Cooperative Research Centre for Temperate Hardwood Forestry

ANNUAL REPORT 96/97

Established and supported under the Australian Government's Cooperative Research Centres Program

CRC
AUSTRALIA

CENTRE OBJECTIVES

General:

The general objectives of the Centre are:

- to undertake high-quality scientific and technological research which con tributes to national forestry objectives, including economic and social development and the development of an internationally competitive industry sector;
- to ensure that industry captures the benefits of research and to strengthen the links between research and its commercial and other applications by the active involvement of the industrial participants in the work of the Centre;
- to develop a centre of forestry research by promoting cooperative research and through it a more efficient use of resources;
- to provide relevant education and training, particularly in graduate programs, through the involvement of researchers from outside the higher education system in educational activities and by involving graduate students in major research programs;
- to operate effectively and efficiently according to international standards and under sound financial control;
- to ensure staff are well motivated, appropriately skilled and work safely.

Specific:

The Centre aims to become a national centre for developing and promoting innovation in hardwood forestry by:

- developing forest management systems to increase wood productivity in temperate hardwood forests in an environmentally sustainable and responsible way;
- improving the quality of wood from hardwood forests to ensure its market suitability for efficient, value added processing;
- gaining a competitive advantage for Australia's forestry sector over other hardwood producing countries;
- developing a national centre of excellence for postgraduate training with emphasis on training graduates relevant to the industry sector.

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CRC AUSTRALIA

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UNIVERSITY OF TASMANIA

Participating Organisations

The CRC for Temperate Hardwood Forestry has chosen Australian-made paper for the body of this report.

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Abbreviations

APP	Australian Paper Plantations
ANM	Australian Newsprint Mills
BARC	Browsing Animal Research Council
CRC-HFPS	Cooperative Research Centre for Hardwood Fibre and Paper Science
DELM	Department of Environment and Land Management
DPI	Department of Primary Industry
DIST	Department of Industry, Science and Technology
GI	Genetic Improvement
RP	Resource Protection
SME	Small to Medium-sized Enterprise
SSM	Soil and Stand Management
STBA	Southern Tree Breeding Association
TFRC	Tasmanian Forest Research Council

Obituary

Harold William Woolhouse

Harold William Woolhouse, plant scientist and former CRC Visitor, born 12 July 1932; died 19 June 1996.

Harold Woolhouse was born in Sheffield, England and after he obtained his doctorate at Adelaide University, he returned to Sheffield to take up a position as lecturer at Sheffield University. There he became known as an able young lecturer and amassed an impressive body of publications in the areas of plant senescence, photosynthetic adaptations to the aerial environment and plant-soil nutritional relations. He left Sheffield in 1969 to take up the chair of botany at the University of Leeds. His innovative ideas, which met with strong opposition from some of the 'incumbents', benefited the students enormously and his graduates were noted for their intellectual independence and ability to tackle scientific problems.

Harold left Leeds in 1980 to become director of the John Innes Research Station at Norwich. As part of his task there, he had to reorganise the Plant Breeding Institute at Cambridge and bring part of it, together with the Nitrogen Fixation Unit in Sussex, to Norwich. Although heavily involved in genetics, genetic engineering and molecular biology at the John Innes Institute, Harold maintained his interest in several other research fields and wrote perhaps his best scientific paper at this time, a review about metal tolerance in plants.

In 1990, ahead of prospective retirement, Harold was appointed director of the Waite Agricultural Research Institute in Adelaide. Here too, he carried out massive but constructive reorganisation, merging a number of research and university institutions.

He was appointed Visitor to the CRC-THF in 1994. He was also the Visitor for the CRC for Hardwood Fibre and Paper Science and the CRC for Industrial Plant Biopolymers.

Chairman's Letter

CRC Secretariat
GPO Box 9839
Canberra City
ACT 2601

Dear Sir

I am pleased to present to you the 1996/97 Annual Report of the Cooperative Research Centre f Temperate Hardwood Forestry.

This document summarises the major research and education activities of the CRC for Tempera Hardwood Forestry which, during its six years of operation, has made a very significant contribution forest science in Australia and heralds the start of the new CRC for Sustainable Production Forestry.

I am delighted that the proposal for a new CRC, the Cooperative Research Centre for Sustainab Production Forestry, has been accepted. It is a credit to the efforts of the Director, Professor Jim Re and the staff of the Cooperative Research Centre for Temperate Hardwood Forestry and an affirmatio of the spirit of cooperation embodied in the CRC program, that the new Centre has been developed.

With the inclusion of many more partners, the new Centre will build on and expand the excelle foundation achievements in research and education set by the CRC for Temperate Hardwood Forestr I feel confident of its success in maintaining standards of excellence and innovation in scientifi research for Australia's forestry industry.

Yours sincerely

John Kerin
Chairman

25 August 1997

Director's Report

This year has been one of substantial change for our CRC. It began with the Stage Two of our Fifth Year Review and the submission of a proposal for the continuation of the CRC under the new title of Cooperative Research Centre for Sustainable Production Forestry. The review was conducted by the CRC Committee and our review panel consisted of Dr Geoffrey Vaughan, Mr Jim Miller and Dr Ken Eldridge. The review was favourable, indicating that the CRC had met all the requirements of the Commonwealth Agreement and the four CRC Program objectives and is thus making a substantial contribution to Australia's research effort. The Stage Two Review also endorsed the very positive findings of the Stage One Review into the scientific and technical aspects of the CRC.

In December 1996 we were notified that our application for continued funding had been successful, with a Commonwealth contribution of $2.3 million per year until July 2004 (total of $15.45 million). We were the only CRC from the original group of Agriculture and Rural Based Manufacturing CRCs to be given continued funding. The CRC for Sustainable Production Forestry involves a number of new parties including the Primary Industries Corporation (Qld), Southern Cross University, CSIRO Division of Entomology, Griffith University, Australian National University, The University of Queensland, Australian Forest Growers, Southern Tree Breeding Association, and Silvagene Pty Ltd. The Joint Venture and Commonwealth Agreements have been finalised and new research and education programs developed after considerable debate. The Centre will have a much broader scope than the CRC for Temperate Hardwood Forestry because of the addition of work on tropical plantation species and numerous new partners across Australia. It will be a difficult challenge within a limited budget, but one that I am sure all members of the CRC face with high expectations.

The research of the Centre has continued to make substantial progress during 1996-97, and the results have been effectively transferred to our industry partners via seminars, workshops, technical publications or by our involvement with industry associations such as the Southern Tree Breeding Association. The number of research students in the Centre has reached a plateau with 42 enrolled. Ten of these were attracted from industry and most are supported by scholarships from industry or national competitive schemes. We have continued to be successful in attracting additional resources to the CRC from competitive grants in innovative areas. For example, Dr Neil Davidson was awarded a grant from the Science and Technology Awareness Program run by DIST to encourage women to develop careers in forestry.

There have been numerous staffing changes during the year. It is with thanks and a degree of sadness that several key staff members of the CRC have moved on to other endeavours, including Dr David de Little, our Deputy Director, Dr John Madden, Program Manager, Resource Protection, Mr Robin Cromer, Program Manager, Soil and Stand Management and Mrs Jan Lynch, our Business Manager. Prof Pip Hamilton, former Pro-Vice Chancellor (Research), at the University of Tasmania and Mr Ken Felton, General Manager, Forest Management, Forestry Tasmania have also resigned from our Board. They are replaced by Prof Geoff Parr, the Acting Pro-Vice Chancellor (Research) and Dr Hans Drielsma, General Manager, Forest Management, Forestry Tasmania.

Prof James B Reid
Director

Management

The Board

The Board of Management of the CRC is comprised of an independent Chairman, the Director and Deputy Director of the CRC and the Chief Executive (or representative) from each participating organisation. The Board determines policy and sets guidelines for the efficient running of the Centre.

Structure

The Management Structure of the CRC is headed by the Board and links are depicted in Fig. 1. Operation of the four programs is directed through three committees: the Management Committee, the Industry Research Committee and the Scientific Review Committee.

Management Committee

The Management Committee coordinates the day-to-day running of the CRC and is comprised of the Director, the Deputy Director, the Executive Officer (Administrative Officer and Business Manager) and Program Managers.

Prof Jim Reid
Director

Dr David de Little
Deputy Director

Mrs Shelley Caswell
Administrative Officer

Mrs Jan Lynch
Business Manager
(vacant from December 1996)

Dr Nuno Borralho
Genetic Improvement Program

Mr Robin Cromer
Soil and Stand Management Program

Dr John Madden
Resource Protection Program

Dr Neil Davidson
Education and Technology Transfer Program

Ms Jean Richmond is Secretary to the Director and the Board.

Mr Geoff McArthur
Executive Manager
Bunnings Treefarms

CRC Board

Mr John Kerin
Chairman

Prof Jim Reid
Director

Dr David de Little
CRC Deputy Director
Manager Forest Biology
North Eucalypt Technologies

Prof Pip Hamilton
Pro-Vice Chancellor
(Research)
University of Tasmania

Mr John Cameron
Manager, Group Development
Australian Paper

Mr Allan Jamieson
Manager
North Eucalypt
Technologies

Dr Glen Kile
Chief
CSIRO Forestry & Forest
Products

Mr Ken Felton
General Manager
Forest Management
Forestry Tasmania

Mr Neil Humphreys
General Manager
ANM Forest Management

Mr Ross Wainwright
Manager
Boral Timber Tasmania

The Scientific Review Committee

The Scientific Research Committee reviews projects in each research program. It performs the role of monitoring the quality of the research conducted at the Centre for the Board and is comprised of outside experts in each of the research program areas. Its members are:

Dr Russell Haines
Director, Queensland Forest Research Institute
(Genetic Improvement)

Dr Sadanandan Nambiar
Chief Research Scientist
CSIRO Forestry and Forest Products, Canberra
(Soil and Stand Management)

Dr Lindsay Barton Browne
Honorary Fellow
CSIRO Division of Entomology, Indooroopilly
(Resource Protection)

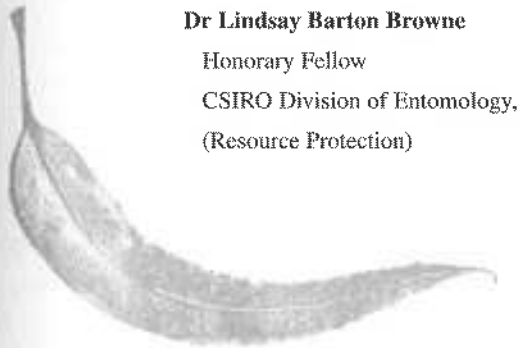
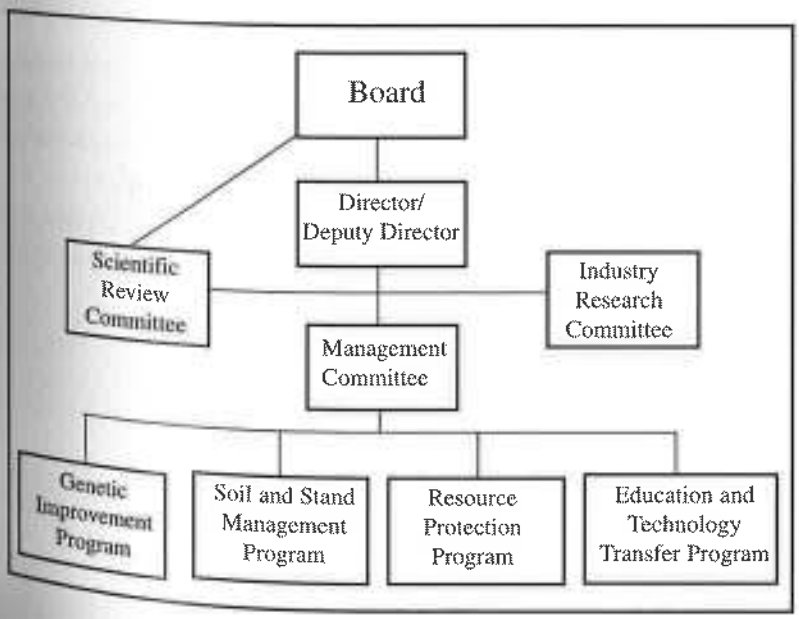


Figure 1 Management Structure



Industry Research Committee

The Industry Research Committee is comprised of senior research scientists from all participating organisations and the Management Committee and advises the Board on the research priorities for the Centre. This committee is chaired by a leading industry researcher, Dr David de Little from North Forest Products, and its members are:

Dr David de Little
Manager, Forest Biology, North Eucalypt Technologies

Mr Peter Volker
Silviculture Superintendent, ANM Forest Management

Dr Humphrey Elliott
Chief, Division of Silvicultural Research and Development, Forestry Tasmania

Mr Peter Naughton
Research and Planning Forester, Boral Timber

Mr Philip Whiteman
Technical Manager, Australian Paper Plantations
(resigned February)
Replaced by **Ms Silvia Pongracic**

Mr Richard Breidahl
Chief Forester, Bunnings Treefarms

Prof Jim Reid
Director, CRC-THF

Dr Nuno Borralho
Program Manager, CRC Genetic Improvement

Mr Robin Cromer
Program Manager, CRC Soil and Stand Management

Dr John Madden
Program Manager, CRC Resource Protection

Dr Neil Davidson
Program Manager, CRC Education and Technology Transfer

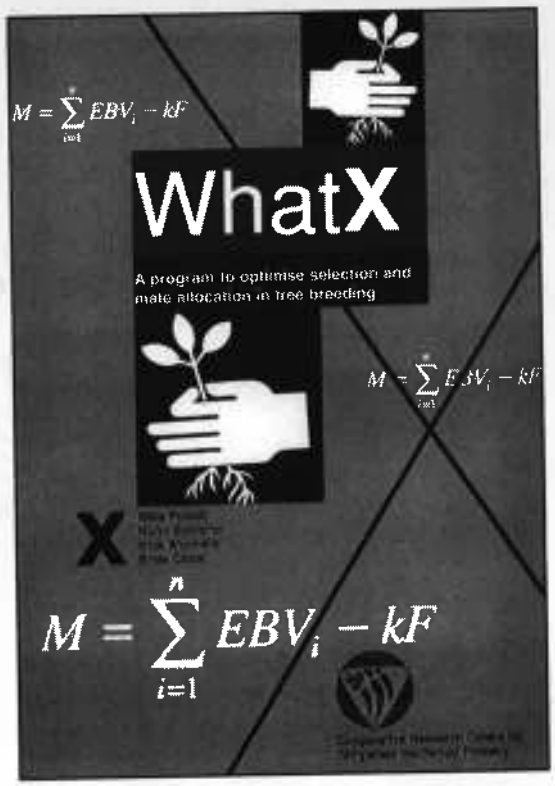
Prof Robert Hill
Head, Department of Plant Science, University of Tasmania

Dr Geoffrey Gartside (resigned, 18 April 1997)
Co-Director, CRC for Hardwood Fibre and Paper Science

MAJOR DEVELOPMENTS

Optimising selection and mate allocation in tree breeding

The aim of a tree breeding program is to maximise the rate of genetic improvement in planting stock each year. This includes selecting the trees to be used in a crossing program, deciding which pairs of trees are to be mated and what subset of the progeny is to be planted (deployed). The way this is done will have an important bearing on the effectiveness of the breeding program.



WhatX, a new software program from the CRC for Temperate Hardwood Forestry

An appropriate objective of a breeding program is to determine, from a total number of M candidates in a breeding program, which m selections should be used for crossing or deployment, such that the progeny resulting from matings have the highest genetic merit. However, the breeding population is commonly structured as families (progeny from a single mother tree), so selecting on the basis of genetic merit alone will result in some level of relatedness amongst the m selections. Selection decisions should therefore include some penalty for the relatedness between trees, in order to reduce future inbreeding in the breedi population. The objective function (H) to maxim genetic gain can then be defined as:

$$H = G_m - k a_m$$

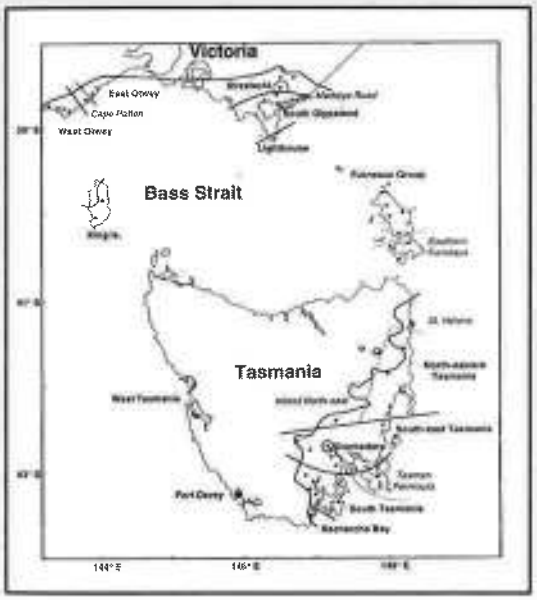
where G_m is the expected genetic merit of the selec group of m trees, k is a specified weight, and a_m is t average coancestry amongst the m trees. The use o high k will penalise relatedness and result in selection of unrelated trees. The use of a low k will penalise related trees and some selections will related. Both G_m and a_m depend on the set of m tre selected. Finding a solution for this problem important when designing an appropriate crossing pla a seed orchard or choosing clones.

However, an obvious problem in finding optimum directly is that there are a large number possible combinations of m selections from M tre The CRC-THF, in collaboration with indus mathematicians at the University of Melbourne a Monash University have developed a simple progra called WhatX, to find a near optimum solution to t problem. WhatX uses a simulated annealing algorith to perform the optimisation. The algorithm has be tested on real data and found to converge consistent for a range of parameters to optimum solutions, given by linear programming techniques. WhatX written in C, and compiled for execution under DOS or Windows™ operating system. It should on any personal computer with a 386 microprocesso better. A free copy of the software and documenta can be obtained by contacting the CRC-THF. T software is being used by industry in Australia overseas in planning the crossing program and des of seed orchards.

MAJOR DEVELOPMENTS

Race classification of *Eucalyptus globulus* ssp. *globulus* and its intergrades

There is much genetic variation detectable within a single eucalypt species, and within commercial species such as *E. globulus* it is important to take account of this variation when making selections for the purposes of improving growth rate and fibre quality. *E. globulus* has in the past been divided into the subspecies *globulus*, *maidenii*, *pseudoglobulus* and *bicostata*, and there exists intergrade areas between these subspecies where they are adjacent. Within subspecies *globulus* there are races that have been defined which have unifying characteristics just like those in human beings. Failure to account for races in genetic models can have a dramatic effect on the trees that are selected for a trait (depending on the distribution of race effects), with gain being reduced by as much as 20%.



New races and sub-races (in italics) of Eucalyptus *globulus, with sampling locations indicated*

A major revision of the race classification of *E. globulus* ssp. *globulus* and its intergrades with related subspecies has just been completed by Greg Dutkowski and Brad Potts using a wide variety of traits. The data have been collected over many years by Brad Potts' team and North Forest Products' staff from North's comprehensive trials of the 1987/88 CSIRO seed collections. These same seed lots form the basis of many breeding trials around the world. The traits that have been used include growth, pilodyn penetration, flowering precocity, bark thickness, sawfly damage, and leaf traits. The classification is very useful because it reflects variation in a wide range of traits, not only traits of economic interest, making it very robust.

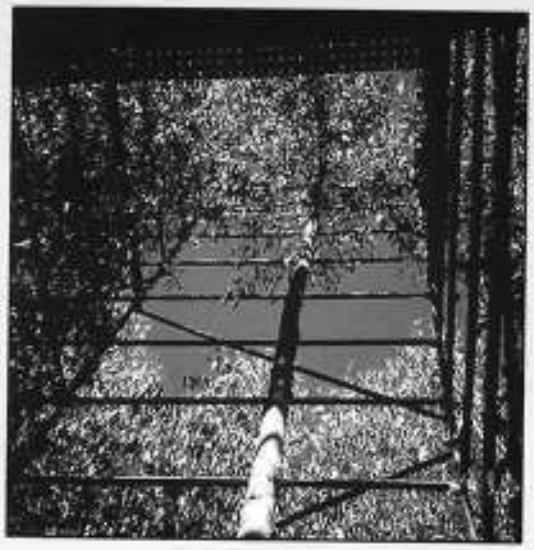
The classification has identified a number of new races which had not been evident in previous racial classifications, which were mainly based on capsule morphology or growth. There is a major division between the west and east Otway range populations. Differences between the Furneaux Group have been found and the boundaries between races in eastern Tasmania have been better identified. While the continuous nature of the variation in many areas has made the delineation of precise race boundaries difficult, the classification has identified those areas that are outlying from, or intermediate between, major racial groups, and given them sub-race status.

This revision of race classification will allow more weight to be given to race and family information in picking the best trees.

MAJOR DEVELOPMENTS

Green pruning an option for sawlog plantations

One option for establishing eucalypt plantations for production of high quality logs for sawn timber and veneer, is to plant at high densities and then to prune and thin progressively during the rotation. *E. nitens* is highly suited to the range of sites available in Tasmania and other parts of south-east Australia for establishing such plantations. Since 1991, the Forests and Forest Industry Council of Tasmania has established 7000 ha to this species for production of sawlogs. This resource will partly replace areas of native forest in Tasmania which have been removed from sawlog production.



Pruned tree of E. nitens with lower 50% of crown removed, at Gould's plantation near Dover, Tasmania. The scaffolding tower provides access for in-canopy measurements of photosynthesis and biomass distribution.

Eucalyptus nitens is a fast-growing species which retains rather than sheds dead branches. Retention of branches causes wood to be knotty and can significantly decrease the quality of wood recovered at final harvest. This can be overcome by green pruning; that is, the removal of live branches to a predetermined height. Green pruning has the advantages of minimising the size of the central knotty core of the stem and reducing the incidence of loose knots. If removal of branches is timed to coincide with the vigorous growth phase around canopy closure, rapid occlusion of stubs will occur, minimising the incidence of disease entry.

A detailed study of the growth and physiology of *E. nitens* in response to green pruning has been undertaken by postgraduate student Libby Pinkard. She has shown that if growth rates are rapid and pruning is timed to coincide with canopy closure, this species can be selectively pruned to remove (from the base) up to 50% of the lower green-crown length without loss of height or diameter growth or dominance. The target tree size for first-lift pruning is about 7.5 m in height, and pruning to about 2.7 m from the ground in the first lift will result in 40% crown removal. This research has demonstrated that this is an effective strategy for first-lift pruning and that thinning is unnecessary at this pruning. Pruning was shown to induce only transient changes in stem shape.

Removal of 50% of green crown length resulted in a 38% reduction in the total amount of carbon fixed by photosynthesis each day, but compensatory physiological changes in the crown resulted in similar levels of carbon fixation in pruned and unpruned trees within six months of pruning. The rapid recovery of carbon fixation following pruning was caused by increases in light-saturated rates of photosynthesis of up to 175% and greater efficiency of utilisation of carbon in the crowns in pruned compared to unpruned trees. Within 13 months of treatment, 50%-pruned trees had increased total leaf area to a level similar to that of unpruned trees. Similar physiological responses were observed following more severe levels of pruning and carbon fixation may eventually recover to levels similar to those of control trees. However, severe pruning (e.g. removal of 70% of green crown length) resulted in a 75% reduction in carbon fixation which significantly reduced growth and may result in loss of dominance.

