Cooperative Research Centre for Temperate Hardwood Forestry

ANNUAL REPORT 1994/95

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 contributes 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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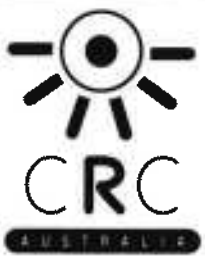

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AMCOR PLANTATIONS PTY LTD

UNIVERSITY OF TASMANIA

Participating Organisations

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Cover photo: Delegates at the CRCTHF/IUFRO Conference 'Eucalypt Plantations: Improving Fibre Yield and Quality', 19-24 February 1995, at Wrest Point Convention Centre, Hobart.

Executive Summary

Prof J Reid
Director

This year has been one of substantial achievement and change. A new Strategic Plan was developed by the CRC Board. The new mission of the Centre is brief but focused and states that the Centre will:

'Enhance the economic return from temperate hardwood forests and sustain productivity into the future.'

Together with the general objectives of the CRC program, four specific objectives were set:

- 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.

The four programs in the Centre, Genetic Improvement, Soil and Stand Management, Resource Protection, and Education and Technology Transfer have been charged with addressing these objectives within the priorities set by the Industry Research Committee and the Board. New targets and performance indicators have been set covering the research programs, education and technology transfer, management, external linkages and resources. This plan will guide us to the crucial fifth year review and determine whether the Centre will be extended beyond its original seven year horizon.

During 1994/95 a two-stage third year review process was conducted. The first stage involved a detailed examination of the outcomes and future plans for all projects and programs by the Scientific Review Committee. Whilst the overall review was positive it led to recommendations for specific changes in various projects. The second stage of the review involved an external review committee coordinated by the CRC Secretariat which focused at a higher level on the outcomes and future plans at the program level, and how the Centre had built up cooperative linkages and added value to the research of the individual parties in the Centre. Again, our 'report card' was generally good with five recommendations for changes. These recommendations have been examined by the Board and significant changes made to implement the key elements. In particular, the Centre has advertised for a Business Manager and will produce a business plan to develop the Centre's funding requirements beyond the end of our initial seven-year term. The 'public good' research that we carry out will be highlighted and our interaction with other research organisations and relevant community groups further developed. The Education

Three key people involved in the organisation of the CRCTHF/ IUFRO Conference 'Eucalypt Plantations: Improving Fibre Yield and Quality' from left to right; Brad Potts, Nuno Borralho and Peter Volker.

and Technology Transfer Program will take a leading role in these activities. Finally, the Soil and Stand Management Program and the Resource Protection Program will be further strengthened to ensure their international standing.

The Centre ran an international conference on 'Eucalypt Plantations: Improving Fibre Yield' during February 1995. This was an outstanding success both scientifically and financially. We attracted 270 delegates from 23 countries and the plaudits flowed in from world-wide. The organising committee must be congratulated on an excellent job and in particular thanks must go to Peter Volker, Brad Potts, Neil Davidson, Jane Burrell and the staff of Mures Convention Management. Nuno Borralho must also be congratulated on being elected to chair the key IUFRO committee on 'Eucalypt Silviculture and Breeding', an honour both to him and the Centre.

A major achievement this year has been the development, in collaboration with Southern Tree Breeding Association (STBA), of breeding plans for *Eucalyptus globulus* and *E. nitens*, including a clear definition of the breeding objectives, the development of a work plan and the costs of the breeding activities such as crossing, testing and assessment of material. A cost-benefit analysis indicated that there are substantial short- and long-term benefits of such a cooperative breeding program. This is a significant outcome for the Centre and was only possible because of the innovative research on the application and improvement of mixed models to tree breeding, coupled with large assessment programs for growth and wood density in over 1000 families and 100,000 trees established across Australia and New Zealand. This has resulted in international recognition of the Centre as the key site for research on the genetics and breeding of temperate eucalypts.

The research programs have continued to produce significant outcomes with a substantial rise in the output of publications. Highlights of this year's research include:

- the confirmation of pilodyn measurements as a cost effective, indirect assessment method of wood density in eucalypts;
- the genetic parameters for frost resistance, rooting ability, defoliation, wood density, early survival and *Mycosphaerella* damage have been determined;
- the establishment of a single, easily accessible database for growth and pilodyn measurements from over 100,000 trees of *E. globulus* and *E. nitens*;
- the development of the appropriate models for analysis of these datasets based on mixed model Best Linear Unbiased Prediction (BLUP) methods;

Prof Peter Kanowski, visiting scientist in the Genetic Improvement Program (photo courtesy of *The Mercury*).

- the relationship of the *Eucalyptus* subgenera with *Angophora* was determined using chloroplast molecular markers;
- the identification of Quantitative Trait Loci (QTL) for frost tolerance, branching frequency and leaf morphology on a linkage map involving the F_2 from the cross *E. globulus* x *E. gunnii*;
- major problems associated with the determination of genetic parameters from open-pollinated seed were quantified by comparison with estimates from controlled crosses;
- somatic embryos up to the globular stage were produced from *E. nitens*;
- the substantial effects on photosynthesis of sub-lethal frosts in *E. nitens*;
- the effects of pruning on photosynthesis and subsequent growth appear less severe than previously thought;
- early fertiliser applications result in little growth response on some soil types, leading to a re-evaluation of current operational procedures;
- a substantially simpler model has been developed to predict annual canopy photosynthetic production;
- susceptibility to attack by *Chrysophtharta bimaculata* was shown to be under strong genetic control in *E. regnans* and *E. nitens*;
- a major experimental plantation area for vertebrate browsing research has been established;
- aerial spaying trials have shown the range of droplet size, dispersion characteristics and application rates of *Bacillus* formulations that will kill 95% of early stage *C. bimaculata*;
- feeding preferences of *C. bimaculata* appear related to patterns of leaf oil production.

The Centre has again had significant imput from a number of international visitors including Dr Peter Kanowski from the Oxford Forest Research Institute and Professor Alan Berryman from Washington State University. We have appointed several new staff including Dr Clare McArthur to lead our vertebrate browsing project, Dr Allie Muneri to increase our expertise in measuring wood characteristics and Dr Dorothy Steane to increase our effort in molecular genetics. The building of a major new molecular biology laboratory was also commenced within the Life Sciences complex of the University of Tasmania. The CRC's molecular genetics group will occupy a substantial component of this building.

It is with regret that our Visitor, Professor Harold Woolhouse has vacated his position due to ill health. His replacement is Dr Peter Nelson who was one of the founding co-directors of the CRC for

Hardwood Fibre and Paper Science. This appointment will maintain the strong links established between the two CRCs.

Management

The Board

Board of Management of the CRC (Fig. 1) is comprised of an independent Chairman, the Director and Deputy Director of the CRC and the Chief Executive or his representative from each participating body. The Board determines policy and sets guidelines for the efficient running of the Centre.

There has been one change to the Board. The Deputy Director, Dr Philip West resigned in January 1995 to take up an appointment as Director of the CRC for Management of Tropical Savannas and the position remains to be filled.

Structure

The **Management Structure** of the CRC is headed by the Board and links are depicted in Fig. 2. 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 Administrative Officer, Program Managers, the Director and the Deputy Director.

Mrs Shelley Caswell	-	Administrative Officer
Prof Jim Reid	-	Director
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

Industry Research Committee

The **Industry Research Committee** is comprised of Senior Research Scientists from all participating organisations and sets the research priorities for the Centre. This committee is chaired by a leading industry researcher, Mr Peter Volker from ANM Forest Management and its members are:

Mr Peter Volker	-	Silviculture Superintendent, ANM Forest Management
Dr Humphrey Elliott	-	Chief, Division of Silvicultural Research and Development, Forestry Tasmania

Dr David de Little	-	Research Manager, North Forest Products
Mr Peter Naughton	-	Research and Planning Forester, Boral Timber
Mr Philip Whiteman	-	Technical Manager, Amcor Plantations
Prof Jim Reid	-	Director, CRC
Dr Nuno Borralho	-	Program Manager, CRC Genetic Improvement
Mr Robin Cromer	-	Program Manager, CRC Soil and Stand Management Program Manager, Hardwood Plantations, CSIRO Division of Forestry
Dr John Madden	-	Program Manager, CRC Resource Protection
Dr Neil Davidson	-	Program Manager, CRC Education and Technology Transfer
Prof Robert Hill	-	Head of Department, Plant Science University of Tasmania

The **Scientific Review 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 composed of outside experts in each of the research program areas. Its members are:

Dr Garth Nikles	-	Officer in Charge Tree Breeding, Queensland Dept of Primary Industries, Forest Service (Genetic Improvement)
Dr Russell Haines	-	Director of Primary Industries - Queensland Forest Services (Genetic Improvement)
Dr Lindsay Barton Browne	-	Honorary Fellow, CSIRO Division of Entomology, Indooroopilly (Resource Protection)
Dr Sadanandan Nambiar	-	Chief Research Scientist, CSIRO Division of Forestry, Canberra (Soil and Stand Management)

Figure 1 Board of Management of the CRC

Mr John Kerin
Chairman

Professor Jim Reid
Director

Dr Phil West
Deputy Director
(until Feb 1995)

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

Mr Ken Felton
Commissioner (Management)
Forestry Tasmania

Mr Allan Jamieson
Technology Manager
North Forest Products

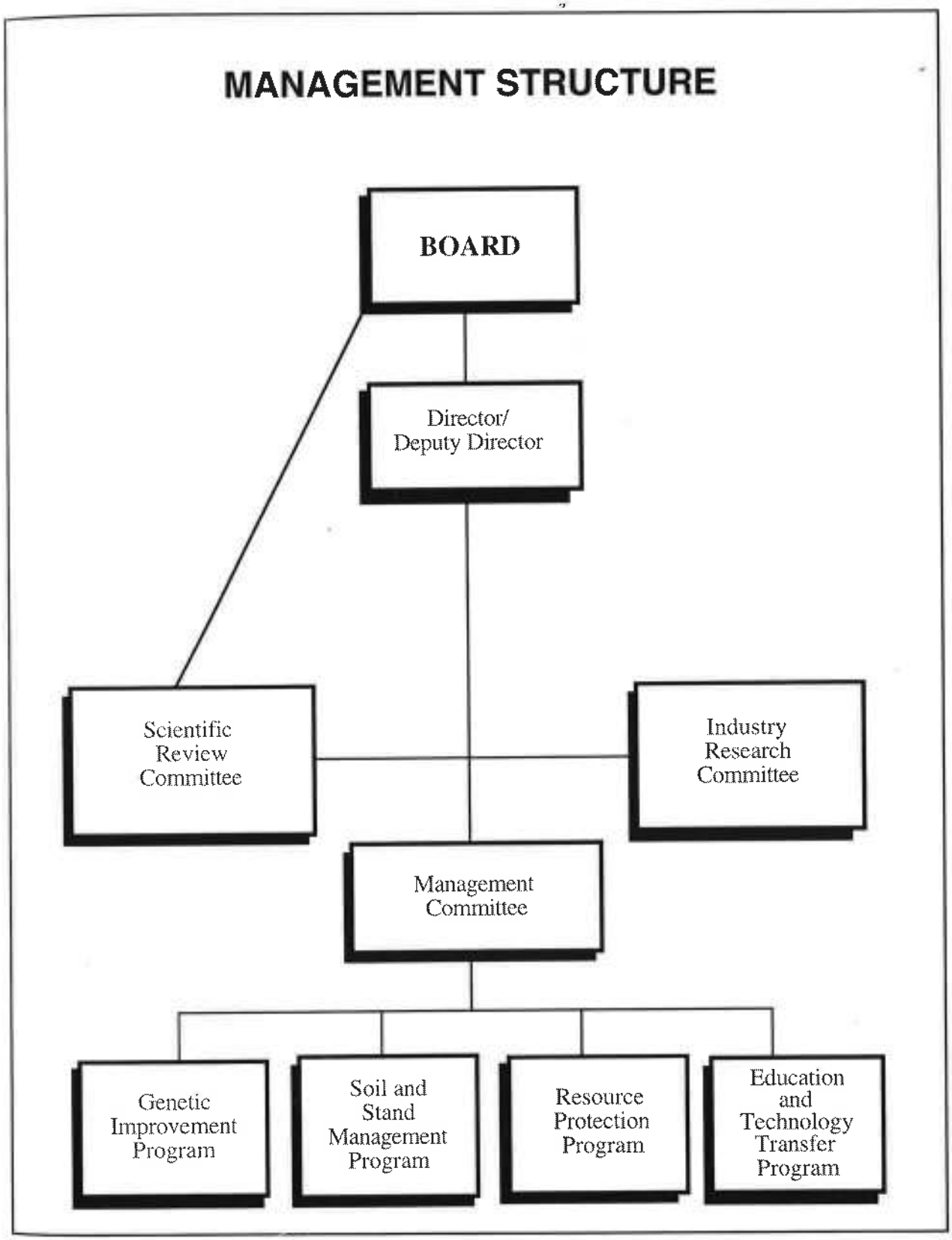
Dr Glen Kile
Chief
CSIRO, Division of Forestry

Mr Neil Humphreys
General Manager
ANM. Forest Management

Mr Ross Waining
General Manager
Boral Timber Tasmania

Mr John Cameron
Manager, Corporate Development
Amcor Paper Group

Figure 2 Management Structure of the CRC



Research

Genetic Improvement Program

Michael Baxter making random selections of seedlings from 250 families for field trials on breeding conducted in conjunction with Boral Timber.

Program Manager
Dr N Borralho

Objectives

The program aims to achieve gains in plantation productivity by improving the genetic quality of planting stock. This requires two major thrusts.

Firstly, economic information must be used to derive appropriate breeding objectives for the industry and forestry sector in general. This should be paralleled by a correct understanding of the genetic control of economically important traits, with a strong emphasis on wood quality, and the use of appropriate statistical methods and database management for genetic evaluation of current breeding populations. These elements form the basis of a successful tree breeding program.

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.

The program also expects to improve our understanding of the genetics, at the quantitative and molecular levels, in domesticated and wild populations, the phylogeny of the genus and the ability to manipulate more effectively the breeding systems for temperate eucalypts. This research is vital for the development of more effective short- and long-term breeding strategies.

Major achievements

The year 1994/1995 has seen substantial progress in achieving important milestones for the program.

- Two large studies involving more than 589 families of *E. globulus* (with over 70,000 trees measured), and 350 families of *E. nitens* (with over 35,000 trees), established across more than 30 sites in Australia and New Zealand, were completed. This represents a substantial improvement in our understanding of the genetic control of growth and the magnitude of the genotype-environment interaction for the two most important temperate eucalypt species in Australia. These estimates are now being incorporated in the national evaluation schemes for both species.

- Several other studies, on the inheritance of frost tolerance, rooting ability, defoliation, wood density, and early survival, have been completed.

- Pilodyn, a simple device which shoots a pin with a known force into wood, was confirmed as an effective indirect assessment

Dave Armstrong of Amcor Plantations using a pilodyn to measure wood density.

method for wood density in eucalypts. Studies on the best sampling procedures were made. As a result, the pilodyn is now being used as a selection criteria in the *E. globulus* and *E. nitens* breeding programs.

- Data for growth and pilodyn measurements from over 100,000 trees of both *E. globulus* and *E. nitens* from trials belonging to the CRC industry partners are stored in a single database. The Program has now developed appropriate models for the analysis of these large datasets, based on mixed model (BLUP) methods, which is pioneering work in forest tree breeding.

- A document outlining the expected genetic progress, costs and recommended structure of a cooperative *E. nitens* and *E. globulus* breeding program was completed, in collaboration with the STBA and the industry partners.

- The improved micropropagation procedure developed by CSIRO and the CRC has been successfully used by one of our industry partners. We are also obtaining the first results from the work on somatic embryogenesis.

- The program has strengthened its position as a leader of research in eucalypt genetics and breeding, attracting a growing number of students, scientists and tree breeders. During 1994/1995, the program produced a record number of publications, with 15 refereed papers, 22 conference papers, two book chapters and a number of unrefereed publications. Dr Peter Kanowski (recently appointed Professor of Forestry at the Australian National University) spent three months as a visiting scientist in the Centre. Mr Peter Kube (Forestry Tasmania) and Mr Greg Dutkowski (Bunnings Forest Products) were seconded to the Centre for two months and three weeks, respectively. Other visitors to the Centre included Dr Wayne Tibbits (North Eucalypt Technologies), Ms Sue Jarvis (Southern Tree Breeding Association), Mr Ian Bail (Centre for Forest Tree Technology) and Dr Arthur Gilmore (NSW Dept. of Agric.). The results from these visits contributed significantly to the development of breeding strategies for *E. globulus* and *E. nitens*.

Sub-program 1

Genetic Resources

- To be successful, tree breeding programs must understand and use effectively their natural genetic resources, and progressively improve these via selection and interbreeding of superior trees to produce planting stock of constantly improving genetic quality. Research should provide more powerful and flexible

breeding and deployment strategies, particularly in the following areas: (i) amount and type of variation in the population, (ii) which selection strategies to use, (iii) the best mating and testing strategies; and (iv) more efficient turnover of generations. Four research projects have been established within this sub-program to address these issues and to explore novel ways of increasing the economic return to Australian forestry from breeding programs.

Project 1

Leader
Dr N Borralho

Staff

Dr Nuno Borralho
Mr Xianming Wei
Mr Paul Chambers
Mr Andrew MacDonald
Mr Bruce Greaves

Looks belie its pedigree. This tree is highly valued for breeding purposes because of the high growth rate and excellent form of its progeny.

Strategies for breeding and deployment

Objectives

The aims of this project are to:

- define appropriate breeding objectives for sawn timber, pulpwood and pulp and paper production systems;
- provide guidelines to optimise breeding and deployment options for temperate hardwood species, taking account of the economics of the forestry sector in Australia and the genetic characteristics of the species;
- provide direct support to industry partners in the implementation of breeding and deployment programs, so that resource allocation and benefits from breeding are maximised.

Outcomes

- A breeding plan for *E. globulus* and *E. nitens* was completed (Jarvis and Borralho 1995). The document, a joint CRC-STBA publication, outlines the major elements of a cooperative breeding strategy, including a clear definition of the breeding objectives, a description of the genetic evaluation and the work plan and costs for the breeding activities (crossing, testing and assessment). The document also includes a cost-benefit analysis for the short- and long-term running of the program.
- The use of mixed models in tree breeding results in greater accuracy of selection of trees across different sites, with different amounts of information and from different generations (Borralho 1995, Jarvis *et al.* 1995). Project 1 also plays a leading role in training tree breeders through workshops and seminars. Recent results include the incorporation of native stand types in analyses (Borralho and Potts 1995), accounting for thinning in progeny trials and the use of genetic groups to model provenance effects.

- A database with diameter and pilodyn measurements and pedigree information for the large majority of the *E. globulus* and *E. nitens* breeding populations growing in Australia is now running at the CRC, including data on growth and pilodyn from all our industry partners (MacDonald *et al* 1995). Additional data from the New Zealand Forest Research Institute and other breeding organisations in Chile, Portugal and Spain have also been included in the database.

- A first deployment objective for tissue cultured clones was developed, incorporating operational and genetic parameters for multiplication rate, rooting and weaning ability (Rasmussen *et al.* 1995).

- As part of his PhD project Bruce Greaves is developing a general forest and pulp mill production model. This is being used to determine a breeding objective for chemical pulpwood production. Economic weights are derived, based on the impact of volume production per hectare, wood density, stem straightness and pulp yield on production costs, (including establishment, maintenance, harvesting, logging and pulping costs). Economic weights and selection efficiencies are being compared for a range of conditions and pulp mill types.

- An Australian Postgraduate Research Award - Industry (APRA-I) research project, jointly submitted by the CRC and ANM, started in February 1995. It aims to derive economic weights for traits of relevance in Australian forestry. Paul Chambers' PhD project will compare alternative selection schemes, in terms of their impact on overall profitability, and produce a set of recommendations for optimising tree selection for pulp and sawlog production in Australia.

- Individual tree mixed models, using the genetic relationship between all trees, can be used to obtain unbiased estimates of genetic parameters and predict breeding values in trials that have been thinned. Xianming Wei's PhD project is looking at the effectiveness of mixed models in accounting for thinning, using two *E. urophylla* progeny trials as case studies. These results have important implications on how to analyse genetic trials where silvicultural regimes include thinning. Preliminary work on the genetic control of growth in these trials has already been completed (Wei and Borralho 1995).

Goals

- Compare gains and inbreeding of breeding programs based on mixed model (BLUP) methods and overlapping generations,

with traditional index or family selection, and discrete generations, based on stochastic simulations.

- Continue to improve the statistical models used in the estimation of genetic parameters and breeding values in forestry, in particular to account for competition and within-block environmental variability.

- Determine the economic importance of fitness traits such as survival, frost, drought and disease tolerance, and study the importance of reproductive traits, in particular the onset of flowering, and rooting ability, in current breeding programs.

- Compare alternative deployment strategies for the CRC industry partners on *E. globulus* and *E. nitens*.

Project 2

Wood properties

Leader
Ms C Raymond

Staff
Ms Carolyn Raymond
Dr Allie Muneri
Mr Bruce Greaves

Objectives

The aims of this project are to:

- provide a direct linkage between the CRC for Temperate Hardwood Forestry and the CRC for Hardwood Fibre and Paper Science, to allow ideas and new technology to pass between the centres, in particular regarding the incorporation of wood properties in breeding programs;

- determine suitable sampling designs and sampling strategies for wood property assessments;

- obtain accurate estimates of genetic parameters for wood, fibre and pulping traits and their correlations with other traits of economic importance.

