RESEARCH AND DEVELOPMENT

ANNUAL REPORT 2004/2005

science and research

NSW DEPARTMENT OF PRIMARY INDUSTRIES

FORESTS NSW

RESEARCH AND DEVELOPMENT
ANNUAL REPORT 2004/2005

Our Mission

Research and development that underpins innovative sustainable forest management systems, adds value to Forests NSW's key objectives and benefits the people of New South Wales

Research and Development Annual Report 2004/05
is a supplement to the Forests NSW's Annual Report
and Social, Environmental and Economic Report 2004/05

Front Cover: Forty-year-old *Eucalyptus cloeziana* (Gympie messmate selection
Photo: Warwick Moore

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Foreword

Since the formation of NSW Department of Primary Industries, Forests NSW's research and development objectives are delivered through DPI Science and Research, as well as the Plantation and Tree Improvement units of Land Management and Technical Services. These groups provide strategic research support to the organisation's operation and service branches.

The Forest Resources Research Unit is based at the DPI Forest Science Centre of Excellence, located within Cumberland Forest at West Pennant Hills. Two staff working on the Burning Study Area are located in Eden. Tree Improvement for hardwoods is based at Coffs Harbour and the newly established Grafton Forest Technology Centre, while softwood tree improvement is centred in Tumut. Plantation Improvement has staff at Tumut, Coffs Harbour and Bathurst as well as Cumberland Forest.

Focus is on innovative science-based outcomes for forest resource development and sustainability. Research in fields which can add value to the planted forests, commercial services and native forests businesses of Forests NSW remain a priority. Emphasis includes establishment, management and product quality of sustainable planted forests. Research on the range of important potential benefits to be derived from returning trees to the rural landscape is also an important objective. Benefits include; timber, sequestered carbon, bioenergy, enhanced biodiversity and salinity mitigation.

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Report compiled and edited by:
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Tree Improvement

Tree Improvement Manager:
Michael Henson

Aim:

Improved softwood and hardwood genetic material available and in use throughout planted forests.

Objectives:

Genetically improved planting stock delivered for use across a range of sites of softwood and hardwood plantations

Genotypes matched to sites and specific end-products

Hardwood tree improvement and vegetative propagation
H Smith

The development of an efficient and effective clonal propagation system for hardwoods, using mini-cuttings, will allow rapid deployment of improved material of some species into operational plantations. It will enable Forests NSW to move towards clonal forestry for some species or hybrids if desired. Propagation of hybrid clones that may be matched to site characteristics or that extend the planting range of key species will not be possible without a suitable vegetative propagation system in place. Gains achieved in growth and other traits should be substantial, when using well-adapted improved clones over unselected seedling material.

Planting of clones in both operational plantings and field trials will allow the Tree Improvement Program to more clearly define the gains that can be made by planting selected genetic material over the routine seedlings currently deployed into plantations. This will have implications for the expected volume and quality of wood to be harvested by the operational division in the future.

Clonal seed orchards established using grafted plants of selected superior individuals will produce genetically improved seed for deployment as seedlings into operational plantations. This is particularly important for those species that are “difficult to root” by cuttings, that will be dependent on seed for their deployment strategy.

Information on solid wood properties of important commercial species and appropriate assessment techniques for these traits, will ensure wood quality traits are a routine selection criteria in tree improvement trials of a suitable age. This will lead to material being released by the Tree Improvement Program for deployment into operational plantations being improved for both growth and wood quality traits, increasing both the productivity within the plantations and the value of the harvested product from the plantations.

The recent focus for the Hardwood Tree Improvement Team has been fivefold:

1. to capture value from the older trials by assessing trials and making selections of superior genotypes, for capture by grafting or cuttings from coppice and subsequent use in the controlled breeding or deployment programs;

2. to fill gaps in the current series of field trials to ensure resources are available for all potential species of interest, as pure species or hybrids, for operational use;

3. assessing the wood properties of breeding populations and trials of selected species to ensure that sawn wood quality is a factor considered in improvement and deployment strategies;

4. deploying improved material of priority commercial species into operational plantations and developing efficient and cost effective deployment strategies;

5. developing a breeding program using controlled pollinations to produce superior genotypes of pure species or hybrids for testing on NSW sites.

Capture of selected genotypes from older species and provenance (non-pedigreed) trials can provide a resource of semi-improved material of eucalypt species for Forests NSW. These species may not necessarily be priority species for Forests NSW but may be species that are useful in the controlled breeding program to produce hybrids to extend the planting range and improve the productivity of key species. A eucalypt species trial at Barcoongere State Forest was assessed in December 2004 (at 22 years) for DBH and form. A total of 29 selections were made of superior individuals for a range of species from this and a second species trial in the same forest. All trees were felled and any seed or pollen collected. Coppice from the stumps was collected in autumn 2005 and propagated by cuttings.

Forty-year-old *Eucalyptus cloeziana* (Gympie messmate) selection
Photo: Warrick Moore

A total of 25 selections were also made from the 1964 series of *Eucalyptus cloeziana* (Gympie messmate) provenance trials, using historic growth data and current form. Pollen and seed were collected where possible and scions grafted or trees felled for coppice production. A 1979 *E. agglomerata* (blue-leaved stringybark) progeny/provenance trial was revisited and 35 selections made for collection of seed, pollen and scions for grafting onto rootstocks to establish a clonal seed orchard (CSO). A bulk collection of seed from the superior trees was made for deployment as seedlings into operational plantings in the Hunter Valley.

The Tree Improvement team reviewed the potential for developing “short–rotation” tree crops in the Hunter Valley and concluded that the area holds significant potential for the growing and marketing of plantation hardwood. We have aggressively undertaken the establishment of a series of progeny and clone trials to widen the genetic base of material being planted in the Hunter and also provide a resource, in designed trials, where the best genotypes for the Hunter Valley can be selected and developed. During 2004/05, progeny trials of *E. badjensis* (big badja gum), *E. longirostrata*, (grey gum) and *E. moluccana* (grey box) were established. These species perform well on relatively hard sites and have potential to provide good alternative species for the Hunter Valley, particularly for mine rehabilitation sites, as they are productive high density species suitable for pulp and co-firing end uses. They may also act as a hybrid parent to extend the planting range of other high value timber species. *Eucalyptus badjensis* may also be an alternative species to *E. nitens* (shining gum) in the central and northern tablelands areas.

Maintenance and assessment of trials continued this year. All *Corymbia citriodora* subsp. *variegata* (spotted gum - CCV) progeny trials were measured and assessed for damage caused by ramularia shoot blight and frost and superior genotypes selected for grafting of plants to be included in the clonal seed orchards (CSOs). The CCV clone trials were also assessed for growth, ramularia shoot blight and attack by eriophyid mite, and clones selected for multiplication and deployment into small commercial demonstration blocks.

The 1973 Cascade species trial at Wild Cattle Creek State Forest was assessed for growth and form. Measurements were made with acoustic, density and strain testing equipment, ahead of a possible sawing study. Results will show efficiencies of various tools in predicting solid wood properties and provide information for economic modeling of diameter classes for several species. It is unlikely that any germplasm capture will occur at this site.

Tissue culture generated *Corymbia citriodora subsp. variegata*(spotted gum) clones in nursery awaiting deployment
Photo: Chris Moran

The oldest *E. pilularis* (blackbutt) clone trial, established in 1999, was measured and assessed for growth and form, followed by extensive testing in an attempt to rank clones on wood quality. This was a pilot study in preparation for the large scale assessment, in 2005/06, of wood properties of the *E. pilularis* breeding populations. Many devices were tested: five acoustic tools, pilodyn (density), sapwood grain angle and strain gauge. The best 15 clones were selected on growth and form and three individuals of each felled for assessment of solid wood properties.

Acoustic tool used for assessing wood quality in a six-year-old clonal *Eucalyptus pilularis* (blackbutt) trial
Photo: Steve Boyton

A 26-year-old South African *E. grandis* (flooded gum) progeny trial was assessed using the FAKOPP acoustic tool. The trial was felled at age 20 years and extensive historic solid wood quality data is available. The acoustic assessment done this year was on the six-year-old coppice and will be used to determine the efficiency of acoustic testing on juvenile wood in predicting rotation-age wood quality.