Table 1 Cooperative Linkages

	CRC Staff	Collaborator(s)	Research
Genetic Improvement			
Project 1 Strategies for breeding and deployment	**Within centre links**		
	Nuno Borralho	North Forest Products	Genetic control of rooting ability in *E. globulus* based on a tissue culture system
	Nuno Borralho	North Forest Products, University of Melbourne, Monash University	WhatX - a program to optimise selection and mate allocation in tree breeding
	Greg Dutkowski	Bunnings Treefarms	Developing strategies for genetic improvement of drought resistance
	National links		
	Nuno Borralho	Primary Industries Corporation (QLD), Australian National University, Hyne and Son	Forest and Wood Products Research and Development Corporation project on breeding objectives for sawn timber in tropical pines
	Greg Dutkowski and Nuno Borralho	New South Wales Agriculture, Southern Tree Breeding Association, Primary Industries South Australia, Centre for Forest Tree Technology	Analysis of genetic trials using spatial auto-correlation models Membership of Technical Committee for Eucalypt Breeding
	Greg Dutkowski	Southern Tree Breeding Association	Participation in development of integrated breeding information system
	Greg Dutkowski and Andrew MacDonald	Southern Tree Breeding Association	Data modelling
	International links		
	Nuno Borralho	New Zealand Forest Research Institute	Estimation of genetic parameters and prediction of breeding values for pulp production in the *E. nitens* breeding program in NZ
	Nuno Borralho (consultant)	RAIZ, Portugal	Development of breeding strategies in eucalypts
	Nuno Borralho	Ence, Spain	Analysis of longicorn beetle damage in *E. globulus*
Project 2 Wood properties	**Within centre links**		
	Allie Muneri and Carolyn Raymond	SSM Project 3, Aust Paper, NET, Bunnings Treefarms	Genetic parameters and G x E interaction on wood density and pilodyn and pulp yield

	CRC Staff	Collaborators	Research
Project 2 Wood properties	**National links**		
	Carolyn Raymond	SSM Project 3, Australian Paper Plantations and Bunnings Treefarms	Effect of fertiliser on wood dens and fibre length
	Carolyn Raymond and Allie Muneri	Steve Read, Lauri Shimleck and Gerd Bossinger, CRC for Hardwood Fibre and Paper Science	Mapping genes that affect cambi activity in *Eucalyptus* Measuring NIRA
Project 3 Molecular genetics	**Within centre links**		
	René Vaillancourt	Brad Potts GI (Project 4)	QTL analysis in *E. globulus*
	René Vaillancourt	Jim Reid GI, Project 6; Brad Potts GI, Project 4	Population genetics of *E. globula*
	National links		
	René Vaillancourt	Caroline Mohammed, CSIRO and Dept of Agriculture, Uni of Tas; Mike Powell, NFP	Genetics of *Mycosphaerella* resistance
	International links		
	René Vaillancourt, Dot Steane	Wayne Powell Head, Cell & Molecular Genetics Dept Scottish Crop Research Institute, UK	Develop microsatellite markers in *E. globulus*
Project 4 Genetic parameters	**Within centre links**		
	Brad Potts	Anthony Clarke, RP Project 4; Sandra Hetherington, ANM	Genetic control of susceptibility o *E. globulus* to sawfly defoliation
	Brad Potts	John Madden, RP	Phytochemical framework for studying eucalypt pest interaction
	Brad Potts, Andrew MacDonald, Greg Dutkowski, Nuno Borralho	Wayne Tibbits and Mike Powell, NET	Age to age correlations for growth in *E. globulus*
	National links		
	Brad Potts	Peter Gore, STBA; David Pilbeam, Bunnings	Selection and genetic control of s incompatibility
	Brad Potts, Greg Dutkowski, Nuno Borralho, Peter Volker	Peter Gore, STBA; Silvagene Pty Ltd; D. Spencer, CSIRO; NET	Genetic control and estimation of breeding values for flowering time in *E. globulus*
	Brad Potts and Paul Tilyard	Raymond Bereton, DELM	Flowering patterns in *E. globulus* and their effect on the reproductive success of the swift parrot

	CRC Staff	Collaborators	Research
	Brad Potts Heidi Dungey	Peter Ades and Angus Carnegie, Uni of Melb	Quantitative genetics of *Mycosphaerella* spp. resistance
	International links		
	Brad Potts	Tom Whitham, Uni N Arizona,	The effect of forest tree genetics on biodiversity
	Brad Potts	R Ipinza, Cooperativa de Mejoramiento Genetico	Production of a manual on controlled pollination
Project 5 Vegetative Propagation of Selected Genotypes	**Within centre links**		
	Jean-Noël Ruaud	North Eucalypt Technologies, sole industry partner with tissue culture facilities	Micropropagation and somatic embryogenesis
Project 6 Breeding systems and development	**Within centre links**		
	Dean Williams, Brad Potts and Jim Reid	Phil Smethurst, Chris Beadle, Dale Worledge and Ann LaSala, SSM	Effects of environmental and silvicultural factors on flowering in *E. nitens*
	Dean Williams, Brad Potts and Jim Reid	Sandra Hetherington, ANM	Genetic control of precocity flowering in *E. nitens*
	Dean Williams, Brad Potts and Jim Reid	Kelsey Joyce and Michael Powell, NET	Interaction of fertiliser and paclobutrazol on flowering in *E. nitens* and environmental effects on flowering of *E. nitens* clones
	Dean Williams, Brad Potts and Jim Reid	Peter Kube, Forestry Tasmania	Effect of spacing on *E. nitens* flowering
	Brad Potts	Wayne Tibbits, NET; Sandra Hetherington, ANM; Peter Gore, STBA	Technical manual on reproductive biology and controlled pollination of *Eucalyptus*
	National links		
	Dean Williams, Brad Potts and Jim Reid	John Ross, Dept Plant Sci, Uni of Tas	GA inhibitor effects
	International links		
	Jim Reid	Peter Davies, Cornell University, USA	Hormonal control of flowering

	CRC Staff	Collaborators	Research
Soil and Stand Management	**Within centre links**		
	Chris Beadle, Ann LaSala and Jane Medhurst	Boral Timber	Development of thinning regimes for *E. nitens* plantations
Project 1 Plant production and water use	Chris Beadle and Dale Worledge	ANM Forest Management	Scheduling irrigation in eucalypt plantations and impacts of irrigation on wood quality
	National links		
	Chris Beadle, Paul Adams and Philip Smethurst	Neville Mendham, Ag Sci Dept, Uni of Tas; Paul Dredge, Forestry Tasmania	Weed management studies
	Chris Beadle and Dale Worledge	CRC for Hardwood Fibre and Paper Science	Impacts of available water on wood quality, cambial development and diameter growth of *E. globulus* and *E. nitens*
Project 2 Dynamics of carbon and nutrients	**Within centre links**		
	Robin Cromer and Ann LaSala	ANM Forest Management, North Eucalypt Technologies, Boral Timber Tasmania	Experimental sites for nutrition research
Project 3 Nutrient supply and acquisition	**Within centre links**		
	Philip Smethurst, Chris Beadle and Paul Adams	Neville Mendham, Ag Sci Dept, Uni of Tas; Paul Dredge, Forestry Tasmania	Weed management studies
	National links		
	Philip Smethurst	Phil Moody and Jonnie White, DPI Queensland	Effects of soil water content on K availability and uptake
	Philip Smethurst and Trevor Garnett	Ian Newman and his group, Physics Dept, Uni of Tas	Nitrogen uptake studies using microelectrodes
	International links		
	Philip Smethurst	Gunda Matschonat, Uni Bayreuth, Germany	Solid-liquid phase partitioning of NH_4
Project 4 Modelling plantation systems	**Within centre links**		
	Michael Battaglia	Libby Pinkard, SSM Project 1	Modelling photosynthesis following pruning
	Peter Sands and Michael Battaglia	Nuno Borralho, GI Project 1	Significance of ProMod for identifying physiological traits for breeding objectives
	Peter Sands	Clare McArthur, RP Project 3	Modelling animal behaviour

	CRC Staff	Collaborators	Research
	Michael Battaglia	Steve Candy, Forestry Tasmania	Relationship between site quality and defoliation by *Chrysophtharta bimaculata*
	National links		
	Michael Battaglia, Daryl Mummery and Peter Sands	Regional Forest Agreement, Bureau of Research Science, Forestry Tasmania	Develop and provide software to implement ProMod for use in predicting potential productivity based on bioclimatic factors
	Peter Sands and Michael Battaglia	Bill Rawlins, CSIRO Forestry and Forest Products, Melbourne	Scheduling irrigation in the Murray-Darling
	International links		
	Peter Sands	Eberhard Voit, South Carolina Medical University, USA	Application of S-systems to forest growth modelling
Resource Protection	**Within centre links**		
	John Madden	Chris Beadle	Entomological research and canopy dynamics
Project 1 Leaf and tree factors influencing host tree location and attack by insects	**National links**		
	John Madden	Dr Richard Milner, CSIRO Entomology	Entomopathogens
	John Madden	Dr Christine Stone, State Forests, NSW	Entomological research
Project 2 Control of insect defoliators	All staff	All partners	Integrated Pest Management Program
Project 3 Vertebrate browsing in eucalypt plantations	**Within centre links**		
	Clare McArthur and Sarah Scott (Hons student)	Brad Potts, GI Program; David de Little, NET; Sandra Hetherington, ANM	Genetic basis of susceptibility of *Eucalyptus* species and hybrids to possum damage
	Clare McArthur and Mark Flint (Hons student)	Sandra Hetherington, ANM; Mick Statham, DPIF; Othmar Buchmann, Dept Zoology, Uni of Tas	Seedling damage as a function of choice of feeding patches by pademelons and Bennett's wallabies
	Clare McArthur and Jenny Sprent (Hons student)	Sandra Hetherington, ANM	Food availability and diet selection of herbivores on a plantation
	James Bulinski and Clare McArthur	David de Little, NET; Sandra Hetherington, ANM; Peter Naughton, Boral Timber	Risk assessment model for predicting damage to plantations by vertebrate browsers

	CRC Staff	Collaborators	Research
	Nadia Marsh and Clare McArthur	David de Little, NET	Browsing of *Eucalyptus* seedlings in plantations by marsupial herbivores
	Kirsten le Mar and Clare McArthur	David de Little and Ian Blanden, NET	Use of eucalypt plantations and surrounding habitat by three marsupial herbivore species
	Clare McArthur	Sandra Hetherington, ANM	Preferences of possums and pademelons for seedlings of forestry species
	Clare McArthur	Paul Dredge, Forestry Tasmania	Role of cover crops in control of browsing damage
	National links		
	Kirsten le Mar and Clare McArthur	Mick Statham, DPIF	Use of eucalypt plantations and surrounding habitat by three marsupial herbivore species
Project 4 Biology of other insects	**Within centre links**		
	Zoltan Lukacs and Tony Clarke	North Eucalypt Technologies	Autumn gum moth field research
	Tara Simmul and Tony Clarke	North Eucalypt Technologies	Biology of fire blight beetle
	National links		
	Zoltan Lukacs	Robert Floyd, CSIRO Entomology, Canberra	Parasitoids of autumn gum moth

RESEARCH

Genetic Improvement Program

Manager

Dr Nuno Borralho

Introduction

The program aims to improve the productivity of plantations by improving the genetic quality of planting stock. This requires two major thrusts. Firstly, the characteristics required in plantation trees (breeding objectives) and the natural variation in traits affecting these objectives (available genetic resources) must be identified, and then reliable estimates of the heritability of these characteristics (genetic parameters) determined. This information should then be integrated (using advanced statistical models) so that breeding programs can be effectively managed. Secondly, once genetically superior material has been identified, it must be transferred to plantations as quickly as possible either by seed or by vegetative propagation.

Research carried out in the program has made important contributions to our understanding of (i) economic aspects of breeding and breeding decisions, (ii) relations between wood properties and the end use for the wood, (iii) genetic structure of native and domesticated populations, (iv) inheritance of traits of economic or adaptive importance at the molecular and quantitative level, and (v) the ability to manipulate flowering and vegetative propagation of eucalypts.

Project 1

Leader

Dr Nuno Borralho

Staff

Mr Paul Chambers

Mr Greg Dutkowski

Mr Xianming Wei

Ms Michelle McGranahan

Mr Andrew MacDonald

Strategies for breeding and deployment

Background

This project aims to select elite trees more accurately for breeding the next generation of eucalypt plantations. This involves: (i) clearly defining breeding objectives for the pulp and paper, and sawn timber production systems, (ii) developing improved statistical models to predict the breeding value of a tree (its value as a parent) using available information from all sites, measurement ages and generations, (iii) optimising selection and crossing to take account of the economic importance of different traits, and (iv) recognising the genetic and reproductive constraints characteristic of the species.

The project also provides direct support to industry partners in the implementation of results in their breeding and deployment programs.

Outcomes

- A collaborative project between the Genetic Improvement Program, industry partners, and mathematicians from the University of Melbourne and Monash University resulted in the development of simple software to help breeders choose which trees to use in a crossing program, or which clones to deploy in a seed orchard. The program, called WhatX, is freely available. The software will be used for the culling of seed orchards by North Forest Products and Forestry Tasmania and the selection of clones for grafted seed orchards by the New Zealand Forest Research Institute. Its use has been demonstrated to the Southern Tree Breeding Association.
- There has been considerable progress in the development of more effective breeding strategies for trees, in particular the evaluation of the so-called 'rolling-front' breeding. In 'rolling front' breeding, all operations are carried out on an annual basis, with expected breeding values being updated regularly using Best Linear Unbiased Prediction. Simulations have found that, for a fixed amount of resources, gains per unit time for 'rolling front' breeding results are over 25% greater than for traditional discrete generation breeding. 'Rolling front' schemes are being implemented by the Southern Tree Breeding Association, RAIZ (Portugal) and Cooperativa de Mejoramiento Genetico (Chile).
- Bruce Greaves' PhD research has shown that the optimum selection age for wood density and growth in *E. nitens* seems to be around three years,

much earlier than previously thought. This may dramatically affect the way selections are made in eucalypts.

- Fibre length has been identified as the single most important trait for minimising the cost of production of mechanical pulp from pines. This result is being used as part of Paul Chambers' PhD to define appropriate breeding objectives for pine plantations grown for pulpwood and sawn timber.
- The importance of accounting for race in the prediction of breeding values has been demonstrated for a number of traits.
- Clonal seed orchards or the conversion of existing trials to seed orchards, have been shown to be the most effective strategies for maximising economic gains from breeding of temperate eucalypts in Australia. While family based clonal forestry was not recommended because of high unit plant costs, a target for lowering plant costs was identified which if reached could make clonal forestry competitive with other options.
- Survival has been shown to be more important than individual growth in breeding for maximum volume gain per unit area when mortality is higher than 10%.
- A collaborative project with Ence of Spain has shown that resistance of *E. globulus* to longicorn beetle (*Phoracantha semipunctata*) is under moderate genetic control and there is substantial race variation. The insect is responsible for severe mortality in drought-prone environments in many countries around the world, including Australia.
- A simple model to incorporate measurements at different ages into prediction of breeding values, by accounting for changes in selection accuracy as a function of age and repeatability of annual growth increments, has been developed by Xianming Wei. The method is already being in a number of breeding programs.
- A more complete genetic model, which allow additive and dominance effects, epistatic intera and inbreeding depression, has been developed applied to forestry by PhD student Craig Har in collaboration with the Animal Genetics Breeding Unit at the University of New Eng (New South Wales). This model allows estimation of the breeding value of trees different levels of inbreeding.
- New analytical methods for the estimatio breeding values and genetic variances (Ave Information REML and Gibbs Sampling) have b explored in large breeding populations w complex pedigrees and data structures. The for is now being routinely used in data analysis.
- Centre staff, Greg Dutkowski and And MacDonald, have been involved in the develop of an integrated breeding information system for Southern Tree Breeding Association.

Goals

- Determine the improvement in the accuracy predicted breeding values from using 'ra models' which account for spacing and competi
- Determine the reliability of breeding valu obtained for *E. globulus* using data from a rang different environments, and implications f national and international exchange of gene material

Project 2

Leader

Ms Carolyn Raymond

Staff

Dr Allie Muneri

Mr Bruce Greaves

Mr Jason Lawson

Wood properties

Background

This project provides a direct linkage between the CRC for Temperate Hardwood Forestry (CRC-THF) and the CRC for Hardwood Fibre and Paper Science (CRC-HFPS) allowing for development of joint projects and the sharing of new technology such as SilviScan, Near Infrared Reflectance Analysis (NIRA, an indirect measure of kraft pulp yield) and cellulose analysis between the Centres. Research is conducted in collaboration with the pulping laboratories of the industry partners. A major study with ANM on the relationship of wood and paper properties was completed this year.

Andrew MacDonald extracting core samples from E. nitens at the Gog Range, northern Tasmania

Work in the CRC-THF has concentrated on:

- defining the relationship between wood, pulping and paper properties;
- developing non-destructive sampling strategies for wood and fibre properties;
- determining the feasibility of altering wood properties by breeding and silviculture.

Outcomes

- Non-destructive sampling work has been completed with strategies determined for basic density, NIRA, fibre length and fibre coarseness for *E. globulus* and *E. nitens* based on studies of longitudinal (lengthwise) variation within trees. Sampling recommendations have been provided to industry and implemented immediately.
- The joint CRC report on 'Sampling plantation eucalypts for wood and fibre properties' has been extensively restructured and rewritten for publication as a book in the latter half of 1997.
- Wood core samples have been collected from four *E. globulus* progeny trials across southern Australia (from Western Australia to Tasmania) to examine genotype by environment interactions for basic density and NIRA.
- A new joint project has been established between Forestry Tasmania, ANM pulping laboratory and CSIRO Forest Products laboratory to examine genotype by environment interactions for basic density, wood colour, fibre length and microfibril angle in *E. nitens*. Core samples have been taken from families at three sites in Tasmania. This project is part of a PhD project for Peter Kube (Forestry Tasmania).
- Three fertiliser trials have been sampled in Victoria and a fourth trial will soon be sampled in Western Australia.

Goals

- Publish the book on sampling strategies, and participate in teaching at a joint CRC workshop on this topic.
- Implement cellulose determination method recently developed by CRC-HFPS.
- Complete processing and analysis of *E. globulus* and *E. nitens* cores and determine the magnitude and importance of genotype by environment interactions.
- Process cores from fertiliser trials to examine the effects of nitrogen and phosphorus fertiliser applied at trial establishment on basic density, fibre length, NIRA, cellulose, N and P content of the wood.

Project 3

Leader

Dr René Vaillancourt

Staff

Prof Jim Reid

Dr Brad Potts

Dr Dorothy Steane

Mr Peter Bundock

Ms Alexandra Mitchell

Mr Andrew Milgate

Mr Stuart Skabo

Mr Hamish Jackson

Molecular genetics

Background

The objectives of this project are to:

- develop molecular markers (simply inherited genetic factors) that can be used for fingerprinting trees;
- use markers to study population and species relationships within *Eucalyptus*;
- use molecular markers to study the inheritance of quantitative trait loci (QTL) such as growth and wood properties, in order to ascertain the usefulness of Marker Assisted Selection (MAS).

Outcomes

- Fine-scale genetic structure was detected in *E. globulus* ssp. *globulus* forests. Trees within 25 m of one another were highly related and there was an abrupt drop in genetic similarity after 25 m.

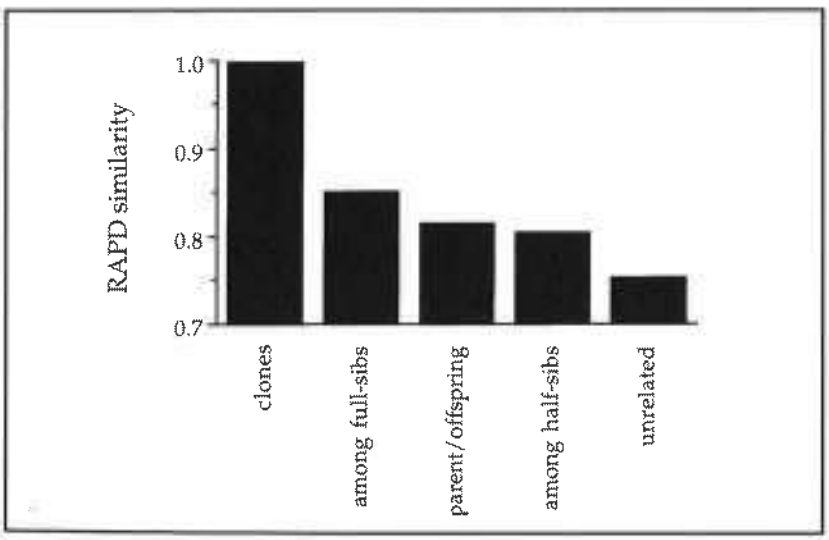


Figure 2 *Average RAPD similarity (simple matching coefficient) observed in* E.globulus *ssp.* globulus *showing that RAPD markers can be used to distinguish different degrees of relationship among individuals (Nesbitt* et al. *in press)*

Collectors of native *E. globulus* seed should sample trees separated by a minimum of 25 m to avoid collecting closely related individuals.

- *E. globulus* ssp. *globulus* has a level of genetic diversity that is average for a eucalypt species with a regional distribution. However, the deg genetic differentiation between localities and is high compared to other eucalypts.
- In a pilot study conducted in 1995, a sparse li map (a map of gene order along the chromos was constructed and used to detect a QTL growth. To confirm the usefulness of carrying studies to search for QTLs, this study has expanded and will provide a reference map fo *globulus*.
- The search for microsatellites (markers numerous alleles, ideal for paternity and mapp analysis) in *Eucalyptus* was rewarded with discovery of our first such marker. To make rapid progress we have embarked on a coopera study with Wayne Powell (Head, Cell Molecular Genetics Dept, Scottish Crop Rese Institute, UK).

Goals

- Develop microsatellite DNA markers
- Improve the *E. globulus* linkage map
- Complete an isozyme survey of *E. globulus*
- Study resistance to *Mycosphaerella* infection *E. globulus* using molecular methods
- Complete a survey of cpDNA and its variation *globulus* and in the series *Viminales*

Project 4

Leader

Dr Brad Potts

Staff

Mr Peter Kube

Mr Peter Volker

Mr Paul Tilyard

Ms Helena Nermut

Ms Corinna Kelly

Mr Mike Powell

Dr Wayne Tibbits

Genetic parameters

Background

This project provides the fundamental quantitative genetic information necessary for effective exploitation of forestry species for breeding and assessment of breeding options. It specifically aims to:

- provide basic information on genetic variation and inheritance (genetic parameters) for traits of economic and biological importance;
- determine the reliability of genetic parameter and breeding value predictions derived from open-pollinated (OP) progenies;
- provide the biological and genetic information necessary to assess the role of interspecific hybrids in eucalypt breeding;
- identify and provide specialised, pedigreed genetic material to support molecular and quantitative genetic studies.

Corinna Kelly, Honours student, measuring bark thickness of E. globulus

Outcomes

- A new racial classification of *E. globulus* ssp. *globulus* and intergrade populations which has been developed (see Project 1) to summarise patterns of variation, allows consistency in seed lot classification and incorporation of race into mixed model analyses. Thirteen races and 21 sub-races have been identified. The classification is believed to be robust as it is based on genetic variation in 32 variables which encompass traits such as growth, survival, flowering precocity, vegetative phase change, bark thickness and wood density.
- The time to first flowering is a major factor slowing progress in breeding programs. We have now shown flowering precocity is highly heritable in *E. globulus*, exhibits little genotype x environment interaction, and at the genetic level is slightly positively correlated with growth rate up to age four and with wood density. In *E. globulus* and other species, the transition to reproductive maturity has been shown to be genetically independent of the transition to adult foliage.
- Major genetically based differences in relative thickness of bark have been demonstrated between races of *E. globulus*, and this may have an impact on the efficiency of using over-bark measurements of diameter as a selection trait.
- Field trials have shown large differences between eucalypt species in susceptibility to possum attack, a trait which is generally inherited in an intermediate manner in F_1 hybrids. Virtually all the genetic variation in susceptibility within the populations of *E. globulus* studied was non-additive, whereas both additive and non-additive genetic variations were detected within *E. nitens*.

Goals

- Determine the genetic control of bark thickness, flowering time and vegetative phase change in *E. globulus*
- Identify age-age correlations for growth in base population (age eight years) and controlled crosses (age six years) of *E. globulus*
- Determine the level of non-additive genetic control of pilodyn penetration in *E. globulus* and *E. nitens* using controlled crosses
- Determine the performance of hybrids between *E. nitens* and *E. globulus*
- Review genetic parameter estimates from the *E. globulus* base population

Project 5

Leader

Dr Jean-Noël Ruaud

Staff

Mr Keith Churchill

Mr Scott Pepper

Vegetative propagation of selected genotypes

Background

The development of clonal forestry for temperate eucalypts has great potential. However, conventional propagation methods are usually not economic and this has led to the development of *in vitro* techniques. Our project has developed a new micropropagation procedure (called IMP) useful for research projects such as estimates of genetic control of rooting ability. We have also been involved in developing somatic embryogenesis which has a great potential for the large-scale vegetative propagation of genetically improved genotypes.

Dr Jean-Noël Ruaud

Outcomes

- Somatic embryogenesis has been qualitatively improved by modification of culture media (nutrition as well as physical status). Four embryos developed to the mature stage, two of the four germinated and are still developing on a simple medium without growth regulators.
- Accurate estimates of genetic control of roo ability, survival and multiplication rate, both cuttings and tissue culture, were obtained fr three large controlled pollinated rooting abi experiments, one in collaboration with N Eucalypt Technologies (a CRC Partner) and an with RAIZ (Portugal). The analyses will allow two companies to identify superior genotypes large-scale clonal programs.
- The comparison of zygotic (seed) and somat embryo development is underway: *E. globu* capsules were sampled every fortnight for weeks, and placenta structures were excised a fixed.
- A field trial aimed at comparing tissue cultu *E. globulus* plants with half-sib seedlings has be established in collaboration with North For Products.

Goals

- Compare the zygotic and somatic embryogene process at the cellular level (histological analy aimed at understanding the blockage in the somat embryo development
- Complete the establishment of the series of fi trials comparing seedlings and cutting materi from known families

Project 6

Leader

Prof Jim Reid

Staff

Dr Brad Potts

Dr Craig Hardner

Mr Dean Williams

Ms Alexandra Mitchell

Breeding systems and development

Background

The aims of this project are to:

- develop an understanding of the control of flowering in *E. globulus* and *E. nitens*. In particular, identify the role of hormones in combination with the effects of environmental factors in promoting flowering;
- investigate factors affecting inbreeding in native stands and the impact of inbreeding on estimation of genetic parameters and genetic gain, and the management of breeding populations;
- examine genetic, environmental and silvicultural factors influencing the quantity and quality of seed produced from orchards of *E. globulus* and *E. nitens*;
- develop more efficient means of controlled pollination and systems for mass supplementary pollination;
- determine the role of the plant hormones, abscisic acid, gibberellins (GA) and auxin (IAA), in seasonal variations in growth and development;

Controlled pollination of Eucalyptus nitens by technician, Helena Nanmut, private seed orchard, Bream Creek, south-eastern Tasmania

Outcomes

- One of the highest levels of inbreeding depression for a forest tree species was detected in the rates of survival of a 15-year-old *E. regnans* plantation. Outcrossing levels at planting were 59%, but this increased to 83% after 15 years following intense post-planting selection against selfs, with selfs unlikely to survive to reproductive maturity in native stands. This selection was shown to re-distribute phenotypic variation. Variation in the survival amongst the OP families was unrelated to additive genetic effects or the performance of selfs.
- Long-term field trials have been established to examine the effects of (i) different levels of inbreeding on genetic parameters and (ii) the relationship between breeding value and the performance of open-pollinated and self families.
- The growth of controlled crosses between trees separated by varying distances has provided the first evidence of a family group structure in native forests of *E. globulus*, which has been confirmed, at a smaller scale, with molecular markers (Project 3). Progenies from crosses between nearest-flowering neighbours were less vigorous than crosses between mates separated by greater distances. Nearest-flowering neighbours have an average relationship equivalent to at least half-sibs. There was no evidence for inbreeding depression when parent trees were separated by 250 m or more, suggesting a relatively sharp decline in relatedness with distance.
- Alternative GA inhibitors, prohexadione and CCC, have been ineffective in influencing vegetative growth of 18-month-old *E. nitens* seedlings when applied as water based foliar sprays, whereas the widely used inhibitor paclobutrazol produced a significant response.

- A manual on controlled pollination of *E. globulus* and *E. nitens* has been published in collaboration with scientists from Chile.

Goals

Determine:

- the genetic control of flowering precocity in new base population trials of *E. nitens*;
- the effect of nitrogen and phosphorus fertilisation on flowering precocity and abundance in *E. nitens*;
- the effect of water stress and altitude on flowering abundance and synchrony, capsule set and seed quality in *E. nitens*;
- the synergistic effects of nitrogen and paclobutrazol applications on flowering abundance in *E. nitens*;
- the effect of spacing on flowering and capsule abundance in *E. nitens*;
- the potential of developing a one-stop pollination system using (i) pollination at anthesis and (ii) style removal treatments for *E. globulus* and *E. nitens*.

Litter traps used to monitor flowering, Lewisham, southern Tasmania

Soil and Stand Management Program

Manager
Mr Robin Cromer

Introduction

The Soil and Stand Management Program aims to develop silvicultural management and planning tools which will optimise the economic return to forest growers from their investments, while ensuring that management practices are sustainable over future rotations. In order to achieve this, research projects have been developed to examine forest growth and yield in relation to environmental factors, particularly temperature, the availability of water and nutrients and soil physical properties, and silvicultural practice, for example application of fertiliser, irrigation, pruning and thinning. These studies will allow description of the functioning of plantation ecosystems in quantitative terms and, using modelling procedures, simulate outcomes from alternative management systems, predict the potential productivity of individual sites more accurately, and identify the degree to which environmental factors and silvicultural practice influence growth.

Project 1

Plant production and water use

Leader
Dr Chris Beadle

Staff
Dr Neil Davidson
Mr Greg Unwin
Dr Mark Hovenden
Dr Don White
Mr Mark Hunt
Ms Libby Pinkard
Mr Paul Adams
Ms Jane Medhurst
Mr Sven Ladiges
Mr Grant Westphalen
Mr Dugald Close
Ms Maria Cherry
Mr Dale Worledge
Mr Ray McLeod

Background

The aims of this project are to improve the productivity and quality of eucalypt plantations for pulpwood and sawn timber through an understanding of their physiological responses to environmental factors and silvicultural practices. Photosynthetic, water-relations and water-use characteristics have been measured in the context of the production of leaf area and biomass. The environmental variables of most concern to the project have been available water and temperature, and some attention has been given to available macro- and micro-nutrients. The silvicultural practices of irrigation, pruning and thinning, vegetation management and fertiliser application all have an impact on photosynthetic production and have been the focus of several studies in the project. In addition there are student projects which consider the impact of logging, clearing and natural disturbance on regeneration and growth in wet and dry sclerophyll forests.

