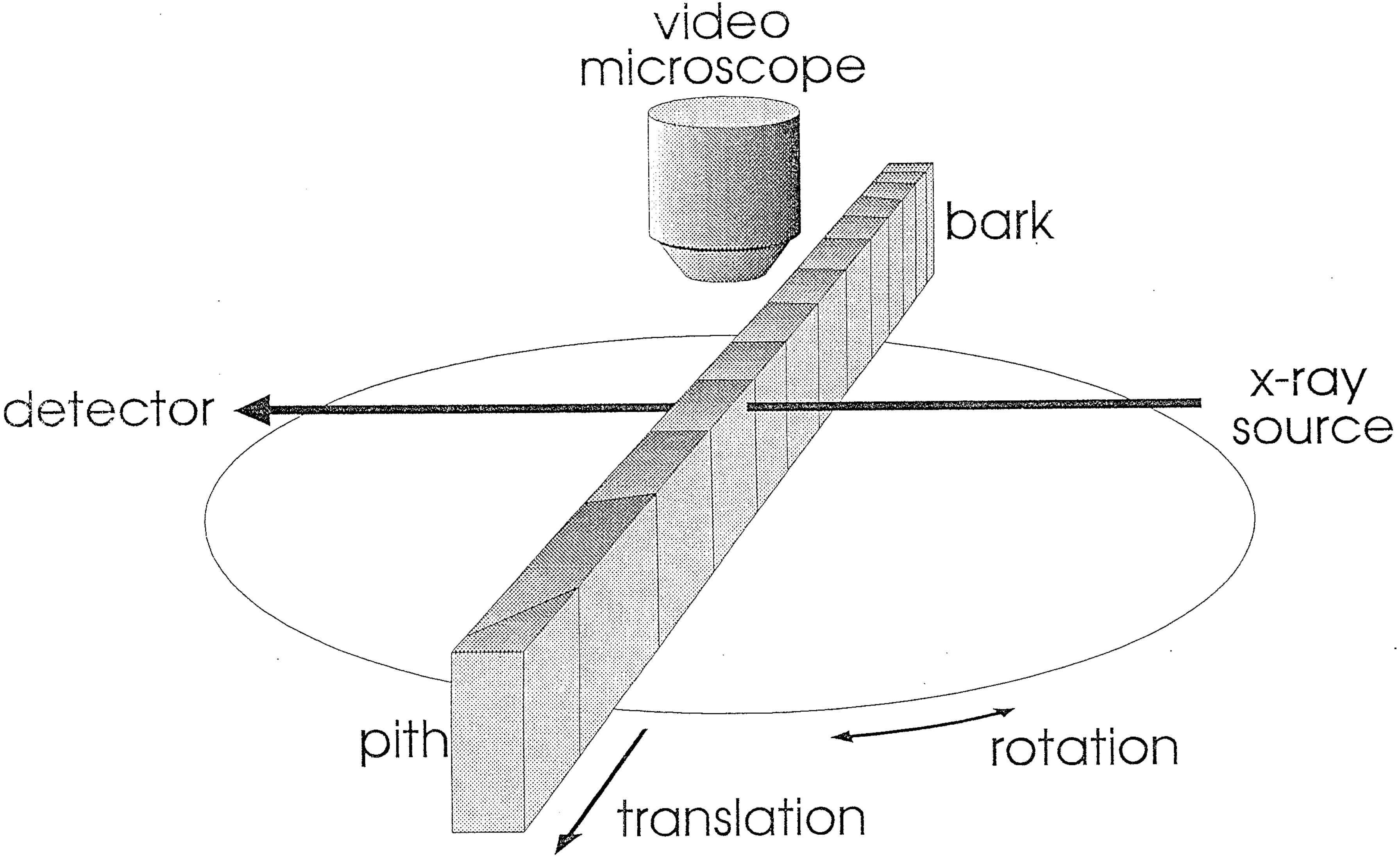
TAKE IN FIGURE 2

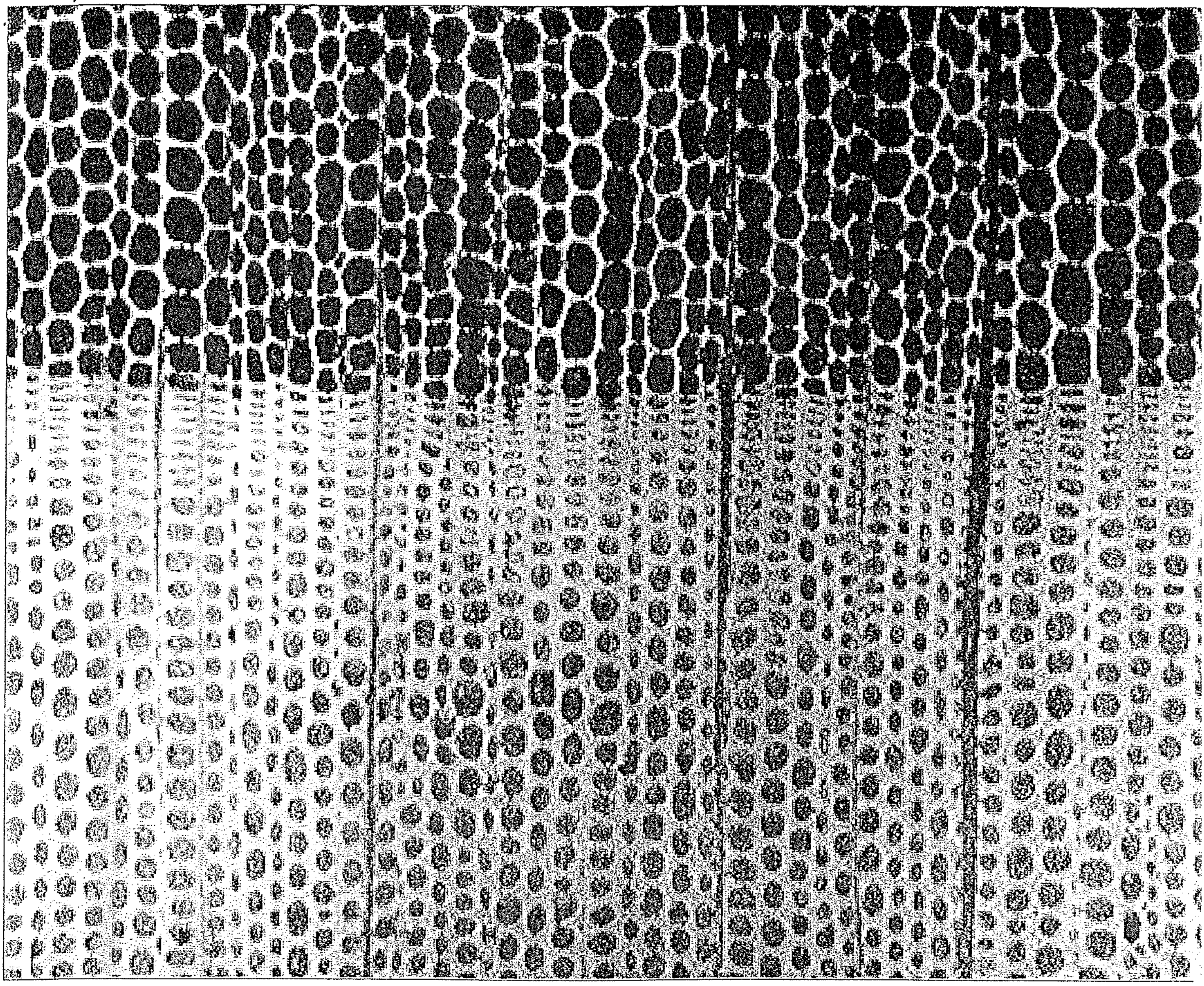
The following simple relationships, given in various forms in previous publications (e.g., Stamm 1964, Britt 1965, 1966, Scallan and Green 1974, 1975, Yao 1978), are useful approximations for softwoods in which tracheids occupy most of the wood volume:

$$P = 2\,(R+T)$$
$$C = R\,T\,D$$
$$w = P/8 - (P^2/16 - C/d)^{0.5}$$

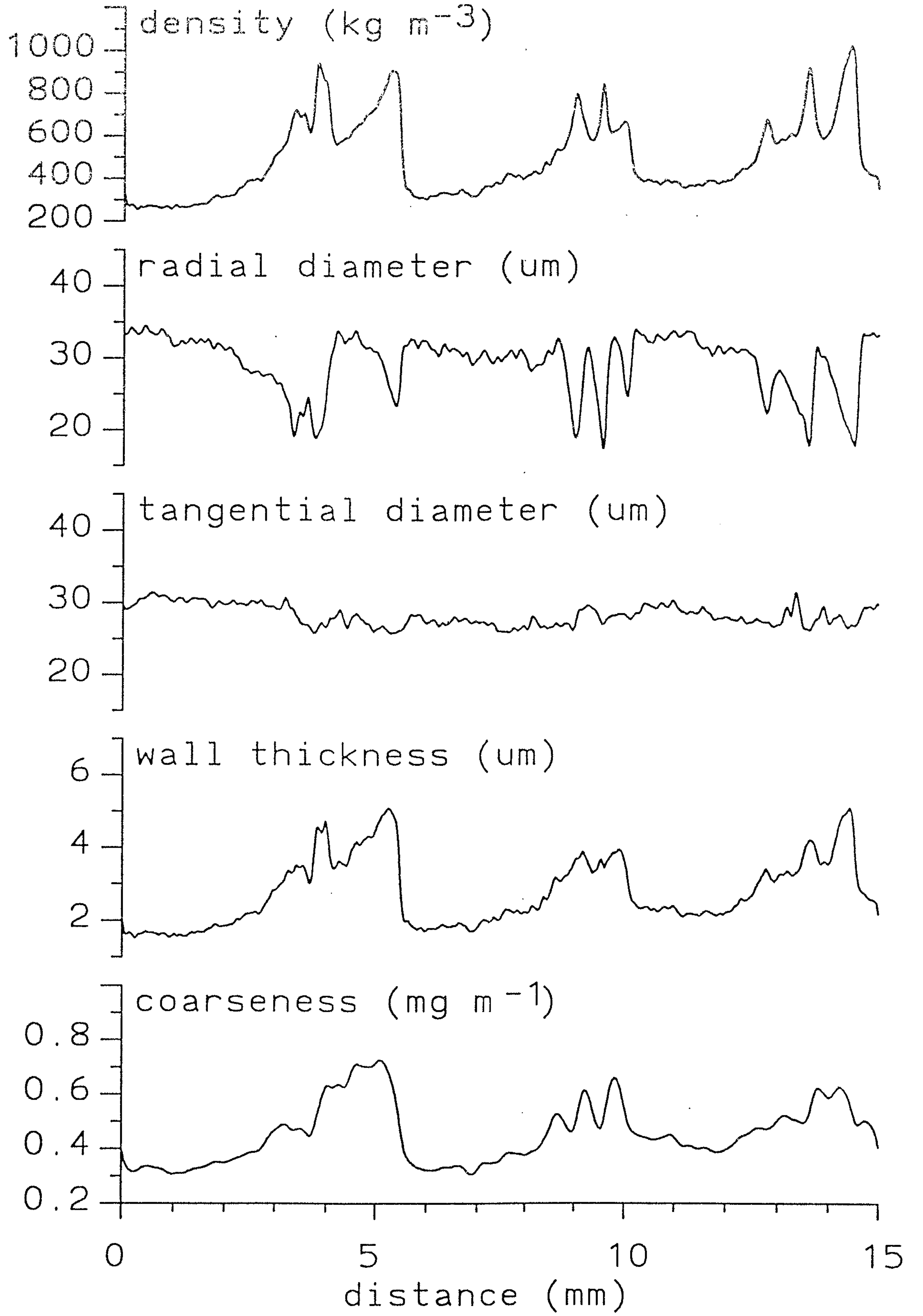
where:

w = tracheid wall thickness
P = external perimeter of rectangular tracheid cross-section
R = radial tracheid dimension (pith to bark direction)
T = tangential tracheid dimension (parallel to the rings)
D = wood density
d = tracheid wall density
C = tracheid coarseness (mass per unit length)