Vegetative propagation and deployment of superior clones and families of CCV and *E. pilularis* has been successfully achieved this year. Over 10 000 plants of selected clones of CCV were propagated by micropropagation. Over 35 000 plants of *E. pilularis*, from selected superior families, were propagated by minicuttings. Some of these plants were deployed in autumn but, due to dry conditions, the remainder have been grown-on over winter for deployment in spring. In addition, another 10 000 plants of various species and hybrids were propagated by minicuttings for deployment in field trials.

Twenty-month-old *Eucalyptus pilularis* (blackbutt) clonal plantation
Photo: Piers Harper

Seed production is the best option for propagating genetically improved planting stock of some important plantation eucalypts in NSW, particularly for those species that are difficult to root by cuttings, limiting their deployment by plants propagated by cuttings. This is likely to be true for *E. dunnii* (Dunn's white gum), possibly CCV, and the emerging species of *E. nitens*. Several additional clonal seed orchards (CSOs) have been established for production of genetically improved seed for deployment as seedlings in operational plantations or for bulking up via minicuttings for plantations. A CSO of *E. pilularis* was planted on Grafton research station and CSOs of CCV, *E. dunnii*, *E. argophloia* (Chinchilla white gum) and *E. camaldulensis* (river red gum) were established as joint ventures with landholders. Both of the older CSOs of *E. dunnii* and *E. pilularis*, established in 2001 and 2002, have had their first flower crop and some controlled pollinations were carried out with the flowers in both orchards. Due to limited and asynchronous flowering in the *E. dunnii* CSO, a seed crop will not be collected this year but will be deferred until more prolific flowering occurs.

Successful grafting of selected genotypes of CCV, *E. nitens* and *E. dunnii* will lead to establishment of further CSOs next spring as well as provide plants for the controlled breeding program. Serial grafting has also been carried out to extend the current CSOs for all species. Grafting of several new species of interest, *E. agglomerata*, *E. cloeziana* and

E. laevopinea (silvertop stringybark), has had poor results despite trying a different grafting technique, but work will continue on protocol development during 2005/06.

The controlled crossing program was expanded from its initial stage, using controlled pollinations (CP) of selected genotypes that have flowered. The hybrid seed produced from last season's small CP program has been harvested and sown. Some genotypes will be bulked up by minicuttings and all material will be used in field trials to assess the genotypes on NSW planting sites. Seed produced by CP by CSIRO and CSIR (South Africa) has been grown for a late winter planting of a field trial as per our obligations to the ACIAR funded project "High performance eucalypts and interspecific hybrids for marginal lands in south and eastern South Africa and south-eastern Australia".

Controlled cross pollinations to produce hybrid seed
Photo: Helen Smith

Australian Low Rainfall Tree Improvement Group (ALRTIG)

H Porada

Although Forests NSW established no new trials for the Australian Low Rainfall Tree Improvement Group (ALRTIG), seven trials were assessed for survival and/or early growth. While some experimental treatments are showing reduced survival (eg *Pinus radiata* (radiata pine) at very high stocking), other treatments are showing good growth and form on some agricultural sites (eg genetically superior *Pinus pinaster* cuttings at Junee, southern NSW).

The key implications flowing from early outcomes of the ALRTIG softwood trials will be the ability to select genotypes that are superior/better adapted for commercial plantations on sites regarded as marginal or high risk for current, high productivity radiata genotypes. The development and selection of "dryland radiata genotypes" of good growth and survival, albeit at lower stocking, and identification of *Pinus pinaster* genotypes of good form and acceptable growth on fertile agricultural land, will allow the softwood industry and private landowners to develop commercial plantations on more marginal sites within current supply zones. While early in the program, other conifer species are proving to be of lower productivity though, for some species such as *Pinus brutia*, survival continues to be very good, even on sites where grass competition is fierce.

At present, however, species comparison/selection should be viewed with caution. Until stands gain full site occupancy – canopy closure, existing soil moisture reserves will offset the impact of lower rainfall. For some trials the coming growing season will see species/treatments reach full site occupancy (maximum stand transpiration potential) and early selection for species or family adaptability to dryland conditions *per se* will be possible.

Softwood tree improvement – radiata pine

H Porada

The key outcomes from this year's program were the measurement of the 1992/93 series of progeny trials and the establishment of the next generation of progeny trials of material from the Radiata Pine Breeding Company. Results from both of these activities will allow Forests NSW to identify and capture genotypes best suited to its diverse operating environments and to meet wood quality fitness-for-purpose requirements. These outcomes relate directly to the strategic management objectives outlined above. For instance, the ability to identify genotypes (families) that show limited potential for improvement in key traits or which are less well suited for a particular soil type, or more prone to snow damage, will allow plantation managers to deploy planting stock that optimises site specific environments or that meets processing requirements.

Also of significance from this year's program will be the outcomes from the five yield trials established across all regions. These trials will provide comparative information of production seedlots used by Forests NSW and so allow commercial as well as productive evaluation for the continuing development and deployment of genetically improved planting stock.

Four major progeny trials established in Hume Region in 1992/93 were assessed for growth and form and all data entered for analysis. Assessment covered some 12 000 trees from over 100 first and second-generation families. Two companion trials, one in Macquarie Region and one on the northern tablelands, have also been assessed. Results from these trials will provide an insight into the effect of genotype by environment interactions and the value of constructing region cum site specific deployment strategies for genetically superior planting stock. In conjunction with the assessment of the above progeny trials, an undergraduate Honours Project with the Australian National University has been agreed. This project provides data and material to an undergraduate forestry student to investigate wood quality parameters of radiata pine families in the above progeny trials. This will not only provide an effective means of research but also be an excellent public relations initiative with forestry students.

Early assessment of a five-year-old trial established in collaboration with Proseed NZ (Forests NSW's major seed supplier) was completed in April 2005. The trial was planted on highly fertile agricultural land to investigate the complex interactions of family-trait-site. The trial was assessed for growth and form, with wood quality traits, in particular stiffness, yet to be measured using acoustic technology developed by the University of Canterbury (School of Forestry). While preliminary analysis indicated good stability of family and trait groupings, more detailed analysis across a range of environmentally different sites is still to be completed.

As part of Forests NSW's membership to the Radiata Pine Breeding Company (RPBC), a series of progeny trials are in the process of being planted. Seed was provided by the Company and grown at Forests NSW's nursery at Grafton NSW. Progeny from some 200 radiata families and some 100 radiata hybrid families are to be tested across a range of sites in all four plantation regions. This planting represents the most comprehensive testing of genetic material from the RPBC and will form a strategic part of Forests NSW's future deployment strategy.

Also in the process of being planted are five yield trials (each of three hectares and twenty seedlots) to test the performance of operational seedlots from commercial seed orchards or seedlots for comparative purposes from additional seed producers/research agencies. These trials will be established under more operationally real conditions as a guide to the commercial outcomes from tree improvement.

Because of the tightening of land availability in premium radiata growing regions, three trials are being planted to test radiata genotypes/commercial seedlots on more marginal, drier planting sites. Seedlots include hybrids of radiata pine from the Mexican island provenances of radiata, as well as hybrids with other *Pinus* species. Seed for these trials was provided by Proseed NZ and the trials are to be managed collaboratively.

Survival assessment and maintenance of trials established last year was completed, with all trials showing excellent early survival.

Softwood clonal testing

H Porada

The key outcome of softwood clonal testing, for Planted Forests Operations, is to provide genotypes matched to sites for specific end use. Implicit in this is that the commercial benefits, both direct and down-stream, are positive for Forests NSW as well as its customers. The ability to identify clones, their subsequent multiplication and ultimately deployment to identified site specific environments and end product requirements, will allow managers to formulate silvi-economic strategies that reduce rotation length without sacrificing wood quality or productivity.

Previously estimated productivity gains of ~20% over planting stock derived from open pollinated seed orchard seed continue to appear achievable based on results coming to hand from trials on lands managed by collaborating agencies. Such gains will have a two-pronged effect - firstly to reduce rotation age (thereby increase return on investment) and, secondly, they can reduce the area of land under plantation - or reduce the area of new land required to meet supply agreements.