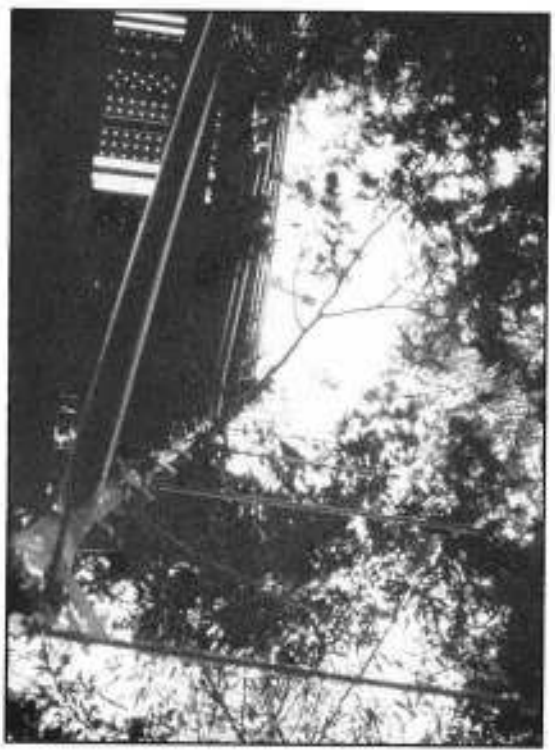
Outcomes

- Cold-hardened seedlings of *E. nitens* and *E. pauciflora* have a higher photosynthetic capacity and increased capacity for dissipation of non-radiative energy than non-hardened seedlings, thereby decreasing the susceptibility of photosynthesis to photoinhibition at low temperature. Faster recovery from photoinhibition observed in *E. pauciflora* is consistent with its occurrence in colder habitats than *E. nitens*.
- A conservative relationship between the photochemical efficiency of open PSII centres (F_v'/F_m') and the proportion of absorbed light utilised in PSII photochemistry (f_{PSII}, measured as DF/F_m') across a range of green plants, including *E. nitens*, can be used to predict minimal fluorescence, F_o'. The ratio of observed F_o' to that predicted by this method is a possible indicator of photodamage.
- *Eucalyptus globulus* maintained a higher ratio of leaf area to sapwood area than *E. nitens* during the first six years of growth and this was independent of water availability. It can be shown that there is a positive correlation between stem hydraulic conductivity and water availability. *E. globulus* grew more rapidly than *E. nitens* under irrigated and rainfed conditions and this highlights the importance of conductivity to growth during periods of drought.
- If growth rates are rapid and pruning is timed to coincide with canopy closure, *E. nitens* can be selectively pruned to remove 50% of lower green crown length without loss of height or diameter growth or dominance. Pruning induces only transient changes in stem shape.

Staff cont.

Mr Martin Tyson
Mr Mark Grubert
Mr Charles Warren
Mr Matthew Marrison
Mrs Natalie Papworth
Mr Paul Black
Dr Greg Holz
Mr Peter Naughton
Ms Silvia Pongracic
Mr Bill Neilsen
Ms Sandra Hetherington

- Competition from regenerating *Acacia dealbata* in eucalypt plantations peaked at age two to six years before declining as the *A. dealbata* canopy was suppressed. At ages two to four years, *E. nitens*' basal area was highly correlated inversely, with both *A. dealbata* stem frequency and basal area. However, by age six years no such relationship existed.
- *A. dealbata* regeneration contributed significantly to stand water use in eucalypt plantations, although in this study there was no evidence that competition for water *per se* limited growth of the eucalypts. The relative contribution by *Acacias* to stand water use was greater in four-year-old than in eight-year-old eucalypt stands. However, total water use, which decreased with the proportion of *Acacia* competition, was less than would be expected for a closed eucalypt canopy.



Light sensors (see horizontal bars from bottom of photo) used to study light climate within a Eucalyptus nitens *plantation where growth rate has been reduced by competition from silver wattle* (Acacia dealbata)

- Clearing native forest sites with an exce… increased diameter and volume increme… subsequent plantations at age six to seven … compared to clearing with a bulldozer. The r… indicate that clearing practice can have an im… on growth at least in the medium term and prov… a strong case for limiting the use of bulldozers … standard blades.

Goals

- Provide a physiological base for fertiliser-indu… micronutrient deficiencies
- Describe the impact of irrigation and availa… water on wood quality
- Develop physiological indicators for describing … early establishment of eucalypt seedlings
- Measure the impact of weed competition on … growth of *E. globulus*
- Determine the effects of thinning on … development of leaf area in *E. nitens*
- Describe the impact of clearfelling on microclima… at the boundary between unlogged forest … logged coupes in wet sclerophyll forest

Project 2

Leader

Mr Robin Cromer

Staff

Dr Rabi Misra
Ms Paulina Teixeira
Mrs Ann LaSala
Mr Charles Turnbull
Ms Linda Ballard
Mr Andrew Gibbons
Mr Martin Tyson
Mr Mark Grubert
Dr Greg Holz
Ms Silvia Pongracic
Mr Peter Naughton
Ms Sandra Hetherington

Dynamics of carbon and nutrients

Background

The aims of the project are to:

- investigate the accumulation, allocation and cycling of carbon and nutrients in plantations of *E. nitens* and *E. globulus*, particularly in response to nutrient availability;
- determine the partitioning of biomass and nutrients to roots;
- identify specific nutrient deficiency or toxicity problems that become evident in plantations.

Growth of hardwood plantations in response to additions of the major nutrients, nitrogen (N) and phosphorus (P), has been studied in five fertiliser trials established in 1992 and 1993 on representative but contrasting sites in Tasmania. These trials have been conducted in collaboration with ANM Forest Management (ANM), North Eucalypt Technologies (NET) and Boral Timber (BT). The experiments have also provided important field study sites for other projects in the program.

Outcomes

- Increase in stem biomass of *E. nitens* occurred between two and three years of age in response to fertiliser on several important soil types: yellow podzolics derived from mudstone in central Tasmania (ANM, Tim Shea and West Field) and red clay loams derived from basalt in north-eastern Tasmania (BT, Nunamara).
- In two of the above experiments, N and P were applied in factorial combination, and the primary element which limited growth was nitrogen. By age three, stem biomass in the optimal fertiliser treatment showed greater than 30% increase over controls (eg Fig. 3a).
- At one site (Westfield) where significant growth responses to fertiliser have occurred in *E. nitens* since age two, a significant increase in the allocation of biomass to above-ground components was observed in trees treated with fertiliser at two and 26 months compared with unfertilised treatments (Fig. 3b). A similar effect was observed for allocation of P in biomass components but not for N.

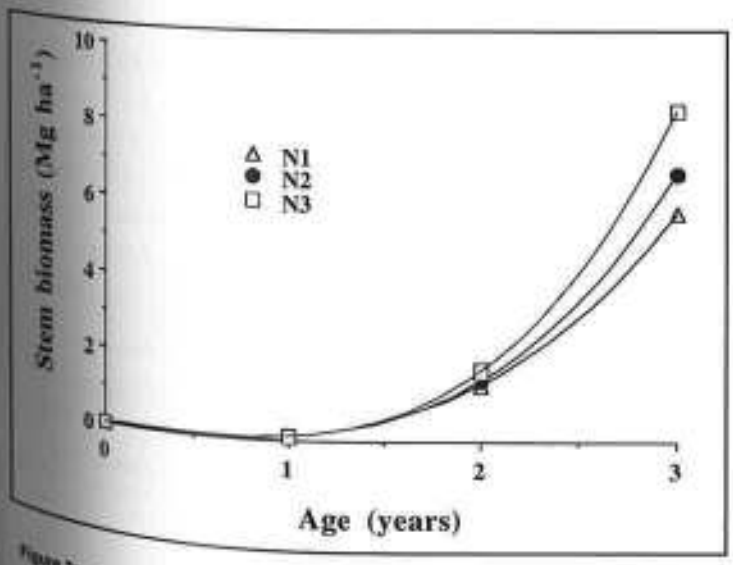


Figure 3a. *Accumulation of stem biomass (wood plus bark) in* E. nitens *at Nunamara in response to nitrogen fertiliser treatments (N1=0, N3=150, N4=300 kg ha^{-1} elemental up to age two years).*

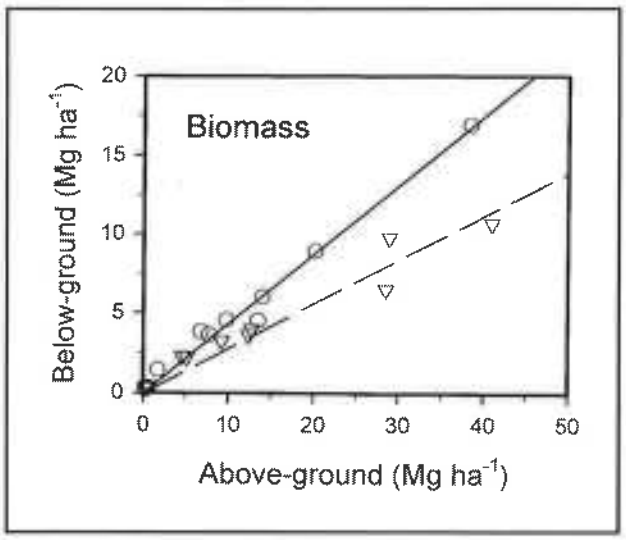


Figure 3b. *Difference in allocation of biomass between below-ground and above-ground components of* E. nitens *trees at Westfield. Symbols denote trees from unfertilised control (—) and fertilised (- - -).*

Project 3

Leader

Dr Philip Smethurst

Staff

Dr Rabi Misra
Mr Trevor Garnett
Mr Daniel Mendham
Mr Martin Moroni
Ms Paulina Teixeira
Mr Paul Adams
Ms Linda Ballard
Mr Rick Hand
Ms Joanne Dingle
Dr Greg Holz
Ms Sandra Hetherington
Mr Peter Naughton
Ms Silvia Pongracic
Dr Chris Shedley

Nutrient supply and acquisition

Background

The aims of this project are:

- to determine the nutrient supply characteristics of the major soil types on which eucalypt plantations are commonly grown;
- to determine the factors which control nutrient acquisition by tree roots;
- to improve the management of nutrients, particularly fertiliser applications, in order to increase the productivity and profitability of plantations.

Outcomes

- Measurements made at several sites in Tasmania indicate that N supply is often adequate to support high growth rates of *E. nitens* for up to two or three years after planting, especially on ex-pasture sites, but trees on some ex-forest sites will require N fertiliser at time of planting. Availability of N is low in older plantations (three to six years old) on ex-forest sites, which has led to strong responses in tree growth to application of N fertiliser at this age.

Mr Wang Baoping, visiting scientist from China, studying phosphorus availability and root growth around the spots of fertiliser applied at the time of planting, in a newly established plantation of E. nitens

- At age three years *E. nitens* plantations at two sites showed a strong response to applications of urea fertiliser (an ammonium-N source), despite apparent high availability of nitrate-N at both sites. This observation has reinforced our previous speculation, based on solution culture studies, that this species may not be able to fully utilise all the nitrate available to it in the field and that ammonium-N sources would maximise N uptake.
- In a soil with a high P-fixing capacity, a [illegible] application of diammonium phosphate at plan[illegible] resulted in high P availability for at least four [illegible] (and probably most of the rotation) and great[illegible] increased root growth around and under [illegible] fertiliser spot (Fig. 4a). It is unlikely that repeat[illegible] fertilisation will be needed.
- The commonly used methods for determin[illegible] 'available' nutrients in soils (KCl-extractab[illegible] ammonium and nitrate, and Bray No.2-extractab[illegible] P) were found to be reliable predictors of nitra[illegible] concentrations in soil solution but unreliable [illegible] predicting concentrations of ammonium an[illegible] phosphate.
- Most of the increase in root-length density duri[illegible] the first three years of a rapidly growing *E. nitens* plantation occurs during the second year of growt[illegible] (Fig. 4b). More than 50% of roots were within th[illegible] upper 30 cm of soil. Such a high density of fi[illegible] roots (ie >2 cm cm^{-3}) is likely to have promoted rapid uptake of mineralised and applied nutrients.
- At a favourable air temperature (16-22°C) exposure of the roots of *E. nitens* seedlings to a soil temperature of 5°C for three weeks stopped growth of shoots and roots, whereas shoot and root growth of *E. globulus* continued. This may be a direct effect of temperature or a function of seedling size. Seedlings of both species were of similar age, but the size and weight of *E. globulus* was much greater due to their substantially larger seeds compared with *E. nitens*.
- Indices of relative mechanical stability have been developed for a range of soils subject to erosion, where losses of sediment quantity and quality (including N content) are being investigated.

Goals

- Complete current evaluations of N and P in soil solution as indicators of nutrient supply in typical eucalypt plantations.

- Complete current studies aimed at describing the development of root systems in a zero to three-year-old *E. nitens* plantation with a high growth rate.
- Define relationships between slope, rainfall intensity and erosion for several plantation soils.
- Recommend N and P management options for temperate eucalypt plantations.

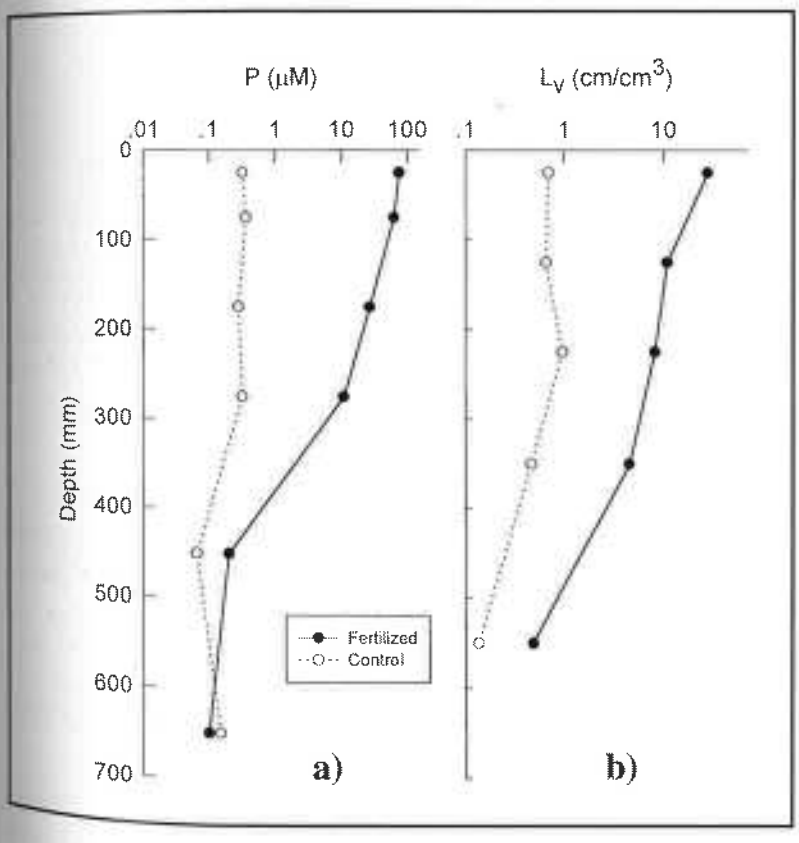
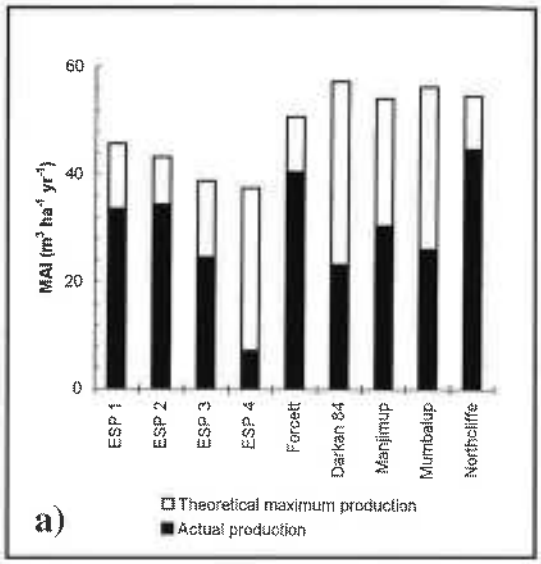


Figure 4
a) An application of fertiliser in a spot increases concentrations of phosphorus in soil solution (P) and root length density (L_V) under the fertiliser spot (•), compared with unfertilised control plots (o)
b) Vertical distribution of length density of fine roots (<1mm dia) of E. nitens during the first three years after planting at high growth-rate-site. Horizontal bars indicate SE (n=40).



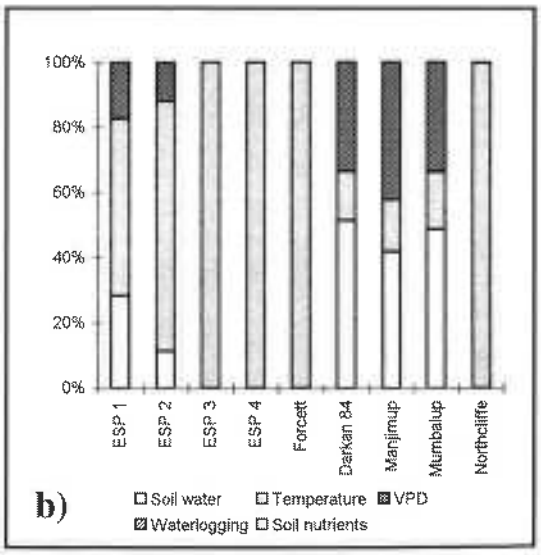


Figure 5
In project 4, ProMod was used to rank factors limiting production at five sites in southern Tasmania (Esperance 1-4 and Forcett) and four sites in Western Australia (Darkan, Manjimup, Mumbalup and Northcliff);
a) is a comparison of theoretical maximum and actual production,
b) is relative importance of various factors limiting production.

Project 4

Leader

Dr Peter Sands

Staff

Dr Michael Battaglia

Mr Daryl Mummery

Ms Susan Lennon

Ms Libby Pinkard

Dr Greg Holz

Modelling plantation systems

Background

The project aims to produce process-based models that can be used as management tools for predicting plantation yield in response to environmental, site and silvicultural factors. As comprehensive process-based models of plantation growth and development are complex and require input data which are not readily available, the project is focusing on simple models which combine the empirical and process-based approaches but require only readily available input data.

Outcomes

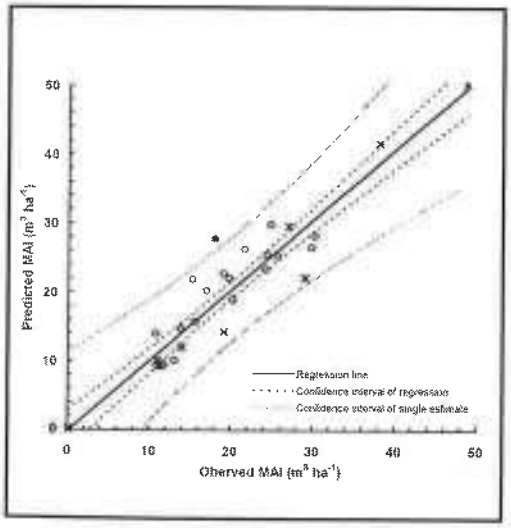


Figure 6 *Plot of predicted versus observed mean annual increment, showing regression line and confidence intervals. Symbols (x and •) indicate research plots and (o) indicates validation plots. The 1:1 line is coincident with the regression line.*

- A review of forest growth models, according to their intended use, highlighted reasons why few process-based models have been applied in forest management, and provided guidelines for the desired structure of models for specific management applications.

- PROMOD, a simple model for predicting site productivity of eucalypt plantations, was developed and a set of parameters determined on the basis of nine research trials of *E. globulus* in south-eastern Tasmania and Western Australia, and validated using 19 plots in northern Tasmania (Fig. 6). The standard error of the estimate of any single prediction was 6 m^3 ha^{-1}.

- PROMOD was applied to answer various questions posed by the CRC partners, including:
  - rank factors limiting production at particular sites (eg see Fig. 5, see previous page)
  - generate climate-based site productivity maps of Tasmania (for the Regional Forest Agreement process)
  - evaluate production at potential plantation sites in north-east and east Tasmania (for NET)
  - examine water use at various sites in WA and adjust estimates of site index to correct for the effects of a three-year drought (for Bunnings)
- Green-pruning of *E. nitens* by removal of 50% of the canopy from below, at or just before canopy closure does not reduce growth because:
  - net production of the lower crown decreases rapidly within six months of canopy closure and is at the point of becoming a net carbon sink prior to crown lift
  - an increase in rates of assimilation following pruning and subsequent changes in leaf area and foliage distribution more than compensates for the decrease in light interception

  It was concluded that pruning was unlikely to significantly decrease tree growth provided that a minimum residual LAI of 4 m^2 m^{-2} was maintained following pruning from below.

Goals

- Incorporate into PROMOD a soils classification system based on soils-map data and generate productivity maps for Tasmania taking soil characteristics into account
- Develop PROMOD parameter sets for *E. nitens* and *Pinus radiata*
- Demonstrate to the CRC-THF industrial partners a user-friendly implementation of PROMOD and its application to questions of interest to forest managers
- Develop models for assistance with canopy management, eg pruning or later-age fertilisation
- Develop a simple model for cambial activity and wood quality in seedlings

Resource Protection Program

Manager

Dr John Madden

Eucalyptus leaf beetle, Chrysophtharta bimaculata

Introduction

Invertebrate research in the Resource Protection Program has been directed toward reducing dependence on pesticides through the development of environmentally sensitive strategies for the effective management of major insect pests of native and plantation forestry. A major emphasis has been placed on the implementation and refinement of an Integrated Pest Management program for controlling the *Eucalyptus* leaf beetle, *Chrysophtharta bimaculata*. Basic studies on the biology, behaviour and ecology of this beetle and other real and potential pest species have been undertaken to assist in the effectiveness of control strategies for specific pests.

Similarly, detailed studies have been initiated on the basic life histories and habits of three major vertebrate browsers affecting natural regeneration and plantation seedlings. These studies are providing essential background data for the development of alternatives to poisons such as 1080 for managing damaging populations of vertebrates.

Project 1

Leader

Dr John Madden

Staff

Dr Anthony Clarke

Mr Bradley Howlett

Mr Stephen Paterson

Leaf and tree factors influencing host tree location and attack by insects

Background

The aim of this project is to identify those physical and chemical factors that influence the behaviour of the adult *Eucalyptus* leaf beetle, *C. bimaculata*, in locating, feeding and ovipositing on commercial eucalypt species and individual trees within species. It endeavours to identify those specific tree qualities that affect tree susceptibility so that the potential use of trees less preferred and/or resistant to attack may be explored.

Outcomes

- Oviposition preference by *C. bimaculata* for leaves of different host tree species is influenced by differences in rates of leaf development and leaf shape.
- Newly hatched larvae initially feed on remnant chorion (egg case) but then require young, soft and expanding leaves upon which to feed and survive.
- Larvae originating from egg batches laid on remote (ie 0.5 m or more away from young leaves) and on unsuitable leaves have the capacity to migrate to suitable foliage with high survival.
- Egg batches on tree species with more glaucous leaves are more vulnerable to detachment by wind and rain.
- Within mixed stands of *E. delegatensis* and *E. regnans* mature females lay eggs on the former and feed on the leaves of the latter species.
- Publication of papers describing variation in volatile leaf oils and waxes of Tasmanian eucalypt species and leaf waxes.

Goals

- Determine to what extent the presence of conspecific and interspecific egg batches deter subsequent oviposition
- Confirm the effect of beetle density on egg batch distribution within trees
- Analyse laboratory and field data on the relationship between adult feeding and oviposition behaviour
- Complete analysis of foliage dynamics and nutritive status on *C. bimaculata* feeding and oviposition on *E. delegatensis, E. regnans* and *E. nitens*
- Publish papers relating to all aspects investigated within the project

Project 2

Leaders

Dr Anthony Clarke

Dr Jane Elek

Staff

Dr Humphrey Elliott

Ms Sue Baker

Mr Steven Candy

Mr Alastair Hunt

Mr Vin Patel

Control of insect defoliators

Background

This project aims to refine the Integrated Pest Management (IPM) strategy currently used to protect eucalypt plantations from defoliation by leaf beetles. The research is directed at:

- determination of the impact of the *Eucalyptus* leaf beetle, *C. bimaculata*, on growth of *E. nitens* and *E. regnans*;
- evaluation of the most effective and environmentally acceptable methods for controlling leaf beetles;
- increasing our understanding of the biology of *C. bimaculata* and its natural enemies.

Outcomes

- Stem injection of ten-year-old *E. nitens* with a systemic organophosphate reduced the level of defoliation from greater than, to less than, 50% of the new season's growth.
- Manual defoliation trials have shown that removal of greater than 50% of the new season's growth significantly reduced wood formation.
- Differential levels of larval mortality occurred following spraying of first and third stage larvae with *Bacillus thurigiensis* var *thurigiensis* (Btt). In laboratory tests 50% mortality of first stage larvae was obtained after seven days with an estimated application rate of 0.2 l/ha, but for third stage larvae this estimate was increased to 23.0 l/ha.
- Following Btt application at rates sufficient to cause mortality, larval mortality is always higher in the laboratory than the field. This difference is considered to be due to a lack of persistence of Btt following rain. However, surviving larvae do eat significantly less foliage than larvae on untreated trees.
- A number of strains of the entomopathogen fungal genera, *Beauveria* and *Metarhizium* were selected from large strain banks (DPIF Tasmania and CSIRO Entomology) and locally collected strains to evaluate their efficacy against egg, adult and larval stages of *Chrysophtharta* species. Spore dosage-mortality studies indicated significant differences between genera and within genera strains. Significant larval mortality and consequent reduction of the degree of defoliation was demonstrated in a field trial with *Beauveria* sp. being the most effective.
- *C. bimaculata* dispersal was examined under different spatial scales to determine whether the pattern of environmental occupancy could help to predict the risk to stands and the potential use of 'resistant' trees in the future. This study has followed three approaches.

  i) Isozyme analysis of beetles collected from throughout the state indicated little genetic difference, suggesting high levels of movement between the forests of all regions, with only some slight differentiation between the north-west and north-east regions. (This work was done in collaboration with the CRC for Tropical Pest Management.)

  ii) Beetle dispersion within and between coupes was patchy, with patches of about 100 m diameter. The feeding and oviposition period was about 14 days.

  iii) In a comparison between adjacent regeneration and mature sites, approximately equal numbers of larvae were intercepted entering the soil to pupate.
- Host tree species preferences by the eucalypt weevil, *Gonipterus scutellatus* were demonstrated in a CSIRO Forestry and Forest Products multi-species tree performance trial.