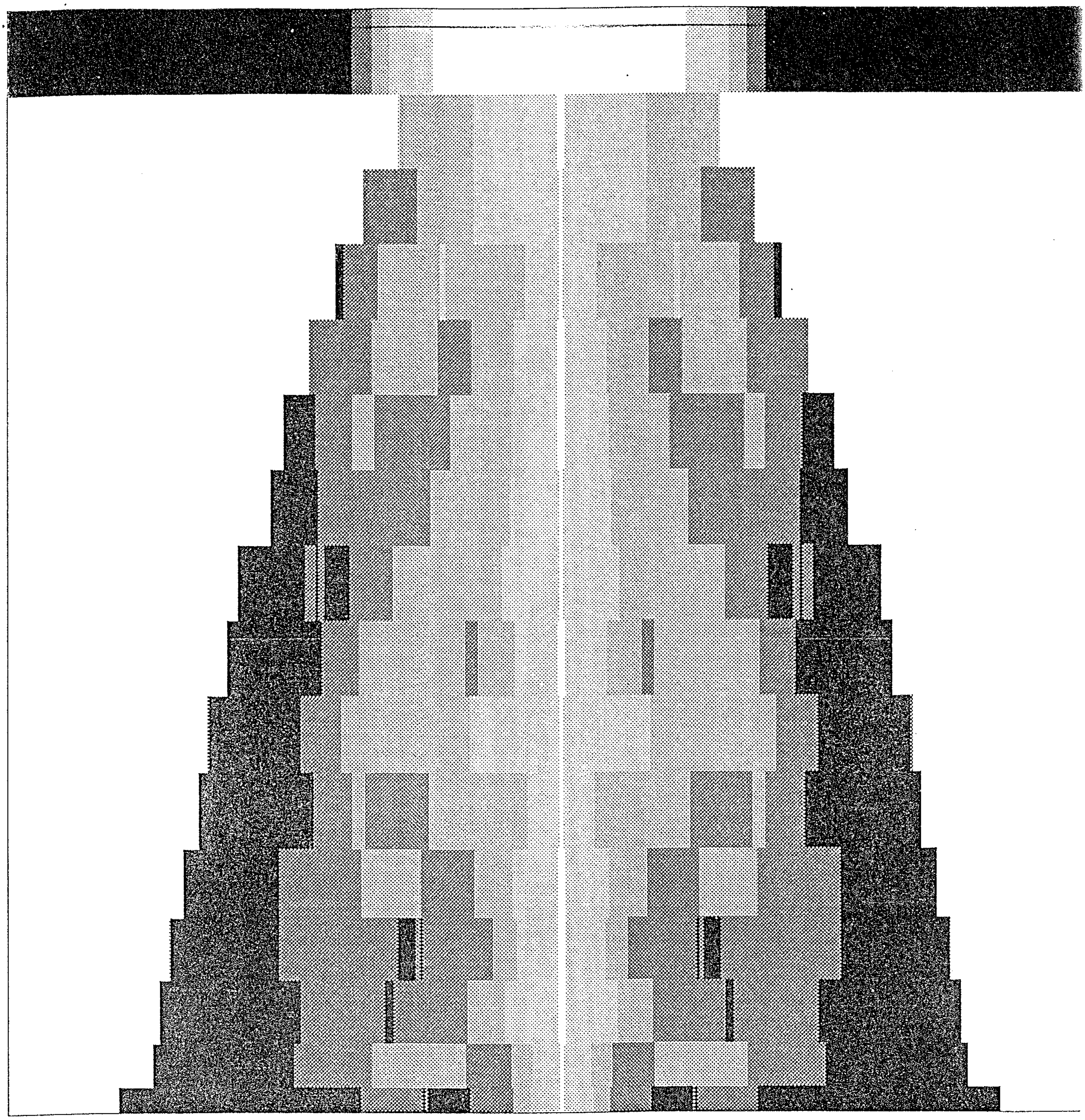

video
microscope
bark
detector
x-ray
source
pith
rotation
translation



Latewood (bottom) and springwood (top) of P. radiata



A densitometry printout as assessed by image analysis



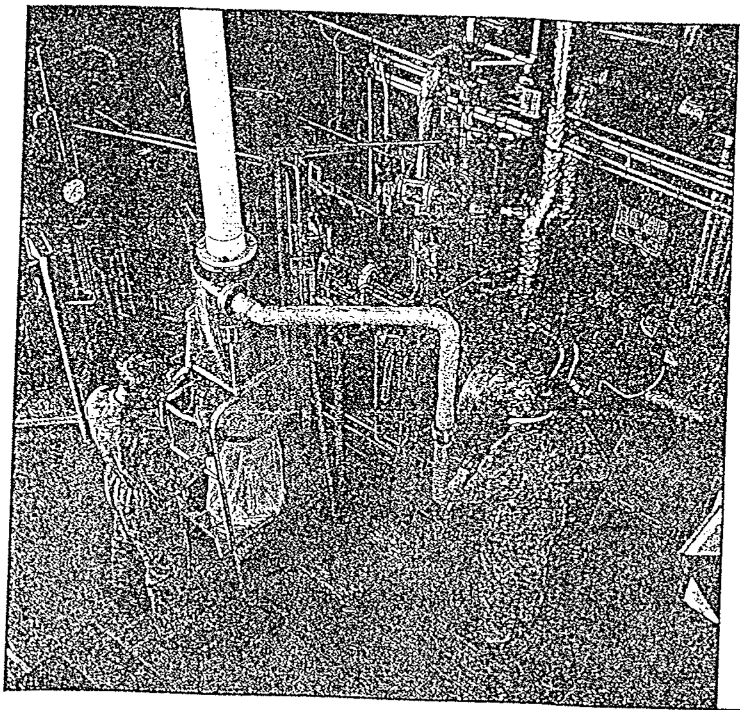
APPENDIX IV

The CSIRO High Yield Pulping Group

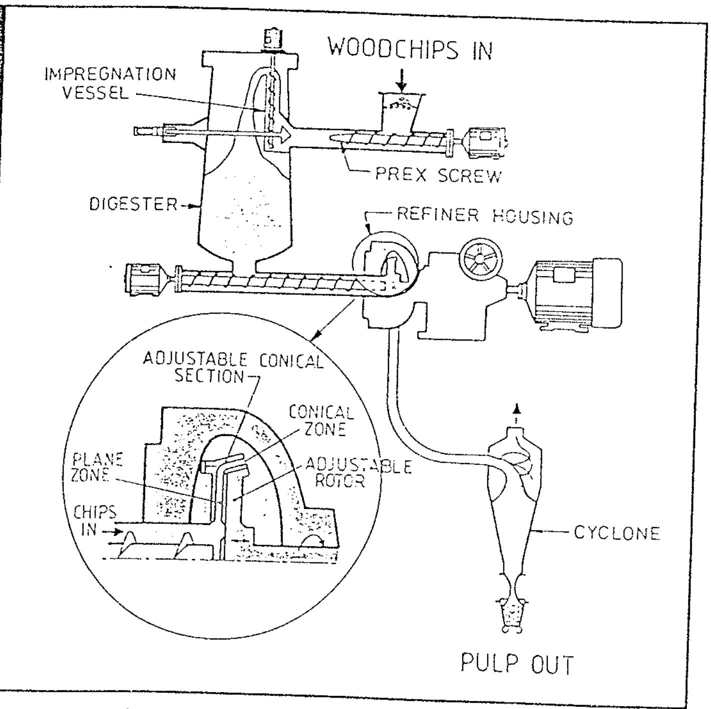
INTRODUCTION

The HIGH-YIELD PULPING GROUP has many years of expertise in the pulp, paper and forest products industries. It has carried out research on a range of Australia's wood resources using a wide variety of pulping and bleaching techniques. The Group has collaborated with industry both in a short term service role and long term collaborative research. The Group is backed by the Division's extensive capabilities and experience in chemical and semi-chemical pulp production and paper testing.

The expanding studies in wood and fibre science will lead to an improved underpinning of high-yield pulping thus extending the usefulness of the Group.



The Sunds Defibrator CD300 refiner



Schematic diagram of the CD300 refiner

DEFIBRATOR PILOT PLANT

The Sunds Defibrator CD300 pilot plant refiner is the only one of its type in the southern hemisphere. It can be steam pressurised to 1.7 MPa (200°C). The unit consists of a plug screw feeder (PREX), a chemical impregnator, and a single disc refiner with independently controlled conical disc refining plates. Only 25kg (o.d.) of woodchips is required for a pulping run.

WHAT CAN WE DO?

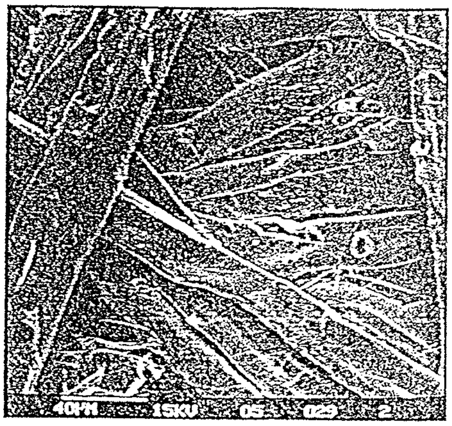
- conduct collaborative research with industry, academia and other research institutions