Eleven clonal trials, representing approximately 36 hectares in area, have been established across Forests NSW's estate. These trials cover all the radiata pine regions, and include a range of environmentally different growing sites from the Victorian border north to Armidale on the northern tablelands. Such geographic diversity likewise encompasses a range of soil and climate types, ideal for testing clone by environment plasticity.

During the past year, all trials received a scheduled maintenance and survival check and all trials continue to show excellent survival.

Trials established in 2000/01 will reach early assessment age in the next 12 months and are scheduled for growth and form assessment. This will provide an important early guide to operational selection as many of these clones are in test with collaborating organisations and, being under test for two to four years longer, will provide important comparative information for early assessment and evaluation for commercial opportunity.

For 2005, two major plantings of 25 tree clonal blocks are underway. These are the planting of 175 clones at Orange NSW on highly fertile ex-agricultural land and 262 clones on first rotation land at Bombala in southern NSW. These larger block plantings fill an important gap in Forests NSW's clonal program as they provide a more realistic commercial guide to the potential development of a clonal plantation program.

New Forests

Program Leader:
Annette Cowie

Aim:

A sound scientific basis established for the use of planted forests to benefit the environment.

Objectives:

Carbon sequestration quantified in managed forests and forest products

Suitable tree species and management systems available for catchment protection and management

Ecologically sustainable systems which use forest biomass to generate bioenergy and other value added products

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Carbon in forests
K Montagu, A Zerihun

Forests sequester carbon during growth and can play a short-term strategic role in slowing the build-up of greenhouse gases during the transition to greenhouse friendly technologies. A market for carbon credits now exists under the NSW Greenhouse Gas Abatement scheme.

To underpin any trading in carbon, a cost-effective measurement and forecasting system is required. The Carbon in Forests project develops improved methodologies for measuring carbon stored in above- and below-ground biomass in forests. This assists in the development of cost-effective estimates of carbon sequestration rates in reforestation/revegetation to underpin trading in carbon under the NSW Greenhouse Gas Abatement market.

Develop aboveground biomass prediction equations for woodland eucalypts

Although eucalypt woodlands cover relatively large area, there are very few biomass prediction equations even for the most common woodland *Eucalyptus* spp. To fill this important gap, the Carbon in Forests Project has continued developing biomass prediction equations by extending the species (as well as geographic) range to include those from woodlands. As a result of this effort, robust above-ground biomass prediction equations are now available for woodland eucalypts and related species.

Determine pattern of root to shoot ratio of woodland eucalypt ecosystems along rainfall gradients

In forests, carbon sequestered in root biomass can be a sizable fraction of the total forest biomass carbon pool. However, the contribution of root-carbon to the total carbon sequestered in a forest is highly variable. This variation may be *inter alia* a function of rainfall. Since root biomass is difficult to measure routinely, development of root : shoot ratio as a function of environmental variables, such as mean annual rainfall, allows estimation of root biomass from knowledge of above-ground biomass. In this regard, the Carbon in Forests Project has developed rainfall zone specific root : root ratios that may be used for estimating root biomass carbon in woodland eucalypts.

Greenhouse gas balances of biomass and bioenergy systems

A Cowie

Forests can provide greenhouse mitigation benefits through carbon sequestration and displacement of fossil fuel energy. It is critical that a life cycle assessment approach is taken to assessing the greenhouse benefits of carbon sequestration and bioenergy projects. IEA Bioenergy Task 38 is an international collaborative project working on developing methods and promoting best practice in assessing greenhouse gas balances of biomass and bioenergy systems.

As Australian National Team Leader for Task 38, Annette Cowie participates in planning task activities, undertakes projects that contribute to the Task, and coordinates Australian input to the Task.

Bioenergy potential from plantation forestry in north-east New South Wales

A series of case studies applying the standard methodology developed by the Task to specific actual or proposed projects in the member countries has been completed. The Australian case study examined the potential green house gas (GHG) emission reduction from bioenergy utilising thinning, harvest and sawmill residues from plantation forests in northern NSW.

The expanding plantation industry clearly has potential to contribute significantly to reducing GHG emissions in NSW through supply of biomass for bioenergy: from 180 000ha plantations, through co-firing in existing coal-fired plants, emissions reduction of 2.63MtCO_2e per annum is predicted. The emission reduction benefits are 26% lower for wood-fired power plants, due to the greater efficiency of co-firing. This conclusion is dependent on the technology of the wood-fired plant; new generation Integrated Gasification Combined Cycle technology may achieve similar efficiency to co-firing.

Soil carbon dynamics in bioenergy systems

There is a risk of depletion of soil carbon stocks in biomass production systems, because a higher proportion of the organic matter and nutrients are removed from the site, compared with conventional agricultural and forestry systems. A paper analysing the impact of soil carbon change on the greenhouse gas balance of bioenergy systems has been completed. The paper reviews the factors that influence soil carbon dynamics in bioenergy systems and utilises the model FullCAM to investigate the likely magnitude of soil carbon change where bioenergy systems replace conventional land uses. Environmental and management factors govern the magnitude and direction of change. Soil C losses are most likely where soil C is initially high, such as where improved pasture is converted to biomass production. Bioenergy systems are likely to enhance soil C where these replace conventional cropping, as intensively cropped soils are generally depleted in soil C. Measures that enhance soil C include maintenance of productivity through application of fertilisers, inclusion of legumes, and retention of nutrient-rich foliage on-site.

Modelling results demonstrate that loss of soil carbon in bioenergy systems is associated with declines in the resistant plant matter and humified soil C pools. However, published experimental data and modelling results indicate that total soil C loss in bioenergy systems is generally small. Thus, although there may be some decline in soil carbon associated with biomass production, this is negligible in comparison with the contribution of bioenergy systems towards greenhouse mitigation through avoided fossil fuel emissions.

Life cycle analysis of wood products

WD Gardner, F Ximenes

The research into life cycle analysis of wood products is being conducted within the CRC for Greenhouse Accounting (CRCGA) and has demonstrated that wood products are a long-term store of carbon. It demonstrates that the most conservative option for accounting for post-harvest biomass removals – oxidation in the year of harvest – is significantly underestimating the true term of storage of carbon that was sequestered in the trees. Changing the carbon trading accounting methodology to include on-going carbon storage in wood products would significantly increase the returns to Forests NSW from carbon trading and may make other land acquisition and management options viable.

The project is to develop data to support an accounting system for carbon that is stored in wood products. To achieve that aim, six sub-projects were developed. These are:

- Developing a database on the manufacture of wood products in Australia.
- Determining the carbon content and density of Australian wood products.
- Determining the carbon efficiency of harvesting a range of species and converting them to a range of wood products.
- Determining the wastage associated with the use or manufacture of articles or products from wood products.
- Determining the service life of wood products in Australia.
- Determining the fate of wood products disposed to landfill.

The experimental work for these sub-projects has been largely completed and the data generated demonstrate clearly that wood products are a long-term store of carbon. The scope of the work has been expanded to include the development of a model – TimberCAM - to determine the fate of carbon in wood products from harvest through to end of life – reuse, recycle, burnt for energy or disposed to landfill.

TimberCAM and other additional research that has been conducted on a co-funded basis with Australian Greenhouse Office (AGO) is summarised below.

TimberCAM

TimberCAM is a model for determining carbon storage in wood products that has been developed within the CRCGA. The original schedule was to have TimberCAM developed and externally evaluated by July 2006. Significant extra effort has been put into the development work this year to allow interested groups to have access to the model for research purposes at the earliest opportunity. TimberCAM has been finalised and is available on the CRC web site with a users' guide. The model has been downloaded by at least 150 people from 40 countries.

Decay of coarse roots

This research was a collaborative project that was co-funded by Australian Greenhouse Office and CRC for Greenhouse Accounting. The aim of the research is to develop qualitative data on the decomposition of coarse roots to assist in the calibration of current estimates which assume that coarse roots decay in as little as 10 years.

It was reported in the 2003-04 Annual Report that hardwood stumps had been excavated at the three sites where the total biomass studies were conducted. Forests NSW harvesting plans provided information that allowed the time since the trees were harvested to be determined. Time since harvest ranged from 25 to 50 years. Additional studies have been conducted on the decay of hardwood and softwood coarse roots in Mejum State Forest, near Narrandera, and Belanglo State Forest, near Mittagong.