- The importance of native protein sources on longevity and fecundity of the predator *Cleobora mellyi* was demonstrated.

Goals

- Quantify the impact of *C. bimaculata* adults and larvae on tree growth
- Develop a growth model which will include economic injury and economic threshold levels so as to allow selection of appropriate control options following the input of data from regular monitoring of forests
- Refine monitoring systems to better estimate economic thresholds with the potential use of 'trap' tree species to provide an early warning system
- Improve Btt and fungal entomopathogen formulations to increase field effectiveness and persistence
- Conduct semi-operational field trials for the control of defoliators with *Beauveria* and *Metarhizium* formulations
- Continue investigations on the impact of proximal floral diversity on the abundance and efficacy of predators attacking egg and larval stages of *C. bimaculata*
- Examine the feasibility of augmenting biological control by field collection of overwintering coccinellid predator adults for subsequent release in areas of known high risk at the time of beetle arrival and oviposition

Defoliation of Acacia dealbata *by the autumn gum moth, Wyena, north eastern Tasmania*

Project 3

Leader

Dr Clare McArthur

Staff

Mr James Bulinski

Ms Nadia Marsh

Ms Kirsten le Mar

Dr David de Little

Ms Jennifer Sprent

Ms Sarah Scott

Mr Mark Flint

Mr Miles Lawler

Ms Julieanne O'Reilly

Vertebrate browsing in eucalypt plantations

Background

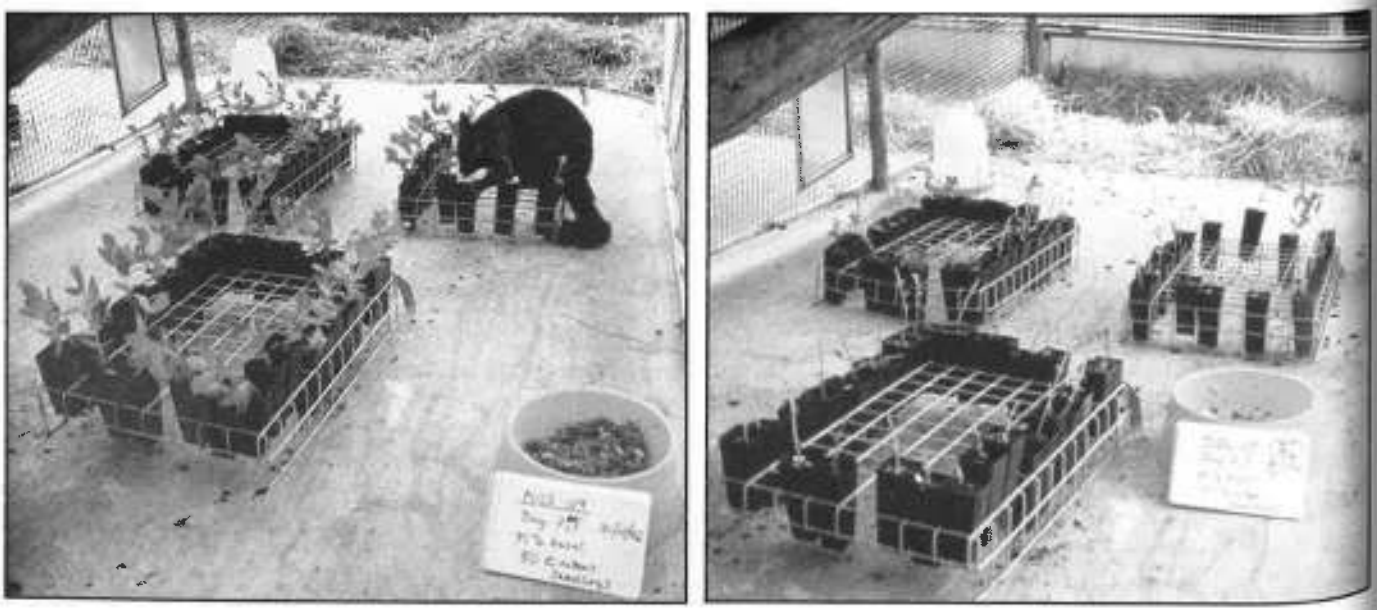
The aims of the Vertebrate Browsing Group are to:

- determine how and under what conditions plantations and seedlings are used by the three main native pest species (pademelon, Bennett's wallaby and brushtail possum);
- provide ways of improving the efficiency and effectiveness of current methods for reducing browsing damage;
- consider and develop alternative methods for reducing damage.

Understanding the feeding ecology of the herbivores is an important basis for improving current control methods and assessing the potential of alternative methods. Our research includes an examination of diet and preferences of the herbivores, degree of variation in susceptibility of plant types to browsing damage, how individuals and populations use plantations and surrounding habitats, whether the three species differ in that use, and to what extent different plantations are at risk to browsing and why.

Outcomes

- A rapid, accurate method for estimating relative food availability was developed for studies on diet selection of pest herbivore species on plantations.
- In summer, in a three-year-old pine plantation with about 1500 *E. nitens* seedlings planted in a small area and abundant alternative vegetation, grasses and dandelion made up 90% of the diet of both Bennett's wallabies and pademelons feeding in the area. Both species avoided pine under those conditions, and the *E. nitens* seedlings remained undamaged over three months.
- In captivity, the overall ranking (high to low) of feeding preferences for seedlings was, (i) possums: *E. gunnii*, *E. globulus* and *E. nitens*, *E. regnans*, *P. radiata*, *A. melanoxylon*; (ii) pademelons: *A. melanoxylon*, *P. radiata*, *E. globulus*, *E. gunnii*, *E. regnans* and *E. nitens*.



A feeding trial at the University of Tasmania animal house, determining how many E.nitens seedlings an individual possum can eat overnight

- In captivity when alternative food was abundant, individual possums damaged about the same number of *E. nitens* seedlings per night as pademelons (~ 30 seedlings each), but possums ate much more of the leaves than pademelons (70% of leaves eaten per seedling cf 13%, respectively). When alternative food was restricted, possums damaged many more seedlings than pademelons (51 cf 30) and also ate more of the leaves of each seedling (85% of leaves eaten cf 42%).
- In a 1ha enclosure trial, reduced levels of alternative vegetation (mainly pasture grasses) tended to expose *E. nitens* seedlings to more damage by Bennett's wallabies and pademelons.
- In a field trial conducted over summer, no damage to *E. nitens* seedlings was recorded in two plots with no herbicide (high pasture grass vegetation), although tree seedling growth was severely impeded. In the two plots treated with herbicide (with no alternative vegetation followed by thistles) there was some seedling damage in the first five rows from the bush edge.
- In the field, possum damage to F_1 hybrids of *E. gunnii* and *E. globulus* was intermediate between the susceptible *E. gunnii* and the resistant *E. globulus* parents, and varied from 7% to 60% of leaves eaten. Despite no significant variation in possum damage between F_1 hybrids in the field, in experiments with captive possums, preferences for specific F_1 hybrids were demonstrated (with Brad Potts, Genetic Improvement Program).
- Short-term feeding trails conducted in captivity (three days) reflected field damage better than longer-term trials (12 days), allowing rapid estimation of susceptibility of plant types to damage by possums.

Goals

- Determine preferences of rabbits for seedlings of various forestry species
- Compare relative damage to seedlings by browsers in plantations with various alternative understorey vegetation types
- Determine relative use of newly established plantations by the three pest browser species
- Determine the relative significance of older plantations, rainforest and grasslands as refuges and feeding areas for the three pest species
- Examine the preferences of browsers for different families of *E. nitens*

From left, Kirsten le Mar and Clare McArthur assessing intensity of grazing by possum and wallaby on a plantation site, Surrey Hills northern Tasmania. The fenced area in the background is designed to allow entry to possums only.

Project 4

Leader

Dr Anthony Clarke

Staff

Mr Zoltan Lukacs

Ms Tara Simmul

Dr David de Little

Ms Sandra Hetherington

Mr Peter Volker

Dr Mick Statham

Mr Paul Dredge

Mr Peter Naughton

Biology of other forest pests

Background

The aim of this project is to investigate insects other than *Chrysophtharta* which are current or potential pests of native hardwoods. These include: the coreid bugs (genus *Amorbus* and *Acantholybas*), 'sap sucking' insects which attack the growing tips of eucalypts and cause tip-wilt and shrubbing; the autumn gum moth (*Mnesampela privata*) a defoliator which feeds on the glaucous juvenile foliage of blue-gums; and fireblight beetle (*Pygroides orphana*) also a defoliator which feeds on silver- and black-wattle. Results of ecological studies are used to:

- assess the potential pest status of these insects in plantations;
- provide information valuable to the formulation of pest management strategies.

Outcomes

- Revision of the genus *Acantholyblas* (Breddin) (Hemiptera:Coreidae) was completed.
- Seasonal phenology and developmental biology of the eucalypt-feeding bugs *Amorbus obscuricornis* (Westwood) and *Gelonus tasmanica* (Le Guillou) was fully described and reported.
- The influence of eucalypt host plant architecture, foliar quality and host response to infestation and exploitation by coreid bugs was defined.
- A comparison of levels of autumn gum moth (*M. privata*) summer activity within and between different Australian states was made and showed that summer populations of the moth are large in Tasmania (where populations are at high altitude) in comparison with locations in SE Australia.
- Studies on temperature-related development of eggs, larvae and pupae of the autumn gum moth showed that there was little difference between populations in development of eggs and lavae but that there were differences in the responses of the pupal stages due to different temperature cues at their respective sites of origin.
- A survey of the distribution of *Pyrgoides orphana*, a chrysomelid defoliator of *A. dealbata*, within Tasmania indicates it is present at most locations of *A. dealbata* in the state.
- Studies of the population ecology of *P. orphana* show they are active in winter but most attacks occur in spring.

Fire blight beetle, Pygroides orphana

Goals

- Examine the genetics of autumn gum moth populations with contrasting seasonal phenologies
- Develop a predictive model which accurately describes the developmental status of the autumn gum moth and the potential pest risk for different regions of the insects' occurrence
- Complete temperature-development studies for *P. orphana* and construct a day-degree development model for interpretation of field population events
- Examine dispersal of *P. orphana* populations
- Determine the basis of the choice of *P. orphana* that results in the common phenomenon of individual trees remaining unattacked when up to a majority of trees within a stand are completely defoliated

Education and Technology Transfer

Manager

Dr Neil Davidson

Staff

Ms Jane Burrell

Prof Jim Reid

Prof Robert Clark

Prof Robert Hill

Prof Robert Menary

Dr Robert Wiltshire

Ms Kristen Williams

Mr Ross Peacock

Introduction

The Education and Technology Transfer Program organises the intake of postgraduate and honours students, coordinates their supervision across the three research programs, and oversees the time allocation of CRC research staff to undergraduate teaching in units where their expertise is most valuable. The program coordinates the transfer of technology from research programs to the industry partners, and organises exercises which raise public awareness of the expertise and activities of the Centre. The program's principal objectives are:

- to develop a national centre of excellence for postgraduate training with emphasis on training graduates relevant to the industry sector in the areas of tree genetics, forest protection, and stand management;
- to transfer rapidly the technology arising from research conducted at the Centre to industry partners and other end-users;
- to raise public awareness of the CRC's objectives and the high quality and relevance of its research.

Outcomes

Education

- The Centre has 42 PhD, MSc and honours students currently enrolled; ten were attracted from industry, ten are on scholarships with industry support (APA-I, FFIC, LWRDC), and a further eight are on competitive national scholarships (APA, AIDAB). Only ten are supported solely by CRC PhD scholarships (see Table 2).
- Supervision of postgraduate and honours students is widely distributed amongst CRC partner institutions with 22 of the 32 supervisors of honours, MSc and PhD projects being non-University departmental staff (see Table 3).
- Seven PhD and two honours graduates of the CRC found employment this year, mostly in the forest industry (Don White, CSIRO Forestry and Forest Products, WA; Heidi Dungey, Cooperativa de Mejoramiento Genetico, Chile; Ross Peacock, Sate Forests of NSW; Martin Steinbauer, CSIRO Entomology, Darwin; Craig Hardner, CSIRO Plant Industry, Brisbane; Trevor Garnett, University of Adelaide; Bruce Greaves, Research Fellow, University of Tasmania; Martin Tyson, CSIRO Forestry and Forest Products, Canberra; Charlie Warren, PhD scholarship on plantation forestry, University of Western Australia).
- Seven CRC-funded scientists contributed to university courses in fields allied to their research: Anthony Clarke lectured in agricultural entomology, Rabi Misra in soil physics, Neil Davidson in physiological plant ecology, Michael Battaglia in quantitative ecology, Philip Smethurst in soil and nutrition, Brad Potts in genetics, and Dorothy Steane in molecular genetics. Neil Davidson also coordinated a four-year undergraduate course, Forest Ecology, designed for students with an interest in forestry.
- The Centre had six postdoctoral fellows in 1996/97: Jean-Noël Ruaud in somatic embryogenesis; Allie Muneri in wood science; Dorothy Steane in molecular genetics; Anthony Clarke in entomology (Project Leader); Clare McArthur in vertebrate browsing (Project Leader); and Mark Hovenden on effects of low temperature on photosynthesis.
- Six eminent scientists worked in the Centre under the Visiting Scientists scheme: Prof Peter Davies (Cornell University, USA) in the Genetic Improvement Program on hormonal control of flowering, (July to Dec 1996); Dr Arthur Gilmour (NSW Agriculture) on ASREML for estimation of

variance components and prediction of effects (May 1997) and Prof David Newman (University of Georgia, USA) on quantifying benefits from genetic improvement (Jan to March 1997). Prof Ken Van Rees (University of Saskatchewan, Canada) worked in the Soil and Stand Management Program on spacial patterns of eucalypt fine roots (Feb to March 1997). Dr Richard Milner (CSIRO Entomology) worked in the Resource Protection Program on entomopathogens, and Dr Christine Stone (State Forests of NSW) on entomology projects.

Technology transfer

- In the last year the program ran 23 seminars, four workshops, one short course and two field days, and produced 15 issues of the technical publications and information sheets, 'Hot off the seedbed' and 'Beyond the black stump' (Table 4).
- Fifty seven research papers were published in 1996/97, 21 in refereed journals; and eight PhD and honours theses were completed.
- One international consultancy was undertaken in 1996/97. Nuno Borralho worked with RAIZ in Portugal on a project entitled 'Development of breeding strategies in eucalypts'.
- The program produced quarterly issues of the newsletter 'Overstorey' and an Annual Report.

Competition by acacias within eucalypt plantations, the subject of Mark Hunt's PhD research, was discussed at a field day, Wyena, northern Tasmania 10 December 1996

Public awareness

- A project aimed at encouraging women to develop careers in forestry commenced in July 1996. The project is being funded through a grant of $26,00 from the Science and Technology Awareness Program.
- Teaching kits for 10-15-year-olds are being developed to demonstrate the importance to Australian society of technological advancement in the forestry sector.
- The Centre conducted a panel presentation on 'The search for new technology in Australian forestry' in Hobart (July 1996) and Burnie (April 1997), under the auspices of the Royal Society of Tasmania.
- A series of public seminars on Farm Forestry were presented on three successive days at 'Natives Treefest' during 'Agfest' in May 1997.
- During the last year there have been 12 articles in newspapers and industry news sheets, three radio interviews and two television interviews relating to the Centre.
- The Centre's World Wide Web site was upgraded.
- The program assisted in the organisation of the 1998 ANZAAS Conference on 'Sustainability of Southern Ecosystems' (Prof Jim Reid is Chairman and Dr Neil Davidson is Secretary of the Organising Committee).

Goals

Education

- Support and encourage MSc and PhD students to complete their degrees within the prescribed time (3.5 years full-time)
- Maintain present numbers of research higher degree students in the new CRC for Sustainable Production Forestry

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- Continue the involvement of partner staff in the supervision of student projects
- Continue the involvement of CRC scientists, who are not teaching staff in University departments, in teaching at the undergraduate level.

Technology transfer

- Increase the rate of technology transfer through combined use of direct contact and 'Hot off the seedbed' and 'Beyond the black stump', seminars, workshops and technical publications.
- Continue to gain coverage for the Centre in newspapers and partner news sheets, and present news releases to the electronic media.
- Organise the 1998 ANZAAS Conference on 'Sustainability of Southern Ecosystems' and make a major contribution to the session on 'Sustainable forestry'

Students from local primary and secondary schools enjoy the hands-on display at the opening of the Upper Derwent Valley Landcare Resource Centre at Hamilton, central Tasmania, September 1996

Public awareness

- Continue to develop the 'women in forestry' project
- Produce the first forestry teaching kits for schools, grades 6-9
- Maintain the Centre's World Wide Web site
- Organise public displays and open days

Table 2 Summary of student enrolments in the CRC

CRC Research Students 1996/97

No	First Name	Last Name	Degree	Topic	CRC Program
1	Paul	ADAMS	PhD	*Sources of competition from weeds in plantations*	Soil & Stand Management
2	Karen	BARRY	PhD	Defence mechanisms against decay in *E. nitens*	Resource Protection
3	James	BULINSKI	PhD	Effect of plantation design on feeding behaviour of wallaby	Resource Protection
4	Peter	BUNDOCK	PhD	Genetic control of coppice ability in *E. globulus*	Genetic Improvement
5	Steve	CANDY	PhD	Mathematical models to support IPM of leaf beetles	Resource Protection
6	Paul	CHAMBERS	PhD	Quantitative genetics and the economic flow-ons from genetic gains	Genetic Improvement
7	Dugald	CLOSE	PhD	Environmental constraints on early growth of seedlings in eucalypt plantations	Soil & Stand Management
8	Greg	DUTKOWSKI	PhD	Improvement of mixed models for prediction of breeding values in forestry and application to breeding programs	Genetic Improvement
9	Mark	FLINT	Hons	Effect of vegetation on patch chronology and seedling damage in plantation	Resource Protection
10	Trevor	GARNETT	PhD	Kinetic parameters for uptake of nitrate and ammonium by eucalypt roots	Soil & Stand Management
11	Bruce	GREAVES	PhD	Age to age correlations in eucalypts	Genetic Improvement
12	Bradley	HOWLETT	PhD	Host location by *Chrysophtharta bimaculata*	Resource Protection
13	Mark	HUNT	PhD	Competition between understorey species and plantation eucalypts	Soil & Stand Management
14	Hamish	JACKSON	Hons	Variation in cpDNA of *Eucalyptus globulus*	Genetic Improvement
15	Corinna	KELLY	Hons	The adaptive significance of variation in bark characteristics in eucalypts	Genetic Improvement
16	Peter	KUBE	PhD	Breeding objectives and genetic control of traits for the production of sawlogs from plantation grown *Eucalyptus*	Genetic Improvement
17	Sven	LADIGES	PhD	Micronutrient deficiencies in eucalypts induced by excess application of N & P	Soil & Stand Management
18	Kirsten	LE MAR	PhD	Comparison of eucalypt plantations use by three herbivorous marsupial species	Resource Protection
19	Susan	LENNON	PhD	Modelling cambial growth	Soil & Stand Management
20	Zoltan	LUKACS	PhD	Ecology of the autumn gum moth	Resource Protection
21	Matthew	MARRISON	Hons	The importance of islands in lakes in the central Plateau on regional biodiversity	Soil & Stand Management
22	Nadia	MARSH	PhD	Browsing of eucalypt seedlings by pademelons (*Thylogale billardierii*)	Resource Protection
23	Michelle	McGRANAHAM	PhD	Genetic control of propagation ability in *Pinus radiata* and strategies for their use in breeding programs	Genetic Improvement
24	Jane	MEDHURST	PhD	Thinning of *Eucalyptus nitens* stands	Soil & Stand Management
25	Daniel	MENDHAM	PhD	Process based predictions of nutrient limitations to plants	Soil & Stand Management
26	Andrew	MILGATE	PhD	The genetic basis of resistance to *Mycosphaerella* in *Eucalyptus globulus*	Genetic Improvement
27	Alexandra	MITCHELL	PhD	Reproductive biology and breeding systems for *E. globulus*	Genetic Improvement
28	Maria	MORONI	PhD	Nitrogen mineralisation	Soil & Stand Management
29	Natalie	PAPWORTH	Hons	Germination niche for dry sclerophyll eucalypts	Soil & Stand Management
30	Ross	PEACOCK	PhD	Regeneration after cable logging	Soil & Stand Management
31	Libby	PINKARD	PhD	The effect of pruning on productivity and resource allocation in *E. nitens*	Soil & Stand Management
32	Sarah	SCOTT	Hons	Browsing susceptibility of *Eucalyptus* species in relation to genetic identity and environmental effects	Resource Protection
33	Tara	SIMMUL	PhD	Biology of the fire blight beetle	Resource Protection
34	Jennifer	SPRENT	Hons	Comparison of diet and bud damage to seedlings by three marsupial herbivores in a plantation	Resource Protection
35	Paulina	TEIXEIRA	PhD	Soil structure and erosion in eucalypt plantations	Soil & Stand Management
36	Peter	VOLKER	PhD	Estimation of genetic parameters for eucalypt hybrids	Genetic Improvement
37	Ian	WARDLAW	PhD	*Armillaria* butt and root rot of eucalypts	Resource Protection
38	Xiaoming	WEI	PhD	Efficiency of selection in eucalypts	Genetic Improvement
39	Grant	WESTPHALEN	MSc	Indicator species for sustainability in native forest systems	Soil & Stand Management
40	Dean	WILLIAMS	PhD	Reproductive biology of *Eucalyptus*	Genetic Improvement
41	Kristen	WILLIAMS	PhD	Modelling *Eucalyptus* distribution	Education
42	Steve	WILSON	PhD	Early growth and survival of eucalypt seedlings	Soil & Stand Management

CRC Research Students 1996/97

No	First Name	Last Name	Field	Scientific Supervisors	Funding	PT/F Time	Start	Finish
1	Paul	ADAMS	Weed biology	Dr C Beadle, Dr P Smethurst	UWRDC	Full	1996	1999
2	Karen	BARRY	Forest pathology	Dr C Mohammed	APA-I	Full	1997	2000
3	James	BULINSKI	Vertebrate browsing	Dr C McArthur	CRC	Full	1994	1997
4	Peter	BUNDOCK	Eucalypt genetics	Dr R Vaillancourt	APA	Full	1995	1998
5	Steve	CANDY	Entomology	Dr J Madden, Dr H Elliott	FCT employee & SM	Part	1993	1999
6	Paul	CHAMBERS	Quantitative genetics	Dr N Borralho	APA-I	Full	1995	1998
7	Dugald	CLOSE	Eucalypt physiology	Dr P Brown, Dr C Beadle, Dr G Holz	APA	Full	1997	2000
8	Greg	DUTKOWSKI	Tree breeding	Dr N Borralho, Dr A Gilmour	Tree Breeder (CRC)	Part	1996	2003
9	Mark	FLINT	Vertebrate browsing	Dr C McArthur, Dr D Bachmann, Dr M Statham	Self supporting	Full	1996	1997
10	Trevor	GARNETT	Tree nutrition	Dr P Smethurst, Dr N Davidson	CRC	Full	1993	1996
11	Bruce	GREAVES	Eucalypt genetics	Ms C Raymond, Dr B Potts, Dr N Borralho	APA	Full	1993	1997
12	Bradley	HOWLETT	Entomology	Dr J Madden, Dr A Clarke, Dr P McQuillan	FPC	Full	1993	1996
13	Mark	HUNT	Eucalypt ecology	Dr N Davidson, Dr C Beadle	CRC	Full	1994	1997
14	Hamish	JACKSON	Molecular biology	Dr R Vaillancourt, Dr DSteane, Dr BPotts	CRC	Full	1997	1997
15	Corinna	KELLY	Eucalypt genetics	Dr B Potts, Dr N Borralho, Prof J Reid	CRC	Full	1997	1997
16	Peter	KUBE	Tree Breeding	Dr N Borralho, Ms C Raymond	FT employee	Part	1996	2003
17	Sven	LADIGES	Tree nutrition	Prof R Meurisse, Dr C Beadle	CRC	Full	1996	1999
18	Kirsten	LE MAR	Vertebrate browsing	Dr C McArthur, Dr D de Little, Dr M Statham	APA	Full	1996	1999
19	Susan	LENNON	Modelling	Dr P Sands, Dr M Battaglia	CRC	Full	1995	1998
20	Zoltan	LUKACS	Entomology	Dr A Clarke, Dr J Madden, Dr R Floyd	APA	Full	1994	1997
21	Matthew	MARRISON	Ecology	Dr N Davidson	Self supporting	Full	1996	1997
22	Nadia	MARSH	Vertebrate browsing	Dr C McArthur	CRC	Full	1993	1996
23	Michelle	McGRANAHAM	Forest Genetics	Dr N Borralho	APA	Full	1998	1999
24	Jane	MEDHURST	Tree physiology	Dr C Beadle, Dr N Davidson	FPC	Full	1996	1999
25	Daniel	MENDHAM	Soil nutrition	Dr P Smethurst, Prof R Meinary, Dr G Holz	APA-I	Full	1995	1998
26	Andrew	MILGATE	Forest pathology	Dr C Mohammed, Dr R Vaillancourt	APA-I	Full	1997	2000
27	Alexandra	MITCHELL	Eucalypt genetics	Dr B Potts, Dr R Vaillancourt	CRC	Full	1995	1998
28	Maria	MORONI	Soil nutrition	Dr P Smethurst, Prof R Meaney	APA-I	Full	1995	1998
29	Natalie	PAPWORTH	Forest ecology	Dr N Davidson	CRC	Full	1997	1997
30	Ross	PEACOCK	Forest ecology	Dr N Davidson, Dr M Brown, Prof R Hill	State Forests of NSW	Part	1994	1998
31	Libby	PINKARD	Eucalypt physiology	Dr C Beadle, Dr N Davidson	FPC	Full	1994	1997
32	Sarah	SCOTT	Vertebrate browsing	Dr C McArthur, Dr Brad Potts	Self supporting	Full	1996	1997
33	Tara	SIMMUL	Insect ecology	Dr A Clarke	APA-I	Full	1996	1999
34	Jennifer	SPRENT	Vertebrate browsing	Dr C McArthur	Self supporting	Full	1996	1997
35	Paulina	TEIXEIRA	Soil structure and erosion	Dr R Meiss	CRC	Full	1993	1995
36	Peter	VOLKER	Eucalypt genetics	Dr B Potts, Dr N Borralho	ANM employee	Part	1992	1996
37	Ian	WARDLAW	Pathology	Dr C Mohammed, Dr G Kile	FCT employee	Part	1994	2000
38	Xiaoming	WEI	Quantitative genetics	Dr N Borralho	AIDAB	Full	1994	1997
39	Grant	WESTPHALEN	Plant ecology	Dr M Brown, Dr N Davidson	CRC	Full	1996	1998
40	Dean	WILLIAMS	Reproductive biology	Prof J Reid, Dr B Potts	CRC	Full	1996	1999
41	Kristen	WILLIAMS	Eucalypt ecology	Prof J Reid, Dr M Austin, Dr M Brown	DPI-Forestry	Part	1991	1995
42	Steve	WILSON	Eucalypt ecology	Prof B Clarke, Mr P Volker	APA-I (TFRC)	Full	1993	1996

Table 3 Summary of student enrolments in the CRC

Postgraduate Students

Number of Students

Full/Part Time:	Full time	35
	Part time	7
Degree:	Forest Ecology Hons	1
	BSc Honours	7
	MSc	1
	PhD	33
CRC Program:	Genetic Improvement	12
	Soil & Stand Management	17
	Resource Protection	12
	Education	1

Supervisors:

Dr M Austin CSIRO W & E	1	Prof R Clark* Agr Sci UT	1	Prof R Hill* Plant Sci UT	1	Dr C Mohammad* Agr Sci UT	3	Dr S Steane CRC	1
Dr M Battaglia CSIRO FFP	1	Dr A Clarke CRC	3	Dr G Holz NET	1	Prof R Menary* Agr Sci UT	3	Dr M Statham DPIF	2
Dr C Beadle CSIRO FFP	6	Dr N Davidson CRC	8	Dr G Kile CSIRO FFP	1	Dr B Potts CRC	7	Dr R Vaillancourt* Plant Sci UT	4
Dr N Borralho CRC	8	Dr D de Little NET	1	Dr J Madden* Agr Sci U	3	Ms C Raymond CSIRO FFP	2	Mr P Volker ANM	1
Dr P Brown* Agr Sci UT	1	Dr H Elliott Forestry Tas	1	Dr C McArthur CRC	6	Prof J Reid* Plant Sci UT	3		
Dr M Brown Forestry Tas	3	Dr R Floyd CSIRO Ento	1	Dr P McQuillan* Geography UT	1	Dr P Sands CSIRO FFP	1		
Mr O Buchmann* Zoology UT	1	Dr A Gilmour NSW Ag	1	Dr R Misra CRC	1	Dr P Smethurst CRC	4		

Funding:	CRC (Honours Scholarship)	3
	CRC (PhD/MSc Scholarship)	10
	APA with CRC top up	7
	APA - Industry	6
	FFIC	3
	AIDAB	1
	Employed in forest industry	7
	LWRDC	1
	Self-supporting	4

* University Department Staff
DPIF Department of Primary Industry and Fisheries
CSIRO FFP Commonwealth Scientific and Industrial Reseach Organisation Forestry and Forest Products
CSIRO W & E Commonwealth Scientific and Industrial Reseach Organisation Wildlife and Ecology
UT University of Tasmania
NET North Eucalypt Technologies
ANM Australian Newsprint Mills

Utilisation and Application of Research

Strategy for Technology Transfer

The principal objective of the Technology Transfer Program is to transfer the technology rapidly to the industrial partners and other end users. This involves the following steps:

1. Involvement of industrial partners in planning research projects and running experiments

Most CRC research is conducted using company trials, or trials established on company land, so companies are involved at the outset with the planning and implementation of research projects and have ownership of them. Research plans for these experiments are lodged with the companies, and these include an agreed protocol for the research. The company partners allocate staff time (in-kind contributions) to CRC research projects so effective interaction can occur. Ultimately, the Industry Research Committee of the CRC retains an overview of these research projects and can support, reject or modify any research project.