- manufacture a broad range of high-yield mechanical "alphabet" pulps including: RMP; TMP; CMP; CTMP from softwoods and hardwoods by batch or continuous processing with the CD300 and /or the ROP 20 refiners
- pulp non-woody fibre such as bagasse, wheat straw, rice husks and cotton stalks
- manufacture fibre for panel board products such as MDF and particleboard
- carry out bleaching trials

OUR INTERESTS

The HIGH-YIELD PULPING GROUP is active in many research areas associated with the forest products industry, including:

- assessment of the value of forest resources for pulpwood
- the correlation between fibre structure and pulp properties
- tree age, site and provenance trials
- utilisation of non-woody fibre
- multistage chemical impregnation trials
- in-refiner and impregnator bleaching
- evaluation of bleaching chemicals
- optimisation of pulping conditions
- reducing effluent impact
- utilisation of recycled paper

Technibrite Micro TB-IC



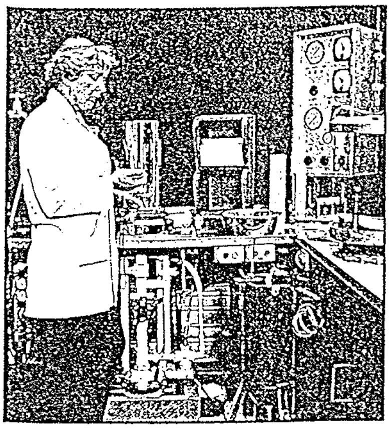
SEM micrograph of P.radiata TMP

OTHER FACILITIES

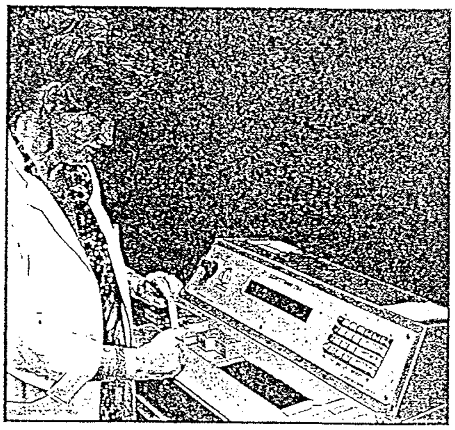
Bleaching
Bleaching trials can be conducted within the pilot plant and laboratory

Fibre Measurements
Fibre characteristics can be determined using the Pulmac Shive Analyser and the Kajaani FS200 fibre analyser. We have access to an SEM with EDS, trace element detection and real time colour imaging. Our access also extends to X-ray densitometry and image analysis of wood microstructure.

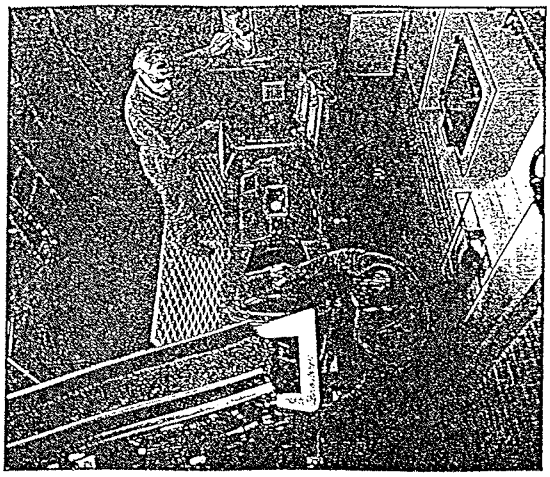
Pulp Evaluation
For high-yield pulps, we use a sheet machine fitted with a white water recirculation system for fines retention. Australian standards and the "MUST" auditing system are used which combine to provide accurate reliable results.