Both hardwood and softwood stumps were excavated in Mejum State Forest. The hardwood stumps were from grey box trees harvested 25 and 50 years ago. The softwood stumps were from cypress pine trees harvested 50 years ago.

Cross section of root from a 50-year-old cypress stump - Mejum State Forest
Photo: David Gardner

Cross section of root from hardwood stump 87 years after harvest
Photo: David Gardner

Cypress stump 50 years after harvest - Mejum State Forest
Photo: David Gardner

The data and observations from the stumps in Mejum State Forest confirmed the data and observations from the spotted gum stumps that the time for coarse roots to decay is significantly greater than the 10 years currently assumed. The Mejum grey box and cypress stumps from the trees that were harvested 50 years ago still contained significant quantities of coarse roots. These roots were less likely to have fungal degrade than the spotted gum roots from Flat Rock State Forest but more likely to have lost section due to termite attack.

Hardwood and softwood stumps were also excavated in Belanglo State Forest. The hardwood stumps were in a radiata pine plantation that was established in 1918, making it at least 87 years since the trees were harvested. The softwood stumps were radiata pine from a plantation that was established in 1950 and harvested in 1985, making it 20 years since the trees were harvested.

The observations from the hardwood stumps in Belanglo State Forest also confirmed that the current assumption of decay of coarse roots in 10 years is excessively conservative. Of the 10 hardwood stumps that were excavated, seven still had significant remnants of coarser roots. The softwood stumps from Belanglo State Forest also confirmed the observation that the assumption of decay of coarse roots in 10 years is excessively conservative. All the softwood stumps had significant coarse roots intact 25 years after harvest but they were all suffering significant fungal degrade.

Excavating 87-year-old hardwood stump - Belanglo State Forest
Photo: David Gardner

Results to date indicate that the current assumption that decay of coarse roots in 10 years over-estimates the rate of coarse root decay for a range of softwood and hardwood species in a range of climatic zones and forest types.

Hardwood stump 87 years after harvest - Belanglo State Forest
Photo: David Gardner

A more realistic estimate of the rate of decay of coarse roots will be proposed when the laboratory data on the Belanglo State Forest samples are available.

Radiata pine thinning harvesting trials

This research was a collaborative project co-funded by the Australian Greenhouse Office and CRC for Greenhouse Accounting. The aim was to determine the recovery of biomass in commercial logs following radiate pine thinning operations. Two sites with 15- (first thinning, T1) and 25- (second thinning, T2) year-old plantations were identified with the help of Forests NSW Hume Region personnel at Green Hills State Forests. Thinning operations are typically carried out twice before the final harvest.

The studies involve weighing a representative number of commercial trees and their log products following typical harvesting operations. The total recovery to commercial logs was higher for T2 trees. In addition, over 80% of the biomass in the logs from T2 was retained in sawlogs. T1 trees with higher DBHs had slightly larger recoveries than those with lower DBHs. The total recovery in commercial logs was not affected by DBH for T2 trees. The proportion of sawlogs obtained for T2 trees generally increased with an increase in the DBH range.

Workshop on the decomposition of wood and paper products in landfill

A workshop was organised in collaboration with Dr Morton Barlaz of North Carolina State University (NCSU). The workshop was held at NCSU. The purpose of the workshop was to develop methodologies and principles that will be used in future sampling at Australian and US landfills to determine the decomposition rate of paper products and add to the current data on the decomposition of wood products in landfill. There were Australian and US attendees with expertise in greenhouse policy, landfill research, landfill management, wood technology, paper technology and analytical chemistry.

David Gardner searching for treasures at North Carolina landfill

... with paper products excavated after 18 years in landfill

…….... and hamburger bun and fork!!!

Photos: Fabiano Ximenes

Methodologies and principles were agreed for future landfill sampling to determine the rate and extent of decomposition of wood and paper products in landfill. The multi-disciplinary approach of the workshop will assist in developing data that are acceptable for informing policy. A proceedings from the workshop and a research proposal for landfill sampling in Australia are in preparation. The proposal will be for collaborative research with several of the workshop participants.

Wood products arriving at North Carolina MSW landfill

Photo: David Gardner

Sub-catchment impacts of tree planting on salt mobilisation, stream water quality and flow

P Walsh, C Barton

In order to identify the optimum management solutions to reduce salt mobilisation, and not make the problem worse, an understanding of how the groundwater system operates at different scales is required. Continued monitoring of the Baldry site will assist NSW Department of Primary Industries (DPI) in developing models that predict the impacts of plantations on salt mobilisation, water yield and water quality in granitic catchments throughout the central-west of NSW. The project will also underpin the development of expertise within NSW DPI in the environmental services provided by plantations to support market-based solutions to dryland salinity management.

For the past year the main activity on the Baldry site has been ongoing low level data collection and equipment maintenance, with minimal data interpretation. The Baldry project is now a sub project of a larger collaborative project between NSW DPI and the Department

of Infrastructure, Planning and Natural Resources (DIPNR) titled 'Key sites for hydrology and salinity measurement and model validation'. This larger project combines the following two projects established under the NSW Salinity Strategy and National Action Plan -

- Recharge validation
- Model farms

If the apparent complexity of the groundwater system at the Baldry site is typical of granitic catchments throughout the central west of NSW, then unravelling the causes of this complexity and developing accurate salinity models to guide land use planning will be a major challenge in the coming decade. Monitoring of salt stores (Figure 1), groundwater levels and groundwater chemistry over the preceding year has provided some interesting results. The groundwater in the catchment appears to be highly compartmentalised with little horizontal groundwater movement through the site. The compartmentalised nature of the groundwater is evident through the different hydrographic response and chemistry of the deep and shallow bores (Acworth 2005) located throughout the catchment. The highest groundwater salinities occur beneath mid-slope positions in the catchment, whilst the lowest groundwater salinities occur around the saline scalds at the base of the slopes. Surface-groundwater modelling and hydrochemical modelling are planned so that an improved conceptual model of the site can be developed. Examination of radiometric and magnetic imaging of the catchment may also assist in unravelling the apparent groundwater complexity inherent at the Baldry site.

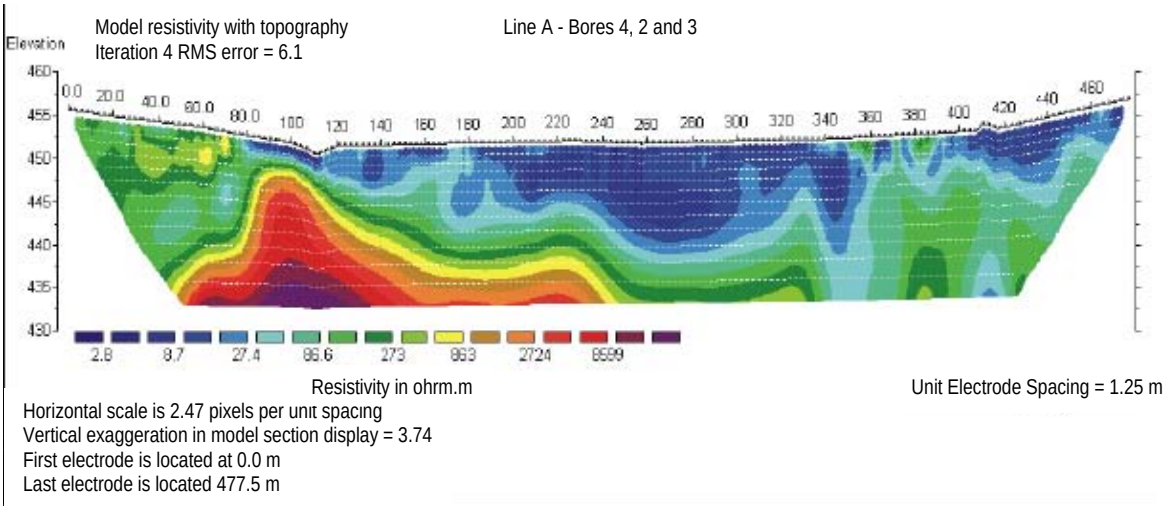


Figure 1. An example of an electrical image derived from the electrical resistivity technique used at Baldry to identify and monitor salt stores in the catchment.