2. Early transfer of results

The early transfer of results starts with informal interaction (telecommunication, electronic mail and visits to company sites). The first stage in formal transfer involves faxing a summary of the implication/application of research on an A4 page eg 'Hot off the seedbed' and 'Beyond the black stump'. Company responses then determine whether the next form of presentation of the information will be a seminar, workshop, short course or field day. Where an individual company shows particular interest, this presentation may be conducted at the company operations. Where interest is more general there may be visits to each company by research staff or a course or workshop run at the CRC. The next stage in transfer takes the form of a technical report, unrefereed paper, or refereed journal paper.

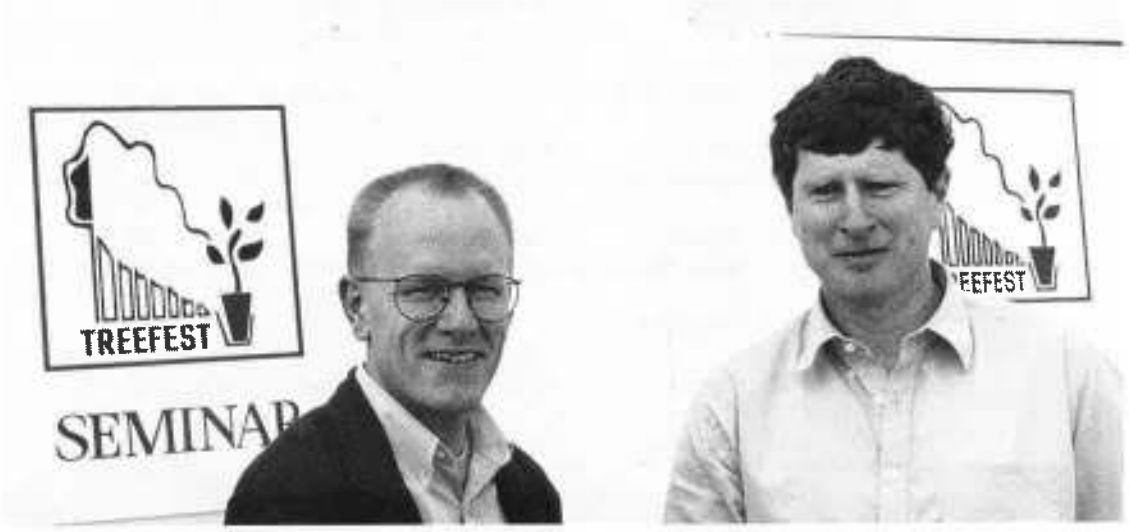
3. Development of training courses in modern forestry techniques for company staff

Technology transfer also occurs at the postgraduate research level. There were nine company staff enrolled as PhD or MSc candidates during 1996/97. Six were conducting their research while still employed; Tim Wardlaw (Forest Pathologist, Forestry Tasmania), Steve Candy (Statistician, Forestry Tasmania), Peter Kube (Tree Breeder, Forestry Tasmania), Peter Volker (Principal Research Forester, ANM), Don White (Research Scientist, CSIRO FFP), Ross Peacock (Research Scientist, Dept. Planning, NSW). Three resigned their positions to conduct research but intend returning to industry; Greg Dutkowski, (Research Manager, Bunnings), Paul Adams (S.A. Dept. Primary Industry), Jane Medhurst (Forestry Tasmania).

During the life of the CRC, 17 of our students have been employed in the forest industry. In 1996/97 seven PhD graduates (Don White, Ross Peacock, Heidi Dungey, Martin Steinbauer, Craig Hardner, Trevor Garnett and Bruce Greaves), and two honours graduates (Martin Tyson and Charlie Warren) of the CRC have found employment in the forest industry. In addition, ten CRC students are currently funded by industry scholarships: Paul Adams (LWRDC) on weed competition with eucalypts; Bradley Howlet (FFIC) on host location by *C. bimaculata*; Jane Medhurst (FFIC) on thinning of *E. nitens* stands; Libby Pinkard (FFIC) on the effect of pruning on *E. nitens*; Paul Chambers (APA-I) on economic value of genetic gains; Dana Mendham (APA-I) on prediction of phosphorus limitations; Martin Moroni (APA-I) on nitrogen mineralisation; Tara Simmul (APA-I) on the biology of fire blight beetle; Steve Wilson (APA-I) on survival of eucalypt seedlings; and Andrew Milgate (APA-I) on the genetics of resistance to *Mycosphaerella* in *E. globulus*.

Major Outcomes

- During the first five years of the Centre, we estimate Technology Transfer activities reached approximately 15,000 people through a major international conference, 98 seminars, 24 workshops, four symposia, six short courses, eight field days and tours. During 1996/97, 23 seminars, four workshops, one short course and two field days were conducted (Table 4). Future activities appear in Table 5.
- Publication of 190 refereed, 221 unrefereed papers and 37 theses during the life of the CRC. The publication of 57 research papers in refereed journals, 21 unrefereed articles and 8 theses in 1996/7 (see Publications).
- During the last five years there have been 34 articles in newspapers and industry news sheets, and 16 items in the electronic media relating to the Centre. There have been 12 articles in newspapers and industry news sheets, and 5 items in the electronic media relating to the Centre during 1996/97 (see Public Presentations, Public Relations and Communication, Table 4).
- In each of the Research Programs of the CRC several research projects have lead to the production of technology which has been transferred or is being transferred to the company partners (Table 6)
- There are a wide range of end users of the technology developed by the CRC including small and medium sized enterprises (SME's) (Table 7)
- Public good research conducted by the CRC (Table 8).



Prof Peter Kanowski, (left) School of Forestry, ANU, with Dr Neil Davidson, Manager, CRC Education and Technology Transfer, at the National Treefest Seminar Series, Agfest, Northern Tasmania, May 1997.

Table 4 Technology Transfer Activities conducted in 1996/97

Date	*Form*	*Author/Content*	*Reach*	*Program*	*Time (days)*
18/6/96	Seminar to industry	Applications of ProMod (Launceston)	12	SSM	1
21/6/96	Seminar to industry	Applications of ProMod (Hobart)	10	SSM	1
July 96	Overstorey		180	ETT	
15/7/96	Hot off the Seedbed	Nuno Borralho	150	GI	
July 96	Seminar series	Royal Society of Tasmania Forum 'The search for new technology in Australian forestry'	150	ETT	1
26/7/96	Beyond the Black Stump	Michael Battaglia Peter Sands	100	SSM	
Aug 96	Workshop (technical)	Water use and water relations (at CRC)	20	SSM	2
Aug 96	Workshop	Tree stress and insect host selection	20	RP	1
28/8/96	Beyond the Black Stump	Philip Smethurst	100	SSM	
28/8/96	Hot off the Seedbed	Greg Dutkowski	150	GI	
26/9/96	Beyond the Black Stump	Chris Beadle	100	SSM	
Oct 96	Overstorey		180	ETT	
Nov 96	Seminar	Clonal forestry in Portugal (at CRC)	30	GI	1
Nov 96	Workshop	Sampling eucalypts for wood properties (at NET)	25	GI	1
18/11/96	Beyond the Black Stump	Chris Beadle	100	SSM	
Dec 96	Overstorey		180	ETT	
Dec 96	Field day	*Acacia* as weeds in eucalypt plantations at Wyena (hosted by Boral Timber Tas)	50	SSM	1

Date	*Form*	*Author/Content*	*Reach*	*Program*	*Time (days)*
Jan 97	Technical publication	Predicting pulp yield using NIRA for *E. globulus* and *E. nitens*: Within tree variation and sampling recommendations	40	GI/SSM	
8/1/97	Beyond the Black Stump	Robin Cromer	100	SSM	
23/1/97	Hot off the Seedbed	Paul Chambers	150	GI	
28/1/97	Beyond the Black Stump	Michael Battaglia Greg Holz	100	SSM	
Jan 97	Technical publication	Fibre length and fibre coarseness in *E. globulus* and *E. nitens*: Within tree variation and sampling recommendations	40	GI/SSM	
Feb 97	Technical publication	Progress report on results of feeding trials with brushtail possum (*Trichosurus vulpecula*) and pademelon (*Thylogale billardierii*), and implications for forestry	40	RP	
Feb 97	Seminar	The importance of including survival in breeding objectives (at CRC)	40	GI	1
17/2/97	Hot off the Seedbed	Nuno Borralho	150	GI	
Feb 97	Seminar	Breeding objectives for pulp production in *E. nitens* (at CRC)	40	GI	1
17/2/97	Beyond the Black Stump	Philip Smethurst	100	SSM	
Feb 97	Seminar	Technical meeting of STBA 'Research in the Genetic Improvement Program'	100	GI	1
Feb 97	Field day	STBA visited CRC-THF and Forestry Tasmania trials	30	GI	1
19/3/97	Seminar to industry	Applications of PROMOD (Canberra)	8	SSM	1
20/3/97	Seminar to industry	Applications of PROMOD (Brisbane)	10	SSM	1
Mar 97	Seminar	Tasmanian branch of APPI 'Successful new technology from the CRC-THF'			
Mar 97	Overstorey		180	ETT	
April 97	Workshop	Use of ASREML	15	GI	1
April 97	Workshop	Australian Paper Plantations, Gippsland: Research Developments in the SSM Program.	15	SSM	2

Date	*Form*	*Topic*	*Reach*	*Program*	*Time (days)*
16/4/97	Seminar to industry	Applications of PROMOD (Morwell)	8	SSM	1
May 97	Seminar Series	National Treefest seminars on farm forestry	100	ETT	3
May 97	Seminar proceedings	National Treefest seminars on farm forestry	300	ETT	
May 97	Seminar	Biology Teachers Association of Tasmania (BIOTA) conference	20	GI	1
May 97	Computer program	WhatX, assists tree breeders in optimising selection and mate allocations - distributed to industry	40	GI	
June 97	Technical publication	Recommendations for deployment options for improved germplasm (seed orchards versus clonal forestry)		GI	
June 97	Seminars	Forest pest management (at NET)	20	RP	1
June 97	Overstorey		180	ETT	

Table 5 Technology Transfer Activities proposed for 1997/98

Date	*Form*	*Topic*	*Reach*	*Prog.*	*Time (days)*
July 1997	Seminars	Innovations in (at ANM) forest planning	20	SM	1
Aug 1997+	Overstorey	4 issues of newsletter in the year	180	ETT	
July 1997+	Hot off the seedbed	Implications of research faxed to partners (at least 6 for the year)	40	GI	
July 1997+	Beyond the Black Stump	Implications of research mailed to partners (at least 6 for the year)	100	SM	
May 1997	Display	Amazing World of Science exhibition in Canberra	14000	ETT	
Nov 1997	Symposium	Genetics and breeding of *Eucalyptus globulus* (Hobart)	40	GI	2
Nov 1997	Symposium	Genetics and breeding of *Eucalyptus globulus* (Western Australia)	50	GI	2
Feb 1998	6 Workshops	Farm Forestry, in association with Greening Australia and Private Forests Tas.	180	ETT	6

Table 6 Technology transferred

Genetic Improvement Program

- Wood density identified is an important characteristic in pulping costs
  - breeding objectives adjusted (1995)

- Pilodyn measurements have allowed large-scale estimates of basic density
  - Pilodyn assessment included in the STBA eucalypt breeding program (1995)

- Provenance of *E. globulus* with desirable high density has been identified
  - used by seed collectors (1995)

- More accurate prediction of breeding values in forestry
  - collaboration with STBA to improve the accuracy of breeding value predictions in the national genetic evaluation of E. globulus *ssp* globulus *and* E. nitens *breeding programs. Provides end users other than CRC partners with access to the results of CRC genetics projects (1994-1997+)*

- Reduction in growth due to inbreeding in native stand seed for *E. globulus*
  - incorporated into the evaluation of breeding values in breeding programs (1995)

- Hormonal control of flowering in *Eucalyptus*
  - paclobutrazol used in seed orchards (1993)

- Flowering times of *E. globulus* families determined
  - used in crossing programs and seed orchard design (1994)

- Recommendations for non-destructive sampling of basic density, predicted pulp yield, fibre length and coarseness
  - program used in a few breeding programs (1997)

- Incorporation of the race classification for *E. globulus* in national genetic evaluations
  - incorporated into the evaluation of breeding values in breeding programs (1997)

- Report and recommendations to industry partners on benefits for deployment options (seed orchards versus clonal forestry) for improved germplasm
  - report with recommendation (1977)

- WhatX, a program to assist tree breeders in optimising selection and mate allocation has been distributed to industry partners
  - computer program available to partners (1996), and in the CRC homepage (1997).

- Predicting pulp yield using NIRA for *E. globulus* and *E. nitens* within tree variation and sampling recommendations
  - recommendation confidential (1997)

- Fibre length and fibre coarseness in *E. globulus* and *E. nitens* within tree variation and sampling recommendations
  - recommendation confidential (1997)

Soil and Stand Management Program

- On most ex-forest sites tested, N mineralisation is sufficient to sustain high growth rates during the first one to two years
  - application of urea at year three
  - urea is quickly converted to ammonium, preferred N source for E. nitens*(1996)*

- P requirements for eucalypts are low, but on most sites tested, application of P at planting improved growth and later applications are not required
  - spot application of P at planting only (1995)

- Copper deficiency implicated in gross stem deformities in *E. nitens* plantations established on highly fertile ex-pasture sites that received additional N and P fertiliser.
  - no fertiliser application (1994)

- Use excavators rather than bulldozers to form windrows as less topsoil and organic matter is removed. This also provides a larger area for planting, a more uniform stand and increases tree growth (at year 7)
  - excavators recommended for clearing on ex-native forest sites (1993)

- Ripping at establishment is generally not required, while surface cultivation (mounding) is required prior to planting to maximise plantation growth
  - ripping not required (1995)

- Good pre-planting weed control on native forest sites eliminated need for expensive post-planting applications of atrazine
  - employment of good pre-planting weed control (1993)

- *E. globulus* is more tolerant than *E. nitens* of moderate water stress during the growing cycle
  - *planting of* E. globulus *on sites subject to moderate water stress (1996)*

- Pruning of up to 50% of the crown of *E. nitens* had no significant effect on height growth
  - *pruning of* E. nitens *to obtain solid wood products (1996)*

- Simple models of biomass partitioning and canopy assimilation, and relationships between leaf area index and site factors have been derived
  - *potential to predict site productivity for plantations in a form (MAI) likely to be useful to forest managers (1996)*

Resource Protection Program

- Development (with Forestry Tasmania) of an Integrated Pest Management Program
  - *control of defoliating insects (1992-1997+)*

- Trap trees of *E. regnans* to control insect numbers in adjacent plantations of *E. nitens*
  - *used by North Forest Products (1996)*

- Differences between provenances of *E. nitens* in susceptibility to browsing by pademelons
  - *potential for use in breeding programs (1996)*

Table 7 List of end users of technology

End user	Research Program
ANM	all programs
North Forests Products	all programs
Australian Paper Plantations	all programs
Bunnings Treefarms	Genetic Improvement and Soil and Stand Management
Boral Timber	all programs
Forestry Tasmania	all programs
CSIRO	all programs
University of Tasmania	all programs
Public good research	all programs
STBA membership:	
ANM	as above
North Forests Products	as above
Australian Paper Plantations	as above
Bunnings Treefarms	as above
Forestry Tasmania	as above
Primary Industries (SA) Forestry	Genetic Improvement
Kimberley-Clark Australia	Genetic Improvement
Silvagene Pty Ltd*	Genetic Improvement

* Small to medium sized enterprise (SME)

Contracts conducted

Personnel	Contracting organisation	Project
Dr N Borralho	RAIZ, Portugal	Development of breeding strategies in eucalypts

Table 8 Public good research conducted by the CRC

Genetic Improvement Program

- The identification of 13 races within *E. globulus* provides a frame work for the identification and conservation of the genetic resources of the species.
- Advances have been made in somatic embryogenesis of eucalypts. The techniques developed may well be applied in the future to genetically engineered eucalypts.
- A hybrid breeding project has produced F_2 and advanced generation hybrids between *E. globulus* and both *E. nitens* and *E. gunnii*. These could lead to the development of synthetic lines to exploit marginal sites.
- Molecular genetics research conducted at the CRC has aided in the taxonomic revision of the genus *Eucalyptus*.
- An atlas of the natural distribution of the Tasmanian eucalypt species has been published. It quantifies the geographical and altitudinal distributions and flowering times of the 29 Tasmanian species, provides detailed accounts of their ecology, and highlights distributional anomolies which require clarification.
- A study of susceptibility of artificial eucalypt hybrids between *E. amygdalina* and *E. risdonii* to insect herbivores is one of the first to show how biodiversity can be under genetic control. Insect species richness was significantly higher on F_1 and F_2 hybrids than controls of the pure eucalypt species, which was remarkably consistent with patterns observed in natural populations.
- An invited review in the field of eucalypt genetics and genecology has been completed by Brad Potts and Robert Wiltshire. This review has been directed at a wide audience from plant breeders to ecologists and will appear in a book 'Eucalypt Ecology: Individuals to Ecosystems' (J Williams and J Woinarski, eds) to be published by Cambridge University Press towards the end of 1997.

Soil and Stand Management Program

- Excavators (in comparison with bulldozers) conserve topsoil during clearing, maintaining site productivity and sustainability of forest practice.
- Water use of plantations has been partitioned into layers so models can more accurately predict species response to climatic variables, enabling prediction of soil-water balance.
- Kinetics of NO^{3-} and NH^{4+} uptake by eucalypt roots is work pioneered by the Centre.
- Effect of temperature on photosynthesis, temperature acclimation and depression of photosynthesis after frost will be used in models of plantation productivity, to determine location of plantations at high altitude and retention of native forests for other purposes.

Resource Protection Program

- A survey of the leaf volatile oils and waxes in eucalypts has allowed identification of biochemical markers at the species, series and subgeneric level which provides a framework for the study of eucalypt-pest interactions.
- The taxonomy of the coreid bugs (sap sucking insects) has been revised and the ecology elucidated for a group of potential insect pests (seven publications).

Staffing and Administration

Staffing

During 1996/97 some major changes to the staff of the CRC occurred.

John Madden, Manager of the Resource Protection Program, retired at the end of June 1997. Robin Cromer relocated to CSIRO FFP, Canberra at the end of June and Chris Beadle replaced him as Manager of the Soil and Stand Management Program. The Director, Jim Reid has assumed responsibility for the Resource Protection Program until the new CRC for Sustainable Production Forestry commences.

Anthony Clarke, leader of two projects in the Resource Protection Program, resigned in April 1997 to lead an ARC project at the University of Queensland.

Mark Hovenden, Postdoctoral Fellow in the Genetic Improvement Program, obtained an ARC Fellowship and moved to the Plant Science Department, University of Tasmania in June 1997.

The Business Manager, Jan Lynch resigned in December 1996 to take up a position with the Chamber of Commerce in Launceston.

Technical Assistant Mark Grubert was appointed to replace Martin Tyson. He worked with Robin Cromer in the area of nutrient partitioning, and with Chris Beadle in the area of canopy processes, until June 1997. Technicians whose contracts expired on 30 June 1997 included: Andrew Gibbons, Helena Nermut, Juliane O'Reilly, Stephen Turner and Mark Grubert.

New students starting with the Centre this year included four PhD students: Dugald Close, Andrew Milgate, Karen Barry, Kirsten le Mar; and five honours students: Jennifer Sprent, Sarah Scott, Mark Flint, Matthew Marrison, Natalie Papworth. Ross Peacock upgraded from MSc to PhD.

Company changes

CRC partner, Amcor Plantations Pty Ltd changed its name to Australian Paper Plantations Pty Ltd. Phil Whiteman moved to a new position as Plantations Manager of the company, and Silvia Pongracic replaced him on the Industry Research Committee.

Table 9 Specified personnel in the CRC-THF

Name	Title	Employing Agency	Proportion of time in the CRC
Prof James Reid	Director	University of Tasmania	0.5
Dr David de Little	Deputy Director	North Forest Products	0.42
Dr Nuno Borralho	Manager, Genetic Improvement program	University of Tasmania	1.0
Mr Robin Cromer	Manager, Soil and Stand Management program	CSIRO Forestry and Forest Products	0.6
Dr John Madden	Manager, Resource Protection program	University of Tasmania	0.3
Dr Neil Davidson	Manager, Education and Technology Transfer program	University of Tasmania	1.0

Administration

The number of meetings held by the Board and other Committees during 1996/97 were as follows:

Board of Management	5
Industry Research Committee	1
Scientific Review Committee	*
Management Committee	13

* *Given the relatively short period of time between the Third and Fifth Year Reviews, and the time required to develop a new application, the CRC Board decided against conducting our usual annual review.*

Fifth Year Review, Stage Two, Review Panel and CRC Secretariat representatives from left, Mr Jim Miller, Dr Geoffrey Vaughan, Ms Kate Jones, Dr Ken Eldridge, Mr Colin Hickey

Fifth Year Review

As a first round CRC, the Centre was required to undertake a Fifth Year Review. Stage One of this review took place over the period 24-25 June 1996. Stage Two was held on 3-5 September 1996.

Stage One Review

The Stage One Review Panel consisted of:

- Dr Mike Carson (Chairman), Manager, Biotechnology Division, New Zealand Forest Research Institute
- Prof Roger Sands, Head, School of Forestry, University of Canterbury, New Zealand
- Mr Ian Whyte, Chief Executive, Forest Industries Association of Tasmania.

The CRC's Visitor, Dr Peter Nelson, participated in an advisory/resource capacity, and was in attendance during the two days of the Stage One Review.

Stage One of the Fifth Year Review was a scientific and technical review of the Centre's projects. It was an independent review focused on the quality of the Centre's research activities and their contribution to technology transfer, taking into account utilisation and commercialisation aspects.

Stage Two Review

The Stage two panel consisted of:

- Dr Geoffrey Vaughan, Chairman, CRC Life Sciences Secretariat Panel
- Mr Jim Miller, Member, CRC Life Sciences Secretariat Panel
- Dr Ken Eldridge, Principal Research Scientist, CSIRO Forestry and Forest Products (retired)

The reviews were also attended by Mr Colin Hickey and Ms Kate Jones of the CRC Secretariat.

The Stage Two Fifth Year Review was a review of the technology transfer of the CRC.

The complete Stage One Report, and conclusions and recommendations of the Stage Two Report follow.

Fifth Year Review Stage One Report

Introduction

The following is a report on the quality of the research program at the CRC for Temperate Hardwood Forestry and the extent and effectiveness of technology transfer from research to industry members within the CRC.

The report is based on a review of the CRC in relation to these issues, undertaken by this panel in June 1996. The review involved scrutiny of a very comprehensive and detailed set of briefing papers ('Review Documents') prepared for us by the CRC,

and an intensive two day program of presentations and interviews held at the CRC building in Hobart on 24 and 25 June 1996. The panel wishes to acknowledge here the extremely high quality of both the Review Documents and the presentations, and the outstanding co-operation we received from CRC staff and students and from CRC industry partners, throughout the process. Our task was made far easier by that co-operation.

The panel would also like to acknowledge the assistance we received from Dr Peter Nelson, the CRC Visitor, during the period of the review. He was present throughout the sessions of 24 and 25 June and provided invaluable input to our deliberations.

We have undertaken the review in accordance with guidelines provided to us by the CRC ('Cooperative Research Centres Program: procedures for fifth year reviews') and have structured this report accordingly. The report considers each of the four research programs of the CRC in turn and comment is framed around the six specific aspects of CRC activity the guidelines ask us to address, viz:

(i) research activities to date
(ii proposed research activities
(iii) quality
(iv) progress against agreed milestones
(v) research performance against CRC-THF criteria
(vi) technology transfer.

We have felt it unnecessary to detail research projects and achievements as such, because this has already been done very effectively in the Review Documents. Rather we have sought to present our impressions of the quality of programs and our opinions as to future options.