Outcomes

- A study looking at within-tree variation in *E. regnans* was completed in collaboration with ANM. Fibre length was found to be remarkably stable within a tree whereas density was more variable. The best sampling position was at 15% of total tree height, closely followed by breast height.

- An innovative sampling method to study the patterns of within-tree variation in basic density, combining fixed and relative height, was applied to a series of *E. globulus* and *E. nitens* stands. For *E. globulus*, wood density at the base of the tree is

Dr Allie Muneri

remarkably stable, across sites and age classes, suggesting a fixed sampling height is effective. For *E. nitens* some sites prove to have a stable within-tree density distribution whereas others indicate problems with sampling at a fixed height. For most trees the correlation between basic density and pilodyn penetration was extremely high. Some trees, however, showed aberrant pilodyn readings.

- A mechanised tree corer (developed by CSIRO) was shown to be effective in taking a large number of non-destructive wood samples from a *E. regnans* progeny trial.

- Preliminary results from Bruce Greaves' PhD project, from a *E. nitens* trial in Gippsland, showed that the correlation between pilodyn penetration and basic density taken at 1.3 m was strong (around 0.90) and heritabilities for both pilodyn and density were very high. On the other hand, genetic correlation with diameter was close to zero. Results from this trial will also provide the first estimates of heritability for Near Infrared Reflectance Analysis (NIRA) and density at different ages.

- Dr Allie Muneri, a wood scientist who recently completed his PhD at Melbourne University, joined the project as a post-doctoral fellow in January 1995. He is working with Carolyn Raymond on the development of appropriate sampling procedures for assessing fibre and pulp properties.

Goals

- Continue the study on patterns of within-tree variation across a range of sites in Australia for Near Infrared Reflectance Analysis, fibre length, basic density and pilodyn penetration. This work will be done in collaboration with the CRC HFPS.

- Determine suitable non-destructive sampling strategies for *E. globulus* and *E. nitens*.

- Determine age-age correlations for NIRA in *E. nitens*.

- Determine the influence of fibre length and basic density on paper properties of cold soda pulps.

Project 3

Leader
Dr R Vaillancourt

Staff
Dr René Vaillancourt
Dr Dorothy Steane
Dr Michèle Sale
Ms Katherine Nesbitt
Mr Steve Ogbourne
Mr Peter Bundock
Mr Matthew Hayden
Mr Timothy Eldridge

Dr Dorothy Steane

Molecular genetics

Objectives

In this project we use molecular marker technology to further our understanding of *Eucalyptus* genetics. Molecular markers are used to study quantitative traits, genome organisation, genetic diversity, phylogeny, breeding systems and to fingerprint clones.

The specific objectives of this project are to:

- develop genomic and chloroplast DNA markers and show their cross species usefulness. This work will lead to a better understanding of the genetic relationship between species and provenances.
- analyse Quantitative Trait Loci (QTL), through genome mapping, to provide knowledge of the inheritance of quantitative traits such as rooting ability, wood properties, growth, and flowering time.
- use molecular markers to study inbreeding depression and heterosis. Both of these phenomena have been shown to significantly affect tree performance in *Eucalyptus* (Project 4).
- attempt to isolate genes involved in the control of vegetative phase change (the change from juvenile to adult leaves) in eucalypts using a technique called differential messenger Ribo Nucleic Acid (mRNA) display.

Outcomes

- PhD student Michèle Sale (PhD awarded 1995) demonstrated the usefulness of DNA markers across many species, by completing a phylogeny of the genus *Eucalyptus* using chloroplast DNA markers (Sale 1995). One important finding was that the genus *Angophora* and members of the subgenera *Corymbia* and *Blakella* form a monophyletic group separate from the other *Eucalyptus* subgenera.
- Katherine Nesbitt, as part of her PhD project, utilised RAPD markers to study the pattern of genetic variation in *E. globulus* ssp. *globulus* across its geographical range (Nesbitt *et al.* 1995). When genetic variation is partitioned into the components: locality, regions and subspecies, more than 75% of the genetic variation in *E. globulus* can be found within locality which is consistent with isozyme studies done in other species.

- The first linkage map ever produced in a *Eucalyptus* interspecific F_2 cross was completed by Timothy Eldridge and René Vaillancourt (Vaillancourt *et al.* 1995). The objective was to study the genetic control of frost resistance in a cross between *E. globulus* x *E. gunnii*. One marker (U63-695) was significantly associated with frost tolerance, branching frequency and leaf morphology. A significant proportion of the variation in frost tolerance (ANOVA R^2=18.5%) was explained by this marker. An interesting outcome of the project was that numerous markers with disturbed segregation were clustered together. We believe that these markers may be linked to deleterious genes exposed by inbreeding.

- No correlation was found between genetic distance, calculated using RAPD markers, and heterosis measured as the specific combining ability for growth rate of *E. globulus* F_1s at two years of age. There was also no correlation between the difference in breeding value between parents and heterosis (Vaillancourt *et al.* in prep.).

- Steve Ogbourne obtained a first class honours working on the technique of mRNA differential display. Numerous differences were found between adult and juvenile leaf forms. In fact so many differences were found that it was concluded that using this technique it would be difficult to clone the switch genes controlling the phase transition, although it would allow the isolation of genes that are differentially expressed.

Goals

- Investigation of the phylogenetic relationships within *Eucalyptus* series *Viminales*. Series *Viminales* includes many of the commercially important species of *Eucalyptus* (e.g. *E. globulus*, *E. nitens*, *E. dunnii*). Restriction site and sequence data from both the nuclear and chloroplast genomes will be analysed within a cladistic framework.

- Analysis of RAPD from *E. globulus* data set for its congruence with morphological and growth data, and completion of a fingerprinting study of clones using full and half sib families.

- Performance of linkage analysis on *E. globulus* using F_1s from a cross between two King Island parents and investigation of the cross for the presence of QTLs controlling growth, flowering time and wood properties (in cooperation with Dr Allie Muneri of Project 2).

- Investigation of the genetic control of rooting ability in two large families of *E. globulus* (in collaboration with North

Eucalypt Technologies). Peter is also extending the mapping project started by Matthew Hayden to include more F_1s.

- Investigation of the genetic basis of the segregation distortion in the F_2 of the cross between *E. gunnii* and *E. globulus* and of inbreeding depression in other *Eucalyptus* species will determine whether advanced generation hybrid breeding should be pursued.

Project 4

Genetic parameters

Leader
Dr Brad Potts

Staff
Dr Brad Potts
Mr Peter Kube
Ms Heidi Dungey
Mr Peter Volker
Mr Paul Chambers
Mr Peter Gore
Mr Rick Hand
Mr Paul Tilyard

Objectives

This project specifically aims to:

- provide fundamental information on quantitative genetic variation and genetic parameters for traits of economic and biological importance in pure species;
- compare the accuracy of genetic parameters and breeding values derived from open-pollinated progenies with those from controlled-pollinated progenies;
- provide the biological and genetic information necessary to assess the role of interspecific hybrids in eucalypt breeding. The CRC has brought together one of the largest ever collections of pedigreed interspecific hybrids of *Eucalyptus*.

Emasculating *E. globulus* flowers prior to controlled pollination to produce a cross between two high quality parents.

Once a controlled pollination has been performed the fruit is bagged to prevent any contamination from low quality pollen.

Outcomes

- Thirteen races of *E. globulus* ssp. *globulus* have been identified based on geographic distribution and the growth responses of 432 open-pollinated families on five sites in Northern Tasmania (Jordan *et al.* 1994). This racial classification has been used in genetic models for estimating genetic parameters (Borralho *et al.* 1995) and breeding values (Jarvis *et al.* 1995), and to provide a framework for *in situ* conservation of the genetic resource (Jordan *et al.* 1995).
- Genetic parameters have been estimated using mixed model methodology for a wide range of traits in *E. globulus*, *E. nitens* and *E. regnans*, including insect damage (Raymond 1994), growth (Potts and Jordan 1994; Borralho *et al.* 1995), survival (Chambers *et al.* 1995), frost resistance (Volker *et al.* 1994), *Mycosphaerella* damage (Dungey *et al.* 1995), flowering time (Gore and Potts 1995), and hardwood cuttings (England and Borralho 1995) and *in vitro* cloning ability (Rasmussen *et al.*

Andrew MacDonald checking seed set after controlled pollination.

1995). Heritabilities were generally low to moderate but indicated sufficient additive genetic variation for selection of most traits.

- Genetic correlations for the growth of open-pollinated families of *E. globulus* in the major planting estates in Australia range from 0.6 to 0.85 for growth (Borralho *et al.* 1995) and 0.16 to 0.92 for survival (Chambers *et al.* 1995). For growth at least, site x genotype interactions did not appear to be sufficiently large to warrant regionalisation of breeding programs.

- A major analysis of genetic parameters for growth in base population trials of *E. nitens* from both Australia and New Zealand has been completed by Peter Kube in collaboration with the Southern Tree Breeding Association (STBA).

- For *E. globulus*, we have shown that genetic parameters for two-year growth estimated from families derived from open-pollinated (OP) seed collected from native stands were poorly associated with more accurate estimates from controlled crossing (Hodge *et al.* 1995; Potts *et al.* 1995). OP heritability estimates were highly inflated, site x genotype interactions underestimated, and parental breeding values poorly correlated with those derived from controlled crossing. Similar conclusions have been reached for later age growth in *E. regnans* (Hardner and Potts 1995).

- In collaboration with the STBA, pilodyn assessments of North Forest Products base population trials of *E. globulus* have been completed.

Rick Hand collecting adult shoots to graft onto seedling root stock.

- A review of eucalypt genetics and genecology has been completed (Potts and Wiltshire 1995)

- Rick Hand has completed a major grafting experiment examining the response of *E. nitens*, *E. globulus* and their F_1 hybrid scions to a variety of *E. globulus* and *E. nitens* stocks. Grafts are being field planted to examine long-term compatibility.

- An advanced generation *E. nitens* x *globulus* hybrid crossing program has been harvested (143 families) and, in collaboration with Peter Naughton of Boral Timber, families are being grown to establish trials on three sites.

- In her PhD project, Heidi Dungey has demonstrated higher insect pest abundance and diversity occurs on natural eucalypt hybrids of *E. risdonii* x *amygdalina* than on the pure species. This pattern has persisted in an experimental trial, suggesting hybrids are more susceptible to a greater range of pests than

pure species (Dungey *et al.* 1994). Greater leaf damage due to *Mycosphaerella* spp. has been observed in juvenile but not adult leaves of *E. nitens* x *globulus* hybrids (Dungey *et al.* 1995). Fungal and insect loads in hybrid trials are currently being analysed.

- In his PhD project, Peter Volker is comparing genetic parameters derived from open-pollinated progenies and controlled crosses of *E. globulus* and *E. nitens* and their hybrid across sites, and addresses strategies for hybrid breeding. Peter has completed the analysis of seedling frost resistance (Volker *et al.* 1994) and is working on the analysis of four-year growth data (Volker 1995).

Goals

- Complete across-site analyses of CSIRO controlled crosses of *E. globulus*, *E. nitens* and their hybrids for four-year growth.
- Complete studies of the genetic control of vegetative and reproductive phase change in *E. globulus* and *E. nitens*.
- Estimate genetic parameters and patterns of variation in pilodyn penetration in the *E. globulus* base population.
- Establish advanced generation *E. nitens* x *globulus* hybrid trials and an arboretum for grandparents.

Sub-program 2 — *Propagation Strategies*

For any benefit to accrue from breeding, the best material must be transferred into operational forestry as quickly as possible, either by seed or by clonal forestry. The latter offers the most rapid means of capturing genetic gains, providing cheap and robust vegetative propagation methodologies are available. Alternatively, management of seed orchards can be improved by anticipating the onset of flowering and increasing the seed crops. Two projects have been established in this sub-program to address these options.

Project 5

Leader
Mr V Hartney

Staff
Mr Vic Hartney
Dr Jean-Noël Ruaud
Mr Jens Svenssen
Ms Sue Headley


Dr Jean-Noël Ruaud

Vegetative propagation of selected genotypes

Objectives

Vegetative propagation of elite genotypes enables managers to plant superior trees in their plantations sooner than by using seedlings. To do this robust and reliable techniques must be developed that enable the production of large numbers of clones.

Research in this project is concentrating on developing cheap and robust techniques of vegetative propagation by micropropagation and by micro-cuttings, and on developing cheaper alternatives such as somatic embryogenesis.

The project has two primary objectives:

- to test an Improved Micropropagation Procedure (IMP)
  IMP which is proprietary intellectual property of CSIRO, is being evaluated by North Eucalypt Technologies at Ridgley. Joint experiments in laboratories at Hobart and Ridgley will compare IMP to conventional micropropagation and modify IMP for commercial development. Selected genotypes of *E. nitens* and *E. globulus* from other industry partners will be evaluated under commercial conditions after these joint experiments are completed.

- to develop somatic embryogenesis in temperate eucalypts
  Somatic embryogenesis is the production of embryo-like propagules from vegetative tissues. If somatic embryos can be produced from vegetative tissues in simple liquid media with the minimum of handling then this will enable clones of temperate eucalypts to be produced cheaper than alternative techniques of vegetative propagation.

Outcomes

- IMP has been shown to be superior to conventional micropropagation and is now routinely used for the maintenance of all clones of temperate eucalypts in the Hobart laboratory.

- IMP has proved beneficial in the micropropagation of several families of *E. nitens* in the laboratory of North Eucalypt Technologies.

- Modifications to IMP in the basal medium and container design have improved shoot health, growth and subsequent rooting.

- Theoretical studies have shown that vegetative propagation of superior control pollinated families (family multiplication) is unlikely to be a viable economic option for temperate eucalypts. The current techniques of vegetative propagation are too expensive and gains at the family level can be readily achieved through clonal seed orchards.

- Somatic embryos up to the globular stage were produced in a liquid medium from one family of *E. nitens* but development beyond the globular stage has only occurred in isolated cases. Research is concentrating on the initiation of somatic embryos and the further development of globular somatic embryos into plants.

Goals

- To develop cheap and robust methods of micropropagation and somatic embryogenesis for temperate eucalypts aimed at commercial production of clones from outstanding individual trees (gains at the clonal level).

- Determine the level of genetic and phenotypic variation in propagules derived from somatic embryos.

- Transfer technology for vegetative propagation to laboratories of industry partners and to commercial tissue culture laboratories (under licence).

Project 6

Breeding systems and development

Leader
Prof J Reid

Staff
Prof Jim Reid
Dr Brad Potts
Mr Mike Moncur
Dr Omar Hasan
Mr Craig Hardner
Ms Alexandra Mitchell
Ms Ria Matysek
Mr Peter Gore

Objectives

The project is conducting work in three areas.

- It aims to gain an understanding of the control of flowering in *E. globulus* and *E. nitens*, particularly in relation to hormonal signalling and its role in promoting flowering and the effects of environmental and seasonal factors. This knowledge will be utilised in the optimisation of chemical and environmental regimes which will be capable of inducing early flowering in seedling material, and increased flowering and hence seed production in seedling or grafted seed orchards.

- The hormone analysis techniques developed for the first aim will be used to determine the roles of hormones in the control of the meristematic activity of the vascular cambium. This may allow us to gain an understanding of the control of fibre production.

Ria Matysek preparing to load a sample of gibberellins on to a High Performance Liquid Chromatograph for purification.

- Work on inbreeding will focus on the factors affecting the population consequences of non-random mating. The aim is to determine factors affecting the breeding system and how inbreeding in open-pollinated seed lots may affect the estimation of genetic parameters, the prediction and capture of genetic gain, and the management of breeding populations.

Outcomes

- Paclobutrazol application to young plantation trees resulted in substantially reduced levels of the precursors of GA_1 such as GA_{19} and GA_{20}. However, GA_1 levels were not dramatically affected even after six months, indicating a strong homeostasis in GA_1 levels. This is presumably controlled by a feedback system similar to those identified in herbaceous dicots.

- In collaboration with the CRC for Hardwood Fibre and Paper Science, wood from paclobutrazol-treated *E. nitens* trees was found to differ from equivalent non-treated material, with a higher proportion of vessels present in the former. Average fibre lengths in paclobutrazol-treated wood were also generally found to be greater.

- A tentative pathway for paclobutrazol catabolism has been formulated and microorganisms capable of metabolising paclobutrazol have been isolated from soils and identified to genus level.

- Studies of selfed, outcrossed and open-pollinated (OP) progenies of *E. regnans* over a 15-year period have shown that failure to account for the differentially higher mortality of inbreds will underestimate inbreeding depression. In addition, heritability of OP families was inflated at three and four years but declined with age to converge with an increasing heritability estimated from outcrosses. This may be due to intensified competition. However, the correlation between OP parental effects and breeding values were only significant up to four years. The results suggest that cautious use should be made of OP families in eucalypt tree breeding programs, particularly after the start of competition.

- Fourteen thousand seedlings have been grown for the establishment of trials to determine the effect of (i) inbreeding effects at different levels of coancestry, (ii) the relationship between breeding value, open pollinated family and self performance, and (iii) the inheritance of self infertility. The seed was collected in late 1994 and a field trial will be established in mid 1995 on at least two different sites for each experiment.

Goals

- Determine the effectiveness of alternative growth retardants on flowering in order to find less persistent methods of controlling flowering than offered by paclobutrazol and to determine if promotion of flowering is solely a result of reduced growth.
- Consolidate the data so far obtained on the levels of hormones in the cambial region of *E. nitens* by using inhibitors of gibberellin biosynthesis to reduce endogenous gibberellin levels and investigate the direct effects on fibre attributes.
- Determine changes in hormone levels associated with flower initiation and other developmental processes associated with changing environmental factors by examining seasonal changes in the hormonal status of apical leaf tissue.
- Determine the seasonal patterns of flowering phenology in *E. globulus*.
- Determine the influence of stand structure on outcrossing rate using isozyme markers.
- Assess the effect of proximity dependent crossing on the growth of two- to four-year-old *E. globulus* seedlings.
- Determine the importance and dynamics of post-dispersal selection against inbred progeny in *E. regnans*.
- Determine allozyme variation and outcrossing rate in natural populations of *E. globulus*.
- Examine factors affecting the breeding system of *E. globulus* and determine the impact of variation in the breeding system on progeny performance.

Soil and Stand Management Program

Program Manager
Mr R Cromer

Objectives

The aims of this program are to enhance the yield and quality of wood and fibre from hardwood plantations and forests through silvicultural strategies that are economically and environmentally sustainable. To fulfil these objectives, the research program has three main thrusts:

- define the physiological processes which control the uptake and loss of carbon (through photosynthesis and respiration) and uptake and loss of water through the transpiration stream;

- develop an understanding of nutrient uptake through the soil-root interface including the accumulation and cycling of nutrients and carbon through organic matter;

- develop process-based simulation models which integrate our understanding of these processes and enable prediction of alternative strategies for plantation location or silvicultural treatments.

The four projects of the program address these three research areas in the context of sustainable productivity and improving the international competitiveness of Australian forest industries.

Major achievements

- Photosynthesis in *E. nitens* is reduced for one to two days following night-time frosts that do not cause visible cell damage. This has implications for productivity of plantations located at high elevations.

- Photosynthesis of remaining foliage increases substantially following pruning of *E. nitens* trees to more than 50% of crown height. Further growth reduction arising from pruning is less severe than expected based on leaf area loss. This supports the concept of pruning *E. nitens* in plantations to produce hardwood timber free of knots.

- A model of canopy conductance has been developed for irrigated *E. globulus* and *E. nitens* plantations which explains 70% of observed variation.

- A strong allometric relationship between biomass of coarse roots and stem volume was observed in one to two-year-old *E. nitens*.

- Site cultivation before planting initially favoured rooting density, but after two years, rooting densities within and outside zones of cultivation were similar.

- Improved methods have been developed to determine organic matter content and concentrations of nutrients in soil solution that enhance our ability to identify and ameliorate sites of low fertility.

- A new and substantially simpler model system has been developed to predict annual canopy photosynthetic production

in relation to nutrient status and temperature. A technique has also been developed to couple this model to a soil water balance model.

- Important links were established with other research groups in nitrogen nutrition during a workshop held on 19 June 1995 in which results from current research on nitrogen mineralisation in forests were presented to our industry partners.

Project 1

Plant production and water use

Leader
Dr C Beadle

Staff
Dr Chris Beadle
Dr Neil Davidson
Dr Mike Battaglia
Mr Don White
Mr Mark Hunt
Ms Libby Pinkard
Ms Michele Richter
Ms Joanne Dingle
Ms Maria Cherry

Objectives

This project investigates the photosynthetic and water-use characteristics of temperate eucalypts used in hardwood forestry, particularly *E. globulus* and *E. nitens*. Photosynthesis and water-use are being studied in relation to nutrient and water availability, temperature, light intensity, leaf area index and canopy development, pruning strategy, and competition, in stands managed for pulpwood, sawn timber and veneer.