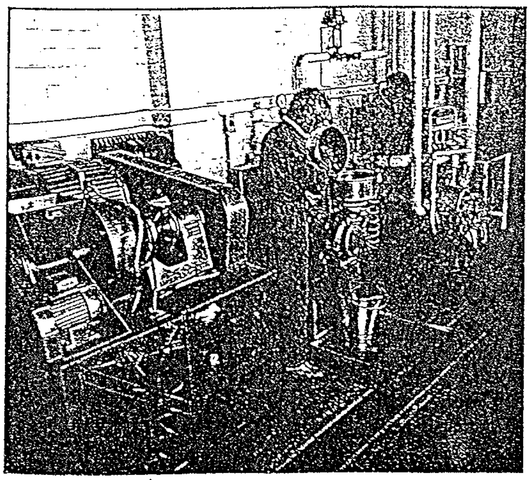
Sheet machine



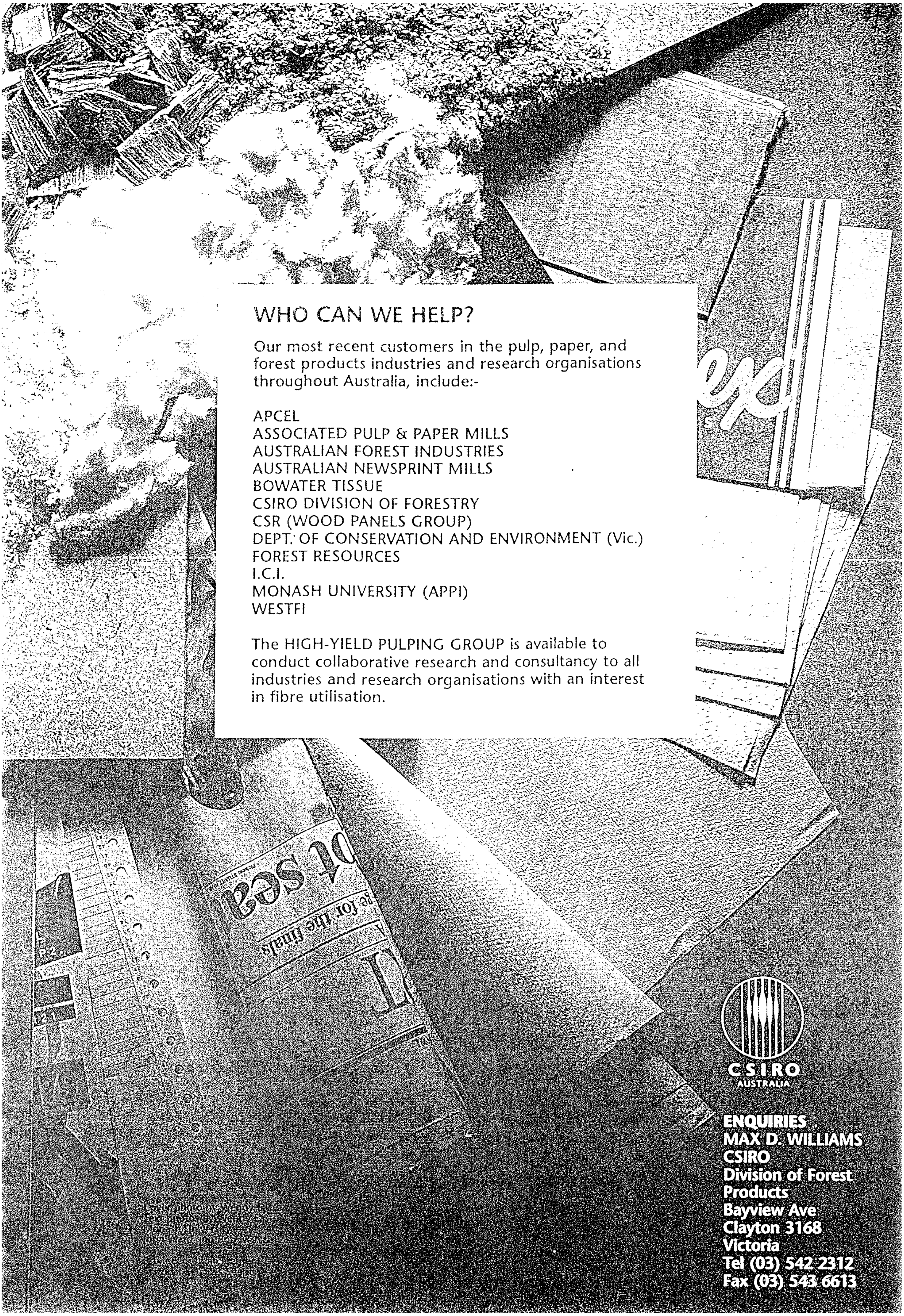
Alwetron TH 1 tensile tester



The ROP 20 secondary refiner



Other high-yield pulping equipment



WHO CAN WE HELP?

Our most recent customers in the pulp, paper, and forest products industries and research organisations throughout Australia, include:-

APCEL
ASSOCIATED PULP & PAPER MILLS
AUSTRALIAN FOREST INDUSTRIES
AUSTRALIAN NEWSPRINT MILLS
BOWATER TISSUE
CSIRO DIVISION OF FORESTRY
CSR (WOOD PANELS GROUP)
DEPT. OF CONSERVATION AND ENVIRONMENT (Vic.)
FOREST RESOURCES
I.C.I.
MONASH UNIVERSITY (APPI)
WESTFI

The HIGH-YIELD PULPING GROUP is available to conduct collaborative research and consultancy to all industries and research organisations with an interest in fibre utilisation.