Dryland salinity trials

C Barton

Dryland salinity species demonstration sites

In 2000, 48 dryland salinity species demonstration sites were established across NSW to determine growth rates of a variety of tree species on different soil types and landscape positions under the low rainfall regime. The growth and survival of some of these trees has been measured annually since their establishment. This year, with the trees at five years-old, all 45 of the remaining viable sites have been measured for diameter, height and form. Twelve of the species demonstration sites have undergone in depth site characterisation in collaboration with CSIRO Forestry and Forest Products funded by the Australian Greenhouse Office. The data for growth are currently being entered and will be analysed in conjunction with the site characterisation information to assess growth rates and species /site interactions.

During the first two years, the black wattle outgrew the other species with the hybrid eucalypts following closely. The black wattle did not fair well during the drought and high mortality occurred at a number of sites, however, on sites where it survived, it has continued to grow well. *Eucalyptus sideroxylon* and *E. argophloia* were good performers across all regions, consistently carried a large leaf area and were generally unaffected by pests and diseases. Observations at four years old suggest that they are starting to catch up in height with those species that grew rapidly initially. *Eucalyptus camaldulensis* had the lowest mortality but its growth was variable and it appeared to be more susceptible to pests and diseases. *Corymbia maculata* and *C. variegata* were either extremely good or extremely poor. The majority of poor sites were related to previous frost damage. On the good sites, both species carried a very large leaf area and exhibited good form. *Pinus pinaster* growth and survival was good in the Murray and Murrumbidgee catchments, reasonable in the Macquarie and very poor in the Namoi and Gwyder catchments.

Allometric relationships between simple measures of tree size, such as diameter, and tree biomass are required in order to assess the amount of carbon stored in forests in a cost-effective way. Biomass harvests of 25 trees of each of five species have been completed on a range of properties in the 500-800 mm rainfall zone including three of the species demonstration sites. Data from these harvests are currently being analysed to determine the relationships between the biomass of various tree components and diameter at breast height.

Biomass sampling of *Eucalyptus sideroxylon* to develop allometric relationships for cost-effective estimation of carbon sequestration by forests
Photo: Craig Barton

Planting trials in dryland region

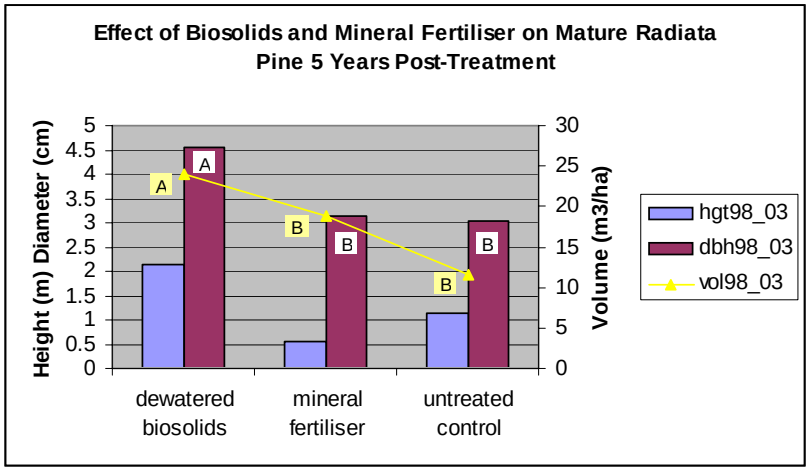
A number of planting trials were established during 2000 to 2003 as part of the State Salinity Strategy funded project to establish 400 ha of trees in the Liverpool Plains region. In 2004, measurement plots were established and in the first year baseline measurements of the establishment techniques, spacing and belt width trials were made to determine growth and survival. Rainfall in the Liverpool Plains was above average in the year June 2003 to June 2004 and growth and survival of the trials has been good. It is still too early to detect treatment effects, which will be assessed in following years.

The use of biosolids in softwood plantations

G Kelly

The benefits of an additional 30% growth from biosolids are not outweighed by loss of timber quality.

The database generated by 15 years of research and demonstration shows that biosolids is a very effective and environmentally appropriate fertiliser for plantation pine. Increases in basal area of up to 30% are not uncommon. Incorporating biosolids prior to establishment gives a greater growth response, but also increases branch thickness, which impacts the tree form and merchantability. Surface application to post thinned stands increases growth and does not affect tree form or wood quality, and is therefore more profitable as most of the treated trees will remain until harvest.



Application of recycled organics in mine site rehabilitation

G Kelly

Recycled organics are proving to be valuable in the early establishment of plantations on mine sites. The trial shows that each recycled organic brings with it its own benefit; biosolids improves growth; mulch suppresses weeds, reduces soil temperature and maintains soil moisture; soil conditioner and municipal waste compost (MWC) improve survival. These recycled organics can be used in combination to overcome site specific problems.

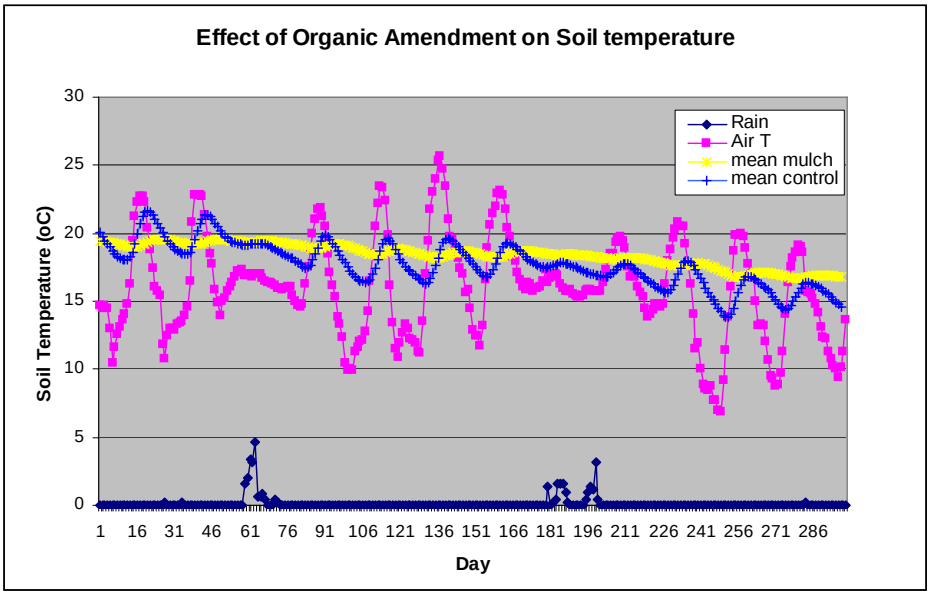
In October 2001, a number of legislative changes to the NSW Government's waste policy and regulatory regime came into effect. This regulation required that all green waste be separated out of the waste stream. The challenge is to find a market for this resource. Mine site rehabilitation potentially presents a significant market opportunity for the recycled organics industry, especially for the lower grades of product.

A 5 ha plantation trial was established on Narama mine in March 2004, using a range of recycled organics as soil amendments. These organics included biosolids, mulch, soil conditioner (made from recycled garden organics) and municipal waste compost (MWC) (composted curb side garbage collection).

The results after 12 months are very encouraging but the trial will be monitored for a further two years, during which time soil and foliage chemistry will be assessed. The initial data indicate that recycled organics can have a significant role in increasing tree growth and survival and improving soil moisture loss thus making them a valuable resource for mine site rehabilitation.

Installing Neutron Probe access tubes to monitor soil moisture

Photo: Georgina Kelly



The plots have been split to compare two eucalypt species, *Corymbia maculata* (spotted gum) and a clonal hybrid *Eucalyptus camaldulensis*grandis* (river red gum/flooded gum hybrid). Whist the species are growing at different rates, they are responding in the same way to treatment. The spotted gum was grown with material from a seed orchard in an effort to overcome the high within-species variability experienced in previous trials. This variability would have significant negative impacts in commercial plantings. Using the improved material form the seed orchard has proved very successful.

Hybrid clones await planting on Narama Mine

Photo: Georgina Kelly

Plots treated with biosolids

Unamended plots - control

Photos: Jagrutee Parekh

Soil amendments maximise forest production on mine sites

G Kelly

The upper Hunter has approximately 20,000 hectares of marginal or degraded lands. Much of this land is in the buffer zones of mining leases. This research proposal directly addresses the top two key priorities identified by the Upper Hunter Commercial Forests Steering Committee:

- Determining timber yields on a range of sites
- Site preparation techniques using ameliorants (such as biosolids), ripping and mounding.