Genetic Improvement Program

This program must without doubt be rated an outstanding success. It started from nothing (i.e. there was not a pre-existing program within either of the major research providers) and has built from a base of past strong industry commitment to be now internationally recognised and respected. It has generated a large volume of research, coverage of the field has been comprehensive, research quality has been outstanding, there has been strong and close industry involvement, and uptake of research outcomes by industry partners has been rapid and effective.

A notable feature of this program is the close relationship it has developed and maintains with the CRC for Hardwood Fibre and Paper Science. This collaboration is highly invaluable for industry partners because it allows the linkage of end use properties of wood products to the genetic parameters which must be understood if the properties are to be influenced by producers at the time of tree growth.

Comment on Specific Aspects

(i) Research activities to date

Detail is set out clearly in the Review Documents.

(ii) Proposed research activities

Planned research directions are generally appropriate in light of outcomes to date and current priorities of industry partners. Of note are:

- a review of the weight to be given to vegetative propagation in future, in view of difficulties with this research problem to date; an increasing focus on solid wood products as distinct from pulp, in view of changing industry partner priorities;
- closer attention to the use of DNA markers for selection and to better understand genetic inheritance, while relying on collaboration with the CRC for Plant Science to meet goals of gene transformation and gene expression.

The panel believes that the review relating to vegetative propagation is of fundamental importance, given the significance of a clonal approach in operational plantation programs for maximum recovery of breeding gains. In the absence of a clonal deployment system many breeding gains may remain unrealised. Such a deployment system does not exist at present. The CRC is not alone in having had limited success with

Eucalyptus globulus and *E. nitens* to date. The problem is a difficult one! Any success in future is likely to be only on the basis of a considerable investment of research resources. The CRC might well consider collaboration with other research institutions along with other options, to generate this investment.

Quite apart from its potential application to operational cloning it may also be worth persisting with research into vegetative propagation to develop cloning techniques which can be used as "research tools".

The panel further suggests that research in this program focus on phenotypic traits which relate to "cost of production" rather than "value of product". It is generally the case that producers can improve commercial profitability more easily by aiming to cut costs than by aiming to achieve increases in value which may or may not be realised in higher prices.

Finally, the CRC should not ignore opportunities for "niche markets" that may arise from pursuit of wood properties favourable to specific sawn timber products.

(iii) Research quality

Research quality has been outstanding in this program.

Of particular note in this regard is the number of refereed papers which have emerged. As the Review Documents note, in 1992 only 10 papers were produced worldwide on genetics and breeding strategies for *E. globulus* and *E. nitens*. By 1995 this program had added 25 to that list on genetic variation alone, and a total of over 70 in genetics and breeding.

The program has clearly attracted high peer regard worldwide. CRC staff are increasingly sought after to undertake consultancies, present courses and present conference papers. There have also been strong links developed with other research institutions, in Australia and overseas.

Quantitative skills developed in the program can have invaluable application in assisting integration of this program with relevant projects in the Resource Protection program (e.g. insect resistance).

(iv) Progress against agreed milestones

In general, milestones have been achieved. Where this has not been the case there have been sound reasons relating to the intractability of research problems. In such cases goals have been redefined appropriately.

(v) Research performance against CRC criteria

Performance has been excellent and has clearly exceeded the original goals.

(vi) Technology transfer

Transfer has been rapid and effective given the relative ability of different industry partners to absorb specific outcomes. The co-operation between researchers and industry staff seems to have been outstanding, and this must contribute substantially to the flow of technology and knowledge.

It is noteworthy that an operational eucalypt breeding co-operative (which includes CRC industry partners) has established close links with the CRC in recent years. This collaboration will form an effective mechanism for the commercialisation of research outputs from this program for those partners.

A full range of techniques has been used including a major IUFRO conference, seminars, courses, publications, newsletters and personal contact.

Soil and Stand Management Program

In general the panel believes this program can be rated as very good to excellent. Results in recent years indicate that this will improve further in future, on the basis of very sound structural developments that have occurred in the CRC and increasingly effective co-operation between partners.

The soil and stand management program has in several ways been a far more challenging program for CRC partners than any of the other programs.

- There tends to be more tension between industry partners and CRC researchers in this area because industry partners tend to look for immediate and

effective solutions from research to practical operational problems, where researchers are inclined to look for a more fundamental understanding of process before progressing to prescription. By comparison, industry practitioners are inclined to be more patient in the area of genetic improvement and pest and disease control.

- In the absence of an existing and suitable set of long term field trials, it inevitably takes several years to establish the database on which useful analysis can be based when we are talking about crop species which can take twenty years or more to mature.
- While CRC partners have all had their own soil and stand management research programs in the past, there was relatively little co-operative effort prior to establishment of the CRC. There has necessarily therefore had to be some degree of compromise by all partners in order to come to a uniform CRC approach. This adjustment has needed time. By comparison in the other programs there has been much more commonality in previous independent work.

The panel believes that the past five years have been a necessary and effective developmental phase for this program. There is no doubt that momentum and outputs will improve substantially in future.

Comment on Specific Aspects

(i) Research activities to date

Detail is set out in the Review Documents.

(ii) Proposed research activities

Proposed research is very appropriate in view of previous work and jointly reviewed priorities.

The research quality of the process-based modelling work (which has been an important part of this program) is very good, but its immediate relevance has been questioned by industry. It is pleasing to see that some aspects of empirical modelling have recently been used to improve the short term applicability of the process-based models and it is recommended that this association between process-based and empirical models be further strengthened.

The panel suggests that there be a continued focus on the sub-soil environment, with perhaps an extra project allocated to sub-soil growth and management.

The panel recommends that a quantitative analysis of the redistribution of soil at the time of site preparation for planting, and the impact of this on site productivity, be an integral part of the continuing research on the use of different machine types in site preparation.

The panel sees benefits to the program pursuing (and presenting) its research in a broad "systems" approach, in which the integration among component projects is clearly understood, and displayed to the users.

(iii) Research quality

Research quality is very good to excellent. As co-ordination between partners has improved, the quality of field trials has also improved. Without doubt the structural improvements which have been put in place in the CRC will see continuing high quality research.

(iv) Progress against agreed milestones

Milestones have been achieved very satisfactorily.

(v) Research performance against CRC criteria

Performance has been excellent.

(vi) Technology transfer

Transfer has been appropriate to the level of information generated and the needs of industry partners. It is most important to understand that the full value of most forestry trials can only be realised after several years have elapsed and trees have approached eventual harvesting age sufficiently to provide useful data. Forestry differs markedly from say agriculture or horticulture in the importance of this long term perspective.

Resource Protection Program

This is a program which started slowly, because of unavoidable delays in the recruitment of suitable research staff, but has now developed to excellent

quality. As with the Genetic Improvement Program, a particular feature of the Resource Protection Program has been the extremely close co-operation between research and industry partners. Technology transfer has been immediate and highly effective for those partners able to implement the results. Industry partners recognise the value of access to program staff for mounting a rapid response to pest problems.

Comment on Specific Aspects

(i) Research activities to date

Details are set out in the Review Documents.

(ii) Proposed research activities

Proposed activities are a very appropriate extension of current research and changing priorities for industry partners.

A characteristic of this program is the site specificity of pests (typical of forestry), and therefore the site (or region) specific nature of projects. Currently for example, all projects are focused on Tasmanian problems.

Changes in focus include increasing attention being paid to vertebrate browsers and possible inclusion of mainland sites (although there is no intention to move out of SE Australia).

There may well be future project opportunities from research that has found a genetic basis for pest resistance in tree species of interest and this is also proposed as an area for investigation.

The panel believes a very worthwhile research project may be one aimed at developing an Integrated Vertebrate Pest Management system for plantations (analogous to the Integrated Pest Management Program under development for insect pest control).

(iii) Research quality

Research quality has been quite excellent. Given the program's small size, a considerable amount of new and invaluable knowledge has been developed for the industry.

(iv) Progress against agreed milestones

All milestones have been achieved.

(v) Research performance against CRC criteria

Performance has been excellent.

(vi) Technology transfer

Technology transfer has been appropriate to the needs of industry partners given the emphasis on Tasmanian problems. In fact the immediacy and effectiveness of this transfer has in some cases been outstanding (eg. the establishment of "trap trees" by one partner for insect pest management).

Education and Technology Transfer Program

The numbers and quality of post-graduate students at the CRC has been and remains absolutely outstanding. Furthermore it is a credit to the CRC that it has been able to attract substantial external funding to supplement its own financial contribution in this area. The panel had the opportunity to meet many of these students and was impressed by the high regard they clearly accord the CRC and its various partners. It should be noted that these students are themselves a major plank on which the CRC research programs depend.

This program also co-ordinates formal technology transfer to industry partners from researchers - for all programs. A wide range of techniques is used, including seminars, courses, papers, newsletters and field tours. Of particular note has been the successful organisation of a major IUFRO conference. Feedback from both researchers and industry partners suggests these techniques have been very effective.

Comment on Specific Aspects

(i) Research activities to date

Set out in the Review Documents.

(ii) Proposed research activities

The CRC plans to maintain both depth and numbers in its post-graduate training program. It also plans to consolidate and expand its technology transfer program. Both moves are appropriate.

(iii) Research quality

The quality of students in the CRC is impressive. A measure is the number of students supported by ARC funding and the number who are successfully obtaining employment in their field, both nationally and internationally.

The quality of technology transfer has also been excellent, given the ability of industry partners to absorb and apply information.

(iv) Progress against agreed milestones

All milestones have been achieved.

(v) Research performance against CRC criteria

All CRC criteria have been met.

(vi) Technology transfer

The overall success of the CRC is due in large part to successful technology transfer in this program. Communications are increasingly being targeted at operational (vs research) staff as research results mature.

Conclusion

The panel believes that the CRC for Temperate Hardwood Forestry must be rated as a very successful example of cooperative research involving traditional research providers and industry.

The quality of the Genetic Improvement and Education and Technology programs in particular, has been outstanding. However no programs have rated less than very good to excellent.

The panel wishes to commend Prof Reid for his management of the CRC as a whole, as it has been clear from our review that the organisation runs very smoothly and efficiently, and that staff and students are well-motivated and well-supervised. Very clearly there is also active support from industry partners.

Temperate hardwood forestry industry in Australia has very definitely benefited from knowledge and technology developed at the CRC.

Fifth Year Review Stage Two Report

Conclusions

1. Having carefully considered all the material provided to it, including the Stage 1 Report, the Stage 2 Review Panel considers that this Centre has met all of the requirements within the Commonwealth Agreement. The Centre should be permitted to complete the agreed program planned for years 6 and 7.

2. The Panel endorses the findings of the Stage 1 Review. It was pleased to observe that the Centre was well focused in its areas of prime interest.

3. The Panel finds that the Centre has met the four CRC program objectives and is thus making a substantial contribution to Australia's research effort. The Centre is contributing to economic and social development; it is offering a broad education program; it has established strong links between the research and industry sectors; and it has strengthened the research networks of the core members.

Recommendations

The Stage 2 Review Panel recommends that:

1. The Centre should place a higher priority on ensuring that its target market for technology transfer of non-sensitive material is broadened to include industry bodies that are not members of the Centre.

2. Planning commence to establish a capacity for a more interactive and intelligent use of databases, with these databases being made readily accessible to off-campus users.

3. The Board be strengthened through increasing the proportion of independent members.

4. The Director look for new opportunities to establish gender balance in committees, and in senior research and management positions within the Centre.

5. The Centre promote the concepts of catchment management, forest management, and positive environmental and economic issues to a wider audience.

6. The Centre seek further increases in the industry cash and in-kind contributions to the Centre budget.

CRC for Sustainable Production Forestry

The bid for a new Cooperative Research Centre for Sustainable Production Forestry was successful. Commonwealth funding of $15.48 m will be provided over seven years until June 2004. The Centre will have a total budget for this period of $62,075,000. The new Centre will build on the achievements of the existing CRC for Temperate Hardwood Forestry (established in 1991), with a broadening of scope to include work on softwoods and tropical and sub-tropical environments.

The CRC for Sustainable Production Forestry will operate as a joint venture between 16 organisations across Australia. They are the University of Tasmania, CSIRO (Forestry and Forestry Products and Division of Entomology), Australian Newsprint Mills Limited, Forestry Tasmania, North Forest Products Ltd, Australian Paper Plantations Pty Ltd, Bunnings Treefarms Pty Ltd, Primary Industries Corporation, Southern Cross University, Griffith University, Boral Timber Tasmania Ltd, Australian National University, The University of Queensland, Australian Forest Growers, Southern Tree Breeding Association Inc and Silvagene Pty Ltd. Over 120 staff from participating organisations will be involved with the new CRC in addition to approximately 30 positions funded by the Commonwealth grant. An estimated 40 post-graduate students will be directly involved in CRC research.

Research in the new Centre will concentrate on:

- the two hardwood species presently considered most suitable for plantation development in temperate regions of Australia, namely *E. nitens* and *E. globulus*, and
- the subtropical species *Pinus elliotii*, *P. caribaea* and *Araucaria cunninghamii*.

Research will also be conducted into other eucalypt species suited to more drought-prone temperate environments, subtropical environments and into aspects of *P. radiata* where the Centre's special expertise is relevant.

The work will be conducted under three research programs-

Genetic Improvement
Sustainable Management
Resource Protection

The Genetic Improvement Program aims to enable the improvement of the genetic quality of planting stock and develop methods to ensure that superior material can be reproduced commercially for transfer to plantations. It will also ensure the maintenance of genetic resources upon which breeding is based. The Sustainable Manangement Program is aimed at managing environmental factors (eg nutrient levels, water availability and competing vegetation) which determine the behaviour of forests, so that growth may be optimised and sustained over many generations without site degradation. The Resource Protection Program is aimed at developing management techniques and products to minimise the effects of biotic factors, such as insects, browsing vertebrates and fungal pathogens which may reduce productivity or quality.

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Genetic Improvement

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Communication

Public presentations

Genetic Improvement

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Tibbits W, Boomsma D and Jarvis S (1997). Distribution, biology, genetics, and improvement programs for *Eucalyptus globulus* and *E. nitens* around the world. Invited speaker at the 24th Southern Forest Tree Improvement Conference, Orlando, Florida, USA, 9-12 June 1997

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Soil and Stand Management

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Public relations

Genetic Improvement

Print

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Soil and Stand Management

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Education

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General article on CRC research. Tasmanian Country, Feb. 1997

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Grants and Awards

Grant/Award	Awarded for	Duration	Recipients	Amount $
ARC Collaborative Grant	Genetics of Radiata pine	3 years	Dr NMG Borralho	100 000
ARC Large Grant	Molecular markers in *Eucalyptus*	3 years	Dr BM Potts Dr R Vaillancourt	140 000
APA Industry Scholarship	Genetics of *Mycosphaerella* resistance in *Eucalyptus globulus*	3 years	Dr R Vaillancourt Dr C Mohammed Mr M Powell	90 540
ARC Postdoctoral Fellowship	Ecophysiology, leaf morphology and palaeoecology of Southern Beech	3 years	Dr M Hovenden	157 000
Wilf Crane Memorial Award	Research excellence in soil-tree interactions	1 year	Mr D Mendham	2 000
Australian Biophysics Society Conference	Excellence in presentation and content	1 year	Mr T Garnett	100
University Writing-up Scholarship	Write papers from PhD thesis	4 months	Mr T Garnett	3 840
North Forest Products	Radio tracking of pest herbivores	1 year	Dr C McArthur Ms K le Mar	21 000
BARC	Seedling preferences and growth rate	1 year	Dr C McArthur Mr J Bulinski	15 516
TFRC	Growth rate and risk assessment	1 year	Dr C McArthur Mr J Bulinski	12 000
ANM	Radio tracking of pest herbivores	1 year	Dr C McArthur Ms K le Mar	2 000
Science and Technology Awareness Program	Attracting women to forestry	3 years	Dr N Davidson	26 400
North Forest Products	Safety Incentive Award		Mr K Joyce	

Performance Against Indicators

Generic Indicators

- Important generic performance indicators will be the number of publications in international, refereed journals, the participation of visiting scientists and the ability to attract external funds.

Publications

The total number of publications is over 448 with half this total in refereed national or international journals or monographs, with a substantial number of the remainder as major papers in conference proceedings (mostly refereed) (Table 10). The output has grown substantially with an approximately six-fold increase from the first full year of operation, 1992 to 1996 (Table 11). This shows the substantial synergy created by the Centre since publications in 1992 largely reflect the productivity of the individual components that came together to form the Centre.

Table 10 Publications by program and type, 1991-1997

Program	Journal Papers & Book Chapters	Conference Proceedings	Conference Presentations & Technical Reports	Theses	Total
GI	64	50	67	20	201
SSM	90	24	46	14	174
RP	36	2	32	3	73
Total	190	76	145	37	448

Table 11 Publications by type and year (note: 1997 figures include articles published or in press)

	1991	1992	1993	1994	1995	1996	1997
Journal papers and book chapters	3	13	25	25	22	73	30
Conference proceedings	0	2	11	10	35	12	6
Conference presentations and technical reports	1	6	12	29	33	42	22
Theses	3	2	6	10	7	5	3
Total	7	23	54	74	97	132	61

Ken Van Rees (University of Saskatchewan, Canada) recording spatial patterns of roots in a Eucalyptus nitens plantation near Dover, southern Tasmania, February 1997

Visiting Scientists

The Centre has attracted a distinguished list of international and national visitors to work in the Centre under its visiting scientists scheme . In addition, many shorter visits have occurred including: Dr Peter Dye (CSIR, South Africa); Dr Robert Teskey (University of Georgia, USA); Dr Ephraim Epstein (Israel); Mr Fernando Baeza Melendez (former Governor of the Mexican State of Chihuahua); Dr Zhang Shaoang (Beijing Forestry University, China); Dr Claudio Balocchi (Universidad Austral de Chile); Prof Nayerah Rastin (University of Göttingen, Germany); Dr Zang Daoqun (Chinese Academy of Forestry); Dr Stephen Read (School of Forestry, University of Melbourne); Dr Philip Moody (Qld Department of Primary Industriy); Mr Li Fang Dong and Mr Wang Bao Ping (FAO Trainees from Paulownia Research Centre, China); Dr Richard Milner (CSIRO Entomology); Dr Christine Stone (State Forests of NSW); plus touring groups of foresters from Brazil, Chile, USA, Indonesia and China. International and national scientists have given numerous seminars during the CRC seminar series each year.

Assoc. Prof David Newman, Warnell School of Forest Resources, University of Georgia, USA, working on productivity in plantations

External funding

External funding obtained by CRC staff totalled $2 653 150 from 1991/92 to 1996/97. 1996/97 funds totalled $570 396. This was received in the form of ARC grants/postgraduate awards of $397 000 across the three research programs; $26 400 from Science and Technology Awareness Program; and $38 517 from industry partners to assist with technical staff and equipment purchases.

Table 12 Visiting Scientists

Dr Gary Hodge	University of Florida	6 months
Dr Eberhard Voit	Medical University of South Carolina	10 months
Dr Myron Zalucki	University of Queensland	3 months
Prof Alan Berryman	Washington State University	1 month
Dr Peter Kanowski	University of Oxford	3 months
Dr Heather Keith	CSIRO Division of Forestry, Canberra	6 months
Dr Robert Floyd	CSIRO Division of Entomology	2 months
Prof Peter Davies	Cornell University, New York	9 months
Prof David Newman	University of Georgia, USA	3 months
Dr Arthur Gilmour	NSW Agriculture	1 month
Dr Ken Van Rees	University of Saskatchewan, Canada	2 months

Management of the Centre

Complete establishment of administrative services and systems at the time the CSIRO Division of Forestry moves to the University campus in March/April 1992.

This indicator was met with the administrative staff and services all in place by the time of occupation of the new CSIRO/CRC building.

Genetic Improvement

Production of reliable estimates of heritabilities and correlations for commercially desirable tree characters and of genetic gains in each generation. Determination of the optimum age for selection of elite lines and the development of breeding plans. Estimates of heritabilities and correlations for important traits will be possible within three years. Assessment of genetic gain, selection age and development of breeding plans is dependent on estimates of heritabilities and correlations.

The last few years have seen a dramatic improvement in our knowledge of heritabilities and genetic correlations for key traits in *E. globulus*, *E. nitens* and *E. regnans*. Published estimates of genetic parameters for growth, wood density and other traits prior to the start of the CRC were very limited (to our knowledge there were only eight papers published in total with two of them including wood properties). They were also based on only a few provenances from the whole range of the natural distribution.

Research carried out by the CRC-THF, often in collaboration with industry partners and breeding organisations, have produced over 25 papers or technical reports on the genetic control of *E. globulus* and *E. nitens*, including the analysis of large *E. globulus* and *E. nitens* base populations, across Australia, for growth (diameter and height), flowering (precocity and peak) and wood density. Work done at the CRC-THF also includes the first estimates from full-pedigree material for *E. globulus* and *E. nitens*, both in Australia and overseas (Portugal). This information has been used in breeding programs in Australia. A cooperative breeding strategy, for both *E. globulus* and *E. nitens*, was developed by the CRC-THF, in collaboration with STBA and industry partners, with the program now underway. Selections carried out in these programs are based on the estimated genetic parameters.

As most parameter estimates published for *Eucalyptus* are derived from open-pollinated progeny from base

Table 13 Staff and post-graduate student numbers recruited in each year of CRC operations (note: data does not include CRC-funded administrative staff, in 1996/97).

Year	Research staff	Postgrad. and Hons. students	Technical staff	All staff
1991/92	4	16	3.75	23.75
1992/93	5	15	9	29
1993/94	1	17	4.5	22.5
1994/95	3	3	3	9
1995/96	2	12	6	20
1996/97	1	10	2	13
Planned No.	9	10*	10	30
Current No.	12	10*	11.8	33.8

* CRC-funded postgraduate scholarships only

populations, considerable work has been done in improving such estimates. We have made major advances in understanding the reliability of such estimates (reviewed in Borralho 1994; Potts *et al.* 1995; Hodge *et al.* 1996 and Hardner and Potts, submitted) as well as their age-trends (Hardner and Potts, submitted) and the impact of site and mortality. We have developed approaches to improving genetic parameter estimates derived from OP progeny (Borralho and Potts 1996) and provided indications of reliability for specific traits by directly comparing OP and controlled cross parameter estimates for growth (Hodge *et al.* 1996; Hardner and Potts 1995, submitted), frost (Volker *et al.* 1994) and disease resistance (Dungey *et al.* submitted).

Selection rules have been defined for current breeding programs. The studies include a detailed economic model of eucalypt plantations for kraft pulp production. Results demonstrating the large benefits of cooperative breeding were pivotal to the development of a cooperative breeding scheme by the STBA.

Show that hybrid seed can be produced successfully and used in field plantings. F_1 hybrid seed will continue to be planted and F_2 seed could be available for planting within two years.

Interspecific F_1 hybrid seed has been produced in large quantities, barriers to its production identified (Potts et al. 1992), and growth of F_1 hybrids monitored (eg Volker 1995;). F_2 and backcross hybrid seed was produced for *E. gunnii* x *E. globulus* and *E. nitens* x *E. globulus* and trials established in 1994 and 1995 respectively.

Develop a system to vegetatively propagate elite material from breeding programs, successfully establish field plantings and reduce production costs. This is an ongoing activity but it is hoped to establish the first reasonable sized field plantings within three years

Significant progress on a cost-effective vegetative propagation system has been made. The improved micropropagation system (IMP) halves the number of

steps required compared with previous systems. IMP has been tested successfully in one industry laboratory. It was found to be a useful system for small-scale research projects such as the screening of rooting ability across genotypes. However, original objectives changed significantly, as a result of the third year review and a more recent workshop with industry partners. The industry partners also agreed to put more emphasis on the somatic embryogenesis project. Research done at the CRC-THF indicated:

- While the program was not able to reliably clone recalcitrant *E. globulus* and *E. nitens* clones, rooting ability was found to be under strong genetic control, with enough genetic variation to enable the identification of good rooters within any given family. Rooted cuttings from this experiment are going to be planted in the field as a demonstration trial.
- Screening methods for rooting ability, both *in vitro* or as cuttings, have been made robust and simple. These results allow the development of a workable cloning strategy for temperate *Eucalyptus*, producing a large number of progeny from outstanding families, and subsequently screening within these families for rooting ability.
- Somatic embryogenesis has been successfully induced in both *E. nitens* and *E. globulus*. The high proportion of genotypes displaying competency with somatic embryogenesis (around 80% whatever the family) does not narrow the genetic variation within progenies. Furthermore, within one genotype, hundreds of somatic embryos can be obtained, indicating the great potential of this method for genetic engineering purposes. However, the somatic embryos do not develop beyond the globular stage. Achieving full development of the somatic embryos, up to the germination stage will be our major challenge for the coming years.

Determine the reduction time for seed production of elite material and the role played by the gibberellins in the flowering process. The gibberellin biosynthesis pathway in eucalypts should be elucidated within two years.

The gibberellin biosynthetic pathway has been determined as the early 13-hydroxylation pathway, with GA1 being the active hormone (Hasan et al. 1994). By chemical and cultural means the seed to seed generation time has been reduced to 2.5 years for *E. globulus* from the 5-10 years found in plantations. While a substantially reduced level of GA1 (less than 0.1 µg.g FW-1) is required to allow flowering, it is not the only factor involved in the promotion of flowering. Cold is also required and it does not act via the reduction in GA1 levels (Hasan and Reid 1995).

Develop techniques for fingerprinting eucalypts using DNA markers. The University has initiated work in this area and it will be possible to establish procedures for differentiation at the broad taxonomic level within two years and develop detailed genomic RFLPs for individual species by the end of five years.

Genomic and organellar DNA markers (RFLP and PCR based) were developed and their usefulness demonstrated at different taxonomic levels: across the whole of the genus *Eucalyptus*; between closely related species; within species such as *E. globulus*, and in fingerprinting man-made and natural clones. In addition, a linkage map in an interspecific F2 of *Eucalyptus* was the first such map produced in the genus. We obtained good evidence for the first case of QTL x environment interaction in *Eucalyptus*. The feasibility of finding QTLs in *Eucalyptus* was demonstrated, which is the first step towards the realisation of MAS.

Soil and Stand Management

Development of silvicultural practices for the judicious management of soils and stands for the short- and long-term management of plantation forests

The following guidelines have been developed for several aspects of silvicultural management of soils and stands in plantations.

Inter-rotation management:

- Top-soil and organic matter should be conserved during clearing for plantation establishment, and can best be achieved using excavators rather than bulldozers with blades.
- Use of bulldozers with blades led to apparent decreases in wood yield in seven-year-old plantations.
- Ripping of most soils is not justified, but mound or surface ploughing should be used on all soils except those that are very well structured.
- Good preplanting weed control is recommended because it can reduce the need for expensive post-planting weed control on ex-native forest sites.
- The planting of *E. globulus* rather than *E. nitens* is recommended on low elevation sites where moderate water stress is experienced as part of the growing cycle.