CSIRO
AUSTRALIA

ENQUIRIES
MAX D. WILLIAMS
CSIRO
Division of Forest Products
Bayview Ave
Clayton 3168
Victoria
Tel (03) 542 2312
Fax (03) 543 6613

APPENDIX V

FLOW CHARTS FOR MAKING RFLP's AND RAPD's

Screening for RFLPs

Extraction of DNA

↓

Cut restriction endonuclease

↓

Agarose gel electrophoresis

↓

Southern blotting onto nylon membranes

↓

Hybridisation - labelled probe

↓

Visualisaton - autoradiography

Screening for RAPDs

Extraction of DNA

↓

PCR - random primers

↓

Agarose gel electrophoresis

↓

Visualisation - UV light

RFLPS vs RAPDs in tree species

RAPDs technologically easier and quicker to do

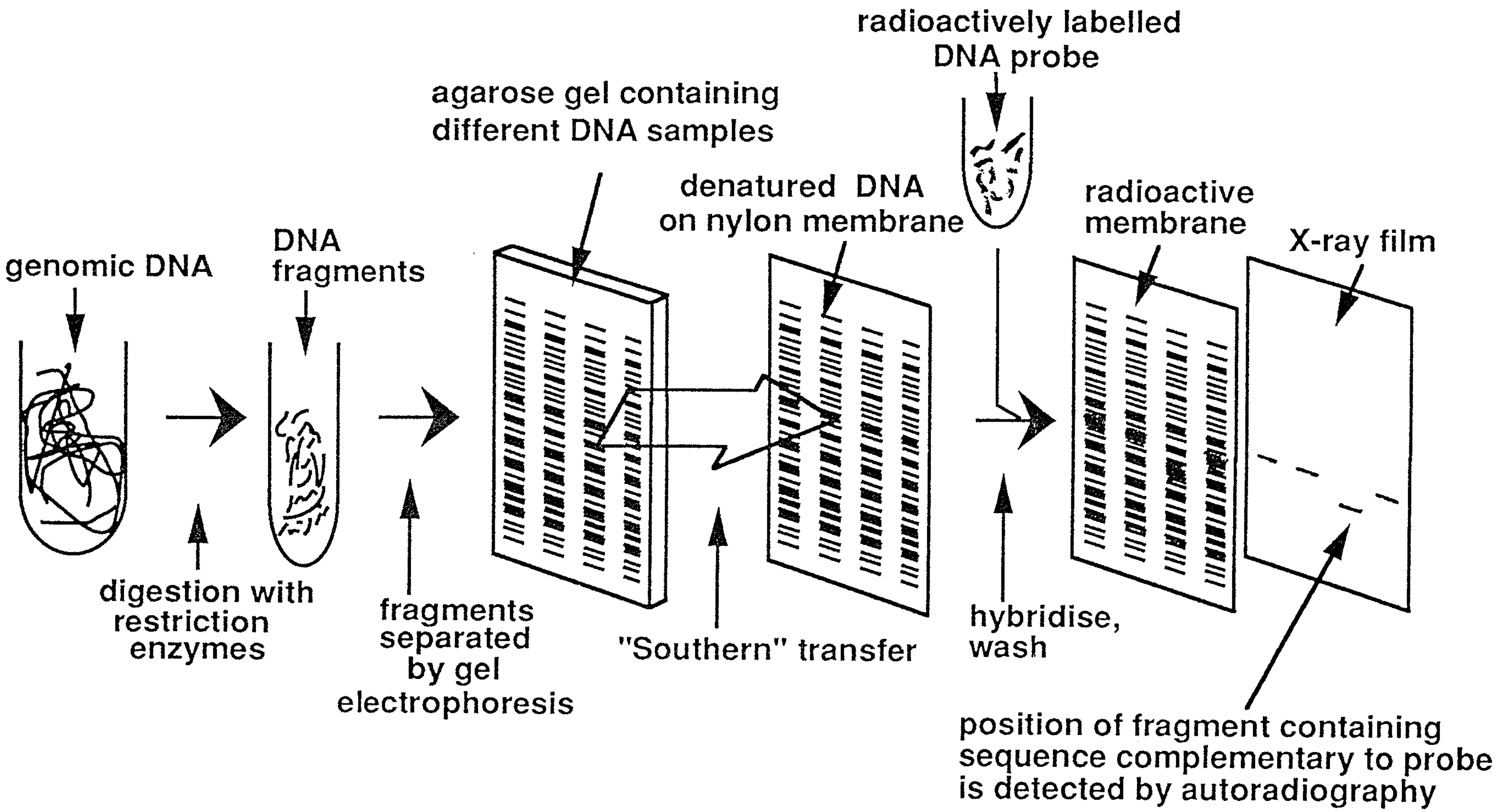
RAPDs require 100-fold less DNA than RFLPs per sample

RFLPs codominant markers, RAPDs generally dominant
    genetic analysis easier and more useful RFLPs
    exception haploid megagametophytes in conifers