By understanding the processes behind improved growth/survival, and not just the site specific response, the results from this study can then be applied to a broad range of situations and sites not only in the Hunter but State-wide and even nationally.

The research program trials a range of species and soil amendments on a variety of land types (river flats, typical buffer land and mine overburden)and provides recommendations for future plantation establishment. To date the results show -

- The clonal hybrid *Eucalyptus camaldulensis*grandis* has good survival and early growth, though it can be subject to leaf blister sawfly. *Eucalyptus camaldulensis* globulus* is growing particularly well with mean diameters of 6 cm at three years and individuals reaching 9-10 m in height. At age four years, *Corymbia maculata* is beginning to grow more rapidly than the clones. Both the clones and spotted gum are suitable species provided due care is taken with site specific issues such as frost.
- Amendment of the soil with biosolids and bottom ash achieved significantly greater growth for faster growing hybrids but had much less effect on the slower growing *C. maculta*. However, in the last year, *C. maculata* (spotted gum) has begun to grow more rapidly and is showing the benefits of treatment with biosolids and bottom ash.
- Biosolids (and biosolids + bottom ash) produces good tree growth on degraded lands (eg minesites). Biosolids should be used at establishment on overburden sites and can be used as an alternative to inorganic fertiliser when establishing plantations on buffer land

Three-year-old *Corymbia maculata* provides biodiversity benefits on rehabilitated coal mine (Coal and Allied, Hunter Valley No 1)
Photo: Georgina Kelly

Bulga mine site plantation trial
G Kelly

A database now exists of sufficient duration (five years) to indicate some appropriate species for planting in the Hunter Valley. Shortcomings (eg within species variability and frost sensitive sites) have been identified and solutions put in place (genetic improvement/provenance selection for spotted gum and alternative species for frost prone areas).

Forests NSW established a trial for Tomen Australia Limited on its Bulga Mine to investigate ways of boosting productivity of planted native species on a mine site in the Hunter Valley. Five species and four treatments (including biosolids) were assessed.

Hybrid clones on reshaped overburden at Bulga mine
Photo: Georgina Kelly

At fives years, the Bulga site is the oldest of Forests NSW's research trials in the Valley. Clonal hybrids were very successful in the early years of all trials in the Hunter Valley and spotted gum was a slow grower with high variability within the species. However, at age four to five years, growth of the clonal hybrids has slowed (particularly in diameter). The form remains good and the stands are uniform. Spotted gum is now growing particularly well. However, the form is not good and the stands have high variability within them.

Data from this trial and other trials in the Hunter Valley, show spotted gum is now appearing to be the species of choice in the Hunter, however, breeding work to reduce variability and improve form is necessary (and has begun). The clones are a very good alternative in areas subject to frost (eg the river flats where the spotted gum have been killed by frost).

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Biosolids produces good tree growth on degraded lands (eg minesites). Biosolids should be used at establishment on overburden sites and can be used as an alternative to inorganic fertiliser when establishing plantations on buffer land.

Overview of Bulga plantation trial
Photo: Georgina Kelly

Plantation Improvement

Plantation Improvement Manager:
Ross Dickson

Aim:

Forest management systems developed which meet international benchmarks of productivity and sustainability.

Objectives:

Robust and cost-effective practices developed for stand establishment and management

Increased value captured from current and future plantation wood production

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Characterising the pine resource
C Raymond, W Joe, R Dickson

This project gathers information and develops predictive models for intrinsic wood properties and product quality of *Pinus radiata* as affected by silviculture, site and genetics within the NSW softwood plantations estate. Building on the initial database of wood density across the estate, the project has expanded the range of wood properties studied and developed initial predictive models relating wood properties to site and climatic effects. Acoustic tools (for use on both standing trees and logs) have been used to determine variation in wood stiffness across large areas of the Hume and Macquarie Regions and to determine the influence of prior land use, variation in initial stocking at planting and the effects of thinning treatments. The merits of using the standing tree acoustic tool for prediction of log quality at harvest age has also been evaluated at a wide range of sites in both Regions.

Prior land use (forest vs ex-pasture) was found to have significant effects on a range of wood properties including wood density, fibre length and acoustic velocity as well as influencing tree diameter and altering tree taper and branch size. However, no differences were found for tree height or traits relating to the quality of the wood for kraft pulp production. In a study that related differences in wood properties to the product properties of medium density fibreboard, low density, short fibre wood was able to produce a similar quality of 9 mm board to high density, long fibre wood. However a greater quantity of the lower density wood was required to meet the product specifications for board density and stiffness.

Initial models for predicting wood density and stiffness from site and silvicultural information have been produced for both Hume and Macquarie Regions. For density, the inputs to the models include forest location, tree age, thinning history, parent rock code and bioclimatic variables including annual mean temperature, rainfall and mean daily temperature range. Such models explained 59% of the variation in Hume and 61% of the variation in Macquarie density data. A predictive model for outer wood stiffness of trees in Hume Region (Buccleuch, Bago and Green Hills State Forests) indicated that stiffness can be reliably predicted (R^2 of 0.88) from knowledge of tree age, forest area, prior land use code and thinning status.

Benchmarking wood quality of Bombala pine resource

W Joe, R. Dickson

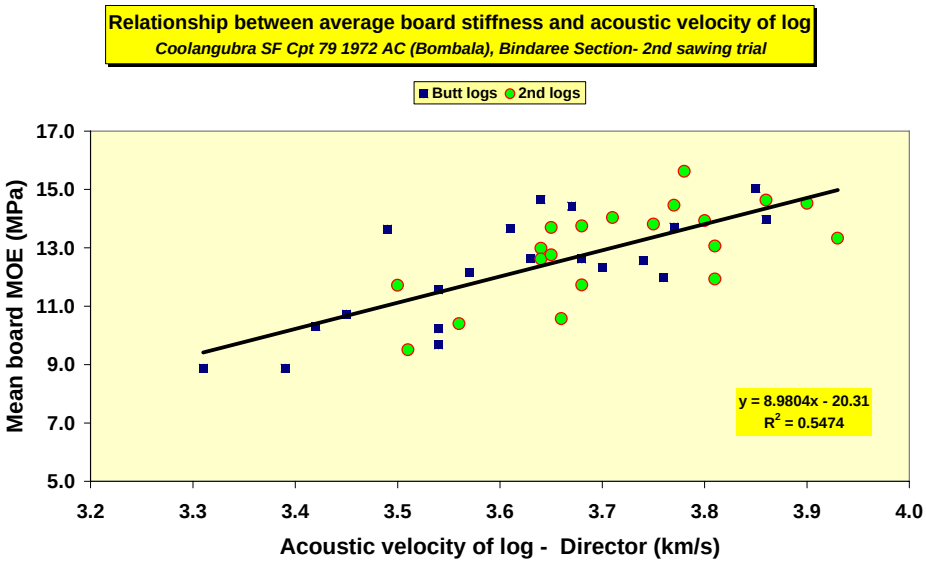
This new project was initiated by Commercial Services along with Planted Forests Operations, Monaro Region, to investigate grade recovery from radiata pine sawlogs sourced from Bombala forests. A series of two sawing trials were undertaken. The first of these assessed run-of-the-mill logs (predominantly from thinned clearfell stands) that were already at the mill yard and the second trial, on logs from a known stand in Bombala, namely an unthinned mature clearfell stand. In both trials, non-destructive (acoustic) and other measurements were made on the study logs prior to milling, drying and grading. In the second trial, information on DBH, height, branch index and acoustic velocity (Fakopp) of the trees were also recorded. In addition, a MARVL assessment of the stand was undertaken for benchmarking against future trials.