Intra-rotation management:

- Fertilisation strategies can be devised for N and P at specific sites. These strategies include expectations of the N and P requirements of the plantations (including weeds and trees), the soils ability to satisfy these needs, and consideration of empirical responses observed at many sites.
- P fertiliser will be needed at planting on all ex-native forest sites; N should also be added (as monoammonium phosphate, or urea with triple superphosphate). No further requirement for P is likely to be needed, but further urea applications will benefit most three- to six-year-old plantations on ex-native forest sites.
- Fertilising soon after planting on highly fertile ex-pasture sites should be avoided because of the potential to induce deformities. Later-age applications of N may also be unnecessary.
- Control of weeds in thinned stands is also recommended because it maximises the growth response of the remaining trees.
- Recovery of the crown after green pruning is rapid, so early pruning of up to 50% of the crown (from the base) followed by thinning can be applied successfully to *E. nitens* plantations to produce clearwood.

Development of process-based models to predict wood yields under a wide range of silvicultural regimes.A number of key outcomes have been achieved which are listed below under four headings.

Reviews:

- A review of existing forest growth models indicated that the appropriate accuracy, scale, types of inputs and range of outputs were suitable for key forest management questions.
- A review of existing models of cambial activity highlighted the possibility of modelling cambial activity of eucalypts as a means to predict pulpwood quality, and has provided the direction for a new PhD project in this area.
- Current forest modelling activity in Australia was the focus of a major seminar and workshop, ForMod95, which has strengthened collaboration and promoted communication between researchers and industry.

Evaluations:

- An evaluation of an existing and widely used process-based model (Forest-BGC) was carried out and the model found to be of limited suitability for forest management purposes.
- An existing empirical model for predicting site quality showed it to be a conservative but biased predictor of site quality for eucalypt plantations.
- Existing datasets suitable for forest growth modelling were evaluated and several selected for collation and use by researchers throughout Australia.

Models have been developed that:

- simulate the light environment of eucalypt canopies;
- predict above-ground biomass partitioning in response to biomechanical constraints on stem-function;
- predict eucalypt seed germination under conditions of variable temperature and soil-water potential;
- estimate daily canopy photosynthesis using readily available meteorological and physiological data;
- predict site quality for eucalypt plantations using only simple and readily obtained site descriptors;
- predict nutrient uptake kinetics;
- predict forest growth where processes such as biomass and nutrient partitioning are poorly understood by utilising the S-system approach to modelling complex systems;
- predict *E. globulus* site productivity as measured by peak MAI, closed canopy LAI and water use of plantations given a simple ranking soil depth, texture, stoniness and fertility and mean monthly climatic data;
- predict the net production of *E. nitens* canopy in response to varying degrees of green pruning.

These models have been applied to:

- explain the response of forests to thinning and highlight the role of competition for water between trees and understorey species in reducing the expected thinning response;
- illustrate the importance of considering photosynthetic acclimation to temperature when simulating forest productivity;
- predict the mean annual increment of *E. globulus* plantations significantly better than does the existing prediction system;
- resolve a long-standing international controversy about nutrient uptake kinetics;
- generate climate-based site productivity maps of Tasmania (with FT for the RFA process);
- evaluate production at potential industrial sites in north eastern and eastern Tasmania (for NET);
- examine water usage at various sites in Western Australia and adjust estimates of site index to correct for the effects of a three-year drought (for Bunnings Treefarms).

Resource Protection

Determination of the factors that predispose trees to attack by defoliating insects and mammals. It will be possible to establish the relative importance of phenology and colour in host attraction within two years and this information can then be assessed for utilisation in breeding programs.

Host tree selection, feeding and oviposition by the *Eucalyptus* beetle *C. bimaculata* is regulated by a complex of factors. The location of tree patches is best explained by phenological differences in leaf colour changes and growth rates within and between tree species. The capture of flying beetles on differently coloured sticky traps exhibit distinctive preferences for yellow while the amount of red in the flush of new leaves, and which subsequently turn to green, correlates

with the degree of oviposition and consequent damage with high heritability. Feeding preferences of adult and early stage larvae and larval survival have been shown to be significantly influenced by stage of leaf maturity, terpenoids and the extractives of different species

Operationally the location of small blocks of *E. regnans* trees with *E. nitens* plantations has resulted in preferential and substantial beetle attack, oviposition and subsequent damage to the former species.

The development of biological control techniques to minimise the damage caused. Enhanced biological control for native insect pests has not been tried in Australia before and it is not possible to provide more quantitative indicators.

The Integrated Pest Management (IPM) strategy for suppression of chrysomelid defoliators has been refined by definition of effective dose and application rates in the use of *Bacillus thurigiensis tenebrionis*. The use of spore formulations of the entomopathogenic fungi *Metarhizium* and *Beauveria* spp as an additional control agency for chrysomelid control has been shown to have real potential. The successful aggregation of ladybird predators by the use of sucrose sprays and the impact of natural sources of both carbohydrate and protein on predator longevity and fecundity respectively have demonstrated the potential benefit of increasing floral diversity in areas adjacent to plantations.

Assessment of the feasibility of breeding insect tolerant genotypes of* Eucalyptus *spp CSIRO Division of Forestry and Forest Products has been working in this area for two years. Future direction and strategy depends on confirming that results are repeatable from season to season and this will take at least three years.

The following is a reiteration of the statement in last year's Annual Report. As this is the final report of the CRC Temperate Hardwood Forestry it is appropriate to restate it as a potential initiative for the CRC Sustainable Forest Production considering the expertise of new partners CSIRO Entomology in this field.

It has been demonstrated that the resistance of *E. regnans* and *E. nitens* to insect attack is a heritable trait within family lines. A wide range of resistance classes (from highly susceptible to resistant) have been shown to occur across families. With this information it is now possible to say that breeding for insect resistant genotypes is feasible. The commercial feasibility of incorporating resistance into breeding programs has yet to be approached, but is a new research initiative being considered for the new CRC.

Development of substances which inhibit or eliminate browsing by vertebrates. Given current knowledge of preferred and non-preferred genotype of plantation stock, it is probable key compounds determining palatability of foliage to browsing by vertebrates and invertebrates are likely to be similar, and it should be possible to determine and test these within three years.

Distinctive feeding preferences for different tree species and vegetation types have been demonstrated for possums and pademelons and the preference for commercially valuable eucalypts more intensively investigated at the provenance and hybrid level. These studies together with those on the field behaviour and ecology of the three major browsing species have provided the necessary basis for subsequent operational trials. These trials will evaluate the use of less preferred selections and cover crops in order to minimize the impact of browsing on plantation seedlings and trees.

Education

The number of post-graduate students trained in areas specified.

We reached the target of 25 post-graduate and honours students that was set in the CRC Joint Venture

Agreement within the first two years of the Centre's operation. In 1991/92 there were 16 honours and post-graduate students. This increased to 28 in 1993, 33 in 1994, 37 in 1995, 41 in 1996 and 42 in 1997. The students attracted to conduct PhD projects at the CRC were of the highest standard (a great majority with first class honours), and many recruited from interstate.

The number of students enrolled in special courses.

Special courses designed to train company operational staff commenced in 1994 with two workshops 'Basic Experimental Design' and 'Basic Quantitative Genetics' (November 1994). These were well attended and have been followed by workshops on 'Forest protection' (November 1995, May 1996) and 'Water Use' (June 1996). Each workshop has attracted 20 or more participants, drawn from North Forests, ANM, Amcor, Bunnings, Forestry Tasmania, CSIRO Division of Forestry and the University of Tasmania.

A special four-year undergraduate course in Forest Ecology, which provides university students with the background to continue in the forest industry, attracts 12-15 students a year. This course was redesigned in 1997 to raise its appeal to students interested in forestry.

The Graduate Diploma of Science (Forest Processes) is offered through the Plant Science Department and two students have graduated through this course, but we have found most undergraduates with high academic achievement prefer to enrol in honours.

The quality and numbers of post-doctoral fellows attracted.

During the life of the CRC there have been nine post-doctoral fellows working in the research programs.

In the Resource Protection program, Dr Tony Clarke has played a key role, leading research in projects 2 and 4 on the control of insect defoliators and the biology of other insects pests of *Eucalyptus*. Dr Clare McArthur who was appointed in 1995, has also played a key research role in developing the vertebrate browsing project.

In the Genetic Improvement program, Dr Greg Jordan was appointed post-doctoral fellow in 1991 to conduct a combined analysis of the base populations of *E. globulus*. Dr Omar Hasan was post-doctoral fellow from 1992 to 1994 and identified and quantified gibberellins, auxins and abscisic acid in the cambial tissue of *E. globulus* with the aim of determining their effect on wood properties. Dr Jean-Noël Ruand was appointed in August 1994 on a project investigating the use of somatic embryogenesis in vegetative propagation and is now playing a key role leading the tissue culture project. Dr Allie Muneri who was appointed in January 1995 has made a major contribution to the new area of wood science in project 2. Dr Dorothy Steane who was appointed as a molecular geneticist in project 3 in February 1995 is currently working on the molecular basis for phylogenetic relationships in *Eucalyptus*.

In Soil and Stand Management, Dr Michael Battaglia, who was appointed post-doctoral fellow from May 1993 to June 1994, researched the effect of temperature acclimation and chilling injury on the photosynthesis of *E. nitens* and *E. globulus* (project 1). In 1996, he was appointed to a research scientist position at CSIRO Forestry and Forest Products in Hobart, and now works with the CRC in another capacity. Dr Wendy Wang worked for two years from July 1994 on the important topic of nitrogen mineralisation in soils. Dr Mark Hovenden, who was appointed from June 1995, was investigating the effects of low temperature and photoinhibition on growth and photosynthesis in plantation eucalypts. He recieved an ARC Research Fellowship and started this project in the Plant Science Department in June 1997.

Three of the CRC's post-doctoral fellows, Dr G Jordan, Dr M Battaglia and Dr Mark Hovenden have been successful in securing three-year ARC fellowships at the University of Tasmania. National competition for these fellowships is intense, with only ten per cent of applicants successful.

The acceptance by the forestry community of students on completion of their studies.

During the life of the CRC 17 postgraduate and Honours students have been employed in the forestry industry. In addition , there are 10 scientific staff from industry are currently enrolled in PhD or MSc courses at the CRC and 10 students on scholarships funded by industry. (For details see Utilisation and Application of Research, point 3, page 44)

Technology transfer

The degree of adoption of research results by industry.

Studies conducted in each of the three research programs at the CRC for Temperate Hardwood Forestry have led to commercially useful results which are being adopted by the forest industry (for details see Utilisation and Application of Research, Technology Transferred, Table 6, page 49).

The quality and relevance of technical publications targeted to user groups.

During the life of the CRC, the three research programs have produced 190 refereed publications, 221 unrefereed publications and 37 honours and PhD theses. All of these are of direct or indirect relevance to plantation forestry and most are published in journals of international standing. Copies of these publications are circulated amongst user groups. A short summary of the implications of the research is also sent to each of the industrial partners in our one-page news sheet eg 'Hot off the seedbed' and 'Beyond the black stump'.

The number of seminars, field days, short courses and workshops organised.

We have run 90 seminars, 25 workshops, four symposia, five short courses and seven field days or field tours in the first five years of the Centre. We estimate our various exercises in technology transfer have reached approximately 15 000 people.

Organise one public seminar on the potential role of hardwood plantations in Australian wood supply within twelve months of Centre establishment.

A series of seminars on 'The Role and Potential of Eucalypt Plantations in Australia's Wood Supply' was held in Hobart on 16 June 1992 and attracted 150 participants.

Organise first short course in the second year of the Centre.

Two short courses were held in the second year of the Centre:

- 'Tree Improvement for Future Plantations' – a one-day workshop run by Ms C Raymond (Genetic Improvement program) and Dr P Kriedemann, 12 October 1992 (12 participants).
- 'Establishing Eucalypt Plantations' – held on 5-6 April 1993 for forest growers and organised by Dr C Beadle (Soil and Stand Management program). This was a one-day workshop with presentations by representatives from each of the forestry companies plus a field day and was attended by 50 participants.

Communication with the public

Although there is no performance indicator relating to public communication, in two reviews this has been raised as an important issue.

In the last 18 months we have made great progress towards improving the level of communication with the public through the following initiatives:

- a project, 'Attracting women into forestry', which aims to present positive role models of women in forestry to encourage school girls to consider forestry as a career. This project is funded through a grant of $26 400 from Science and Technology Awareness.
- development of teaching kits in forestry for school children, years 6-9 (10 to 15 years old), which

demonstrate the importance to Australian society of technological advancement in the forestry sector;

- two public Seminar Series on 'Advances in plantation forestry' organised by Royal Society of Tasmania;
- a public Seminar Series on Farm Forestry conducted over three successive days at 'National Treefest' during 'Agfest';
- organisation of the 1998 ANZAAS Conference on 'Sustainability of Southern Ecosystems' (Prof JB Reid is Chairman and Dr NJ Davidson is secretary of the Organising Committee).

Budget

Notes to and forming part of the accounts for 1996/97

Summary of significant accounting policies

All funds under the Cooperative Research Centre's control are administered through the University of Tasmania's Financial Management System (FMS).

The principal accounting policies adopted in preparing the accounts of the unincorporated entity are detailed hereunder.

(a) Basis of accounting and principles of consolidation

The cash accounts have been prepared on the basis of historic costs. Cost in respect to the cash contributions and expenditure is the cash sum exchanged in the financial year determined from transactions recorded on the FMS.

In-kind amounts are the economic values of goods and services declared by each of the joint venture partners and accepted by the entity as being valid.

(b) Interest

Interest is calculated and paid by the University based on the monthly cash balances being held on the FMS on behalf of the entity.

(c) Assets and depreciation

Plant and equipment assets are recorded on the University's asset register in the name of the entity as they are acquired. Their entire cost is expensed in the year of purchase and depreciation is not provided for.

Capital expenditure relates to costs associated with buildings. These costs are also expensed and depreciation is not provided for.

The capital contribution of $150,000 by the University of Tasmania in 1994/95 is part of the provision of new laboratories and accommodation for CRC staff and students in molecular biology. The extension was completed in 1995/96 with a further contribution of $240,000 to capital costs being made by the University.

(d) Employee entitlements

Provision has been made for pro-rata entitlements to annual and long service leave.

(e) Partner contributions

Budget estimates of contributions are taken from the original Commonwealth Agreement and actual figures are provided by the partners.

(f) Allocation from Commonwealth Grant

The CRC received five grant payments during the year 1995/96 (consisting of an outstanding payment from 1994/95 plus the scheduled quarterly payments for 1995/96). During 1996/1997 the CRC received the usual four quarterly grant payments.

PBS
Partners

INDEPENDENT AUDIT REPORT
TO THE COOPERATIVE RESEARCH CENTRES SECRETARIAT DEPARTMENT OF INDUSTRY, SCIENCE AND TOURISM REPRESENTING THE COMMONWEALTH IN RESPECT OF

COOPERATIVE RESEARCH CENTRE FOR TEMPERATE HARDWOOD FORESTRY

Scope

We have audited the attached financial information of the Cooperative Research Centre for the Temperate Hardwood Forestry as set out in Tables 1 to 4 of the Annual Report for the year ended 30 June 1997 as required by clause 14(1)(f) of the Commonwealth Agreement. The Directors of the Cooperative Research Centre are responsible for the preparation and presentation of the financial information contained therein, and have determined that the basis of accounting as described in Note 1 is appropriate to meet the needs of the Members of the Cooperative Research Centres Committee and the Commonwealth. We have conducted an independent audit of the financial information in order to express an opinion to the Commonwealth on its preparation and presentation and to report on the matters identified below in relation to the sources and applications of the Cooperative Research Centre for Temperate Hardwood Forestry funding. No opinion is expressed as to whether the basis of accounting as described in Note 1 is appropriate to the needs of the Members of the Cooperative Research Centres Committee or the Commonwealth.

The financial information has been prepared for distribution to Members of the Co-operative Research Centres Committee and for the purpose of fulfilling the requirements of the Commonwealth Agreement. We disclaim any assumption of responsibility for any reliance on this report or on the financial information to which it relates to any person other than the Members of the Cooperative Research Centres Committee and the Commonwealth, or for any purpose other than that for which it was prepared.

Our audit has been conducted in accordance with Australian Auditing Standards. Our procedures included examination, on a test basis, of evidence supporting the amounts and other disclosures in the financial information. These procedures have been undertaken to provide reasonable assurance that the Cooperative Research Centre for Temperate Hardwood Forestry has complied with Clauses 4, 5(1), 5(2), 5(3), 9(1), 9(5) and 12(2) of the Commonwealth Agreement and to form an opinion as to whether in all material respects, the financial information presents fairly the sources and applications of funding in accordance with the basis of accounting described in Note 1. These policies do not require the application of all Accounting Standards and Urgent Issues Group Consensus Views.

The audit opinion expressed in this report has been formed on the above basis and reports on compliance with the following matters:

1. The multipliers adopted by the Centre to value in-kind contributions other than salary costs have a sound and reasonable basis. The Researcher's Contributions for the year has been provided at least to the value for that year committed in accordance with the Budget and the total value of all contributions for the year under report equalled or exceeded the amount of grant paid during the year.

2. The Researcher has used the grant and the Researcher's contributions for the Activities of the Centre and not for any other purpose.

3. The Researcher's allocations of the budgetary resources between Heads of Expenditure has not been lower or higher than the allocation in the budget by $100,000 or 20% (whichever is the greater amount) without prior approval by the Commonwealth.

4. Capital Items acquired from the Grant and Researcher's Contributions are vested as provided in the Joint Venture Agreement.

5. Intellectual Property in all Contract Material is vested as provided in the Joint Venture Agreement and no Intellectual Property has been assigned or licensed without the prior approval of the Commonwealth.

6. Proper accounting standards and controls have been exercised in respect of the Grant and Researcher's Contributions and income and expenditure in relation to the Activities of the Centre have been recorded separately from other transactions of the Researcher.

Qualification

The Cooperative Research Centre for Temperate Hardwood Forestry has not complied with the following requirements of the Commonwealth Agreement:

Clause 4

The contributions by particular Researcher's for the year under report have not been provided to at least the value for that year committed in the budget. The Researcher's who breached the clause are:

Researcher	Amount Committed $ 000	Amount Provided $ 000
Boral	163.0	3.3
Bunnings Treefarms	169.1	167.3

Page Three.

PBS
Partners

Qualified Audit Opinion

In our opinion the attached financial information presents fairly, in accordance with the basis of accounting described in Note 1, the sources and applications of the Cooperative Research Centre for Temperate Hardwood Forestry funding for the year ended 30 June 1997 and except for the non-compliance detailed above, the Cooperative Research Centre for Temperate Hardwood Forestry has complied with the required clauses of the Commonwealth Agreement.

PBS Partners
Chartered Accountants

Steven A Hernyk
Partner

Hobart
28 August 1997

IN-KIND CONTRIBUTIONS FROM PARTNERS ($000's) TABLE 1

EXPENDITURE

PARTNER		ACTUAL 1991/92	1992/93	1993/94	1994/95	1995/96	1996/97	BUDGET 1996/97	Cumulative to date Actual	Budget	PROJECTED 1997/98	GRAND TOTAL Actual 7 Years	Agreement 7 years	Difference 7 years
CSIRO FORESTRY and FOREST PRODUCTS														
	SALARIES	531.4	610.9	613.6	573.3	600.0	604.8	578.2	3,534.0	3,303.3	589.8	4,123.8	3,893.1	230.7
	CAPITAL													
	OTHER	900.4	1,033.9	1,042.5	909.7	879.2	922.7	889.4	5,688.4	5,426.6	883.8	6,572.2	6,310.4	261.8
	TOTAL	1,431.8	1,644.8	1,656.1	1,483.0	1,479.2	1,527.5	1,467.6	9,222.4	8,729.9	1,473.6	10,696.0	10,203.5	492.5
UNIVERSITY OF TASMANIA														
	SALARIES	488.4	407.7	330.6	372.8	432.0	493.4	503.0	2,524.9	4,038.0	503.0	3,027.9	3,417.3	-389.4
	CAPITAL	40.0			150.0	240.0		0.0	430.0	240.0		430.0		430.0
	OTHER	648.7	636.6	553.5	656.0	767.7	843.3	827.5	4,105.8	3,701.1	827.5	4,933.3	5,792.3	-429.0
	TOTAL	1,177.1	1,044.3	884.1	1,178.8	1,439.7	1,336.7	1,330.5	7,060.7	7,979.1	1,330.5	8,391.2	9,209.6	-818.4
NSW FOREST MANAGEMENT														
	SALARIES	21.0	26.0	38.0	45.4	41.0	25.8	93.0	196.4	290.0	93.0	289.4	651	-361.6
	CAPITAL													
	OTHER	28.0	62.0	98.0	59.0	117.0	173.0	37.0	537.0	490.0	37.0	574.0	259	315.0
	TOTAL	49.0	88.0	136.0	104.4	158.0	198.8	130.0	733.4	780.0	130.0	863.4	910	-46.6
NORTH FOREST PRODUCTS														
	SALARIES	64.0	59.3	70.6	109.8	156.7	163.5	170.0	623.9	596.0	170.0	793.9	1190	-396.1
	CAPITAL													
	OTHER	107.0	103.7	125.4	122.0	221.4	343.2	76.0	1,022.7	880.0	76.0	1,098.7	532	566.7
	TOTAL	171.0	163.0	196.0	231.8	378.1	506.7	246.0	1,646.6	1,476.0	246.0	1,892.6	1722	170.6
BORAL TIMBER TASMANIA														
	SALARIES	39.6	24.2	24.9	3.6	13.8	0.5	123.0	106.6	450.0	123.0	229.6	861	-631.4
	CAPITAL													
	OTHER	50.2	42.6	26.7	4.8	15.0	2.8	40.0	142.1	528.0	40.0	182.1	280	-97.9
	TOTAL	89.8	66.8	51.6	8.4	28.8	3.3	163.0	248.7	978.0	163.0	411.7	1141	-729.3
FORESTRY TASMANIA														
	SALARIES	47.2	57.3	69.0	77.2	75.4	85.0	73.0	411.1	258.0	73.0	484.1	511	-26.9
	CAPITAL													
	OTHER	61.0	64.6	78.1	79.5	85.5	104.9	24.0	473.6	324.0	24.0	497.6	168	329.6
	TOTAL	108.2	121.9	147.1	156.7	160.9	189.9	97.0	884.7	582.0	97.0	981.7	679	302.7
AUSTRALIAN PAPER PLANTATIONS														
	SALARIES		118.1	118.6	79.5	90.2	94.3	118.0	500.7	590.0	118.0	618.7	708	-89.3
	CAPITAL													
	OTHER		81.0	60.6	96.3	124.2	163.7	60.0	525.8	300.0	60.0	585.8	360	225.8
	TOTAL		199.1	179.2	175.8	214.4	258.0	178.0	1,026.5	890.0	178.0	1,204.5	1068	136.5
BUNNINGS TREEFARMS														
	SALARIES					44.4	86.1	86.1	130.5	172.2	86.1	216.6	344.4	-127.8
	CAPITAL													
	OTHER					33.9	77.1	83.0	111.0	166.0	83.0	194.0	334	-140.0
	TOTAL		0.0	0.0	0.0	78.3	163.2	169.1	241.5	338.2	169.1	410.6	678.4	-267.8
TOTAL IN-KIND CONTRIBUTIONS														
	SALARIES	1,191.6	1,303.5	1,265.3	1,261.6	1,453.5	1,552.6	1,744.3	8,028.1	9,697.5	1,755.9	9,784.0	11,575.8	-1,791.8
	CAPITAL	40.0			150.0	240.0		0.0	430.0	240.0		430.0	0.0	430.0
	OTHER	1,795.3	2,024.4	1,984.8	1,927.3	2,243.9	2,830.7	2,036.9	12,606.4	11,815.7	2,031.3	14,637.7	14,035.7	602.0
GRAND TOTAL IN-KIND		3,026.9	3,327.9	3,250.1	3,338.9	3,937.4	4,183.3	3,781.2	21,064.5	21,753.2	3,787.2	24,851.7	25,611.5	-759.8

CASH CONTRIBUTIONS ($000's)

TABLE 2

	ACTUAL						BUDGET	Cumulative to date		PROJECTED	GRAND TOTAL		
PARTNERS	1991/92	1992/93	1993/94	1994/95	1995/96	1996/97	1996/97	Actual	Budget	1997/98	Actual	Agreement	Difference
A CSIRO Forestry & Forest Products													
B University of Tasmania	500.0							500.0	500.0		500.0	500.0	
C Forestry Tasmania													
D North Forest Products					12.7			12.7			12.7		
E ANM Forest Management		20.0	20.0	25.0	25.0	20.0	20.0	110.0		20.0	130.0		
F Boral Timber Tasmania													
G Australian Paper Plantations					7.3	10.0		17.3			17.3		
H Bunnings Treefarms						4.1		4.1			4.1		
TOTAL CASH FROM PARTICIPANTS	500.0	20.0	20.0	25.0	45.0	34.1	20.0	644.1	500.0	20.0	664.1	500.0	
INTEREST	10.5	68.6	25.0	60.9	55.6	48.2	50.0	268.8		20.0	268.8		
OTHER EXTERNAL FUNDS			1.8	121.0	84.1	13.9		220.8		20.0	240.8		
FUNDING FROM THE CRC GRANT	948.6	1,448.5	1,723.5	1,320.2	2,226.3	1,826.1	1,796.8	9,494.0	8,947.5	1,766.2	11,260.2	10,164.6	
TOTAL CRC CASH CONTRIBUTION	1,459.1	1,537.1	1,770.3	1,527.1	2,411.0	1,925.1	1,866.8	10,627.7	9,447.5	1,846.2	12,473.9	10,664.6	
Cash carried over from previous year		1,163.4	876.1	961.0	741.4	989.8	989.8			750.9			
Less unspent balance	1,163.4	876.1	961.0	741.4	989.8	750.9	493.7						
TOTAL CASH EXPENDITURE	295.7	1,824.4	1,685.4	1,746.7	2,162.5	2,162.0	2,362.9	9,876.7		2,597.1	12,473.8	10,664.0	
ALLOCATION OF CASH EXPENDITURE BETWEEN HEADS OF EXPENDITURE													
SALARIES	118.8	636.1	1,079.6	1,150.2	1,461.1	1,440.3	1,560.9	5,886.1		1,712.1	7,598.2	7,354.0	
CAPITAL		500.0	52.0	0.0	20.0	22.3		604.3			604.3	500.0	
OTHER	176.9	688.3	543.8	596.5	681.4	699.4	802.0	3,386.3		885.0	4,271.3	2,310.0	

Note: Capital expenditure of $22,310 in 1996/97 was for a motor vehicle

SUMMARY OF RESOURCES APPLIED TO ACTIVITIES OF CENTRE ($000's)