RFLPs more difficult with large genomes e.g. conifers

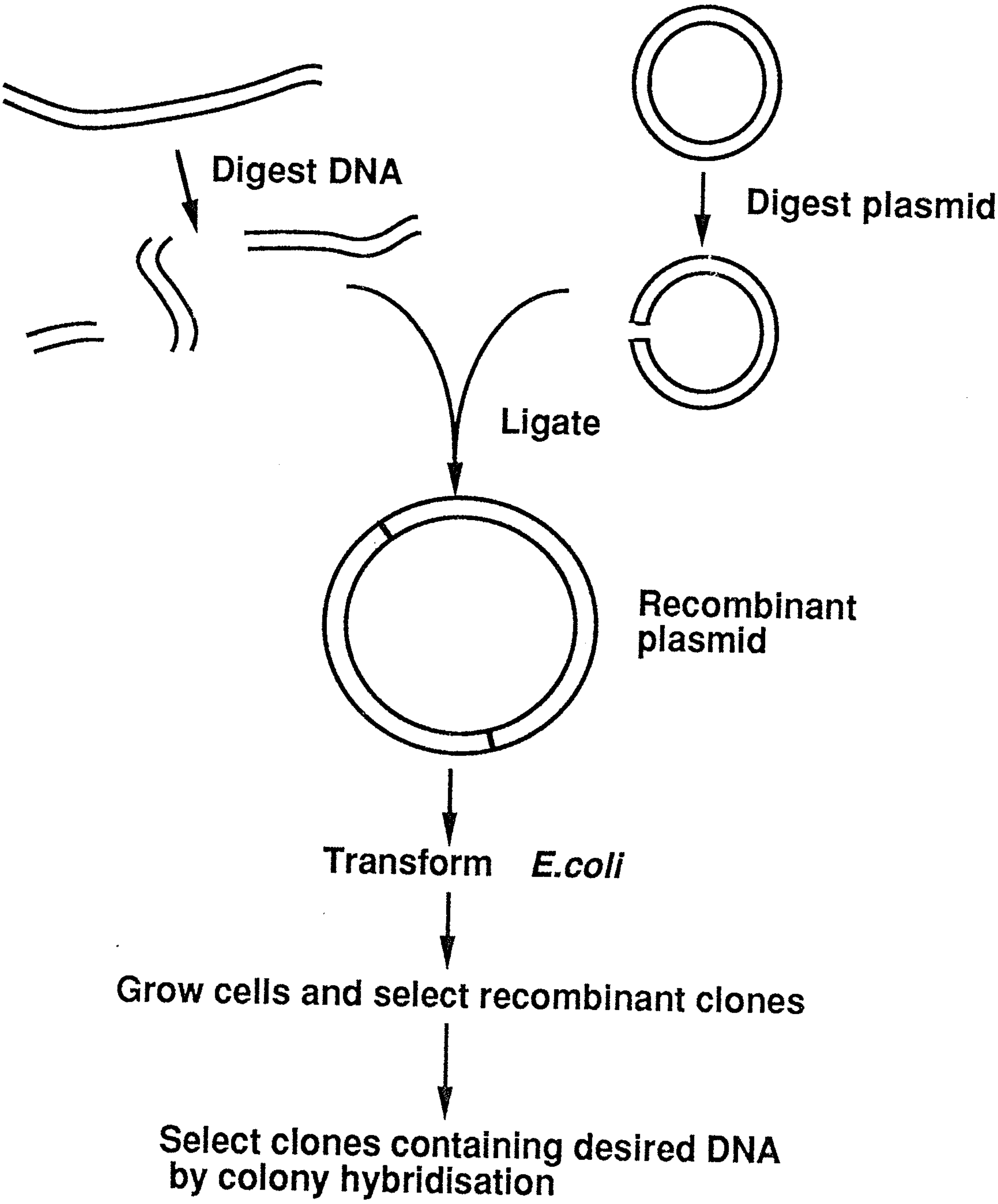
RFLPs make DNA probes, RAPDs buy primers