Outcomes

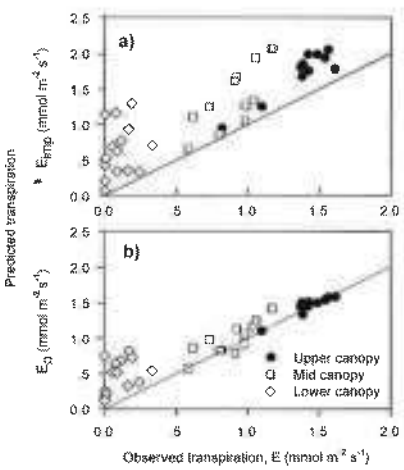
- Studies on chilling injury conducted in high altitude plantations of *E. nitens* showed night-time frosts of -5 to -7.5°C reduce photosynthesis the following day by 15-20% and may reduce annual productivity of these stands by 1-7%. Further, the chilling injury to *E. nitens* appeared to be caused by frost alone and did not require the additional stress of high light intensities (Davidson *et al.* 1995).

- In his PhD project Don White has developed a model which explains 70% of the observed variation in stomatal conductance (g_S) of leaves from the upper crowns of irrigated *E. globulus* and *E. nitens*. The model is driven by solar radiation (Q), air temperature (T) and vapour pressure deficit of the air (D).

- Studies conducted by Don White on three canopy layers (lower, middle and upper) have also shown that, under some circumstances, the canopy conductance (and transpiration) of *E. globulus* may be weakly coupled to the prevailing atmospheric conditions (Fig. 1), such that beneath the canopy of a plantation the air can be quite humid, even on days of low atmospheric humidity.

- PhD student Mark Hunt is investigating the competition between *E. nitens* and *Acacia dealbata* in plantations in north-eastern

Fig. 1 Predicted versus observed transpiration for the upper, middle and lower third of the canopy of *E. globulus*, a) assuming perfect coupling and b) taking account of decoupling (ie different humidity environments within the canopy).



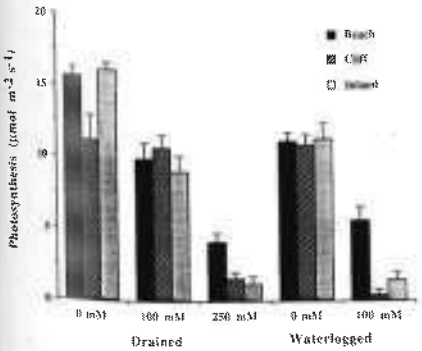
Libby Pinkard (at right) and Sonja Hedenstroem preparing leaves and branches from pruned and unpruned *E. nitens* for biomass analysis.

Tasmania where it is thought the presence of *A. dealbata* is reducing the productivity of plantations. Measurements of the transpiration rates and water potentials during the unusually dry 1994/95 summer demonstrated that the minor water deficits developed in five- to six-year-old plantations were not sufficient to explain the observed effects on growth.

- Libby Pinkard in her PhD project demonstrated that pruning trees to 50-70% of green crown height caused a significant increase in photosynthetic rate in the remaining foliage. The increase in photosynthetic rates started to become evident approximately six weeks after pruning in the oldest remaining leaves in each tree (Pinkard *et al.* 1995). The effect then progressively became greater and spread throughout the crown in the period 6-12 months after pruning. A similar effect was produced over a much shorter time frame by pruning potted seedlings. The reduction in tree growth was less than might be expected based on the removal of leaf area, and only in the 70% trees were growth rates significantly lower than controls.

- Honours student Joanne Dingle showed that the salt tolerance of *E. globulus* families was related to the site origin of their seed. Coastal beach-side populations of *E. globulus* were more salt tolerant than coastal cliff-top populations which, in turn, were more salt tolerant than inland populations. The effects were large and significant for maximum rate of photosynthesis (Fig. 2) but non-significant for height growth and biomass.

Fig. 2 Photosynthetic rates of *E. globulus* families from three site types; coastal beach, coastal cliff top, and inland after four weeks of exposure to one of three levels of salinity (0, 100 and 250 mM NaCl) and two levels of waterlogging (drained and waterlogged).



Goals

- Investigate the long-term effects of chilling injury on the productivity of *E. nitens*. A frost chamber study will be conducted to test whether chilling injury affects the carbon allocation within trees, which in turn may influence the capacity of trees to grow rapidly in the following spring.

- Identify physiological characters in *E. globulus* families that are indicative of drought resistance and can be used to screen planting stock destined for drought-prone sites in collaboration with Bunnings Treefarms, and in a more general study, investigate the mechanisms of drought tolerance in eucalypts (a PhD project just commenced by Michele Richter).

- Incorporate water stress as a function in a canopy conductance model, then use the canopy conductance model to simulate transpiration in irrigated and water-limited *E. globulus* and *E. nitens* plantations.

- Continue the investigation of the competition between *E. nitens* and *A. dealbata* in plantations by concentrating on growth, biomass partitioning and competition for light. Commence research on other aspects of weed competition with plantation eucalypts (in collaboration with Project 2).

- Identify the mechanism determining photosynthetic responses to pruning, starting with an investigation of foliar starch concentrations and the amount of starch stored in stems and roots.

Project 2

Dynamics of carbon and nutrients

Leader
Mr R Cromer

Staff

Mr Robin Cromer
Mr Charles Turnbull
Dr Rabi Misra
Ms Ann LaSala
Mrs Linda Ballard
Mr Andrew Gibbons
Ms Joanne Dingle

Objectives

The aims of this project are to:

- tinvestigate 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.

A major function of this project has also been to establish and maintain a set of nutrition experiments that provide field research sites for several projects. Five fertiliser experiments have been established on representative but contrasting sites (in soils and climate), in collaboration with Australian Newsprint Mills (ANM), North Forest Products (NFP) and Boral Timber (BT).

Outcomes

- Major differences in accumulated biomass were evident between the three sites after 21 months. Tree growth was most rapid at Westfield (ANM, 430 m elevation), slowest at Middlesex (NFP, 600 m elevation) and intermediate at Nabowla (BT, 100-240 m elevation). Growth increased with increasing rate of applied fertiliser on the duplex soils at Nabowla (*E. globulus*) but there was no response in *E. nitens* on the other soil types (Fig. 3; Cromer *et al.* 1995).

- Concentrations of N and P in the foliage of trees that did not receive fertiliser differed significantly among sites at 21 months. Highest concentrations were at Middlesex, followed by Westfield

Fig. 3 Total above-ground biomass produced at 21 months over three sites. Fertiliser treatments were (N:P, kg ha-1):
T1 = 0:0
T3 = 150:75
T5 = 600:300

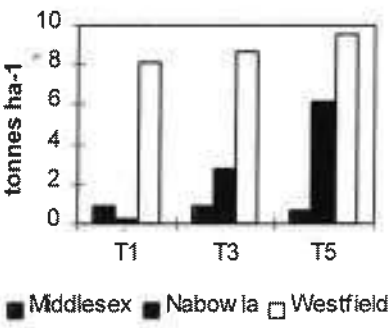


Fig. 4 Concentrations of a) Nitrogen and Phosphorus in foliage of trees at three sites (without fertiliser treatment).

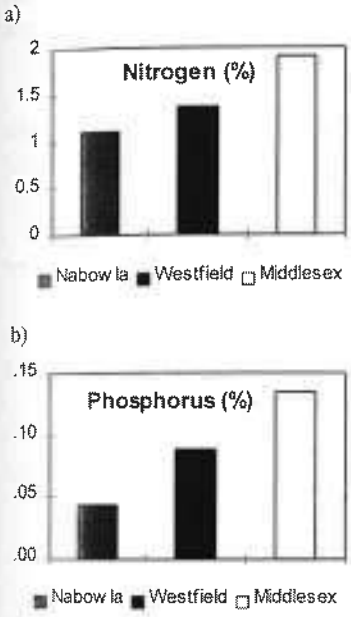
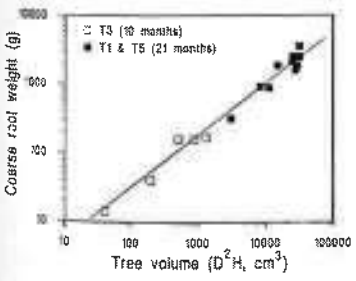


Fig. 5 Relationship between tree volume and mass of coarse roots (> 3 mm) for *E. nitens* at Westfield (D = diameter at 15 cm, H = tree height)



(at both these sites no fertiliser response occurred), with lowest concentrations at Nabowla where substantial responses occurred (Figs. 4a and 4b). Fertiliser treatment increased nutrient concentrations in some above-ground biomass components, particularly P in foliage at Nabowla and to a lesser extent at Westfield.

- There was no consistent effect of increased rates of applied fertiliser on the mass density of roots at 10 or 21 months (Westfield).

- Estimation of total root biomass per unit ground surface area is difficult and prone to error when spatial variation in root distribution is significant. In this study, spatial variation in distribution of roots was high (concentrated along cultivation lines) at 10 months but not significant at 21 months, which initially led to an over-estimate of root biomass of single trees (published in the previous annual report).

- A strong allometric relationship was found between coarse root biomass and stem volume that was independent of age and fertiliser treatment at Westfield (Fig. 5) which will improve estimation of coarse roots without the need for extensive harvesting of roots.

- Potential sources of error in determining nutrient status of *E. nitens* roots due to processing and storage have been identified and improved procedures introduced (Misra 1994). Concentrations of N and P in roots at 21 months increased with increasing amounts of fertiliser.

Goals

- Compare biomass accumulation in above-ground components of trees at the three experimental sites, during the first three years after planting.

- Analyse nutrients from third year of sampling and evaluate differences in rate of nutrient accumulation and allocation over fertiliser treatments and sites.

- Compare accumulation of biomass and nutrients in roots of *E. nitens* across several nutrient treatments at one experimental site for the first three years after planting.

- Evaluate effect of fertiliser treatments on tree form of *E. nitens*.

Project 3

Leader
Dr P Smethurst

Staff

Dr Philip Smethurst
Dr Rabi Misra
Dr Wendy Wang
Mr Trevor Garnett
Mr Daniel Mendham
Ms Paulina Teixeira
Mr Andrew Herbert
Mrs Linda Ballard
Mr Andrew Gibbons

Dr Wendy Wang sieving air dried soil prior to analysis for N mineralisation.

Nutrient supply and acquisition

Objectives

The goals of the project are to:

- determine characteristics of nutrient supply and acquisition, particularly for nitrogen (N) and phosphorus (P), that will provide opportunities to improve the nutritional management and productivity of hardwood plantations;
- determine temporal variation in the availability of N and P from soils under fertiliser treatments at several sites and to relate these to tree growth and nutrient uptake;
- characterise rooting density to permit prediction of nutrient uptake;
- determine the response of eucalypt roots to soil strength and the ameliorative effect of cultivation;
- study loss of soil and nutrients through erosion results from the impact of rain and runoff.

Outcomes

- A paste method has been developed to estimate concentrations of nutrients in soil solution in all soils, even where soil water content is too low to enable extraction by traditional methods.
- The simple method of loss-on-ignition was shown to be a good method for measurement of organic carbon in soils when compared with more accurate, but less convenient, methods for a range of eucalypt plantation soils.
- Concentrations of nutrients measured at root surfaces agreed with conventional measures of fertility at two field sites (Table 1; Cromer *et al.* 1995). Dual measures of fertility of this type improves our ability to identify and ameliorate low fertility sites.
- Basalt soils which previously supported native forest, either open *E. delegatensis* forest or closed, mixed eucalypt-myrtle forest, were found to have intermediate potential for N mineralisation between pasture sites (highest) and those which previously supported *Pinus radiata* (lowest). These differences were unrelated to concentrations of organic matter, but rather to concentrations of total N and C:N ratio. Hence, there may be scope for tailoring N management strategies to broad classes of previous vegetation.

	Westfield	Nabowla
Common Soil Indicators		
Parent Material	Siltstone	Sandstone
pH(1:5 soil:water)	5.0	5.2
EC (dS m^{-1})	0.08	0.04
$C_{W\&B}$ (mg g^{-1})	60	17
Total N (mg g^{-1})	5.5	0.8
C:N ratio	10	22
Available P_{Bray2} (g g^{-1})	44	2
P buffer power	1700	200
Concentrations at Root Surface		
NH_4 (mM)	0.49	0.19
NO_3 (mM)	4.33	0.002
PO_4 (M)	0.5	0.02
Trees Heights @ 21 Months (m)		
Control	3.2	1.1
Fertilized	3.5	3.5

Table 1. Traditional and root surface indicators of N and P fertility in relation to tree growth to combined NP fertilization.

Key to abbreviations

pH	pH of a 1.5 soil:water suspension
Ec	electrical conductivity of a 1:5 soil:water suspension
C	Carbon concentration by Wilkley and Black Method
Total N	Total nitrogen concentration by acid digestion
C:N	ratio of carbon to nitrogen
P	Phosphorous concentration by Bray and Kurtz No 2 method (acidified flouride extraction)
ammonium	
P buffer power	by 17 hour equilibration

Fig. 6 Variations in the lengths of the primary roots including the lateral axes with variation in soil strength (penetrometer resistance) for 17-day old *E. nitens* seedlings.

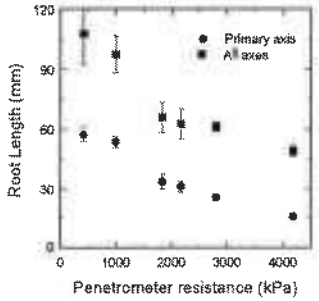
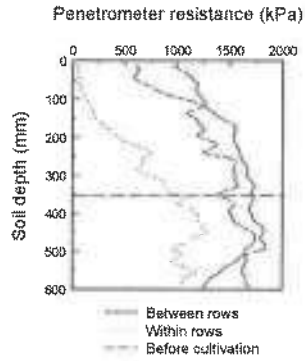


Fig. 7 Spatial distribution of soil strength (penetrometer resistance) at an eucalypt plantation site (near Dover) 4 weeks before cultivation, and within and between rows after cultivation.



Cultivation favoured early root growth, but after two years, rooting densities within and outside the zone of cultivation were similar. Two years after planting, fine root density in surface soil (0-10 cm) was considerably higher than in *P. radiata* plantations of comparable age (1.8 compared with 0.08 cm^{-3}).

- An analysis of published data indicated that the critical value of bulk density for root growth is 1.1-1.2 Mg m^{-3} and that of penetrometer resistance is 2-3 MPa for soils with >60% clay. Although laboratory studies on root growth of *E. nitens* seedlings showed a reduction of about 75% in the length of the primary root axis with an increase in penetrometer resistance from 0.5 to 4 MPa, root growth continued in soils of high strength (Fig. 6).

- At a plantation site near Dover, differences in soil strength (penetrometer resistance) in cultivated (within rows) and uncultivated (between rows) sites were significant within the top 350 mm of the soil (Fig. 7).

- A portable rainfall simulator has been tested in the field and equipment to study erosion has been developed.

Goals

- Continue detailed investigations of soil solutions as indicators of nutrient availability (a project to be conducted under an Australian Postgraduate Award - Industry, in collaboration with University of Tasmania and North Eucalypt Technologies).

- Complete measurements of N mineralisation at four sites, which will define the seasonality and annual rates of N supply in relation to tree requirements.

- Evaluate the accuracy of available models for predicting N mineralisation, in collaboration with CSIRO Division of Forestry.

- Initiate a study on N mineralisation in basalt soils (a project to be conducted under an Australian Postgraduate Award - Industry in collaboration with University of Tasmania and North Eucalypt Technologies).

- Initiate a study on the mechanisms of competition between weeds and trees under a grant from Land and Water Resources Research and Development Corporation in collaboration with the University of Tasmania and a consortium of forest industries.

- Determine fine and coarse root growth in response to combined N and P application in three-year-old trees at the Westfield site.
- Examine root growth of *E. nitens* in response to different soil strengths in the presence and absence of channels provided by decomposing roots.
- Quantify changes in soil strength and root growth with age of plantation.
- Continue studies of erosion processes in the PhD program of Paulina Teixeira.

Project 4

Modelling plantation systems

Leader
Dr P Sands

Staff
Dr Peter Sands
Ms Susan Lennon
Ms Sarah Wall

Objectives

This project aims to integrate the work of other projects into models which describe plantation growth. The models produced will provide industry with tools to predict forest wood yields under a variety of management regimes and environmental circumstances.

Outcomes

- A simple model has been developed for estimating daily canopy photosynthesis from standard daily meteorological data and parameters characterising the single-leaf light response curve (Sands 1995a, 1995b).
- A technique for coupling the canopy production model to a soil water balance model has been developed which will allow effects of soil-water status on photosynthesis to be taken into account.
- S-system models are well suited where processes in a system are poorly understood or their mechanisms unknown. The use of S-system models is being explored in a forestry context (Voit and Sands 1995a, 1995b) and a technique which uses the particular structure of an S-system to facilitate the estimation of the parameters in S-system models has been developed.
- Measurement of elasticity in a 70-year-old eucalypt stem suggests sapwood elasticity is independent of height, but heartwood elasticity varies with both height and physiological age of the heartwood.

- A review of current models of cambial activity in conifers and the possible generalisation of these to eucalypts has been conducted (Sands 1995c).

Goals

- Validate the coupling of the canopy production model to a soil-water balance model using data collected from a local experimental site (in collaboration with Project 1).
- Apply the canopy production model in conjunction with a Tasmanian meteorological database to predict potential production at a wide range of sites.
- Include nutrient cycling in a simple S-system model of forest growth.
- Investigate the biomechanics of the stems of living trees (e.g. the variation of elasticity within the stem of a living tree and the relationship of elasticity to other wood properties) in a PhD project commenced by Sarah Wall.
- Model cambial activity and pulp wood quality. The properties of paper are largely the result of the geometrical and mechanical properties of wood fibres formed as the result of cambial activity and xylem formation. The project will investigate the cambial activity in a PhD project commenced by Susan Lennon.

Resource Protection Program

Program Manager
Dr J Madden

Objectives

The Resource Protection Program endeavours to increase the understanding and knowledge of existing and potential pests of hardwood forest trees; their biology, behaviour, ecology and potential impact on the viability of plantation and natural hardwood forests.

A review of progress over the first three years of the CRC has provided new insights into old problems and new directions for future research.

Chrysophtharta bimaculata on an *E. regnans* leaf.

Major achievements

- Aerial spraying trials have demonstrated the range of droplet size, dispersion characteristics and application rate of undiluted *Bacillus thuringiensis* var. *tenebrionis* formulations that will kill 95% of early stage *Chrysophtharta bimaculata* larvae.

- For three successive years specific and heavy attack by *C. bimaculata* occurred in two small blocks of *E. regnans* that were located adjacent to a *E. nitens* plantation. It is considered that the two *E. regnans* plots successfully diverted beetle attack from the *E. nitens* which carried little damage. Collectively, *E. regnans* trees represented only 1.6% of the total number of trees.

- Susceptibility to attack by *C. bimaculata* was shown to be under strong genetic control with heritabilities of 0.3 and 0.4 for *E. regnans* and *E. nitens*, respectively.

- Predator species have been aggregated in large numbers in areas in which the foliage of trees (*E. regnans*) has been sprayed with sugar solutions or raw sugar provided in weather-proof feeding stations. Surveys to record the incidence of predators feeding on flowering or insect-infested native shrubs have been conducted and various diets assessed.

- The vertebrate browsing project within the program has been strengthened with the appointment of Dr Clare McArthur (post-doctoral fellow) as leader of the project. Further, Dr Michael Statham of the DPIF has been appointed Honorary Research Associate to the program. He has considerable experience in a wide range of options for control/exclusion of vertebrate browsers.

Project 1

Leader
Dr J Madden

Staff
Dr John Madden
Dr Anthony Clarke
Mr Bradley Howlett
Mr Mark Van den Berg
Mr Stephen Paterson

Leaf and tree factors influencing host location and attack by insects

Objectives

This project aims to identify tree and environmental factors that influence:

(i) host tree selection, feeding and oviposition behaviour of adult *C. bimaculata*; and

(ii) survival and growth rates of *C. bimaculata* larvae.

By understanding the physical and chemical characteristics of eucalypts which influence tree selection and acceptance by leaf-beetles, we increase our understanding of the role of these qualities in affecting tree susceptibility or resistance to insect attack and so

may be able to identify specific resistance mechanisms. It is then possible to use this information to evaluate the potential of developing non-preferred or resistant trees for commercial use.

Outcomes

- In eucalypts, leaf oil characteristics are affected by genotype, leaf development and site. Qualitative variation in oils between tree species and hybrids has been shown to be determined by genotype, whereas variation in the quantity of oil was influenced by season, leaf age and site (Li *et al.* 1994; Li and Madden 1995).

- Susceptibility to defoliation by *C. bimaculata* was shown to be under moderate to strong genetic control in *E. regnans* and *E. nitens* (h^2 of 0.3 and 0.4 respectively). For *E. regnans* families, levels of defoliation were repeatable across sites and years (Raymond 1995).

- Specific attack on two small blocks of *E. regnans* on the perimeter of a large stand of *E. nitens* was recorded for the three successive seasons. *E. regnans* made up only 1.25% of the total number of trees. This preferential attack is being tested experimentally and could be deployed as a practical form of control and/or monitoring system within *E. nitens* plantations (Madden *et al.* 1994).

Goals

- Focus research attention on documenting the seasonal phenology of tree growth, leaf colour change and insect attack.

- Increase research aimed at determining the optimum tree species and planting configuration for the development of commercially acceptable trap-tree trials.

- Assess the survival and dispersal behaviour of first stage *C. bimaculata* larvae.