Radiata pine logs are colour coded on the ends with a template to track sawn boards in the mill during processing
Photo: Bill Joe

A number significant findings were made in both these trials. Firstly, the wood quality (wood density, acoustic velocity and board stiffness) were equivalent if not better than other Regions such as Hume, suggesting that the resource in Bombala was not unique. The percentage grade recovery of structural boards were excellent with around 75-80% of the sawn boards making structural grades MGP10 or better. Also of significance was the finding on unthinned clearfells which, although had a greater percentage of corewood or juvenile wood (ca 40-50%) in the log, resulted in more higher grade (MGP12) boards overall, largely due to the slower growing and higher density outer wood. There was good correlation between the acoustic measurement on the log and the average stiffness of the boards, indicating that non-destructive tools, such as the one used in this project can be quite useful for detecting and sorting out problematic logs. Branch index and wood density were also significantly correlated to board stiffness.

The unique pattern identifier on each board enables relationships to be established between standing tree or log measurements with board quality
Photo by Bill Joe

The project is now essentially completed with the results presented to all the major stakeholders (Integrated Forest Products (ACT), Commercial Services and Planted Forests Operations, Monaro Region) at meetings held in January and June 2005.



This graph shows how well acoustic velocity of a log predicts mean board stiffness in radiata pine sawlogs

Value recovery studies – pulpwood testing for the south coast

R Dickson

The hardwood chip supplied to South East Fiber Exports (SEFE) from NSW is sourced from the south coast, extending from Nowra in the north to the Victorian border in the south. The chip supply comprises a mixture of species, tree ages and chip types (whole log versus sawmill residue). Customers require the final chip product to produce a minimum pulp yield of ca. 50%. Other important pulp variables include basic density and the quantity of alkali (Na2O) used in the pulping process.

A series of eleven tests of spotted gum pulp yield have been undertaken in the last twelve months across a range of environmental variables, management history, tree sizes and estimated ages. A report on these tests has been submitted to both Commercial Services and Native Forest Operations. Pulp yield is strongly related to site productivity, probably rainfall and soil quality.

These studies not only test stand and log assessment technologies but also give detailed site and species wood property information that can be included into a wood quality database for future crop management decisions.

Silviculture spacing trials

R Dickson

With the development of new processing capacity on the south west slopes there will be a need to improve the productivity of existing forests as well as extend forestry operations into the drier rainfall zones. Information on the silvicultural and genetic management of both replacement and new plantations is required.

Work is mainly concentrated on the south-western slopes of NSW. The overall intent of the current trials is to demonstrate the impact of stocking and planting configuration (intra-row spacing and inter-row spacing) and genotype on the impact of wood fibre yield and quality across farm sites and second rotation forest sites. The trials will greatly assist with the extension of information for the establishment and management of new and replacement plantations. The decision to adopt a particular espacement in the past has been influenced

by the size, nature and number of trees grown. Further, factors such as the space needed for mechanical harvesting machines, market opportunities for logs of a certain size and quality, cash flows and the economic viability of the enterprise as whole. There has, however, been limited consideration given to the impact of espacement on radial wood quality variation.

In June 2005, two new spacing trials comprising various improved (GF 28, WD 23) and unimproved seedlots of *Pinus radiata* were established across second rotation land in Hume and Macquarie Regions. Initial measurements will be made on these trials in the spring of 2006.

Impact of post-lifting storage time on radiata pine seedling establishment

R Dickson

The primary objective of this trial is to establish the impact of various nursery packaging treatments on seedling moisture content and their subsequent growth in the field. A secondary objective was to measure the impact of extended storage time following lifting on seedling moisture status and field survival. In the winter of 2004, seedlings were lifted from a well-hydrated nursery bed. They were then packaged according to five different treatments: (1) the current nursery prescription of corex box and gusset bag, (2) a cloth wrap around the roots; (3) root drenches with gel, (4) root dipped in water and (5) root drenched with gel combined with a cloth wrap. At the field site seedling boxes from each treatment were removed from the pod at four, 11 and 18 days after lifting and planted into a completely randomised field trial. From the time of packing to the last planting date, the temperature conditions on each shelf in the pod were logged.

The most striking result from this trial was that the seedling water potential progressively fell to a critical negative water potential as the time from lifting increased to 18 days. Preliminary indications suggest seedling moisture content is progressively depleted as the storage time in the field increases prior to planting. This effect is likely to be exacerbated if ambient air temperatures rise during the planting window.

The longer seedlings are stored in pods following lifting the less likely the potential survival rate in the field will be achieved. Low survival due to extended storage time is likely to be worsened if air temperatures are above average for the season.

Improving the processing of timber from plantation forests: the challenge of managing variability

W Joe, R Dickson

Drying is a key step in processing and adding value to timber. The increasing availability of plantation hardwood timber, with greater variability in its properties than previous resources, presents an opportunity to take advantage of the development of better mathematical techniques for process optimisation and better drying and mechanical models for timber to address this challenge. This project will produce optimised drying schedules, which are combinations of temperatures and humidities used during drying, to effectively dry plantation timber with variable properties, producing timber for high-value and appearance-grade end uses, such as flooring and furniture.

The project is collaborative with the University of Sydney and the timber industry. It seeks to add value to plantation timber from Forests NSW through better understanding of drying behaviour and managing variability in the drying process. A specific outcome is optimal drying conditions for a variable resource that meets market requirements. Blackbutt being an

important species to NSW is investigated in this study. The project is undertaken under an ARC Linkage grant by a PhD candidate (Ms Sherryn Cabardo), and led by A/Professor Tim Langrish from the University of Sydney and co-supervised by Bill Joe and Ross Dickson.

Progress over the last 12 months has focused on the between-tree variability of timber properties that are important for drying regrowth blackbutt. Working collaboratively with J Notaras and Sons, Grafton, and Forests NSW North-East Region, trees were selected from a stand of known history in Lower Bucca State Forest (Cpt 590, Timber Stand Improved in the 1960s) and processed through the sawmill with sample boards taken from each tree for drying and wood properties measurement. These properties include: basic density, diffusion coefficients, failure stress, failure strain and Modulus of Elasticity (both at green and kiln-dried states) and radial, tangential shrinkage (before and after reconditioning). The data is currently being analysed. With this information in mind, they will then be compared with how much variability was found in the two previous regrowth blackbutt experimental trees that were analysed for within-tree variations.

Early pruning trials

Y Long

Pruning has been seen as a major silvicultural measure to improve wood quality by producing knot-free timber (or clearwood), eliminating loose knots and reducing log taper. To predict the growth of pruned trees and/or stands, a growth model, named as “EARLY”, was developed in New Zealand to estimate the growth of *Pinus radiata*. The model, as a major prediction model in STANDPAK, has been extensively used by Planted Forests Division to predict the early growth of *P. radiata* in NSW. Due to the difference in site, climate and planting conditions between New Zealand and NSW, significant bias has been found in using the model. The objective of the project was to establish a series of pruning/thinning trials to collect data for validating and developing the EARLY growth model for the range of sites and genotypes to be used for *P. radiata* plantations in NSW.

EARLY pruning trial plots are established in six State forests (Buccleuch, Sunny Corner, Blenheim, Nanangroe, Vittoria and Walcha) with Growth and Form (GF) series seeds (ie GF16–24) from New Zealand.

The trial plots established in Buccleuch, Sunny Corner and Blenheim State Forests have been fully treated by the end of 2004. The three recently-established trials at Nanangroe, Vittoria and Walcha are only partly treated as the crop trees have not yet reached the required height.

A preliminary data analysis was undertaken to validate the EARLY model in STANDPAK using the data collected. The results obtained from the data analysis indicated that there was significant bias when using the EARLY model to predict basal area increment of *P. radiata* in NSW.

Radiata pine growth and yield modelling

Y Long

Planted Forests Operations requires a series of models to reliably predict the growth and yield of planted forests for management and planning. The models can be integrated in a modelling system and can give a robust estimate of growth of both individual trees and whole stands with confidence across a range of sites, genotypes and silvicultural regimes.

Forests NSW has been using integrated stand growth modelling systems (ie STANDPAK and MARVL) to predict growth and yield and log values of both softwood and hardwood

plantations since 1996. As most of the growth and yield models in the systems were not developed from the data collected in NSW, it is essential to collect data and provide methods to develop and validate the growth models for the use in STANDPAK and MARVL. The effects of site and silvicultural treatments need to be taken into account in the modelling and validating process.

Statistical analyses were conducted on the long-term response of *Pinus radiata* to spacing by fertilising by thinning treatments. Data were collected from a trial established in 1968 in a low-rainfall and phosphate-deficiency site in Penrose State Forest. The trial consists of five spacing treatments interacting with multiple thinning and multiple rates and multiple uses of fertilisers. The trial plots had been harvested later 2003.