"Southern Blotting" And Analysis Of DNA



51

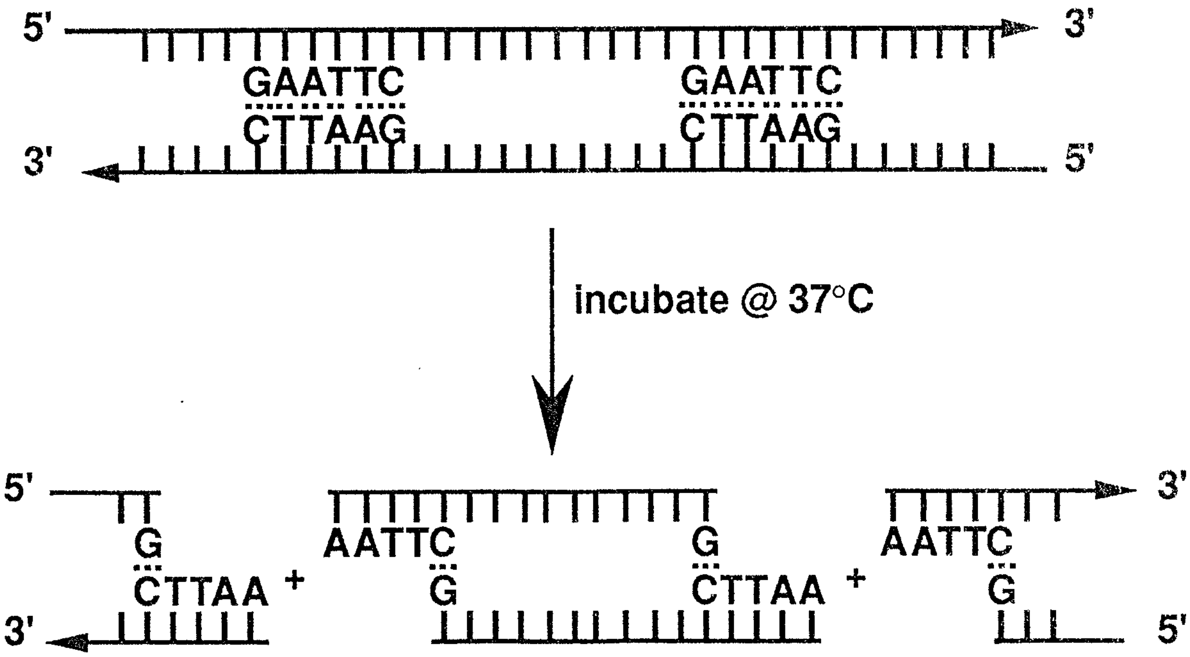
Making A DNA Library



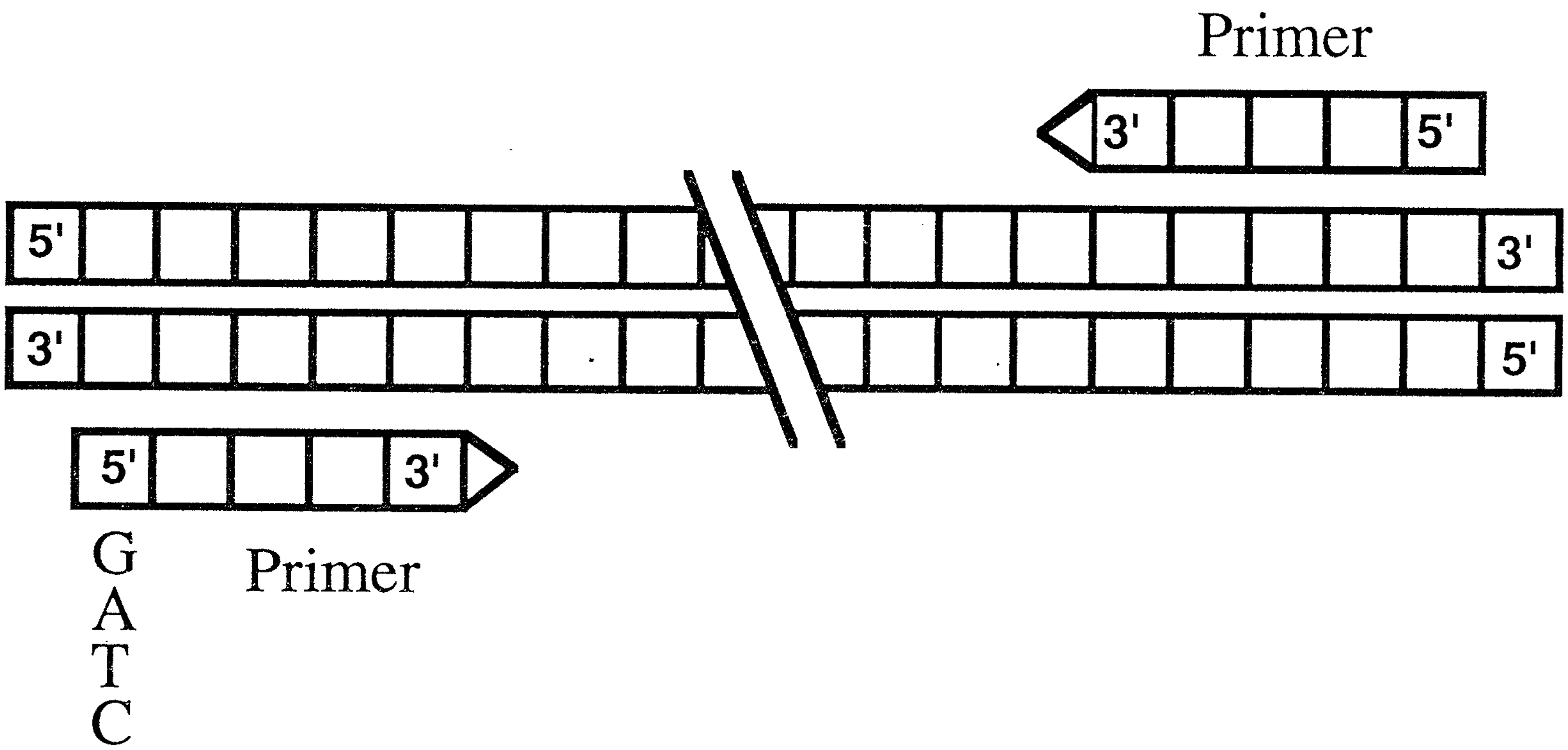
Restriction Enzymes

* recognize a specific sequence
* cleave both strands
* about 1000 known, >>100 commercially available
* may be sensitive to methylated A or C

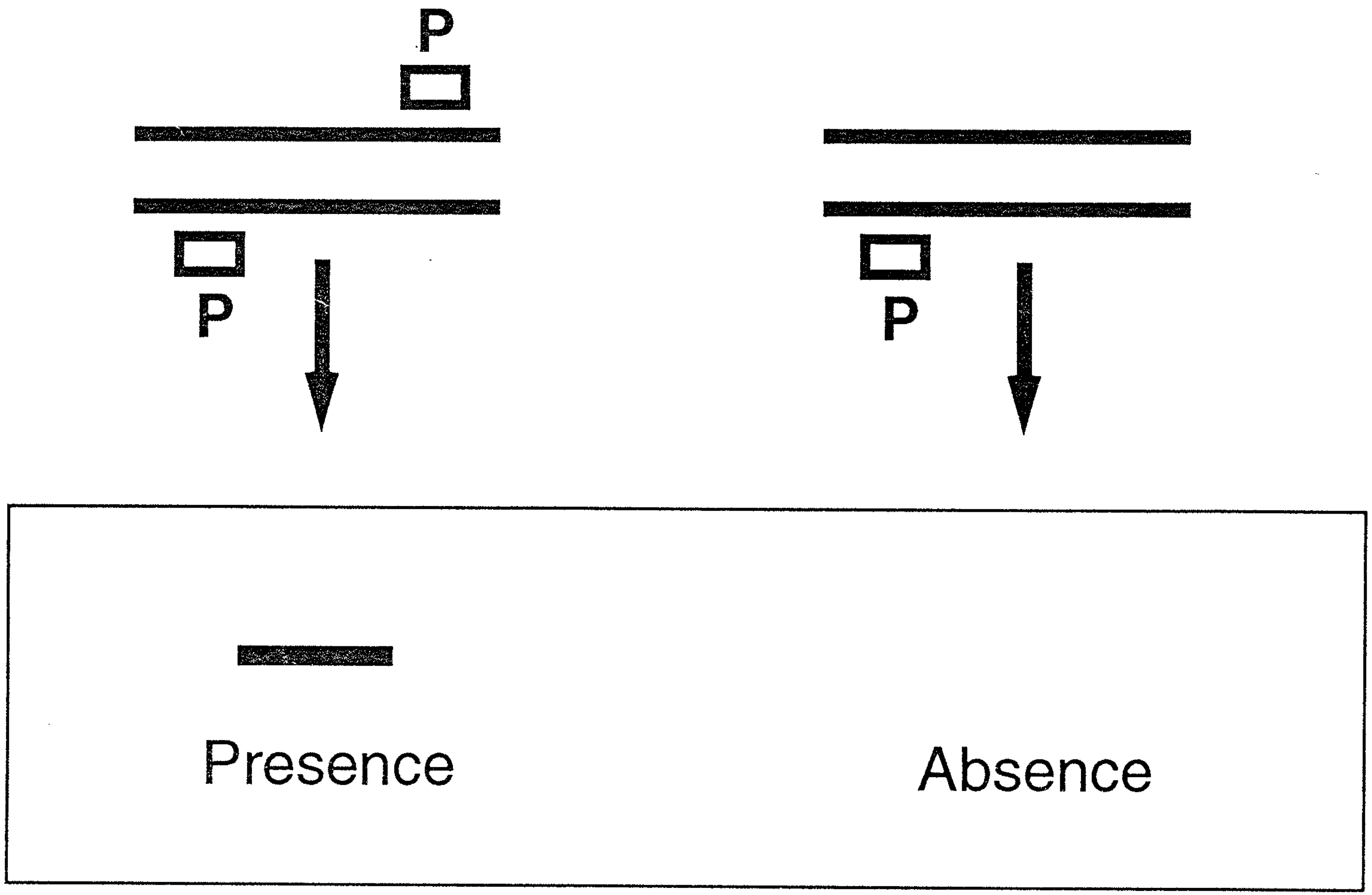
Example: EcoR I   Source - *Eschericia coli* RY13



RAPD Markers



A RAPD Polymorphism



A RFLP Locus - 2 Alleles