Project 2

Leaders
Dr A Clarke
Dr H Elliott
Dr J Madden
Dr J Elek

Staff
Dr Anthony Clarke
Dr John Madden
Dr Humphrey Elliott
Dr Jane Elek
Mr Steven Candy
Mr Alastair Hunt
Ms Sue Baker
Mr Vin Patel
Ms Nita Ramsden
Mr Mark Van den Berg

Control of insect defoliators

Objectives

The objective of this project is to refine the Integrated Pest Management (IPM) strategy currently used to monitor and protect Tasmania's forest plantations from defoliation by leaf beetles. The main research directions are to:

- assess the impact of populations of leaf beetles, *C. bimaculata*, on growth of *E. nitens* and *E. regnans* so that an economic injury level can be determined and thus an economic basis for applying control measures can be established;
- evaluate the most effective and environmentally acceptable methods for controlling leaf beetles;
- increase our understanding of the biology and behaviour of *C. bimaculata* and its natural enemies.

Outcomes

- After six years of an insect exclusion experiment, *E. regnans* trees regularly defoliated by insects grew more slowly than protected trees. As a result, the average diameter (DBHOB) of defoliated trees was 9 cm compared to 14 cm for controls, and height of defoliated trees was 10 m compared to 13 m for protected trees (Candy *et al.* 1994; Elek *et al.* 1995).
- A laboratory study on the feeding efficiencies of *C. bimaculata* larvae on *E. nitens* and *E. regnans* was completed and analysis started. Preliminary results suggest that *C. bimaculata* feed more efficiently on *E. nitens*.
- Aerial spray trials successfully delivered the ranges of droplet sizes and densities of undiluted *Bacillus thuringiensis* var. *tenebrionis* (*Btt*) that were recommended from wind tunnel tests. *Btt* sprayed in the field at four l/ha killed 81%, six l/ha killed 83% and 12 l/ha killed 95% of eggs and first and second instar *C. bimaculata* larvae. In laboratory tests, four l/ha *Btt* killed 98% of first, 24% of second but only 10% of third instar larvae, while 12 l/ha killed 97% of first, 34% of second and 21% of third instar larvae.
- In laboratory trials, *Btt* was shown to be non-toxic to two lady-bird predators of *C. bimaculata*, but adversely affected longevity of a third predator, *Chauliognathus lugubris* (Greener and Candy 1994, 1995).

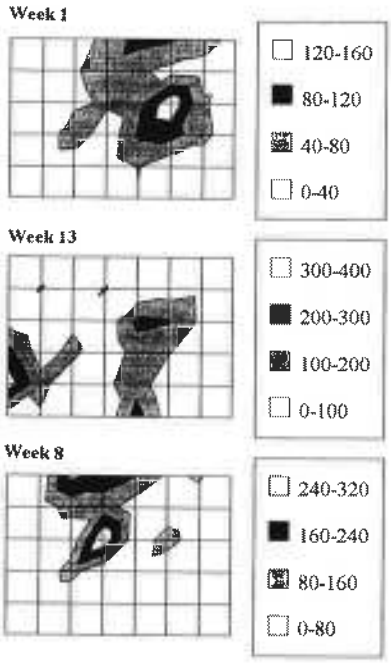


Fig. 8 Trap Catch
Spatial patterns of beetle abundance in a 12 ha forest coupe as measured using a 50m grid of yellow sticky traps.

- The availability of alternative food sources (i.e. psyllids, sucrose sprays) have been implicated in the localised increase in predatory insect numbers (Mensah and Madden 1994). The importance of such food resources in the population dynamics of *C. bimaculata* predators is a focus of continued investigation.

- The spatial and temporal patchiness of *C. bimaculata* adult populations has been quantified. Adult populations of the beetle appear to occur commonly in locally dense aggregations and are highly mobile (Fig 8; Clarke *et al.* 1995a,b).

- *E. regnans* and *E. delegatensis*, species that are more attractive to leaf beetles than *E. nitens*, have been interplanted as trap trees to test whether they will reduce the level of defoliation of *E. nitens*. The trees are still too young to assess, but preliminary observations at Gould's Block, near Dover, suggests that this may be an effective control method (Madden *et al.* 1994).

- The implications of genetic variation in natural enemies and its role in biological control have been reviewed (Clarke and Walter 1995).

- A short critique on the difficulties, rather than benefits, associated with running an IPM program in forestry has been published (Clarke 1995).

Goals

- Continue the *E. regnans* insect exclusion trial and establish a similar trial for *E. nitens* to determine the longer-term effects of insect defoliation.

- Complete artificial defoliation trials designed to relate level of defoliation to growth rate.

- Continue monitoring growth and form of thinned and pruned trees to determine importance of insect attack in various silviculture regimes.

- Incorporate field data into a growth model to estimate the economic injury level and the threshold levels of leaf beetle populations that determine the need to instigate control in the IPM strategy.

- Determine the optimum sampling scheme for estimating threshold levels of leaf beetles and so refine the monitoring system used in the IPM strategy.

Dr Clare McArthur

- To improve the efficacy of *Btt*, refine testing methods and timing of application, and monitor *Btt*'s degree of control for different field-densities of leaf beetles and predator populations.
- In laboratory tests, assessi the dose-response of different age larvae and determine the minimum droplet size that will deliver a lethal dose.
- Continue research on the potential for using silviculture (trap-trees, thinning, pruning) and other control methods, such as pathogenic nematodes or fungi, or enhanced population levels of natural predators, to reduce the impact of leaf beetles on *E. nitens* growth.

Project 3

Vertebrate browsing in eucalypt plantations

Leader
Dr C McArthur

Staff
Dr Clare McArthur
Mr James Bulinski
Ms Nadia Marsh
Ms Kathryn Patterson

Objectives

This project aims to:

- develop a risk assessment model for predicting damage to plantations by vertebrate browsers using broad-scale plantation and surrounding habitat characteristics. This will assist in decision-making for planting and protection of new sites;
- determine the feeding preference of pademelons (*Thylogale billardierii*) for common forestry *Eucalyptus* species and between provenances of *E. nitens*;
- determine the consumption of *Eucalyptus* seedlings in mixed diets of pademelons and brushtail possums (*Trichorus vulpecula*);
- assess the attraction of plantations as feeding areas by comparing the animal use of plantations with that of the surrounding habitat;
- determine the importance of *Eucalyptus* seedlings in the diet of pademelons and Bennett's wallabies so damage can be apportioned between the two browsing species.

Outcomes

- Assessments are being made of habitat, vegetation type and wallaby density and the damage inflicted by browsing at 20 sites for use in a risk assessment model. Early results suggest a

Brushtail possum

correllation exists between the density of pademelom and wallaby and degree of damage.

- Captive feeding trials conducted on pademelons to determine feeding preference between *Eucalyptus* species are complete and indicate a trend towards preference for *Monocalyptus* species (*E. delegatensis* and *E. regnans*) rather then *Symphyomyrtus* species (*E. globulus* and *E. nitens*).

- 110,000 seedlings of five provenances of *E. nitens* have been raised and planted in two 50 ha plantations; and damage assessment, vertebrate browser numbers and vegetation surveys have begun. Preliminary results show higher damage levels in one particular provenance.

Goals

- Increase sample size of sites for improving the risk assessment model.

- Continue comparison of damage to *E. nitens* provenances.

- Continue field trial of damage to *E. nitens* provenances in plantations.

- Commence studies on the effect of various mixed-species diets on damge to *Eucalyptus* seedlings by browsers.

- Commence radio-tracking study to determine utilisation of plantations by wallabies.

Project 4

Leaders
Dr A Clarke
Dr H Elliott

Staff
Dr Anthony Clarke
Dr Humphrey Elliott
Mr Martin Steinbauer
Mr Zoltan Lukacs

Biology of other insect pests of eucalypts

Objectives

This project aims to gain an understanding of the biology of insects other than *Chrysophtharta spp.* which are current or potential pests of native hardwood species.

The two insect groups currently under investigation are the coreid bugs (*Amorbus* and *Gelonus* species) (Hemiptera: Coreidae) and the autumn gum moth (*Mnesampela privata*) (Lepidoptera: Geometridae). Coreids are 'sucking' insects which attack the growing tips of their eucalypt hosts, causing tip-wilt, and in severe cases, 'shrubbing' of the tree. *M. privata*, in contrast, is a defoliating insect, with the larvae preferentially feeding on the glaucous juvenile foliage of eucalypts of the blue gum group.

Martin Steinbauer holds a sap-sucking coreid bug.

Information from this project will be used to:

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

Outcomes

- The taxonomy of the Tasmanian coreids has been clarified. It is now thought that in Tasmania the genus *Amorbus* contains only one species (*A. obscuricornis*), not three as previously considered.
- *Acantholybas kirkaldyi*, a Tasmanian coreid previously known only from the type description, has been recollected. A taxonomic revision has been carried out for this genus.
- A range of *Eucalyptus* species has been tested in no-choice tests to determine their value as adult and nymphal hosts of *Amorbus* and *Gelonus*. Some of the best host-plant species for *Amorbus* among the commercial *Eucalyptus* species are: *E. obliqua, E. nitens, E. globulus* and *E. delegatensis*. Based on feeding damage and host range, *A. obscuricornis* is considered the only coreid likely to cause serious damage to plantations.
- Baseline biological data have been gathered for coreids, including growth rates at constant temperature, female fecundity and seasonal population phenology. These indicate that only under exceptional circumstances could coreids become a major destructive pest.
- A previously unrecorded natural enemy of Australian coreids, *Xenoencyrtus hemipterous* (Girault), has been identified (Steinbauer and Clarke 1995). This egg parasitoid contaminated experimental cultures, but appeared to be rare in the field.
- The chemical constituents of the defensive secretions of Tasmanian coreids have been identified and the quantitative and qualitative differences between and within species recorded (Steinbauer and Davies 1995).
- The spatial dynamics of a severe *M. privata* out-break near Hampshire, N.W. Tasmania, has been plotted and a possible windrow effect identified.

Autumn gum moth damage on *E. nitens*.

Goals

- Conclude coreid studies.
- Have comparative studies on the population phenologies of *M. privata* in the north and south of Tasmania completed by June 1996. These will be compared with *M. privata* population phenologies collected in Victoria and ACT by CSIRO Division of Forestry.
- Quantify the effect of *Telenomus* sp. (an important egg parasitoid of *M. privata*) on *M. privata*.
- Identify when *M. privata* can first successfully establish in *E. nitens* plantations and study the role of population cycling within a plantation.

Education and Technology Transfer Program

Staff
Dr Neil Davidson
Ms Jane Burrell
Prof Jim Reid
Prof Robert Clark
Prof Robert Hill
Dr Robert Wiltshire
Ms Kristen Williams
Mr Ross Peacock
Mr Graeme Wilkinson
Ms Sarah Loughhead

Program Manager
Dr N Davidson

Education

Objectives:

The objectives of the program are to:

- develop a national centre of excellence for post graduate training through:

  i) training graduates relevant to the industry sector in the areas of tree genetics, protection of forests against predation by insects and vertebrates, and eucalypt stand management;

  ii) attracting scientists of high calibre to post-doctoral and visiting scientist positions;

  iii) the involvement of Centre scientists, who are not teaching staff in University Departments, in teaching at the undergraduate and postgraduate level.

- communicate the results of research to Centre industrial partners and the public through conferences, workshops, seminars, field days and a comprehensive Annual Report. This is facilitated by generating a Centre ethos amongst partners who are in some cases remotely located and amongst members of different departments and institutions on the campus at the University of Tasmania.

- raise public awareness of the objectives of the Centre and the public good generated through research conducted by the Centre by;

  i) the development of a media plan and publicity of the public good arising from Centre activities;

  ii) the development of links with farm forestry programs conducted in the broader community.

Major achievements of the program

- The running of an international conference 'Eucalypt Plantations: Improving fibre yield and quality' (19-24 February 1995), in association with the International Union of Forestry Research Organisations (IUFRO), that attracted 270 delegates from 23 countries and included the publishing of a 600 page proceedings. The running of a pre-conference field tour which visited company operations in Victoria and Tasmania, and two post-conference field tours; one in eastern Tasmania to natural *E. globulus* populations, and the other in Queensland to natural populations of eucalypt species used in tropical plantation

Participants take a break during the Basic Genetics technical training workshop.

forestry. After the conference two workshops were run; one on quantitative genetics (BLUP) and the other on the reproductive biology of eucalypts.

- The development of a technical training program which started in November 1994 with two workshops; 'Basic Experimental Design' and 'Basic Quantitative Genetics', run by the Genetics and Soil and Stand Management Programs. There were 44 participants including technicians and foresters from Amcor Plantations, North Forests, ANM, Forestry Tasmania, CSIRO Division of Forestry and the University of Tasmania.

- The appointment of four new postdoctoral researchers; Dr Allie Muneri (wood scientist), Dr Clare McArthur (animal browsing), Dr Jean-Noël Ruaud (somatic embryogenesis) and Dr Dorothy Steane (molecular biology).

- The maintenance of postgraduate and honours students numbers at levels exceeding those proposed at the outset of the Centre. We now have 27 PhD students, five masters students and four honours students (a total of 37).

- The running of two workshops; one on pruning and thinning (November 1994) and the other on modelling of soil nitrogen status (June 1995) by the Soil and Stand Management Program.

- A joint workshop between CRCTHF and CRCHFPS, run in August 1994 was the first joint meeting of both CRCs and industry. The subject was 'Wood and pulping properties'.

Honours and postgraduate students

In the past 12 months the number of students enrolled in honours and postgraduate degrees with the CRC has increased by four to 37. We now have 27 PhD students, five MSc students, four honours students and a graduate diploma student divided amongst the four programs; 12 in Genetic Improvement, 12 in Soil and Stand Management, nine in Resource Protection and four in Education (Table 3). The supervision of these students is shared widely amongst many of the partner institutions (Table 2a).

CRC honours scholarships were offered in 1994 to two students, Matthew Hayden and Martin Tyson, who received excellent results in their third year.

Undergraduate students

This year there are ten students enrolled in the four-year undergraduate course in Forest Ecology, similar to the intake for

Table 2a Topics and supervisors of CRC research students 1994/95

No	Last Name	First Name	Topic	Scientific Supervisors
1	BULINSKI	James	Effect of plantation design on feeding behaviour of wallaby	Dr C McArthur
2	BUNDOCK	Peter	Genetic control of cloning ability in E. globulus	Dr R Vaillancourt
3	CANDY	Steve	Mathematical models to support IPM of leaf beetles	Dr J Madden, Dr H Elliott
4	CHAMBERS	Paul	Quantitative genetics and the economic flow-ons from genetic gains	Dr N Borralho
5	DONALD	Susan	Culture of Dicksonia antarctica for plantations	Dr G Unwin
6	DUNGEY	Heidi	The susceptibility of eucalypt hybrids to pests	Dr B Potts, Prof J Reid
7	GARNETT	Trevor	Kinetic parameters for uptake of nitrogen and ammonium by eucalypt roots	Dr P Smethurst, Dr N Davidson
8	GREAVES	Bruce	Age to age correlations in eucalypts	Ms C Raymond, Dr B Potts, Dr N Borralho
9	HARDNER	Craig	In-breeding in eucalypts	Dr B Potts, Dr N Borralho
10	HAYDEN	Matthew	Mapping growth and time to flowering in E. globulus	Dr R Vaillancourt, Dr B Potts
11	HOWLETT	Bradley	Host location by Chrysophtharta bimaculata	Dr J Madden, Dr A Clarke, Dr P McQuillan
12	HUNT	Alastair	Predators of Chrysophtharta bimaculata	Dr A Clarke, Dr J Madden
13	HUNT	Mark	Competition between understorey species and plantation eucalypts	Dr N Davidson, Dr C Beadle
14	LENNON	Susan	Modelling cambial growth	Dr P Sands, Dr M Battaglia
15	LOUGHHEAD	Sarah	Partitioning variation in seed germination characteristics	Dr M Battaglia, Dr N Davidson
16	LUKACS	Zoltan	Biology of the autumn gum moth	Dr A Clarke, Dr J Madden, Dr R Floyd
17	MARSH	Nadia	Browsing of eucalypt seedlings by pademelons (Thylogale billardierii)	Dr C McArthur
18	MATYSEK	Ria	Hormonal control of growth and development in E. globulus and E. nitens	Prof J Reid, Dr J Ross
19	MENDHAM	Daniel	Process based predictions of nutrient limitations to plants	Dr P Smethurst, Prof B Menary, Dr G Holz
20	MITCHELL	Alexandra	Reproductive biology and breeding systems for E. globulus	Dr B Potts, Dr R Vaillancourt
21	MORONI	Martin	Nitrogen mineralisation	Dr P Smethurst, Prof B Menary
22	NESBITT	Katherine	Molecular markers in E. globulus	Prof J Reid, Dr A West
23	PEACOCK	Ross	Regeneration after cable logging	Drs N Davidson, M Brown, Prof R Hill
24	PINKARD	Libby	The effect of pruning on productivity and resource allocation in E. nitens	Dr C Beadle, Dr N Davidson
25	REID	Catherine	Pre- and post-diapause dispersal of insects	Dr J Madden, Dr A Clarke
26	RICHTER	Michele	Mechanisms of drought tolerance in eucalypts	Dr N Davidson, Dr C Beadle
27	STEINBAUER	Martin	Biology of Tasmanian coreid bugs	Dr A Clarke, Dr J Madden
28	TEIXEIRA	Paulina	Soil structure and erosion in eucalypt plantations	Dr R Misra
29	TYSON	Martin	The age and distribution of genotypes in eucalypt stands	Dr J Reid, Dr B Potts, Dr R Vaillancourt
30	VOLKER	Peter	Estimation of genetic parameters for eucalypt hybrids	Dr B Potts, Dr N Borralho
31	WALL	Sarah	Modelling stem shape of eucalypts	Dr P Sands, Dr T Sprent, Dr C Foster
32	WARDLAW	Tim	Armillaria butt and root rot of eucalypts	Dr M Lyon, Dr G Kile
33	WEI	Xianming	Efficiency of selection in eucalypts	Dr N Borralho
34	WHITE	Don	Water relations of E. nitens and E. globulus under cyclical drought	Dr C Beadle, Dr N Davidson
35	WILKINSON	Graham	Genetic variation in E. obliqua	Prof J Reid
36	WILLIAMS	Kristen	Modelling Eucalyptus distribution	Prof J Reid, Dr M Austin, Dr M Brown
37	WILSON	Steve	Early growth and survival of eucalypt seedlings	Prof R Clarke, Mr P Volker

Table 2b Details of research students at the CRC 1994/95

No	Last Name	First Name	CRC Program	Field	PhD Time	Start	Finish	Degree	Funding
1	BULINSKI	James	Resource Protection	Vertebrate browsing	Full time	1994	1997	PhD	CRC
2	BUNDOCK	Peter	Genetic Improvement	Eucalypt genetics	Full time	1995	1998	PhD	APA
3	CANDY	Steve	Resource Protection	Entomology	Part time	1993	1999	PhD	FCT employee & IFM
4	CHAMBERS	Paul	Genetic Improvement	Quantitative genetics	Full time	1995	1998	PhD	APA-I
5	DONALD	Susan	Education	Plantation research	Full time	1995	1995	Hons Grad Dip	Self supporting
6	DUNGEY	Heidi	Genetic Improvement	Eucalypt genetics	Full time	1992	1995	PhD	Uni Res Schol
7	GARNETT	Trevor	Soil & Stand Management	Tree nutrition	Full time	1993	1996	PhD	CRC
8	GREAVES	Bruce	Genetic Improvement	Eucalypt genetics	Full time	1993	1997	PhD	APA
9	HARDNER	Craig	Genetic Improvement	Eucalypt genetics	Full time	1993	1996	PhD	Uni Res Schol
10	HAYDEN	Matthew	Genetic Improvement	Reproductive biology	Full time	1995	1995	Hons	CRC Hons
11	HOWLETT	Bradley	Resource Protection	Entomology	Full time	1993	1996	PhD	FFIC
12	HUNT	Alastair	Resource Protection	Entomology	Full time	1993	1997	PhD	CRC
13	HUNT	Mark	Soil & Stand Management	Eucalypt ecology	Full time	1994	1997	PhD	CRC
14	LENNON	Susan	Soil & Stand Management	Modelling	Full time	1995	1998	PhD	CRC
15	LOUGHHEAD	Sarah	Education	Eucalypt ecology	Full time	1994	1995	Hons	Self supporting
16	LUKACS	Zoltan	Resource Protection	Entomology	Full time	1994	1997	PhD	APA
17	MARSH	Nadia	Resource Protection	Vertebrate browsing	Full time	1993	1996	PhD	CRC
18	MATYSEK	Ria	Genetic Improvement	Eucalypt physiology	Full time	1995	1995	Hons	Self supporting
19	MENDHAM	Daniel	Soil & Stand Management	Soil nutrition	Fulltime	1995	1998	PhD	APA-I
20	MITCHELL	Alexandra	Genetic Improvement	Eucalypt genetics	Full time	1995	1998	PhD	CRC
21	MORONI	Martin	Soil & Stand Management	Soil nutrition	Full time	1995	1998	PhD	APA-I
22	NESBITT	Katherine	Genetic Improvement	Molecular biology	Full time	1992	1995	PhD	APA
23	PEACOCK	Ross	Soil & Stand Management	Forest ecology	Part time	1994	1998	MSc	Dept Plan NSW employee
24	PINKARD	Libby	Soil & Stand Management	Eucalypt physiology	Full time	1994	1997	PhD	FFIC
25	REID	Catherine	Resource Protection	Entomology	Full time	1994	1996	MSc	Self supporting
26	RICHTER	Michele	Soil & Stand Management	Eucalypt physiology	Full time	1995	1998	PhD	CRC
27	STEINBAUER	Martin	Resource Protection	Entomology	Full time	1992	1995	PhD	APA
28	TEIXEIRA	Paulina	Soil & Stand Management	Soil structure and erosion	Full time	1993	1995	MSc	CRC
29	TYSON	Martin	Genetic Improvement	Eucalypt genetics	Fulltime	1995	1995	Hons	CRC Hons
30	VOLKER	Peter	Genetic Improvement	Eucalypt genetics	Part time	1992	1998	PhD	ANM employee
31	WALL	Sarah	Soil & Stand Management	Modelling	Full time	1994	1997	PhD	CRC
32	WARDLAW	Tim	Resource Protection	Pathology	Part time	1994	2000	PhD	FCT employee
33	WEI	Xianming	Genetic Improvement	Quantitative genetics	Full time	1994	1997	MSc	AIDAB
34	WHITE	Don	Soil & Stand Management	Eucalypt physiology	Full time	1993	1996	PhD	CRC
35	WILKINSON	Graham	Education	Eucalypt genetics	Part time	1990	1996	MSc	FCT employee
36	WILLIAMS	Kristen	Education	Eucalypt ecology	Part time	1991	1995	PhD	DPI-Forestry
37	WILSON	Steve	Soil & Stand Management	Eucalypt ecology	Full time	1993	1996	PhD	APA-I (TFRC)

Table 3 Summary of student enrolments in the CRC

II Postgraduate Students		Number of Students
Full/Part Time:	Full time	32
	Part time	5
Degree:	Grad Dip with Hons	1
	BSc Honours	4
	BAgSci Honours	0
	MSc	5
	PhD	27
CRC Program:	Genetic Improvement	12
	Soil & Stand Management	12
	Resource Protection	9
	Education	4

Supervisor:

Dr M Austin 1	Dr C Foster* 1	Ms C Raymond 1
Dr M Battaglia 2	Prof R Hill* 1	Prof J Reid* 6
Dr C Beadle 4	Dr G Kile 1	Dr J Ross 1
Dr N Borralho 5	Dr M Line* 1	Dr P Sands 2
Dr M Brown 2	Dr J Madden* 6	Dr P Smethurst 3
Prof R Clark* 1	Dr C McArthur 2	Dr A Sprent* 1
Dr A Clarke 5	Dr P McQuillan* 1	Mr G Unwin* 1
Dr N Davidson 7	Dr R Misra 1	Dr R Vaillancourt* 4
Dr H Elliott 1	Prof R Menary* 1	Mr P Volker 1
Dr R Floyd 1	Dr B Potts 7	Dr A West* 1

Funding:	CRC (Honours Scholarship)	2
	CRC (PhD/MSc Scholarship)	11
	Univ Research Scholarship (with CRC top up)	2
	APA (with CRC top up)	5
	APA - Industry	4
	FFIC	2
	AIDAB	1
	DPI - Forestry	1
	Employed in forest industry	5
	Self-supporting	4

* University Department Staff

1994 (Table 2). We expect numbers in this course to remain at this level and that students from other courses run by the Plant Science and Agricultural Science Departments will provide the major source of honours and post-graduate students for the CRC.