TABLE 3

ALL PROGRAMS

EXPENDITURE

	ACTUAL						BUDGET	Cumulative to date		PROJECTED	GRAND TOTAL		
	1991/92	1992/93	1993/94	1994/95	1995/96	1996/97	1996/97	Actual	Budget	1997/98	Actual	Agreement	Difference
GRAND TOTAL (IN-KIND)	3,026.9	3,327.6	3,250.1	3,338.9	3,937.4	4,183.3	3,781.2	21,064.5	21,753.2	3,787.2	24,851.7	25,611.5	-759.8
GRAND TOTAL (CASH EXPENDITURE)	295.7	1,824.4	1,685.4	1,746.7	2,162.5	2,162.0	2,362.9	9,876.7	9,924.2	2,597.1	12,473.8	10,664.0	1,809.8
TOTAL RESOURCES APPLIED TO ACTIVITIES OF CENTRE	3,322.6	4,652.3	4,935.5	5,085.6	6,099.9	6,345.3	6,144.1	30,941.2	31,677.5	6,384.3	37,325.5	36,275.5	1,050.0

ALLOCATION OF TOTAL RESOURCES APPLIED TO ACTIVITIES OF CENTRE BETWEEN HEADS OF EXPENDITURE

TOTAL SALARIES (CASH AND IN-KIND)	1,310.5	1,939.6	2,345.0	2,411.8	2,914.6	2,992.9	3,305.2	13,914.4	15,470.2	3,468.0	17,382.4	19,689.8	-2,307.4
TOTAL CAPITAL (CASH AND IN-KIND)	549.0	0.0	52.0	150.0	350.0	22.3	0.0	1,034.3	752.3	0.0	1,034.3	500.0	534.3
TOTAL OTHER (CASH AND IN-KIND)	1,972.1	2,712.7	2,538.5	2,523.8	2,835.3	3,330.1	2,838.9	15,992.5	15,445.0	2,916.3	18,908.8	16,245.7	2,663.1

Allocation of resources between categories of activities (1996/97)

TABLE 4

PROGRAM	RESOURCE USAGE			
	Cash $000's	In-kind $000's	Staff Contributed	Staff funded by CRC
Research	1,867.3	3,687.7	12.0	12.0
Education	63.5	92.4	0.3	0.5
Commercialisation/ Tech Transfer				
Administration	188.3	403.2	1.3	0.1
Other (transferred ; non CRC activities)	42.9			
TOTAL	2,162.0	4,183.3	13.6	12.6

RESEARCH STAFF RESOURCES (1996/97)

ATTACHMENT B

Employer		Main activity	Total % time	% spent on Research Program			Total on Research	% spent on Education	% Spent on Commercialisation Program	% spent on CRC Administration
				Gen	*SSM*	*Prot*				
ANM										
VOLKER, P		R	10	5			5			5
HETHERINGTON, S		R	20	5	5	10	20			
HUMPHREYS,N		A	5							5
Total			35	10	5	10	25			10
Australian Paper Plantations										
PONGRACIC, S		R	35	20	10	5	35			
WHITEMAN, P		R	25	10	10	5	25			
CAMERON, J		R	5	1.7	1.7	1.7	5			
Total			65	31.7	21.7	11.7	65			
Bunnings Treefarms										
BREIDAHL, R		R	14	4	4		8			6
SHEDLEY, C		R	37	2	30		32	2		3
WILBEAM,D		R	30	25			25	2		3
RICHARDSON,C		R	20		20		20			
MCARTHUR, G		A	10	2	2		4			6
Total			111	33	56	0	89	4		18
North Forest Products										
TIBBITS, W		R	12	12			12			
RASMUSSEN, G		R	13	13			13			
HOLZ, G		R	46		25		25			21
DE LITTLE, D		R	42			18	18			24
OLIVER, C		R	61		61		61			
BARNES, C		R	37		37		37			
DEAN, G		R	7	7			7			
POWELL, M		R	7	7			7			
JONES, H		R	8			8	8			
JAMIESON, A		A	11							11
Total			244	39	123	26	188			56
Forestry Tasmania										
ELEK, J		R	40			40	40			
KUBE, P		R	20	20			20			
ELLIOTT, H		R	10			10	10			
Total			70	20		50	70			

RESEARCH STAFF RESOURCES (1996/97)

Attachment B cont ../2

Employer		Main activity	Total % time	% spent on Research Program Gen	SSM	Prot	Total on Research	% spent on Education	% Spent on Commercialisation Program	% spent on CRC Administration
CSIRO Forestry & Forest Products										
SANDS, P		R	80		80		80			
RAYMOND, C		R	100	50	50		100			
BATTAGLIA M		R	100		100		100			
BEADLE, C		R	70		70		70			
CROMER, R		R	80		80		80			
MUMMERY, D		R	80		80		80			
Total			510	50	460		510			
University of Tasmania										
REID, J		R	50	20			20			30
VAILLANCOURT, R		R	45	45			45			
BORRALHO, N		R	25	25			25			
POTTS,B		R	25	25			25			
MADDEN, J		R	40			40	40			
HILL, R		R	10		10		10			
MENARY, R		R	10	10			10			
WILTSHIRE, R		R	30		30		30			
CLARK, R		R	10		10		10			
LINE, M		R	10		10		10			
BROWN, P		R	10		10		10			
NEWMAN,I		R	5		5		5			
MCQUILLAN,P		R	5			5	5			
MOHAMMED,C		R	3			3	3			
MENDHAM, N		R	5		5		5			
WHITE, R		A	10				0			10
UNWIN, G		E	25					25		
PARR,G		A	5							5
Total			323	125	80	48	253	25		45

RESEARCH STAFF RESOURCES (1996/97)

Attachment B cont ../3

Employer		Main activity	Total % time	% spent on Research Program Gen	SSM	Prot	Total on Research	% spent on Education	% Spent on Commercialisation Program	% spent on CRC Administration
CRC funded										
CLARKE, A	Uni Tas	R	100			100	100			
McARTHUR, C	Uni Tas	R	100			100	100			
DAVIDSON, N	Uni Tas	R	100		50		50	50		
SMETHURST, P	CSIRO	R	100		100		100			
MISRA, R	Uni Tas	R	100		100		100			
HOVENDEN, M	Uni Tas	R	100		100		100			
JORDAN,G	UniTas	R	100	100			100			
POTTS, B	Uni Tas	R	75	75			75			
BORRALHO, N	Uni Tas	R	75	75			75			
MUNERI, A	Uni Tas	R	100	100			100			
RUAUD, J-N	CSIRO	R	100	100			100			
DUTKOWSKI,G	Uni Tas	R	100	100			100			
STEANE, D	Uni Tas	R	100	100			100			
REID,J	UniTas	R	6							6
Total			1256	650	350	200	1200	50		6

SUMMARY OF CONTRIBUTIONS IN PERSON YEARS (100% = 1 person year)

	Total equiv. person years	Person years spent on Research program Gen	SSM	Prot	Total on Research	Person years spent on Education Program	Person years spent on Commercialisation Program	Person years spent on CRC Administration
Total Contributed	13.6	3.1	7.5	1.5	12.0	0.3		1.3
Total funded by CRC	12.6	6.5	3.5	2.0	12.0	0.5		0.1
Grand total	26.1	9.6	11.0	3.5	24.0	0.8		1.4
Proportion of total professional (%) staff resources in each activity	100.0	36.7	41.9	13.2	91.8	3.0		5.2

SUPPORT STAFF

Attachment B cont. ../4

Contributed

Organisation	Number of staff (person years)
ANM	0.1
Australian Paper Plantations	1.0
North Forest Products	1.2
Boral Timber	0.0
Bunnings Treefarms	1.2
Forestry Tasmania	1.1
CSIRO	4.0
University of Tasmania	1.1
Total	9.8

CRC Funded (by employing organisation)

Organisation	Number of staff (person years)
CSIRO	1.0
University of Tasmania	13.8
Total	14.8

CRC FOR TEMPERATE HARDWOOD FORESTRY ATTACHMENT C

CSIRO Forestry & Forest Products

Itemised List of In-Kind Contributions (in $'000's)

SALARIES

Name	Designation	Program	% time CRC	1991/92	1992/93	1993/94	1994/95	1995/96	1996/97	1997/98	TOTAL
Raymond, Ms C	Scientist	Gen	50								
Churchill, Mr K	Technician	Gen	100								
Battaglia, Mr M	Scientist	SSM	100								
Beck, Dr P	Scientist	SSM	80								
Wardle, Dr C	Scientist	SSM	70								
Mummery, Mr D	Scientist	SSM	80								
Turner, Mr R	Scientist	SSM	80								
Raymond, Ms C	Scientist	SSM	50								
Wade, Ms A	Technician	SSM	100								
Cherry, Ms M	Technician	SSM	100								
Reid, Mr F	Technician	SSM	100								
		Total Salary		421.2	484.2	492.4	453.2	474.3	478.1	487.7	3,291.1

Direct On-Costs	*% of total Salary*								
Productivity Benefit	3.0	12.6	14.5	14.8	13.6	14.2	14.3	14.6	
Superannuation	18.6	70.3	80.8	82.1	84.3	88.2	88.9	90.7	
Workers Compensation	0.9			4.5	4.1	4.3	4.3	4.4	
Leave Loading	1.5	6.3	7.2	7.4	6.8	7.1	7.2	7.3	
Long Service Leave	2.5	10.5	12.1	12.4	11.3	11.9	12.0	12.2	
Other		10.5	12.1	0.0					
	Total On-Costs	110.2	126.7	121.2	120.1	125.7	126.7	129.2	859.8
	Total Salaries & On-Costs	531.4	610.9	613.6	573.3	600.0	604.8	616.9	4,150.9

CAPITAL

	Total Capital								

OTHER

	% of Total Salaries & On -Costs								
Divisional Administration/Support	81.0	510.3	586.4	589.0	498.6	459.4	489.9	499.7	3,633.5
Institute O'heads	10.0	47.8	55.0	55.3	68.8	39.6	60.5	61.7	388.7
Corporate O'heads	21.0	127.6	146.5	147.3	114.7	105.0	127.0	129.6	897.6
Amortised capital costs	37.0	196.7	226.0	227.0	212.1	222.0	223.8	228.3	1,535.9
Direct Operating Allocation		18.0	20.0	23.9	15.4	53.2	21.6	20.0	172.1
	Total Other	900.4	1,033.9	1,042.5	909.7	879.2	922.7	939.2	6,627.7
	TOTAL IN-KIND CONTRIBUTION	1,431.8	1,644.8	1,656.1	1,483.0	1,479.2	1,527.5	1,556.2	10,778.7

CRC FOR TEMPERATE HARDWOOD FORESTRY ATTACHMENT C

UNIVERSITY OF TASMANIA

Itemised List of In-Kind Contributions (in $'000's)

SALARIES

Name	*Designation*	*Program*	*% time CRC*	1991/92	1992/93	1993/94	1994/95	1995/96	1996/97	1997/98	TOTAL
Reid J	Scientist	Gen/Admin	50								
Vaillancourt R	Scientist	Gen	45								
Borralho N	Scientist	Gen	25								
Potts B	Scientist	Gen	25								
Menary R	Scientist	Gen	10								
Cummings I	Technician	Gen	40								
Haig G	Technician	Gen	10								
Smolenski A	Technician	Gen	30								
Ashworth C	Technician	Gen	2								
Johnson L	Technician	Gen	2								
Xianming Wei	Student	Gen	100								
Wiltshire R	Scientist	SSM	30								
Clark R	Scientist	SSM	10								
Hill R	Scientist	SSM	10								
Line M	Scientist	SSM	10								
Brown P	Scientist	SSM	10								
Newnam I	Scientist	SSM	5								
Mendham N	Scientist	SSM	5								
Madden J	Scientist	RPP	40								
McQuillan P	Scientist	RPP	5								
Mohammed C	Scientist	RPP	3								
Rumbold B	Technician	RPP	5								
Unwin G	Scientist	ETT	25								
Parr G	Research	Admin	5								
White R	Scientist	Admin	10								
Johnson G	General	Admin	10								
			Total Salary	324.1	270.5	169.9	225.3	246.7	280.8	255.4	1,822.7
	Direct On-Costs		*% total salary*								
	Payroll tax		7.0	22.7	18.9	11.8	11.0	17.3	19.7		
	Superannuation		17.0	55.1	46.0	28.7	26.7	41.9	47.7		
	Workers Compensation		1.0	3.2	2.7	1.7	1.6	2.0	2.6		
	Leave Loading(Academic)		1.3	4.5	3.8	2.4	2.2	3.2	3.3		
	Long Service Leave		3.2	10.3	8.6	5.4	5.0	7.9	9.0		
	Outside study-Academics			68.5	57.2	28.0	26.6	40.4	42.0		
	HECS student contributions					83.7	74.4	72.6	86.3		
			Total On-Costs	164.3	137.2	161.7	147.5	185.3	212.6	216.0	
			Total Salaries & On-Costs	488.4	407.7	330.6	372.8	432.0	493.4	503.0	3,027.9
CAPITAL	Modifications to Plant Science Building			40.0							
	New building/equipment						150.0	240.0			
			Total Capital	40.0			150.0	240.0	0.0		430.0
OTHER			*% of Total Salaries & On-Costs*								
	Academic services		25.0	122.1	101.9	82.6	93.2	108.0	123.3		
	General uni services		41.0	200.3	167.2	135.5	152.9	177.1	202.3		
	Dept office support		10.0	48.8	40.8	33.0	37.3	43.2	49.3		
	Laboratory rent		32.0	156.3	130.5	105.8	119.3	138.2	157.9		
	Office space		8.0	39.1	32.6	26.4	29.8	34.6	39.5		
	Central Science Lab				80.0	83.2	134.8	88.0	88.3		
	Management Agency			82.0	83.6	87.0	88.7	178.6	182.7		
			Total Other	648.6	636.6	553.5	656.0	767.7	843.3	827.3	4,933.2
			TOTAL IN-KIND CONTRIBUTION	1,177.0	1,044.3	884.1	1,178.8	1,439.7	1,336.7	1,330.3	8,391.1

CRC FOR TEMPERATE HARDWOOD FORESTRY ATTACHMENT C

FOREST MANAGEMENT

Itemised List of In-Kind Contributions (in $'000's)

SALARIES

Name	Designation	Program	% time CRC	1991/92	1992/93	1993/94	1994/95	1995/96	1996/97	1997/98	TOTAL
[illegible], P	Scientist	Gen	5								
[illegible]ington, S	Scientist	Gen	5								
[illegible]ington, S	Scientist	SSM	5								
[illegible]ington, S	Scientist	RPP	10								
[illegible], P	Scientist	Admin	5								
[illegible]ngsheys, N	Manager	Admin	5								
		Total Salary		17.0	21.0	29.0	34.4	31.0	19.0		
	Direct On-Costs	*% total salary*									
	Payroll tax										
	Superannuation										
	Workers Compensation										
	Leave Loading										
	Long Service Leave										
	Other										
		Total On-Costs		4.0	5.0	9.0	11.0	10.0	6.0		
		Total Salaries & On-Costs		21.0	26.0	38.0	45.4	41.0	25.0	26.0	222.4

CAPITAL

		Total Capital									

OTHER

	% of Total Salaries & On-Costs							
Office support		11.0	9.0	10.0	10.0	10.0	8.0		
Vehicle costs		7.0	6.0	7.0	11.0	5.0	4.0		
Trial maintenance			22.0	53.0	8.0	54.0			
Experiments		10.0	25.0	26.0	30.0	48.0	41.0		
Land rent							120.0		
	Total Other	28.0	62.0	98.0	59.0	117.0	173.0	104.0	641.0
TOTAL IN-KIND CONTRIBUTION		49.0	88.0	136.0	104.4	158.0	198.0	130.0	863.4

NORTH FOREST PRODUCTS

CRC FOR TEMPERATE HARDWOOD FORESTRY

ATTACHMENT C

Itemised List of In-Kind Contributions (in $'000's)

SALARIES

Name	*Designation*	*Program*	*% time CRC*	1991/92	1992/93	1993/94	1994/95	1995/96	**1996/97**	1997/98	TOTAL
de Little D	Scientist	RPP	18								
Jones H	Scientist	RPP	8								
Gillett J	Technician	RPP	1								
Hingston T	Technician	RPP	1								
Holz G	Scientist	SSM	25								
Oliver C	Scientist	SSM	61								
Barnes, C	Scientist	SSM	37								
Dean, C	Scientist	SSM	7								
Joyce K	Technician	SSM	9								
Tibbits W	Scientist	Gen	12								
Powell M	Scientist	Gen	7								
Rasmussen G	Scientist	Gen	13								
Joyce K	Technician	Gen	10								
Burgess D	Technician	Gen	11								
Hingston T	Technician	Gen	13								
Hammond I	Technician	Gen	11								
Jamieson A	Manager	Admin	11								
deLittle D		Admin	24								
Holz, G		Admin	21								
Hill, D	Secretary	Admin	12								
			Total Salary	58.0	53.7	64.1	86.1	122.9	**128.2**	67.9	580.9
	Direct On-Costs	*% of total salary*									
	Payroll tax										
	Superannuation										
	Workers Compensation										
	Leave Loading										
	Long Service Leave										
	Other										
			Total On-Costs	6.0	5.6	6.5	23.7	33.8	**35.3**	7.3	118.2
			Total Salaries & On-Costs	64.0	59.3	70.6	109.8	156.7	**163.5**	75.2	699.1

CAPITAL

			Total Capital								

OTHER

	% of Total Salaries & On-Costs							
Head Office Overheads		21.0	22.1	17.3	11.3	6.3	**3.9**	17.3	99.2
Office Support		18.0	6.4	4.2	7.0	3.4	**4.9**	4.2	48.1
Office hire		20.0	15.6	18.1	23.0			18.1	94.8
Operational			59.6	85.8	80.7			85.8	311.9
Experiments		8.0							8.0
Land rent							**4.0**		
Other		40.0				211.7	**330.4**		582.1
	Total Other	107.0	103.7	125.4	122.0	221.4	**343.2**	125.4	1,144.1
	TOTAL IN-KIND CONTRIBUTION	171.0	163.0	196.0	231.8	378.1	**506.7**	200.6	1,843.2

CRC FOR TEMPERATE HARDWOOD FORESTRY ATTACHMENT C

FORAL TIMBER TASMANIA

Itemised List of In-Kind Contributions (in $'000's)

SALARIES

			% time	1991/92	1992/93	1993/94	1994/95	1995/96	1996/97	1997/98	TOTAL
Name	*Designation*	*Program*	*CRC*								
Bardon, P	Technician	Gen	1.2								
			Total Salary	31.1	19.0	19.7	2.9	10.8	0.4	8.0	91.9
	Direct On-Costs		*% tot. salary*								
	Payroll tax		7.0		1.4	1.4	0.2	0.8			
	Superannuation		5.5		1.1	1.1	0.2	0.6			
	Workers Compensation		5.0		1.0	1.0	0.1	0.5			
	Leave Loading		8.0		1.6	1.6	0.2	0.9			
	Long Service Leave		2.0		0.1	0.1	0.0	0.2			
	Other										
			27.5								
			Total On-Costs	8.5	5.2	5.2	0.7	3.0	0.1	2.2	24.9
			Total Salaries & On-Costs	39.6	24.2	24.9	3.6	13.8	0.5	10.2	116.8
CAPITAL											
			Total Capital								
OTHER			*% of Total Salaries & On -Costs*								
	Head Office Overheads		12.0	4.8	3.9	3.0	0.5	1.7		1.0	
	Office Support		30.0	19.1	23.5	12.1	1.1	4.1		2.4	
	Operational		30.0	26.3	15.2	11.6	1.1	4.1		2.4	
	Vehicle costs		7.0				0.3	1.0		0.6	
	Trial maintenance		8.0				0.3	1.1	0.4	0.5	
	Experiments		20.0				1.5	2.8		1.6	
	Land rent		2.0					0.2	2.4	0.2	
			Total Other	50.2	42.6	26.7	4.8	15.0	2.8	8.8	150.9
			TOTAL IN-KIND CONTRIBUTION	89.8	66.8	51.6	8.4	28.8	3.3	19.0	267.7

FORESTRY TASMANIA

CRC FOR TEMPERATE HARDWOOD FORESTRY

ATTACHMENT C

Itemised List of In-Kind Contributions (in $'000's)

SALARIES

Name	*Designation*	*Program*	*% time CRC*	1991/92	1992/93	1993/94	1994/95	1995/96	**1996/97**	1997/98	TOTAL
Elliott, H	Chief, Divn of Silviculture	RPP	10								
Elek, J	Research Forester	RPP	40								
Bashford, R	Technician	RPP	10								
Beveridge,N	Technician	RPP	50								
Ramsden, N	Technician	RPP	50								
Kube, P	Research Forester	Gen	20								
			Total Salary	39.6	47.5	57.5	64.4	62.9	**70.9**	76.1	418.9
	Direct on-costs		*% tot.salary*								
	Superannuation		5.0	1.2	2.4	2.9	3.2	3.1	**3.5**	3.8	20.1
	Workers Compensation		3.5	1.8	2.1	2.1	2.3	2.2	**2.5**	2.7	15.7
	Leave Loading		1.2	0.6	0.6	0.7	0.8	0.8	**0.9**	1.0	5.4
	Long Service Leave		3.1	1.2	1.4	1.8	2.0	2.0	**2.2**	2.4	13.0
	Other		7.0	2.8	3.3	4.0	4.5	4.4	**5.0**	5.3	29.9
			Total On-Costs	7.6	9.8	11.5	12.8	12.5	**14.1**	15.2	83.5
			Total Salaries & On-Costs	47.2	57.3	69.0	77.2	75.4	**85.0**	91.3	502.4

CAPITAL

			Total Capital								

OTHER

	% of Total Salaries & On -Costs							
Head Office Overheads	34.6	14.8	16.4	19.6	22.3	21.4	**29.4**	25.9	149.8
Office Support(inc equipment,admin)	22.7	9.7	10.7	13.1	14.6	14.5	**19.3**	17.5	99.4
Corporate Overheads	18.2	7.7	8.6	10.4	11.7	11.3	**15.5**	13.7	78.9
Operational	46.0	28.8	28.9	35.0	30.9	38.3	**40.8**	46.3	249.0
		Total Other	61.0	64.6	78.1	79.5	85.5	**104.9**	103.5	577.0
		TOTAL IN-KIND CONTRIBUTION	108.2	121.9	147.1	156.7	160.9	**189.9**	194.8	1,079.4

CRC FOR TEMPERATE HARDWOOD FORESTRY

ATTACHMENT C

NNINGS TREEFARMS

Itemised List of In-Kind Contributions (in $'000's)

ALARIES

	Designation	Program	% time CRC	1991/92	1992/93	1993/94	1994/95	1995/96	1996/97	1997/98	TOTAL
ley, C	Scientist	Gen	2								
ichi, R	Scientist	Gen	4								
ham, D	Scientist	Gen	25								
om, D	Technician	Gen	15								
s,V	Technician	Gen	5								
ft, M	Technician	Gen	10								
son,Y	Technician	Gen	5								
Arthur,G	Manager	Gen	2								
ley, C	Scientist	SSM	30								
ichi, R	Scientist	SSM	4								
rdson, C	Scientist	SSM	20								
om, D	Technician	SSM	15								
s,V	Technician	SSM	20								
ft, M	Technician	SSM	20								
son,Y	Technician	SSM	25								
Arthur,G	Manager	SSM	2								
ley, C	Scientist	ETT	2								
ham, D	Scientist	ETT	2								
om, D	Technician	ETT	2								
ley, C	Scientist	Admin	3								
ichi, R	Scientist	Admin	6								
om, D	Technician	Admin	3								
Arthur,G	Manager	Admin	6								
ham, D	Scientist	Admin	3								
			Total Salary					37.6	71.1		**108.7**
	Direct On-Costs		*% tot. salary*								
	Payroll tax		6.0					2.3	4.3		
	Superannuation		6.0					2.3	4.3		
	Workers Compensation		6.0					1.1	4.2		
	Leave Loading		1.5					0.5	1.0		
	Long Service Leave		1.7					0.6	1.2		
	Other										
			Total On-Costs					6.8	15.0		**21.8**
			Total Salaries & On-Costs					44.4	86.1	86.1	**216.6**

APITAL

			Total Capital								

THER

	% of Total Salaries & On-Costs								
Head Office Overheads						14.4	16.9	70.0	
Operational						19.5	5.7	13.0	
Office support							6.6		
Corporate Overheads							0.2		
Amortised capital costs							4.4		
Land rent							2.4		
Trial maintenance							0.7		
Experiments									
Other							40.2		
			Total Other					33.9	77.1	83.0	**194.0**
			TOTAL IN-KIND CONTRIBUTION					78.3	163.2	169.1	**410.6**

AUSTRALIAN PAPER PLANTATIONS

CRC FOR TEMPERATE HARDWOOD FORESTRY

ATTACHMENT C

Itemised List of In-Kind Contributions (in $'000's)

SALARIES

Name	*Designation*	*Program*	*% time CRC*	1991/92	1992/93	1993/94	1994/95	1995/96	**1996/97**	1997/98	TOTAL
Whiteman P	Scientist	Gen	10								
Pongracic S	Scientist	Gen	20								
Krygsman M	Technician	Gen	30								
Appleton R	Technician	Gen	15								
Pye C	Technician	Gen	20								
Cameron J	Board	Gen	2								
Whiteman P	Scientist	SSM	10								
Pongracic S	Scientist	SSM	10								
Krygsman M	Technician	SSM	20								
Appleton R	Technician	SSM	15								
Cameron J	Board	SSM	2								
Whiteman P	Scientist	RPP	5								
Pongracic S	Scientist	RPP	5								
Cameron J	Board	RPP	1.7								
			Total Salary		51.3	51.8	63.7	69.3	**78.6**	72.1	386.8
	Direct On-Costs		*% of total salary*								
	Payroll tax										
	Superannuation										
	Workers Compensation										
	Leave Loading										
	Long Service Leave										
	Other										
			Total On-Costs		66.8	66.8	15.8	20.9	**15.7**	21.7	207.7
			Total Salaries & On-Costs		118.1	118.6	79.5	90.2	**94.3**	93.8	594.5

CAPITAL

			Total Capital								

OTHER

			% Total Salaries & On -Costs								
	Land rent								**14.9**		
	Other								**148.8**		
	Head Office Overheads						25.9	39.0		40.6	105.5
	Operational						70.4	85.2		88.6	244.2
			Total Other		81.0	60.6	96.3	124.2	**163.7**	129.2	655.0
	TOTAL IN-KIND CONTRIBUTION				199.1	179.2	175.8	214.4	**258.0**	223.0	1,249.5

Cooperative Research Centre for Temperate Hardwood Forestry

Summary of External Funds Received 1996/97
(for specific projects that are not part of the Activities of the Centre)

Opening Balance at 1/7/96	45806
Add Income	180719
Transfer from G Ledger	42876
Less Expenses	
Salaries	61061
Consumables	56043
Equipment	58790
TOTAL EXPENSES	175894
Closing Balance at 30/6/97	93506

COOPERATIVE RESEARCH CENTRE
FOR TEMPERATE HARDWOOD FORESTRY

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