Post-doctoral fellowships and visiting scientists

There have been five post- doctoral fellows working with the Centre during 1994/95.

In the Resource Protection Program, Dr Anthony Clarke has played a key role, leading research in Projects 2 and 4 on the control of insect defoliators and the biology of other insect pests of *Eucalyptus*. A new post-doctoral fellow, Clare McArthur, was appointed to the vertebrate browsing project in January 1995 and has already started a comprehensive research program.

In the Genetic Improvement Program, Dr Omar Hasan conducted research on identifying and quantifying gibberellins, auxins and abscissic acid in the cambial tissue of *E. globulus* with the aim of determining their effect on wood properties. Three new post-doctoral fellows were appointed to the Genetic Improvement Program: Dr Jean-Noël Ruaud was appointed in August 1994 on a project investigating somatic embryogenesis; Dr Allie Muneri was appointed to the position of wood scientist in January 1995 and Dr Dorothy Steane was appointed as molecular biologist in April 1995.

The Centre received two visiting scientists in the Genetic Improvement Program during 1994/95: Dr Peter Kanowski (quantitative geneticist with Oxford University, recently appointed Professor of Forestry at ANU) and Dr Sue Jarvis (tree breeder with the Southern Tree Breeding Association). Mr Peter Kube (Forestry Tasmania) spent two months at the Centre in the position of Tree Breeder. Professor Alan Berryman (from Washington State University) conducted a workshop and interacted with staff and students of the Resource Protection Program. In the Soil and Stand Management Program, Dr Heather Keith (CSIRO, Division of Forestry, Canberra), conducted a six-month study on the phosphorous nutrition of *E. nitens*.

During the year there were also two Chinese visitors, Mr Li Fang Dong and Mr Wang Bao-Ping, who interacted with researchers in SSM Program on soil nutrition studies. Funding was provided by the United Nations Food and Agricultural Organisation.

International Conference delegates from left to right Mathura Jha, India; Roberto Ipinza, Chile; Jim Reid, Director (CRCTHF) Arnold Viljoen, South Africa; Ruth McConnochie, New Zealand; Dario Grattapaglia, Brazil.

Teaching

Six CRC funded staff are contributing to university courses in fields allied to their research: Dr A Clarke has presented lectures in Agricultural Entomology, Dr R Misra in Soil Physics, Dr N Davidson in Physiological Plant Ecology, Dr Phil Smethurst in Soil Nutrition, Dr Brad Potts in Quantitative Genetics and Dr R Vaillancourt in Molecular Biology. Supervision of post-graduate and honours students is widely distributed amongst CRC partner institutions, such that more than half of the student supervision is performed by CRC staff outside University departments (see Table 1).

Communication and Promotion

In association with the International Union of Forestry Research Organisations (IUFRO), the Centre ran an international conference 'Eucalypt Plantations: Improving fibre yield and quality' (19-24 February 1995) that attracted 270 delegates from 23 countries and from which was published a 600-page proceedings edited by the scientific committee: BM.Potts, NMG Borralho, JB Reid, RN Cromer, WN Tibbits and CA Raymond. A pre-conference field tour was run from 11-18 February, which visited company operations in Victoria and Tasmania. There were two post-conference field tours: one to natural *E. globulus* populations in eastern Tasmania (25-26 February) and the other to natural populations of *E. grandis* near Coff's Harbour (NSW) and Gympie (QLD) (26 February - 4 March). Also, after the conference, two workshops were run by the Genetic Improvement Program; one on BLUP (Best Linear Unbiased Predictions) of breeding values in tree breeding (presented by Nuno Borralho; 27-28 February), and the other on the Reproductive biology and controlled pollination of eucalypts (presented by Brad Potts; 1-2 March).

A joint workshop between CRCTHF and CRCHFPS run in August 1994 was the first joint meeting between the two CRCs and industry. The subject was 'Wood and Pulping Properties'.

Two workshops were run by the Soil, and Stand Management Program. The first on pruning and thinning for sawlog plantations was run by Chris Beadle and Libby Pinkard for the Forests and Forest Industry Council of Tasmania (November 1994). The second was on modelling of soil nitrogen status (19-22 June 1995). This workshop consisted of a half-day of seminars presented to industry partners by CRC SSM Program and CSIRO on their results from current research on nitrogen mineralisation in forests, followed by 1.5 days of modelling sessions and a half day field trip.

Brad Potts gives advice to staff and students at the Taroona High School on the planting and care of endangered eucalypt species.

The Resource Protection Program ran a short course entitled 'Understanding, diagnosing and forecasting forest insect dynamics' (18-19 January 1995) presented by visiting scientist Prof Alan Berryman (from Washington State University).
A technical training program was started in November 1994 with two workshops; 'Basic Experimental Design' and 'Basic Quantitative Genetics', run by the Genetics and Soil and Stand Management Programs, which attracted 22 participants including technicians and foresters from Amcor Plantations, North Forest Products, ANM, Forestry Tasmania, CSIRO Division of Forestry and the University of Tasmania.

National and international consultancies have also been attracted to the CRC. In August 1994 Dr Nuno Borralho ran a two-week consultancy on new quantitative genetics techniques for Indonesian foresters. In November 1994 and in February 1995 Neil Davidson undertook two three-ay consultancies on the effect of waterlogging on tree growth for the Hydro Electric Commission of Tasmania.

The Centre continues to respond to interested community groups who wish to know more about the CRC and its research activities, e.g. Dr Brad Potts explained controlled pollination techniques to the advanced science class at the Taroona High School and advised staff and students on the planting and care of endangered eucalypt species in the school grounds.

CRC ethos and interactions

The three-monthly newsletter, 'Overstorey', has played an important communication role in the Centre during 1994/95 and has been very popular amongst both readers and contributors.

The CRCTHF/IUFRO Conference provided an excellent forum for projecting the Centre's identity to a national and international audience.

Goals

- To develop a media plan and publicity campaign that will demonstrate the public good arising from Centre activities. The campaign will be aimed at the general public and farm forestry concerns.

- To improve communication and the transfer of research results to industry partners, by making visits directly to forest companies to present research which the Centre sees as ready for adoption or implementation.

- To continue the very successful technical training program with a workshop on 'Forest Health' to be held in October 1995.
- To run a series of stories about CRC research in the CSIRO publication 'Onwood'.
- To run a three-day workshop on soil and plant nutrition where the Soil and Stand Management Program, the University of Melbourne and the Australian National University staff and students present their research work and discuss possible research collaboration.
- Instigate informal, fortnightly CRC-wide meetings to familiarise staff and students with the range of projects and activities undertaken by the Centre.

Cooperative linkages

Interactions with outside organisations

Genetic Improvement

A large part of the research of Project 1 is carried out through collaborative projects. The main organisations or people were:

- the STBA (Southern Tree Breeding Association), mostly in the development of a cooperative breeding strategy and genetic evaluation of *E. globulus* and *E. nitens*;
- Dr Peter Kanowski (Oxford Forestry Institute), who was our Visiting Scientist between January and April 1995;
- the Queensland Forest Research Institute and Australian National University, mostly in the development of breeding and deployment strategies for tropical hardwoods, for which a joint Forest and Wood Products Research and Development Corporation project has been submitted;
- several companies such as Soporcel (Portugal), Celbi (Portugal), Instituto Forestal (Chile), Cooperativa de Mejoramento Genetico (Chile), and ENCE (Spain) involved in the analysis of the *E globulus* base population collections;
- the New Zealand Forest Research Institute, in the joint analysis of the *E. nitens* base population collections;
- Tasman Forestry (New Zealand), in the analysis of their *P. adiata* second generation progeny/clonal trials using Mixed Models BLUP;
- Indah Kiat Pulp and Paper (Indonesia), in the development of breeding strategies and analysis of a series of first generation *A. mangium* progeny trials;
- Aracruz Celulose (Brazil), on a joint *E. globulus x E. grandis* hybrid research project.

Several lines of research in Projects 2 and 6 have been conducted in collaboration with the CRC for Hardwood Fibre and Paper Science, in particular research related to sampling, assessment and within tree variation in fibre characteristics, and the effect of gibberellins on wood characteristics. In addition, specific projects being undertaken with ANM Pulp Mill, North Forest Products pulping research group and Amcor Research and Technology Centre.

Project 4 has been collaborating with: (i) STBA in the estimation of genetic parameters in base population trials of *E. globulus* and *E. nitens*; and (ii) Dr Peter Ades and Angus Carnegie of the University of Melbourne on the study of the genetics of *Mycosphaerella* spp. resistance.

Soil and Stand Management Program

In Project 1, interaction is being developed with Dr Marilyn Ball from the Research School of Biological Sciences at ANU (Canberra) to investigate the long-term effects of chilling injury on

plantation productivity. New links have also been established with Bunnings Forest Products (Western Australia) in a study of the drought tolerance characteristics of *E. globulus* families. Dr Chris Beadle is currently on study leave at the University of Essex (UK). The Department of Biology there has pioneered the use of changes in chlorophyll fluorescence as a means of evaluating the impact of low temperature on photosynthesis and crop growth. Dr Beadle is interacting with their program using *E. nitens* as a subject species.

In Project 2, links are being maintained with the Queensland Forest Research Institute to finalise publication of research on sub-tropical eucalypts funded by Shell Australia. Data from that research will be used in modelling studies in Project 4. Project 2 also has strong interactions with industry partners; with trees from the plantations of North Forest Products, Amcor, ANM and Forestry Tasmania being sampled for wood property assessments. In addition, results from the within-tree variation in density work were immediately implemented in Projects 1 and 4.

Links exist between Project 3 and (i) Dr B Atwell, Macquarie University, on studies of N uptake by morphologically different roots; and (ii) Mr P Moody, Queensland Department of Primary Industry, on soil indicators of phosphorous deficiency. Two FAO trainees from the Paulownia Research Centre, China,, have conducted studies of soil physical properties and P availability with project scientists.

In Project 4, links are being developed with other modelling groups at the University of NSW, CSIRO Centre for Environmental Mechanics and CSIRO Division of Soils.

Resource Protection Program

The vertebrate browsing project has close links with (i) Dr M Statham (DPI) who is providing scientific advice on radio-tracking, (ii) Dr WJ Foley (James Cook University), (iii) North Forest Products and (iv) Mr Peter Bird who is providing a link with hunters in Tasmania for collecting samples. Interactions continue with the CRC for Tropical Pest Management and a joint publication on *Chrysophtharta bimaculata* genetics is nearly completed. Links with the CSIRO Division of Entomology are continuing to strengthen and Dr Robert Floyd of the organisation is acting as a research supervisor for Mr Zoltan Lukacs.

Interactions between partners

Genetic Improvement

Project 1 has close collaborative links with all CRC partners and with other CRC programs.

In Project 3, close interaction occurs with Project 4 in quantitative genetic analysis of heterosis and with Projects 1 and 2 in identification of genetic markers for wood density. North Forest Products and Boral Timber have provided genetic material for experiments and Gillian Rasmussen of North Forest Products has provided facilities and assistance with testing for rooting ability.

Project 4 has been collaborating closely with Projects 1 and 3 as well as collaborating with Dr Robert Wiltshire, Department of Plant Science, University of Tasmania, to write a review on eucalypt genetics and genecology. North Forest Products, Forestry Tasmania and Boral Timber have been integrally involved with trial establishment.

In Project 5, joint experiments on micropropagation are conducted with North Eucalypt Technologies at Ridgley and CSIRO in Hobart. North Forest Products is the only industry partner in the CRC that has its own tissue culture laboratory. We intend to transfer technology of vegetative propagation to other industry partners through arrangements with commercial tissue culture laboratories

Project 6 interacts with Forestry Tasmania on the effect of hormone levels on cambium development, with the CSIRO Division of Forestry on the production of earlier and heavier flowering, and with the University of Tasmania on the analysis of hormone levels in different seasons.

Soil and Stand Management Program

In Project 1, strong links have been developed with: (i) North Forest Products in studies of the effects of chilling injury on photosynthesis; and (ii) Boral Timber on two projects (competition between *Acacia dealbata* and *E. nitens*, and the effect of pruning on growth and photosynthesis of *E. nitens*). New links have been established with Bunnings Forest Products (Western Australia) and Nuno Borralho (Project 1, Genetic Improvement Program) in a study of the drought tolerance characteristics of *E. globulus* families.

In Project 2, strong cooperative linkages are in place with North Forest Products, ANM and Boral Timber who support CRC nitrogen and phosphorus fertiliser trials.

Project 3 has links with Drs I Newman and S Shabala of the Physics Department, University of Tasmania,, in microprobe studies of nutrient uptake. Close links also exist with Dr M Line and Prof R Menary, of the Department of Agricultural Science, University of Tasmania, in the supervision of students on joint APA-I awards.

Project 4 has close links with other projects within the SSM Program in the development of models of stand growth, and with the CRC for Hardwood Fibre and Paper Science in modelling cambial activity.

Resource Protection Program

The Resource Protection Program has established links with most partners. For example, Project 2 is jointly managed by CRC and Forestry Tasmania staff. The outcomes of this project are dependent on this collaboration which combines pure ecology and field application. The support of ANM to Project 2 is also significant. In the vertebrate browsing and autumn gum moth projects, the support of North Forest Products has allowed the establishment of major experimental field sites for assessing vertebrate damage.

Utilisation and Application of Research, and Commercialisation

Introduction

In the past 12 months, 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 industry. The Centre attracted national and international consultancies in the Genetic Improvement and Soil and Stand Management Programs. The Centre also ran an International Conference which was a major boost to the profile of the CRC and its members and attracted a large number of industry representatives. The Conference was also a financial success, the proceeds from which have been earmarked for further international collaboration.

Genetic Improvement

In the Genetic Improvement Program researchers have, in association with STBA (Southern Tree Breeding Association), now conducted a complete BLUP (Best Linear Unbiased Prediction) analysis of national and international trials of *E. globulus* and *E. nitens*. The results from this analysis are being used by industrial partners to accurately select elite genetic material for the next generation of tree breeding and have demonstrated the benefits of a single national breeding strategy. Clear breeding objectives have been set and a cost-benefit analysis was conducted. The STBA is implementing the breeding strategy and the projected benefits are estimated to be 9% assuming the discount rate will be $32 million for plantations established by 1999.

The pilodyn is now being used by members as a tool for indirect assessment of wood density and thus is the first quick and easily employed method of measuring wood quality capable of being used in BLUP analyses of breeding values.

In August 1994 Dr Nuno Borralho ran a two week consultancy on new quantitative genetics techniques for Indonesian foresters.

Soil and Stand Management

Researchers in the Soil and Stand Management Program are well advanced in quantifying the rates of nitrogen mineralisation in some typical soils used for tree farming. This work will allow more accurate determination of the optimum timing and level of fertiliser application.

Scientists within the program are also in the process of quantifying the effects of pruning and thinning on growth and physiology of plantation eucalypts (supported by the Forests and Forest Industry Council). A more accurate assessment of the impact of these

silvicultural practices on plantations used for solid wood products will be possible from this work.

In November 1994 and February 1995 Dr Neil Davidson undertook two three-day consultancies on the effect of waterlogging on tree growth for the Hydro Electric Commission of Tasmania.

Resource Protection

The Resource Protection Program as well as continuing to refine their Integrated Pest Management Program through studies of the ecology of *C. bimaculata* have three new initiatives which could directly benefit industry partners. Firstly, strategic plantings of *E. regnans* in *E. nitens* plantations may be used as 'trap' trees for insect defoliators. There is an intensive study being conducted on the autumn gum moth, results of which will help decision making to control a major defoliator of plantation trees. There is also a major injection of resources into a study of the behaviour and preferences of mammalian browsers (wallaby and possum) which are a serious problem at the time of plantation establishment. Results from this project will contribute to the development of a plantation designed to reduce browsing impact and the production of a working model for predicting browsing damage.

Partner Perspectives

Forestry Tasmania

The CRC has been instrumental in getting cooperative breeding programs underway for both *E. globulus* and *E. nitens* and the progress in the *E. nitens* program in 1994-5 is particularly welcome. Data on gains from employing genetic selections for *E. nitens* are very valuable for Forestry Tasmania's future plantation program, and getting appropriate selections into a seed orchard and then into plantations will lead to significant improvements in productivity.

The recent CRCTHF-IUFRO Conference on improving future production from eucalypt plantations brought Australian and International experts to the State. The interchange between these delegates and Tasmanian researchers was extremely useful for focussing the eucalypt plantations research program.

The development of silvicultural regimes for sawlog production from eucalypt plantations is a high priority for Forestry Tasmania as we are now managing 6000 ha of *E. nitens* for sawlog production established under the Intensive Forest Management Program. Work in the CRC's Soil and Stand Management Program on thinning and pruning regimes and the physiological

effects of pruning will greatly assist the development of appropriate practices.

Other work in the Soil and Stand Management program on nutritional regimes for eucalypt plantations across a range of sites and testing Forestry Tasmania's model for determining productivity of potential plantation sites is welcome.

Through the Resource Protection Program we are gaining valuable information on the ecology of eucalypt leaf beetles and developing biological control strategies concentrating on application of *Bacillus thuringiensis* var. *tenebrionis*. Other biological control agents such as nematodes and fungi are also being investigated. Vertebrate browsing studies received a boost this year through the appointment of a post-doctoral researcher and funding of supporting resources. This topic is a very high priority for the commercial forest growers.

- Humphrey Elliott, Forestry Tasmania

North Forest Products

The past year has been a challenging one for the wood-fibre industry in Australia with the focus increasingly shifting to eucalypt tree-farms (ETFs) for future supply. The role of this CRC in underwriting the sustainable production of internationally competitive wood-fibre in Australia through high quality research is therefore vital.

Exciting new CRC initiatives include the commencement of a PhD program investigating the ecology of autumn gum moth, currently in outbreak throughout much of Tasmania's ETFs.

The appointment of Dr Clare McArthur to the vertebrate browsing area should improve the profile of this important area of research. Canadian experience with parasite inundated release was investigated and proved to be not feasible on economic grounds.

Nitrogen and soil phosphorous studies are proceeding well and an important outcome for North has been the quantification of nitrogen mineralised in our tree-farm soils. The biotechnology program has made exciting progress with *E. nitens* embryogenesis studies. Collaborative projects with CRC geneticists have also produced some valuable outcomes for North.

CRC staff are to be congratulated for their hosting in Hobart of a major international conference in association with IUFRO. The conference brought many forest researchers and wood scientists from overseas to Tasmania giving the local industry the opportunity to network and benchmark itself.

- David de Little, North Forest Products

Boral Timber Tasmania

Coming into the middle period of its first seven years, the concepts and performance of the CRC THF are coming into focus. The three-year review panel highlighted strengths and weaknesses that were already becoming evident from in-house scrutiny, and structural changes to programs and emphasis between programs have been incorporated to reflect the concerns of industrial partners, and the capacity of the CRC to respond to these shifts.
The difficulties of staff changes, although ever-present, has seen the import of excellent new staff and a corresponding injection of new enthusiasm - always a welcome aspect. This is also evident with the cooperative arrangements being undertaken with the CRC for Hardwood Fibre and Paper Science in Melbourne, where more emphasis on solid products and their requisite characteristics are being addressed.

The next two years should provide strong, tangible justification for the very existence of such a CRC. With many projects within the various programs already showing indicative results, the incorporation into silvicultural practice of different fertiliser regimes, cultivation techniques, genetically superior seedlings, is already being tested in routine applications. We continue with optimism that advantages gained from focused research will enhance our efforts at eucalypt plantation establishment and management.

- Peter Naughton, Boral Timber

ANM Forest Management

The CRCTHF/IUFRO conference on eucalypt plantations provided a great boost to the profile of the CRC and its members. It demonstrated to the Australian public and international delegates the high degree of scientific knowledge applied to forest management in Australia. A series of workshops aimed at technical and professional staff within the industry were valuable in transferring research results into practice. The success of these courses has shown the need for continuing training within the industry and for researchers to interact with industry at an operational level.

In cooperation with the STBA, analysis of the STBA *E. nitens* data has been carried out, with pilodyn analysis currently underway. This information will form the basis for future grafted seed orchards.

Fertiliser trials are starting to show responses in the third season of growth, confirming our need to conduct more work between age two and canopy closure. Other work with ammonium and nitrate solution culture has proven the need to stick with ammonium based

fertilisers. Trials are currently being established to quantify the effects of weeds on plantation growth.

Within the Resource Protection Program, monitoring of vertebrate pest browsing has shown a large range of damage and susceptibility to browsing in different coupes. This information will be essential for evaluation of possible control measures. The appointment of Dr Clare McArthur has given a much needed boost to the program and ANM looks forward to increased activity in this program.

- Peter Volker, ANM Forest Management

Amcor Plantations Pty Ltd

Amcor Plantations Pty Ltd (formerly APM Forests Pty Ltd) has been extremely pleased by the progress and developments achieved by the CRC in the past 12 months. The CRC has become a true centre of excellence which was proven in the hosting of the CRCTHF-IUFRO Conference in Hobart during February. Without doubt this Conference was a resounding success which has increased the exposure of the CRC (and its members) throughout the international community. Amcor Plantations was proud to be a sponsor and to be a host on the pre-conference tour.

During the past year the Centre conducted a number of training sessions and workshops. These are particularly important to our company as they provide training opportunities for our personnel that were not available prior to the Centre's existence. In particular, the workshop on Experimental Design and Quantitative Genetics was excellent.

Another satisfying aspect of the CRC has been its impact on the availability and accessibility of well qualified scientists for forest research in Australia. It is quite clear to our company that the calibre of the graduates associated with the Centre is high and advertised jobs can expect to attract such people. In particular, the opportunity to utilise the skills of Bruce Greaves for one year while I was studying was invaluable.

The Third Year Review, whilst a lot of work, provided an opportunity to stand back and evaluate the performance of the Centre and re-assign priorities to the various programs and sub-programs. This process was well received by the Centre and has resulted in a better focus for research. Basically only fine tuning to the programs was required which confirmed that the research was close to optimal for the first three years.
Specifically for Amcor Plantations the past year's research has resulted in:

- the development of a pulp-mill costing model which we will use to evaluate eucalypt breeding and silvicultural experiments;
- the development of a protocol for, and an economic evaluation of, assessing wood density using a pilodyn. This is now being used routinely;
- the use of BLUP analysis by the Southern Tree Breeding Association (STBA) on *E. nitens* and *E. globulus* data has enabled the selection of the candidates for the next generation of breeding;
- the assessment and preliminary analysis of soil cultivation experiments and their impact on soil strength and tree growth.

In the forthcoming year we look forward to the strengthening of links with both the STBA and the CRC for Hardwood Fibre and Paper Science, the increase in the focus on the effect of site, silviculture and breeding on wood and fibre properties, the increased resourcing of the vertebrate browsing sub-program, and the provision of suitable technical workshops and short courses.

- Phil Whiteman, Amcor Plantations Pty Ltd

Staffing and Administration

During 1994/95 there were several changes to the staff of the CRC with new appointments of professionals and changes to existing positions reflecting staff turnover.

The Office of the Chief Scientist has appointed a new Visitor to the CRC to replace Professor Harold Woolhouse who retired due to ill health. He is Dr Peter Nelson (APPI) who has also been appointed as Visitor to the CRC for Hardwood Fibre and Paper Science in Melbourne. It is believed that this appointment will be mutually beneficial to both Centres. Dr Nelson will provide advice on the strategic directions of the Centre.

The Deputy Director and Program Manager of the Soil and Stand Management Program, Dr Philip West, resigned in February 1995 to move to Darwin to take up a position as Director of the CRC for Tropical Savannas. Mr Robin Cromer has replaced him as Manager of the Soil and Stand Management Program and the position of Deputy Director has not yet been filled. CSIRO will be making a new appointment in the area of growth modelling to replace Dr West.

Dr Nuno Borralho was appointed Program Manger of the Genetic Improvement Program in September 1994 to allow Professor Reid more time to concentrate on his duties as Director.

Dr René Vaillancourt, post-doctoral fellow in molecular biology, accepted a position as Lecturer with the Plant Science Department (University of Tasmania), but is continuing close interaction with the Centre.

Four post-doctoral fellows were appointed in the last year: Dr Clare McArthur to the vertebrate browsing project (January 1995); Dr Jean-Noël Ruaud to investigate somatic embryogenesis (August 1994); Dr Allie Muneri to the position of wood scientist (January 1995); and Dr Dorothy Steane as molecular biologist (April 1995). Dr Omar Hasan accepted another appointment within the University of Tasmania and left his position as post-doctoral fellow with the Centre in October 1994.

Dr Xiujun (Wendy) Wang was appointed as Research Assistant to Dr Philip Smethurst and is working on nitrogen mineralisation in forest soils. Technical appointments made during 1994/95 were: Mr Andrew Gibbons, to work with Dr Rabi Misra on root studies; and Mr Marcus McKay in the area of canopy processes and nutrient cycling. Mr McKay resigned in February 1995 to take up further studies and was replaced temporarily by Ms Joanne Dingle.

Forestry Tasmania appointed a new research scientist, Dr Jane Elek (funded by the Intensive Forest Management Program) to conduct research in the Resource Protection Program of the Centre. She replaces Ms Anna Greener.

New students starting with the Centre this year include six PhD students: Ms Michele Richter, Ms Alexandra Mitchell, Ms Susan Lennon, Mr Paul Chambers, Mr Peter Bundock, Mr Xianming Wei; and five Honours and Graduate Diploma with Honours students: Ms Sarah Loughhead, Mr Martin Tyson, Mr Matthew Hayden, Ms Ria Matysek and Ms Susan Donald.

After a request from the CRC Secretariat, the specified personnel list has been shortened (see Table 4, page 61). A full staff list for the Centre is presented in Attachment C at the end of this report.

Third Year Review

The Third Year Review of the Centre was held on 12-13 March 1995. The Review Panel consisted of Mr Don Blesing (Chair) (Member of ASTEC), Dr Joe Landsberg (CSIRO), Prof Peter Kanowski (Oxford/ANU), Dr Don Grose (Retired Chairman FCV) and Mr Colin Hickey (CRC Secretariat).

The Review Panel was generally pleased with the progress the Centre had made against its performance indicators in the Commonwealth Agreement (established at the start of the Centre) and the evaluation criteria set by the Office of the Chief Scientist. However, the Review Panel took a broader view of the role of the Centre, in particular regarding the need for 'public good' research and the role of the CRC in the public debate regarding forestry issues.

Recommendations

1) The Board should implement the Panel's recommendations with some urgency, to place the Centre in the strongest possible position to attract funding beyond the current contract period and to capture opportunities presented by Australia's expanding temperate hardwood resource base.

2) The Board should redefine its role to ensure that the Centre priorities are clearly determined by the Board, and to clarify and separate the activities of its Committees, in particular the Industry Research Committee. The Panel believes that the Board's task is to determine roles and directions, to consider strategy, and to participate more directly in priority setting of research programs for the Centre. The Management Committee and the Industry Research Committee should continue to

determine resource location and priority setting within programs. The Board should also grasp the opportunity to define a broader constituency than the current industry partners to include large plantation forestry, farm forestry, and widespread community support for reafforestation. This provides the basis for determination of areas of public good likely to merit long term government funding. This *redefinition* will include an improved understanding of stakeholders, additional independent membership of the Board, and a focus on developing a world-class capacity in forest science and practice that will lead to improved opportunities for funding support.

3) The Board is to strengthen the Centre's capacity in business and technology management by appointing a full-time business manager. This will free the Director to play a more pro-active leadership role.

4) The Board is to take a strong role in developing a robust forward-looking business plan, addressing *inter alia*, the future sources of funding of the Centre on an ongoing basis.

5) The Panel believes that the program areas as selected are appropriate. It recommends the strengthening of the Soil and Stand Management, Resource Protection and Education Programs to ensure that they have the capacity to achieve excellence. The objectives of the Education Program should be revised to reflect the Panel's vision of the Centre's role of excellence in the Australian community.

Response to the recommendations

The Board met to discuss the recommendations and agreed to the following changes:

1) The recommendations have been discussed by the Board as well as the CRC in general and firm decisions (see below) have been taken on how to respond to the recommendations so as to ensure the Centre is in the strongest possible position to attract funding beyond the current contract period and to capture opportunities presented by Australia's expanding temperate hardwood resource base.

2) The Board expressed confidence with the present designation of committee responsibilities since this included Board responsibility for determining the roles, direction and strategy of the research programs of the Centre. However, we will take care to ensure that the Management and Industry Research

Committees are restricted to providing priority setting and resource allocation within programs and that they will only play an advisory role to the Board on issues at the broader program level. This will be aided by the implementation of the recommendation for more frequent Board meetings.

The Board confirmed its commitment to identifying new members and to admitting them on the same terms and conditions as existing members. It stressed that it had done this successfully in the past on several occasions. In addition, the Board would endeavour to develop a system of associate membership that would allow input into the Centre from diverse community groups in a structured way and hoped that this would open up areas for cooperative work. Prospective associate members would have to demonstrate that their membership would be of mutual benefit to both organisations and they may be required to pay an annual fee or to contribute in-kind support.

The Centre already has an expanding involvement with farm forestry, principally through its industry members, and it is expected that this will continue to expand in the future. Community support for reforestation will be addressed through the Education and Technology Transfer Program and a paper dealing with this issue has been developed for the Board's deliberations. The Centre currently undertakes considerable public good research, especially as research higher degree theses, and this will be highlighted in future by classification of projects to include this category. Finally, collaboration with the Forestry Schools at the ANU and Melbourne University will be encouraged and the present considerable collaboration fully documented. A three-day meeting with staff and students from Melbourne University has been arranged for 9-11 August 1995.

Taken together, these strategies show the Board has addressed many of the issues raised by Recommendation 2 while reconfirming the appropriateness of the present structures of the Centre to achieve its stated aims.

3) The Board has authorised the appointment of a Business Manager as recommended. This will free the Director to play a more pro-active leadership role.

4) The Board has accepted a strong role in developing a robust and forward-looking business plan. The first step in this is the appointment of a Business Manager. With the assistance of the Business Manager, the Board will develop a business plan to complement the recently revised strategic plan. This will be implemented in 1995/96.

5) The Soil and Stand Management Program has been strengthened by the appointment of a scientist to model stand development (Dr Michael Battaglia will commence duties during September). This will provide a focus for the use of information collected by the program and provide an output of direct relevance to the industry since it will allow improvements in stand management and predictions of the benefits of modified silvicultural practices.

The flexible resources allocated to the Resource Protection Program have been increased to 20% of total flexible funds for 1995/96 (from 14.8%). This increase will allow the strengthening of the vertebrate browsing project, which is seen as a high priority, without detracting from other projects.

The objectives of the Education and Technology Transfer Program have been revised to better target all Australian forest growers and to reflect the Panel's vision as a centre of excellence in forestry.

These changes, together with further refinement of the programs during our annual review processes, effectively address the issues raised by Recommendation 5 without adversely affecting the Genetic Improvement Program (a minor decrease in flexible funds only), which the review committee believed was operating effectively.

Table 4
Specified personnel in the CRC

Name	Organisation	Proportion of time in the CRC
Prof Jim Reid	University of Tasmania Director	(0.5)
Dr Phil West	CSIRO, Division of Forestry Deputy Director (until Feb 1995)	(0.8)
Dr Nuno Borralho	University of Tasmania Manager, Genetic Improvement Program	(1.0)
Mr Robin Cromer	CSIRO, Division of Forestry Manager, Soil and Stand Management Program	(0.4)
Dr John Madden	University of Tasmania Manager, Resource Protection Program	(0.3)
Dr Neil Davidson	University of Tasmania Manager, Education, & Technology Transfer Program	(1.0)

Publications

Genetic Improvement

Refereed journal publications

Borralho NMG and Kanowski PJ (1995). Correspondence between performance of genetically related clones and seedlings. *Can. J. For. Res.* **25**, 500-506.

Moncur MW and Hasan O (1994). Floral induction in *Eucalyptus nitens* (Deane and Maiden) Maiden. *Tree Physiol.* **14**, 1303-1312.

Potts BM and Jordan GJ (1994a). Spatial pattern and scale of variation in *Eucalyptus globulus* Labill. ssp. *globulus*: Variation in seedling abnormalities and early growth. *Aust. J. Bot.* **42**, 471-492.

Potts BM and Jordan GJ (1994b). Genetic variation in the juvenile leaf morphology of *Eucalyptus globulus* Labill. ssp. *globulus*. *Forest Genetics* **1**, 81-95.

Raymond CA (1995). Genetic variation in *Eucalyptus regnans* and *Eucalyptus nitens* for levels of observed defoliation caused by the *Eucalyptus* leaf beetle, *Chrysophtharta bimaculata* Olivier, in Tasmania. *For. Ecol. and Manage.* **72**, 21-29

Volker PW, Owen JV and Borralho NMG (1994). Genetic variance and covariances for frost tolerance in *Eucalyptus globulus* Labill. ssp. *globulus* and *E. nitens* (Deane and Maiden) Maiden at different temperatures. *Silvae Genetica* **43**, 366-372.

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Conferences/Symposia

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Davidson NJ, Battaglia M and Beadle CL (1995). Mild frosts reduce subsequent photosynthesis in *E. nitens*. IUFRO Meeting, 'Interactive Environmental Effects on Forest Stands'. New Zealand, January/February 1995

Garnett TP and Smethurst PJ (1994). Temperature and pH effects on nitrate and ammonium uptake by *Eucalyptus nitens*. Australian Society of Plant Physiologists Conference, Broadbeach, Queensland, September 1994.

Misra RK and Rose CW (1994). Design and test of a soil conservation system on the basis of erosion processes. Paper presented at the 8th International Soil Conservation Conference, 4-8 December 1994, New Delhi.

Rose CW, Coughlan KJ, Ciesiolka CA and Misra RK (1994). Developments in soil-erosion theory used in tropical soil conservation projects. Paper presented at the 8th International Soil Conservation Conference, 4-8 December 1994, New Delhi.

Pinkard L, Beadle CL and Davidson NJ (1995). Changes in crown productivity and stem growth of *Eucalyptus nitens* in response to green pruning. 34th ASPP Meeting, Broadbeach, Qld.

Pinkard L, Beadle CL and Davidson NJ (1995). Changes in crown productivity and stem growth of *Eucalyptus nitens* in response to green pruning. IUFRO Meeting 'Interactive Environmental Effects on Forests'. New Zealand, January/February 1995.

Sands PJ and Voit EO (1994). Parameter estimation for S-systems: exploration of a strange terrain. Symposium on Integrative Biochemistry, 26-29 June 1994, Barcelona, Spain.

Voit EO and Sands PJ (1994). S-system analysis of biomass partitioning in Scots pine. Symposium on Integrative Biochemistry, 26-29 June 1994, Barcelona, Spain.

West PW (1994). Forestry technology in Australia - its context and impact. AATSE Symposium on Farming Forever: Technologies for Better Crop Production. 25 October 1994, Adelaide, South Australia.

White DA, Beadle CL and Worledge D (1994). Seasonal and drought-induced variation in the tissue water relations of *Eucalyptus globulus* and *E. nitens*. 34th ASPP Meeting, Broadbeach, Qld.

White DA, Beadle CL and Worledge D (1995). The control by boundary layer and stomatal conductance in an irrigated *Eucalyptus globulus* tree. IUFRO Meeting 'Interactive Environmental Effects on Forest Stands'. New Zealand, January/February 1995.

Seminars and Workshops

Pinkard L and Beadle C. Pruning and thinning *E. nitens* plantations; effects on growth and form. Forests and Forest Industry Council of Tasmania Workshop on 'Pruning and Thinning for Sawlog Plantations'.

Open day at Gould's and Creekton plantations. 'Pruning and Thinning Plantations'. 65 participants. Organised jointly by CRC SSM Project 1 and Forestry Tasmania under auspices of Intensive Management Program of Forests and Forest Industry Council of Tasmania. December 1994.

A half-day seminar series on 'Soil Nitrogen Mineralisation' was presented to CRC Industry Partners on 19 June 1995. This was conducted in collaboration with CSIRO Division of Forestry.

Resource Protection

Conferences/Symposia

Candy S, Baker S and Elliott H (1994). Economic impact of leaf beetle browsing in eucalypt plantations in Tasmania. Program and Abstracts, Australian Entomological Society 25th Scientific Conference and AGM, Adelaide, 25-28 September 1994. Poster and abstract, p. 71.

Clarke AR, Madden JL and Zalucki MP (1994). Spatial distribution of the *Eucalyptus* leaf beetle, *Chrysophtharta bimaculata* (Olivier) (Coleoptera: Chrysomelidae). Program and Abstracts, Australian Entomological Society 25th Scientific Conference and AGM, Adelaide, 25-28 September 1994. Paper and abstract, p. 26.

Clarke AR, Madden JL and Zalucki MP (1994). Spatial distribution of the *Eucalyptus*-leaf beetle, *Chrysophtharta bimaculata* (Coleoptera: Chrysomelidae). Joint Annual Meeting of the Canadian and Manitobian Entomological Societies, Winnipeg, Manitoba, 15-19 October 1994. Paper and abstract, p. 25.

Elek J, Greener A and Ramsden N (1995). Effect of leaf beetle populations on eucalypt plantations. Program and abstracts, The A.J. Nicholson Centenary Meeting, 'The Frontiers of Population Ecology'. Canberra, 18-22 April 1995. Poster and abstract, p 65.

Madden JL, Patel VS and Clarke AR (1994). *Eucalyptus* leaf beetle controls: Choice, concealment and weather. Program and abstracts, Australian Entomological Society 25th Scientific Conference and AGM, Adelaide, 25-28 September 1994. Paper and abstract, p 49.

Marsh N (1994). Vertebrate browsing of *Eucalyptus* plantations: olfaction and diet selection. Chemical Signals in Vertebrates VII, Tubingen, Germany, 17-22 July 1994. Poster.

Marsh N (1994). Vertebrate browsing of *Eucalyptus* plantations: olfaction and diet selection. ECRO (European Chemoreception Research Organisation) XI, Bios, France, 25-30 July 1994. Poster.

Seminars and workshops

Clarke AR (1994). 'Interactions between *Eucalyptus* species and their invertebrate browsers.' Invited seminar delivered in the Department of Geography and Environmental Studies, University of Tasmania, Hobart, Tas. April 1994.

Clarke AR (1994).'Managing native insect pests in Tasmanian eucalypt plantations, is classical IPM the answer?' Department of Entomology, Washington State University, Pullman, WA., U.S.A. October 1994.

Clarke AR (1994).'Use of egg parasitoids in forestry pest management: Comments on the Canadian experience.' North Eucalypt Technologies, Ridgley, Tasmania. December 1994.

Clarke AR (1994). Eucalypt plantation forestry and insect pest management in Tasmania, Australia'. Invited seminar delivered at the Faculty of Forestry, University of Toronto, Toronto, Ont., Canada. October 1994.

Clarke AR (1994) 'Eucalypt insects'. Public address, presented at Lakes Head University, Thunder Bay, Ont., Canada. November 1994.

Clarke AR (1994). 'Managing native insects in native forests, an Australian perspective'. Invited seminar delivered at the Forest Pest Management Institute, Sault Ste. Marie, Ont., Canada. November 1994.

Education and Technology Transfer

Conferences/Symposia

CRCTHF/IUFRO Conference: 'Eucalypt Plantations: Improving Fibre Yield and Quality'.

CRCTHF/IUFRO Conference proceedings: 'Eucalypt Plantations: Improving Fibre Yield and Quality' (Eds. B.M. Potts, N.M.G. Borralho, J.B. Reid, R.N. Cromer, W.N. Tibbits and C.A. Raymond). CRCTHF-IUFRO Conf., Hobart, 19-24 Feb. (CRC for Temperate Hardwood Forestry: Hobart).

Seminars, workshops and tours

CRCTHF/IUFRO pre-conference tour to forestry company operations in Victoria and Tasmania (11-18 February 1995).

CRCTHF/IUFRO post conference tour to natural populations of *E. globulus* in eastern Tasmania (25-26 February 1995).

CRCTHF/IUFRO post conference tour of natural populations of *E. grandis* near Coff's Harbour (NSW) and Gympie (QLD) (26 February - 4 March 1995).

CRCTHF/IUFRO Conference workshops:

i) BLUP of breeding values in tree breeding (27-28 February 1995).

ii) Reproductive biology and controlled pollination (1-2 March 1995).

A workshop on pruning and thinning for sawlog plantations was run by Dr Chris Beadle and Ms Libby Pinkard of the Soil and Stand Management Program for the Forests and Forest Industry Council of Tasmania (November 1994).

A workshop on modelling of soil nitrogen mineralisation (19-22 June 1995) was run by the Soil and Stand Management Program and consisted of a half-day of seminars followed by 1.5 days of modelling sessions and a half-day field trip.

A short course entitled'Understanding, diagnosing and forecasting forest insect dynamics' (18-19 January 1995) was run by the Resource Protection Program and visiting scientist Prof Alan Berryman (from Washington State University).

A technical training program was started in November 1994 with two workshops, 'Basic Experimental Design' and 'Basic Quantitative Genetics', run by the Soil and Stand Management and Genetic Improvement Programs. There were 22 participants in each workshop, including technicians and foresters from Amcor Plantations, North Forest Products, ANM. Forestry Tasmania, CSIRO Division of Forestry and the University of Tasmania.

Grants and Awards to CRC staff

Genetic Improvement Program

$30,000 p.a. for 3 years for an Australian Postgraduate Award (Industry) (APA-I) to study the 'Selection procedures in tree breeding programs to maximise profitability of Australian forestry and pulp industry production systems', a project supervised by Dr N Borralho and conducted in collaboration with ANM.
Dr Nuno Borralho was elected Chairman of the IUFRO Working Party S2-08-03 'Improvement and Culture of Eucalypts'.

Soil and Stand Management

$30,000 p.a. for three years for an APA-I **award** to study N mineralisation in basalt soils, a project supervised by Dr P Smethurst and conducted in collaboration with Dr M Line, University of Tasmania, and Dr G Holz, North Eucalypt Technologies.

$30,000 p.a. for three years for an APA-I award to study the use of soil solutions as predictors of nutrient deficiencies, a project supervised by Dr P Smethurst and conducted in collaboration with Prof R Menary, University of Tasmania, and Dr G Holz, North Eucalypt Technologies

$30,000 p.a. for 3 years from the Land and Water Resources Research and Development Corporation to support a student in the study of the mechanisms of competition between weeds and trees. The project will be supervised by Dr P Smethurst (Project 3), Dr C Beadle (Project 1) and Dr N Mendham (University of Tasmania), in collaboration with a consortium of forest industries.

$40,000 p.a. from 1 October 1995 to 30 June 1997 funded by ANM Forest Management for a project led by Dr C Beadle on 'Optimising timing and amount of irrigation in eucalypt plantations'.

Resource Protection

$1,500 to Dr A Clarke, from North Forest Products for research travel to Canada.

$5,000 Dr A Clarke from CRC for Tropical Pest Management in collaboration with Dr B Congdon (CRCTPM) for genetic analysis of *C. bimaculata*.

$68,871 to Dr J Madden from Forests and Forest Industry Council for *C. bimaculata* research and three PhD scholarships.

Performance Indicators

Genetic Improvement

Five specific indicators were set initially for this program and four were already achieved or exceeded during our first three years.

a) Production of reliable estimates of heritabilities and correlations between characters

- This indicator has been fulfilled since heritabilities for commercially important characters such as growth, frost resistance, insect susceptibility, *Mycosphaerella* damage, flowering time, etc have been determined in *E. globulus*, *E. nitens* and *E. regnans*. These parameters have been determined from controlled crosses as well as from open pollinated progeny where increased reliability has been developed by the inclusion of natural stand characteristics. The most extensive determination has been done with the CSIRO *E. globulus* collection whose progeny were grown over many sites across four states. The first estimates of genetic parameters for pilodyn, wood density and rooting ability have also been calculated. A breeding plan has been developed in collaboration with STBA for *E. globulus* and the economic benefit calculated.

b) Production of F_1 and F_2 hybrid seed for field plantings

- The performance of *E. nitens* x *E. globulus* F_1 hybrids and the mode of genetic control have been determined for growth, frost tolerance and rooting ability.
- F_2 plants from *E. globulus* x *E. gunnii* are now 30 months old and an extensive F_2 crossing program for *E. globulus* x *E. nitens* has been completed and the plants grown for establishment of new trials.

c) Development of techniques for vegetative propagation of elite material

- An improved micropropagation procedure for elite material has been developed in conjunction with CSIRO Division of Forestry. This has reduced the costs involved in micropropagation considerably. Due to the difficulty of propagating temperate eucalypts we are examining how propagation ability can be most cost effectively integrated into breeding strategies.

d) Reduction of generation time and determination of gibberellin (GA) biosynthetic pathway

- The GA biosynthetic pathway has been identified and the generation interval for *E. globulus* reduced to 2.8 years. This technique is now being routinely used in commercial breeding programs. Further refinement of this technique is being carried out.

e) Techniques for finger-printing eucalypts using DNA markers

- This goal has been achieved by the use of RAPD markers. Further, a linkage map has been developed for *E. globulus* x *E. gunnii* and QLT's have been identified for branching and frost resistance, well in advance of project outcomes.

Due to the achievement of the major performance indicators set for this program at the commencement of the CRC it is proposed that new indicators be set to include:

1) The determination of breeding objectives for *E. globulus* and *E. nitens* and the development and implementation of the use of economic theory in making tree breeding decisions.

2) Establishment of methods for the routine sampling of wood quality traits for use in breeding programs.

3) The development of improved genetic evaluation techniques for determining breeding for trees across sites, generations and stand characteristics.

4) The direct involvement in eucalypt breeding work in Australia through the STBA.

5) Determination of the feasibility of employing somatic embryogenesis in the propagation of temperate eucalypts.

Soil and Stand Management

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

- Reductions in growth of *E. nitens* following pruning for clear-wood production should be minor, as photosynthetic capacity of remaining foliage increases.
- Application of fertiliser to seedlings soon after planting does not enhance early growth on a number of soil types in Tasmania.
- Cultivation of soils prior to planting favours early root development of planted seedlings.
- Methods to measure soil organic matter and nutrients in soil solution have been improved and will help to identify and ameliorate sites of low fertility.

b) Development of process-based models to predict wood yields under a wide range of silvicultural regimes

- The effects of night-time frosts that do not cause visible cell damage but reduce subsequent rates of photosynthesis in *E. nitens* have been quantified and can be incorporated into growth models.
- The circumstances when conductance and transpiration are coupled only weakly to prevailing atmospheric conditions have been identified and can be incorporated into growth models.

- A new and substantially simpler model system to predict annual canopy photosynthetic production in relation to nutrient status and temperature has been developed, along with a technique to couple this production model to a soil water balance model.

Resource Protection

a) Determination of the factors that predispose trees to attack by defoliating insects and mammals.

- It has been shown in the field that leaf colour (the amount of red in flush) is correlated with *C. bimaculata* oviposition and subsequent damage. It is likely, however, that colour is a correlate, rather than the causative factor of oviposition choice. Elucidation of the causal factors (possibly aspects of leaf biochemistry associated with growth and expansion) have yet to be determined. Early and rapid tree growth has also been shown to lead to lesser amounts of insect damage.

b) The development of biological control techniques to minimise damage caused by insect herbivores

- This milestone is being reached through two separate, but interrelated, approaches. The first is the development and refinement of an integrated pest management (IPM) strategy to control leaf-beetles. The IPM program uses currently available control methods in the most economically efficient and environmentally sensitive way to reduce pest populations. In addition to giving immediate protection to existing plantation estates, this strategy will form a framework into which true biological control techniques can be incorporated.
- The other approach being taken to biological control research is the elucidation of the biology of *C. bimaculata* and the dominant predator species, *Cleobora mellyi*. It has become apparent over the first three years of research that much of the previous 'knowledge' of these insects was too poorly understood to allow immediate development of operational biological control strategies. Rather, it has been demonstrated that there is a strong need to understand the fundamental biology of these insects so that the appropriate strategies may be formulated. Important gains have been made over three years in understanding the population phenology and movement of *C. bimaculata* and the feeding ecology of *Cl. mellyi*.

c) Assessment of the feasibility of breeding insect tolerant genotypes

- 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 highly 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 and will require significant consultation with the Genetic Improvement Program and commercial end users.

d) Development of substances which inhibit or eliminate browsing by vertebrates

- To date, only limited progress has been made towards this milestone. Technical and experimental difficulties involved in the project initially slowed work; however, appointment of a new post-doctoral fellow, Dr Clare McArthur, should increase the speed of future research. A change in research direction of this project will result in new milestones being developed over the 1995/96 financial year.

Education

a) The number of postgraduate students trained in the specified areas

- There are 27 PhD, five MSc, four Honours and one Graduate Diploma with Honours students enrolled at the CRC for Temperate Hardwood Forestry. This number exceeds our target of 25 students in honours and post-graduate study.

b) The number of enrolments in special courses

- There are ten enrolments in the four-year degree course 'Forest Ecology' and one student is enrolled in Graduate Diploma with Honours in 'Forest Processes'.

c) The quality and numbers of post-doctoral fellows and visiting scientists attracted

- There are now six post-doctoral fellows working with the CRC, or soon to be appointed to the CRC.
- In the Resource Protection Program, Dr Anthony Clarke has played a key role, leading research in Projects 2 and 4 on the control of insect defoliators and the biology of other insect pests of *Eucalyptus*. A new post-poctoral fellow, Dr Clare McArthur, has just been appointed to the vertebrate browsing project.
- In the Genetic Improvement Program, Dr Omar Hasan has been identifying and quantifying gibberellins, auxins and abscissic acid in the cambial tissue of *E. globulus* with the aim of determining their effect on wood properties; Dr Jean-Noël Ruaud started in August 1994 on a project investigating the use of somatic embryogenesis in vegetative propagation; Dr Allie Muneri has accepted the position of wood scientist with Project 2; and Dr Dorothy Steane was appointed as molecular biologist to Project 3 in April 1995.
- The 'Visiting Scientist Program' has also brought to the CRC scientists of international standing. Dr Peter Kanowski

(quantitative geneticist with Oxford University, recently appointed Professor of Forestry at ANU) visited the Centre to collaborate on studies of breeding objectives for hardwood plantations with the Genetic Improvement Program. Prof Alan Berryman (from Washington State University) conducted a workshop and interacted with staff and students of the Resource Protection Program.

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

- A PhD student with the CRC, Mr B. Greaves, suspended full-time enrolment for a year to take up a senior management position with Amcor Plantations. He has now returned to the Centre to complete his PhD. Two scientists at Forestry Tasmania, Mr T Wardlaw (forest pathologist) and Mr S Candy (statistician), and a senior manager at ANM Forest Management, Mr Peter Volker, are enrolled in PhD courses at the CRC.

Technology Transfer

a) The degree of adoption of research results by industry

In the past 12 months, 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 industry.

- In the Genetic Improvement Program researchers have, in association with STBA (Southern Tree Breeding Association), now conducted a complete BLUP (Best Linear Unbiased Prediction) analysis of national and international trials of *E. globulus* and *E. nitens*. The results from this analysis will enable industrial partners to accurately select candidates for the next generation of tree breeding.
- The pilodyn is now being used generally as a tool for indirect assessment of wood density and thus is the first quick and easily employed method of measuring wood quality capable of being used in BLUP analysis of breeding values.
- Researchers in the Soil and Stand Management Program are well advanced in the quantification of the nitrogen mineralisation of some typical soils used for tree-farms, which will allow more accurate determination of the timing and level of application of fertilisers.
- Scientists within the program are also in the process of quantifying the growth effects of pruning and thinning (supported by the Forests and Forest Industry Council) which will allow a more accurate assessment of the impacts of these silvicultural practices on plantations used for solid wood products.

- The Resource Protection Program, as well as continuing to refine its Integrated Pest Management Program through studies of the ecology of *C. bimaculata,* has three new initiatives which could directly benefit industry partners. Firstly, strategic plantings of *E. regnans* in *E. nitens* plantations may act as 'trap' trees for insect defoliators. Secondly, management of a major defoliator, the autumn gum moth, will improve with new research being conducted. Thirdly, progress is being made towards developing a plantation plan that will minimise the damage caused by vertebrate browsers.

b) The quality and relevance of technical publications targeted to user groups

- During 1994/95 scientists and students working for the CRC have produced 39 refereed publications, 47 unrefereed publications and seven Honours, MSc and PhD theses. All of these were of direct or indirect relevance to plantation forestry and most refereed articles are published in journals of international standing. Copies of these publications are circulated amongst user groups and their existence is highlighted in meetings and through direct contact between CRC staff.
- The Centre published, and made available at the start, the complete proceedings of the international conference on 'Eucalypt Plantations: Improving Fibre Yield and Quality' which it ran in association with the International Union of Forestry Research Organisations (IUFRO) in February 1995. The proceedings provided a valuable summary of current thought in the subject area, as well as providing a forum to demonstrate the excellence of the Centre, to an audience of 270 delegates from 23 countries (Eds. BM Potts, NMG Borralho, JB Reid, RN Cromer, WN Tibbits and CA Raymond).

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

- We have run 15 seminars, one international conference, three short courses and three workshops during 1994/95 which have attracted more than 650 people to become involved in activities of the Centre.

BUDGET

Tables:

1) In-kind contributions from partners

2) Cash contributions and expenditure

3) Summary of resources applied to activities of centre

4) Allocation of resources between categories of activities

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

EXPENDITURE

PARTNER	ACTUAL							PROJECTED			GRAND TOTAL
	1991/92	1992/93	1993/94	1994/95 Actual	1994/95 Budget	Cumulative to date Actual	Cumulative to date Budget	1995/96	1996/97	1997/98	
CSIRO DIVISION OF FORESTRY											
SALARIES	531.4	610.9	613.6	573.3	555.7	2,329.2	2,158.3	572.4	583.9	595.6	4,081.1
CAPITAL											
OTHER	900.4	1,033.9	1,042.5	909.7	901.1	3,886.5	3,642.1	913.0	930.9	949.1	6,679.5
TOTAL	1,431.8	1,644.8	1,656.1	1,483.0	1,456.8	6,215.7	5,800.4	1,485.4	1,514.8	1,544.7	10,760.6
UNIVERSITY OF TASMANIA											
SALARIES	488.4	407.7	330.6	372.8	758.1	1,599.5	3,032.0	460.3	470.6	480.1	3,010.5
CAPITAL	40.0			150.0		190.0	40.0	200.0			390.0
OTHER	648.7	636.6	553.5	656.0	572.4	2,494.8	2,146.0	711.0	726.5	741.2	4,673.5
TOTAL	1,177.1	1,044.3	884.1	1,178.8	1,330.5	4,284.3	5,218.0	1,371.3	1,197.1	1,221.3	8,074.0
ANM FOREST MANAGEMENT											
SALARIES	21.0	26.0	38.0	45.4	26.0	130.4	104.0	40.9	42.2	43.5	257.0
CAPITAL											
OTHER	28.0	62.0	98.0	59.0	104.0	247.0	416.0	66.0	70.0	75.0	458.0
TOTAL	49.0	88.0	136.0	104.4	130.0	377.4	520.0	106.9	112.2	118.5	715.0
NORTH FOREST PRODUCTS											
SALARIES	64.0	59.3	70.6	109.8	64.0	303.7	256.0	74.5	75.2	75.2	528.6
CAPITAL											
OTHER	107.0	103.7	125.4	122.0	182.0	458.1	728.0	125.4	125.4	125.4	834.3
TOTAL	171.0	163.0	196.0	231.8	246.0	761.8	984.0	199.9	200.6	200.6	1,362.9

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

EXPENDITURE

PARTNER	ACTUAL							PROJECTED			
	1991/92	1992/93	1993/94	1994/95 Actual	1994/95 Budget	Cumulative to date Actual	Cumulative to date Budget	1995/96	1996/97	1997/98	GRAND TOTAL
BORAL TIMBER TASMANIA											
SALARIES	39.6	24.2	24.9	3.6	51.0	92.3	204.0	5.7	9.6	9.6	117.2
CAPITAL											
OTHER	50.2	42.6	26.7	4.8	112.0	124.3	448.0	5.0	8.5	8.5	146.3
TOTAL	89.8	66.8	51.6	8.4	163.0	216.6	652.0	10.7	18.1	18.1	263.5
FORESTRY TASMANIA											
SALARIES	47.2	57.3	69.0	77.2	28.0	250.7	112.0	78.0	78.7	79.5	486.9
CAPITAL											
OTHER	61.0	64.6	78.1	79.5	69.0	283.2	276.0	91.0	97.0	103.0	574.2
TOTAL	108.2	121.9	147.1	156.7	97.0	533.9	388.0	169.0	175.7	182.5	1,061.1
AMCOR PLANTATIONS											
SALARIES		118.1	118.6	79.5	118.0	316.2	354.0	81.1	82.7	84.4	564.4
CAPITAL											
OTHER		81.0	60.6	96.3	60.0	237.9	180.0	98.2	100.2	102.2	538.5
TOTAL		199.1	179.2	175.8	178.0	554.1	534.0	179.3	182.9	186.6	1,102.9
TOTAL IN-KIND CONTRIBUTIONS											
SALARIES	1,191.6	1,303.5	1,265.3	1,261.6	1,600.8	5,022.0	6,220.3	1,312.9	1,342.9	1,367.9	9,045.7
CAPITAL	40.0			150.0		190.0	40.0	200.0			390.0
OTHER	1,795.3	2,024.4	1,984.8	1,927.3	2,000.5	7,731.8	7,836.1	2,009.6	2,058.5	2,104.4	13,904.3
GRAND TOTAL IN-KIND	3,026.9	3,327.9	3,250.1	3,338.9	3,601.3	12,943.8	14,096.4	3,522.5	3,401.4	3,472.3	23,340.0

CASH CONTRIBUTIONS ($000's)

TABLE 2

	ACTUAL							PROJECTED			
PARTNERS	1991/92	1992/93	1993/94	1994/95 Actual	1994/95 Budget	Cumulative to date Actual	Cumulative to date Budget	1995/96	1996/97	1997/98	GRAND TOTAL
A CSIRO Division of Forestry											
B University of Tasmania	500.0				100.0	500.0	400.0	100.0			600.0
C Forestry Tasmania											
D North Forest Products											
E ANM Forest Management		20.0	20.0	25.0	25.0	65.0	60.0	20.0	20.0	20.0	125.0
F Boral Timber Tasmania											
G Amcor Plantations											
TOTAL CASH FROM PARTICIPANTS	500.0	20.0	20.0	25.0	125.0	565.0	460.0	120.0	20.0	20.0	725.0
INTEREST	10.5	68.6	25.0	60.9	31.6	165.0		26.4	16.1	12.2	219.7
OTHER EXTERNAL FUNDS			1.8	121.0	116.1	122.8		30	30	30	212.8
FUNDING FROM THE CRC GRANT	948.6	1,448.5	1,723.5	1,320.2	1,600.0	5,440.8	5,364.0	2,193.5	1,753.7	1,635.4	11,023.4
TOTAL CRC CASH CONTRIBUTION	1,459.1	1,537.1	1,770.3	1,527.1	1,872.7	6,293.6	5,824.0	2,369.9	1,819.8	1,697.6	12,180.9
Cash carried over from previous year		1,163.4	876.1	961.0	961.0			741.4	817.0	462.9	
Less unspent balance	1,163.4	876.1	961.0	741.4	826.5			817.0	462.9	0.0	
TOTAL CASH EXPENDITURE	295.7	1,824.4	1,685.4	1,746.7	2,007.2	5,552.2		2,294.3	2,173.9	2,160.5	12,180.9
ALLOCATION OF CASH EXPENDITURE BETWEEN HEADS OF EXPENDITURE											
SALARIES	118.8	636.1	1,079.6	1,150.2	1,245.9	2,984.7		1,439.8	1,502.6	1,543.2	7,470.3
CAPITAL		500.0	62.0	0.0		562.0					562.0
OTHER	176.9	688.3	543.8	596.5	761.3	2,005.5		854.5	671.3	617.3	4,148.6

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

TABLE 3

ALL PROGRAMS

EXPENDITURE

	ACTUAL							PROJECTED			
	1991/92	1992/93	1993/94	1994/95	1994/95 Budget	Cumulative to date Actual	Cumulative to date Budget	1995/96	1996/97	1997/98	GRAND TOTAL
GRAND TOTAL (IN-KIND)	3,026.9	3,327.9	3,250.1	3,338.9	3,601.3	12,943.8	14,096.4	3,522.5	3,401.4	3,472.3	23,340.0
GRAND TOTAL (CASH EXPENDITURE)	795.7	1,324.4	1,685.4	1,746.7	2,007.2	5,552.2	5,364.0	2,294.3	2,173.9	2,160.5	12,180.9
TOTAL RESOURCES APPLIED TO ACTIVITIES OF CENTRE	3,822.6	4,652.3	4,935.5	5,085.6	5,608.5	18,496.0	19,460.4	5,816.8	5,575.3	5,632.8	35,520.9

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	2,846.7	8,006.9	8,992.3	2,752.7	2,845.5	2,911.1	16,516.2
TOTAL CAPITAL (CASH AND IN-KIND)	540.0	0.0	62.0	150.0		752.0	540.0	200.0	0.0	0.0	952.0
TOTAL OTHER (CASH AND IN-KIND)	1,972.1	2,712.7	2,528.5	2,523.8	2,761.8	9,737.1	9,928.1	2,864.1	2,729.8	2,721.7	18,052.7

Allocation of resources between categories of activities (1994/95) TABLE 4

PROGRAM	RESOURCE USAGE			
	Cash $000's	In-kind $000's	Staff Contributed	Staff funded by CRC
Research	1,596.6	3,284.9	10.0	10.5
Education	72.3	9.0	0.2	
Commercialisation/ Tech Transfer				0.5
Administration	77.8	45.0	0.6	
TOTAL	1,746.7	3,338.9	10.8	11.0

AUDITOR'S REPORT

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Price Waterhouse

INDEPENDENT AUDIT REPORT
TO THE MEMBERS OF THE COOPERATIVE RESEARCH CENTRES COMMITTEE
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 1995 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. We have conducted an independent audit of the financial information in order to express an opinion to the Members of the Cooperative Research Centres Committee 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.

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, 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.

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. [Clause 4].

2. The Researcher has used the grant and the Reasearcher's contributions for the Activities of the Centre and not for any other purpose. [Clause 5(1)].

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 Committee. [Clause 5(2)].

4. Capital Items acquired from the Grant and Researcher's Contributions are vested as provided in the Joint Venture Agreement. [Clause 5(3)].

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 Committee [Clause 9(1), 9(5)].

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. [Clause 12(2)].

Qualification

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

Clause 5(2)

The Researcher's allocations of the budgetary resources between Heads of Expenditure has been higher than the allocation in the Budget by $100,000 or 20%(whichever is the greater amount) without prior approval by the Committee. Capital expenditure of $150,000 was higher than the Budget of Nil.

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
University of Tasmania	1430.5	1178.8
ANM Forest Management	155.0	129.4
North Forest Products	246.0	231.8
Boral Timber Tasmania	163.0	8.4
AMCOR Plantations	178.0	175.8

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 1995 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.

Price Waterhouse
Chartered Accountants

Steven A Hernyk
Partner

Hobart
12 September 1995

CRC TEMPERATE AND HARDWOOD FORESTRY

Notes to and forming part of the accounts

Summary of significant accounting policies

All funds under the Co-operative Research Centre's control are administered through the University of Tasmania 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.

(d) Employee entitlements

Provision has not been made for pro-rata entitlements to annual and long service leave.

PARTNER CONTRIBUTIONS

CSIRO Division of Forestry

CRC FOR TEMPERATE HARDWOOD FORESTRY

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

SALARIES

Name	*Designation*	*Program*	*% time CRC*	1991/92	1992/93	1993/94	1994/95 Actual	1995/96	1996/97	1997/98	TOTAL
Hand, Mr F	Technician	Gen	100								
Hartney, Mr V	Scientist	Gen	70								
Moncur, Mr M	Scientist	Gen	20								
Owen,Mr J	Scientist	Gen	20								
Raymond, Ms C	Scientist	Gen	100								
Svensson, Mr J	Technician	Gen	70								
Beadle, Dr C	Scientist	SSM	70								
Cromer, Mr R	Scientist	SSM	40								
Lasala, Ms A	Technician	SSM	50								
Cherry, Ms M	Technician	SSM	100								
Sands, Dr P	Scientist	SSM	80								
Turnbull, Mr C	Scientist	SSM	70								
West, Dr P	Scientist	SSM	80								
Wiltshire, Mr D	Technician	SSM	40								
			Total Salary	421.2	484.2	492.4	453.2	452.5	461.6	470.8	3,235.9

Direct On-Costs	*% of total Salary*								
Productivity Benefit	3.0	12.6	14.5	14.8	13.6	13.6	13.8	14.1	
Superannuation	18.6	70.3	80.8	82.1	84.3	84.2	85.9	87.6	
Workers Compensation	0.9			4.5	4.1	4.1	4.2	4.2	
Leave Loading	1.5	6.3	7.2	7.4	6.8	6.8	6.9	7.1	
Long Service Leave	2.5	10.5	12.1	12.4	11.3	11.3	11.5	11.8	
Other		10.5	12.1	0.0					
	Total On-Costs	110.2	126.7	121.2	120.1	119.9	122.3	124.8	845.2
	Total Salaries & On-Costs	531.4	610.9	613.6	573.3	572.4	583.9	595.6	*4,081.1*

CSIRO Division of Forestry

CRC FOR TEMPERATE HARDWOOD FORESTRY

		1991/92	1992/93	1993/94	1994/95 Actual	1995/96	1996/97	1997/98	TOTAL
CAPITAL									
	Total Capital								
OTHER	*% of Total Salaries & On -Costs*								
Divisional Administration/Support	87.0	510.3	586.4	589.0	498.8	498.0	508.0	518.1	3,708.6
Institute Overheads	12.0	47.8	55.0	55.3	68.8	68.7	70.1	71.5	437.1
Corporate Overheads	20.0	127.6	146.5	147.3	114.7	114.5	116.8	119.1	886.4
Amortised capital costs	37.0	196.7	226.0	227.0	212.1	211.8	216.1	220.4	1,510.0
Direct Operating Allocation		18.0	20.0	23.9	15.4	20.0	20.0	20.0	137.3
	Total Other	900.4	1,033.9	1,042.5	909.7	913.0	930.9	949.1	6,679.5
TOTAL IN-KIND CONTRIBUTION		1,431.8	1,644.8	1,656.1	1,483.0	1,485.4	1,514.8	1,544.6	10,760.6

UNIVERSITY OF TASMANIA

CRC FOR TEMPERATE HARDWOOD FORESTRY

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	50								
Dungey H	Student	Gen	100								
Gorst J	Scientist	Gen	10								
Cummings I	Technician	Gen	40								
Hardner C	Student	Gen	100								
Haig G	Technician	Gen	20								
Johnson G	Technician	Gen	10								
Menary R	Scientist	Gen	10								
Vaillancourt R	Scientist	Gen	30								
Smolenski A	Technician	Gen	30								
Xianming Wei	Student	Gen	100								
Wiltshire R	Scientist	SSM	10								
Clarke R	Scientist	SSM	10								
Hill R	Scientist	SSM	10								
Line M	Scientist	SSM	5								
Brown P	Scientist	SSM	5								
Howlett B	Student	RPP	100								
Madden J	Scientist	RPP	30								
Unwin G	Scientist	ETT	25								
Williams K	Student	ETT	100								
Total Salary				324.1	270.5	168.9	225.3	275.3	280.8	286.4	1,831.3

UNIVERSITY OF TASMANIA

Direct On-Costs	*% total salary*	1991/92	1992/93	1993/94	1994/95	1995/96	1996/97	1997/98	TOTAL
Payroll tax	7.0	22.7	18.9	11.8	11.0	14.5	14.8	15.1	
Superannuation	17.0	55.1	46.0	28.7	26.7	35.2	35.9	36.6	
Workers Compensation	1.0	3.2	2.7	1.7	1.6	2.1	2.1	2.2	
Leave Loading	1.4	4.5	3.8	2.4	2.2	2.9	2.9	3.0	
Long Service Leave	3.2	10.3	8.6	5.4	5.0	6.6	8.0	8.1	
Outside study-Academics		68.5	57.2	28.0	26.6	36.6	37.3	38.1	
HECS student contributions				83.7	74.4	87.1	88.8	90.6	
Total On-Costs		164.3	137.2	161.7	147.5	185.0	189.8	193.7	1,179.2
Total Salaries & On-Costs		488.4	407.7	330.6	372.8	460.3	470.6	480.1	3,010.5
CAPITAL									
Modifications to Plant Science Building		40.0							
New building/equipment					150.0	200.0			
Total Capital		40.0			150.0	200.0	0.0		390.0
OTHER	*% of Total Salaries & On -Costs*								
Academic services	25.0	122.1	101.9	82.6	93.2	115.1	117.7	120.0	752.6
General uni services	41.0	200.3	167.2	135.5	152.9	188.7	192.9	196.8	1,234.4
Deptl office support	10.0	48.8	40.8	33.0	37.3	46.0	47.1	48.0	301.0
Laboratory rent	32.0	156.3	130.5	105.8	119.3	147.3	150.6	153.6	963.4
Office space	8.0	39.1	32.6	26.4	29.8	36.8	37.6	38.4	240.8
Central Science Lab			80.0	83.2	134.8	86.6	88.3	90.1	563.0
Management Agency		82.0	83.6	87.0	88.7	90.5	92.3	94.2	618.3
Total Other		648.6	636.6	553.5	656.0	711.0	726.5	741.2	4,673.5
TOTAL IN-KIND CONTRIBUTION		1,177.0	1,044.3	884.1	1,178.8	1,371.3	1,197.1	1,221.3	8,074.0

CRC FOR TEMPERATE HARDWOOD FORESTRY

ANM 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
Volker, P	Scientist	Gen	40								
Hetherington, S	Scientist	Gen	20								
Hetherington, S	Scientist	SSM	10								
Hetherington, S	Scientist	RPP	5								
		Total Salary		17.0	21.0	29.0	34.4	31.0	32.0	33.0	197.4

Direct On-Costs	*% total salary*									TOTAL
Payroll tax	7.0									
Superannuation	21.0									
Workers Compensation	2.0									
Leave Loading										
Long Service Leave	1.9									
Other										
	Total On-Costs	4.0	5.0	9.0	11.0	9.9	10.2	10.5		59.6
	Total Salaries & On-Costs	21.0	26.0	38.0	45.4	40.9	42.2	43.5		257.0

CAPITAL

Total Capital								0.0

OTHER

	% of Total Salaries & On -Costs							
Office support	11.0	9.0	10.0	10.0	11.0	11.0	11.0	73.0
Vehicle costs	7.0	6.0	7.0	11.0	11.0	11.0	12.0	65.0
Trial maintenance		22.0	53.0	8.0	12.0	14.0	16.0	125.0
Cash contributions-ref to Table2								0.0
Experiments (land rent)	10.0	25.0	28.0	30.0	32.0	34.0	36.0	195.0
Total Other	28.0	62.0	98.0	59.0	66.0	70.0	75.0	458.0
TOTAL IN-KIND CONTRIBUTION	49.0	88.0	136.0	104.4	106.9	112.2	118.5	715.0

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
Jamieson A	Manager	Admin	10								
de Little D	Scientist	Admin	5								
Ravenwood I	Exec Officer	Admin	5								
Walker B	Secretary	Admin	6								
de Little D	Scientist	RPP	10								
Ravenwood I	Executive officer	RPP	5								
Holz G	Scientist	SSM	20								
Oliver C	Technician	SSM	15								
Tibbits W	Scientist	Gen	30								
Rasmussen G	Scientist	Gen	24								
Joyce K	Technician	Gen	25								
Burgess D	Technician	Gen	16								
Powell M	Scientist	Gen	5								
Dean G	Scientist	Gen	9								
French J	Scientist	Gen	3								
			Total Salary	58.0	53.7	64.1	86.1	67.9	67.9	67.9	465.6

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	6.6	7.3	7.3	63.0
			Total Salaries & On-Costs	64.0	59.3	70.6	109.8	74.5	75.2	75.2	528.6

CRC FOR TEMPERATE HARDWOOD FORESTRY

NORTH FOREST PRODUCTS

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

		1991/92	1992/93	1993/94	1994/95	1995/96	1996/97	1997/98	TOTAL
CAPITAL									
	Total Capital								
OTHER	*% of Total Salaries & On -Costs*								
	Head Office Overheads	21.0	22.1	17.3	11.3	17.3	17.3	17.3	123.6
	Office Support	18.0	6.4	4.2	7.0	4.2	4.2	4.2	48.2
	Office hire	20.0	15.6	18.1	23.0	18.1	18.1	18.1	131.0
	Operational		59.6	85.8	80.7	85.8	85.8	85.8	483.5
	Experiments	8.0							8.0
	Other	40.0							40.0
	Total Other	107.0	103.7	125.4	122.0	125.4	125.4	125.4	834.3
	TOTAL IN-KIND CONTRIBUTION	171.0	163.0	196.0	231.8	199.9	200.6	200.6	1,362.9

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
Naughton, P	Scientist	SSM	5				2.1				
Naughton, P	Scientist	ETT	2				0.8				
			Total Salary	31.1	19.0	19.7	2.9	4.5	7.5	7.5	92.2
	Direct On-Costs		*% tot. salary*								
	Payroll tax		7.0		1.4	1.4	0.2				
	Superannuation		5.5		1.1	1.1	0.2				
	Workers Compensation		5.0		1.0	1.0	0.1				
	Leave Loading		8.0		1.6	1.6	0.2				
	Long Service Leave		2.0		0.1	0.1	0.0				
	Other										
			27.5								
			Total On-Costs	8.5	5.2	5.2	0.7	1.2	2.1	2.1	25.0
			Total Salaries & On-Costs	39.6	24.2	24.9	3.6	5.7	9.6	9.6	117.2

CAPITAL

			Total Capital								

OTHER

		% of Total Salaries & On -Costs								
Head Office Overheads		12.0	4.8	3.9	3.0	0.5	0.7	1.2	1.2	
Office Support		30.0	19.1	23.5	12.1	1.1	1.7	2.9	2.9	
Operational		30.0	26.3	15.2	11.6	1.1	1.7	2.9	2.9	
Vehicle costs		7.0				0.3	0.4	0.7	0.7	
Trial maintenance		8.0				0.3	0.5	0.8	0.8	
Experiments						1.5				
		Total Other	50.2	42.6	26.7	4.8	5.0	8.5	8.5	146.3
TOTAL IN-KIND CONTRIBUTION			89.8	66.8	51.6	8.4	10.7	18.1	18.1	263.5

FORESTRY TASMANIA

CRC FOR TEMPERATE HARDWOOD FORESTRY

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	15								
Bashford, R	Technician	RPP	10								
Baker, S	Technician	RPP	50								
Ramsden, N	Technician	RPP	50								
Elek, J	Research Forester	RPP	40								
Kube, P	Research Forester	Gen	20								
			Total Salary	39.6	47.5	57.5	64.4	65.0	65.7	66.4	406.1
	Direct on-costs		*% tot.salary*								
	Payroll tax		7.0	2.8	3.3	4.0	4.5	4.6	4.6	4.6	28.4
	Superannuation		5.0	1.2	2.4	2.9	3.2	3.3	3.3	3.3	19.6
	Workers Compensation		3.5	1.8	2.1	2.1	2.3	2.3	2.3	2.3	15.2
	Leave Loading		1.2	0.6	0.6	0.7	0.8	0.8	0.8	0.8	5.1
	Long Service Leave		3.1	1.2	1.4	1.8	2.0	2.0	2.0	2.1	12.5
	Other										
			Total On-Costs	7.6	9.8	11.5	12.8	13.0	13.0	13.1	80.8
			Total Salaries & On-Costs	47.2	57.3	69.0	77.2	78.0	78.7	79.5	486.9

CAPITAL

			Total Capital								

OTHER

		% of Total Salaries & On -Costs								
	Head Office Overheads	34.6	14.8	16.4	19.6	22.3	25.0	27.0	30.0	155.1
	Office Support(inc equipment,admin)	22.7	9.7	10.7	13.1	14.6	16.0	18.0	19.0	101.1
	Office hire	18.2	7.7	8.6	10.4	11.7	13.0	14.0	16.0	81.4
	Operational(inc.vehicle,materials,etc)	48.0	28.8	28.9	35.0	30.9	37.0	38.0	38.0	236.6
		Total Other	61.0	64.6	78.1	79.5	91.0	97.0	103.0	574.2
TOTAL IN-KIND CONTRIBUTION			108.2	121.9	147.1	156.7	169.0	175.7	182.5	1,061.1

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								
Krysgman M	Technician	Gen	40								
Appleton R	Technician	Gen	15								
Pye C	Technician	Gen	20								
Whiteman P	Scientist	SSM	10								
Pongracic S	Scientist	SSM	10								
Krysgman M	Technician	SSM	20								
Appleton R	Technician	SSM	5								
Whiteman P	Scientist	RPP	5								
Pongracic S	Scientist	RPP	5								
Total Salary					51.3	51.8	63.7	64.9	66.2	67.6	365.5

Direct On-Costs	*% of total salary*								
Payroll tax									
Superannuation									
Workers Compensation									
Leave Loading									
Long Service Leave									
Other									
Total On-Costs		0.0	66.8	66.8	15.8	16.2	16.5	16.8	198.9
Total Salaries & On-Costs		0.0	118.1	118.6	79.5	81.1	82.7	84.4	564.4

CAPITAL

Total Capital								

AMCOR PLANTATIONS

CRC FOR TEMPERATE HARDWOOD FORESTRY

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

OTHER

	% *Total Salaries & On -Costs*	1991/92	1992/93	1993/94	1994/95	1995/96	1996/97	1997/98	TOTAL
Head Office Overheads					25.9	26.4	27.0	27.5	106.8
Operational					70.4	71.8	73.2	74.7	290.1
Total Other		0.0	81.0	60.6	96.3	98.2	100.2	102.2	538.5
TOTAL IN-KIND CONTRIBUTION		0.0	199.1	179.2	175.8	179.3	182.9	186.6	1,102.9

ATTACHMENT C

CENTRE STAFF

ATTACHMENT C

RESEARCH STAFF RESOURCES (1994/95)

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	40	40			40			
HETHERINGTON, S		R	35	20	10	5	35			
Total			75	60	10	5	75			
Amcor Plantations										
PONGRACIC, S		R	35	20	10	5	35			
WHITEMAN, P		R	25	10	10	5	25			
Total			60	30	20	10	60			
North Forest Products										
TIBBITS, W		R	30	30			30			
RASMUSSEN, G		R	24	24			24			
HOLZ, G		R	20		20		20			
DE LITTLE, D		R	15			10	10			5
RAVENWOOD, I		R	10			5	5			5
DEAN, G		R	9	9			9			
POWELL, M		R	5	5			5			
FRENCH, J		R	3	3			3			
JAMIESON, A		A	10							10
Total			126	71	20	15	106			20
Boral Timber Tasmania										
NAUGHTON, P		R	7		5		5	2		
Total			7	0	5	0	5	2		
Forestry Tasmania										
ELEK, J		R	40			40	40			
KUBE, P		R	20	20			20			
ELLIOTT, H		R	15			15	15			
Total			75	20		55	75			

RESEARCH STAFF RESOURCES (1994/95)

Attachment C cont ../2

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*				
CSIRO, Forestry										
SANDS, P		R	80		80		80			
RAYMOND, C		R	100	100			100			
WEST, P		R	80		60		60			20
BEADLE, C		R	70		70		70			
TURNBULL, C		R	70		70		70			
HARTNEY, V		R	70	70			70			
CROMER, R		R	40		40		40			
MONCUR, M		R	20	20			20			
OWEN, J		R	20	20			20			
Total			550	210	320		530			20
University of Tasmania										
REID, J		R	50	30			30			20
VAILLANCOURT, R		R	30	30			30			
MADDEN, J		R	30			30	30			
HILL, R		R	10		10		10			
GORST, J		R	10	10			10			
MENARY, B		R	10	10			10			
WILTSHIRE, R		R	10		10		10			
CLARKE, R		R	10		10		10			
LINE, M		R	5		5		5			
BROWN, P		R	5		5		5			
UNWIN, G		E	25					25		
Total			195	80	40	30	150	25		20

RESEARCH STAFF RESOURCES (1994/95)

Attachment C cont ../3

Employer		Main activity	Total % time	% spent on Research Program			Total on Research	% spent on Education	% Spent on Commercialisation Program	% spent on CRC Administration
CRC funded				*Gen*	*SSM*	*Prot*				
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			
WANG, X	Uni Tas	R	100		100		100			
POTTS, B	Uni Tas	R	100	100			100			
BORRALHO, N	Uni Tas	R	100	100			100			
MUNERI, A	Uni Tas	R	100	100			100			
RUAUD, J-N	CSIRO	R	100	100			100			
STEANE, D	Uni Tas	R	100	100			100			
Total			1100	500	350	200	1050	50		

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

	Total equiv. person years	Person years spent on Research program			Total on Research	Person years spent on Education Program	Person years spent on Commercialisation Program	Person years spent on CRC Administration
		Gen	*SSM*	*Prot*				
Total Contributed	10.8	4.7	4.2	1.2	10.0	0.2		0.6
Total funded by CRC	11.0	5.0	3.5	2.0	10.5	0.5		
Grand total	21.8	9.7	7.7	3.2	20.5	0.7		0.6
Proportion of total professional (%) staff resources in each activity	100.0	44.5	35.1	14.4	94.0	3.2		2.8

SUPPORT STAFF

Contributed	
Organisation	Number of staff (person years)
ANM	0.0
Amcor Plantations	1.0
North Forest Products	0.6
Forest Resources	0.0
Forestry Tasmania	1.1
CSIRO	3.6
University of Tasmania	1.0
Total	7.3

CRC Funded (by employing organisation)	
Organisation	Number of staff (person years)
CSIRO	0.8
University of Tasmania	12.0
Total	12.8

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