Linear and non-linear mixed-effects model analysis techniques were used in data analysis. A non-linear height-diameter model and a tree volume model were developed. The models can be used to estimate height and volume of individual trees in similar site conditions and age ranges. By taking into account the effects of silvicultural treatments, the growth curves of stand top height, top diameter, basal area, quadratic mean diameter and stand volume over age were derived with non-linear mixed-effects models. The growth potential between the trial site and several other sites (in *Pinus radiata* plantation areas) were compared.

Wood quality assessment of alpine ash

W Joe, R Dickson

The quality of sawlogs supplied to wood processors greatly affects log value and hence revenue from sales. It is in the interest of Forests NSW, as well as its processing customers, that the value of these logs is based on quality, which can be effectively reflected in log grading rules. The information from this study will assist with the efficient marketing of our sawlogs and determine if the grading rules are effective.

Alpine ash boards being stripped out for air-drying at Neville Smith Timbers at Seymour, Victoria

This new project was initiated by Native Forests Operations and Commercial Services in response to concerns about the quality of boards recovered from alpine ash logs. In particular, the effectiveness of the Forests NSW log grading rules to predict grade recovery.

This information, along with wood properties measured on sampled material will be used to establish if there were significant differences in wood quality of the boards among the three groups of logs. It is envisaged this project will be finalised early in 2006.

Grading of alpine ash boards for appearance products after kiln drying and dressing at Neville Smith Timbers at Seymour, Victoria

Photos: Bill Joe

Hardwood plantations - enhancing seedling survival

D Thomas

Enhancing seedling survival is of high importance to plantation forestry. Altering nursery practices to produce hardier seedlings will reduce deaths associated with transplant shock. Water retention gels do reduce risks of seedling deaths. More cost-effective methods of applying these water retention gels to seedlings and cuttings are being examined. All data, but particularly those associated with commercially planted seedlings are being incorporated into a decision support system to assist forestry staff in deciding when to commence planting operations.

A combination of field trials and glasshouse trials was undertaken in the 2004/05 planting season. The main findings were:

1. Drought hardening seedlings in the final stages of nursery production did enhance survival of transplanted seedlings of blackbutt (*Eucalyptus pilularis*) and spotted gum (*Corymbia citriodora* subsp *variegata*). Seedlings had slightly better survival than cuttings in these research trials.

Eucalyptus pilularis coated and uncoated with a kaolin clay particle film just prior to planting out
Photo: Dane Thomas

2. A kaolin clay based powder applied to leaves to reduce leaf temperature and therefore evaporative water loss and seedling death by dehydration was not effective in reducing seedling deaths caused by transplant shock.
3. A water retention gel that is easy to apply and still enables planting with current equipment (shovels, pottiputki) was evaluated. This gel enhanced survival although application methods need to be examined which do not significantly reduce planting time/costs.
4. Seedling survival at several sites that were commercially planted (contract planting staff and managed by either Forests NSW plantation officers or research staff) was evaluated. Correlating survival with soil moisture conditions at planting, soil type and weather conditions after planting is continuing. This research task is being undertaken by Forests NSW staff and the data has also been made available as in-kind support for a Land and Water Australia (LWA) project examining a similar research area.
5. These field trials indicated that deaths may also be due to burning of the stem and not only due to dehydration. Trials are planned to examine this hypothesis and to reduce the likelihood of stem burn.

Hardwood plantations - reducing J-root formation in tap roots of seedlings

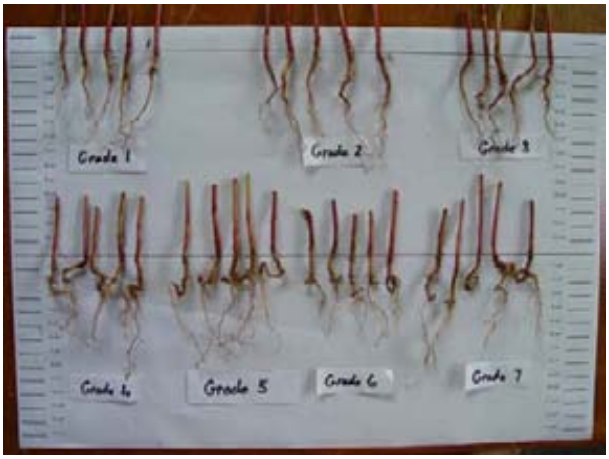
G Heagney, D Thomas

The severity of J-root formation was found to be affected by the species and also the seedlot within a species. This has implications for tree improvement/genetic research as the likelihood of J-root formation could be reduced through breeding programs.

The formation of J-roots in the tap roots of seedlings was also increased after the seedlings were removed from 512 trays and planted into Hyko trays. Research is in progress to

determine which management practice of this removal and planting into the Hyko process has the largest contribution to J-root formation. It was found that staff involved in the removal and planting process (Tubers) and also staff involved in the grading of mature seedlings (Graders) differed in ability to produce seedlings with low J-root formation and the ability to grade to successfully remove affected seedlings.

Darrel Johnston washing roots in J root trial



Geoff Heagney grading the roots

Improving management practices leading to J-root formation will reduce the number of seedlings rejected because they do not meet the quality attributes required by Planted Forests Operations.

Sample of the different grades
Photos: Dane Thomas

Early plant growth of eucalypts in response to fertiliser application

K Weggler

Fertiliser establishment trials on ex-pasture sites have shown that there is limited response of eucalypt plants to fertiliser application on those sites. The work suggests that the fertiliser application regime can be revised and fertiliser application during establishment may not be necessary and this should result in significant financial savings. A factorial experiment showed that there was a moderate growth response of *Corymbia variegata* to N fertiliser application, but no significant growth response of *Eucalyptus pilularis* to N, P or trace elements at the same site. Results may also indicate species specific fertilisers needs.

The detrimental effect of trace element imbalance on the early growth of *E. pilularis* on an alluvial soil, from basalt material
Photo: Karin Weggler

Species specific fertiliser needs was addressed in a pot experiment, using four species. An alluvial soil from basaltic parent material, which caused growth impediments in the field, was used in the study, which showed that growth response across the four species to macronutrients (N, P, K, Mg) was fairly similar. The response to trace element fertiliser application was more profound in *E. pilularis* than in *E. grandis* and *E. dunnii.* The response of *C. variegata* was intermediate.

The comparison of four eucalypt species in a pot trial has shown that there are significant differences in trace element uptake of the major eucalypt species in the plantation program. Under similar conditions the four species showed significantly different leaf nutrient concentrations. *Eucalyptus pilularis*, planted on basalt soils, may need additional trace element fertiliser application to sustain optimum growth. Knowledge of species specific differences in leaf nutrient concentration will enable correct interpretation of field leaf samples from plantations that show growth disorders.

Hardwood plantation silviculture

G Smith

Results of spacing trials indicate initial planting densities in excess of 1250 stems per hectare are often necessary with unimproved seed to achieve 3-400 well spaced trees per hectare without a form defect. Row spacings of up to six metres can be used without any adverse effect on form or branching. These wider row spacings can reduce establishment costs by up to 30% because most establishment costs are related to the length of rows that undergo soil preparation and weed control. Closer within row spacings result in the early onset of competition. This means that delaying thinning may not be an option under such a scenario.

A review of literature and available data recommended early (pre-commercial) thinning to remove defective stems and to minimise the time taken to attain logs of target sizes when solid timber products are the aim of management. Data on stem quality within the eucalypt plantation estate showed up to one-third of stems of unimproved genetic material have serious form defects. As this is unrelated to tree size, thinning is necessary to remove these stems before they become dominant. A preliminary economic analysis showed both these factors gave good financial returns.

Wood quality and silviculture

Wood quality and silviculture work in eucalypt plantations has focussed on knots and branching as this is the major source of timber downgrade. Pruning and thinning trials in *Eucalyptus dunnii, Corymbia variegata* and *E. pilularis* have been measured annually. Branches are largely occluded up to six metres height which will allow analysis of this data and quantification of the wood quality and quantity outcomes of various silvicultural regimes.

A rectangularity trial in *E. pilularis* investigated the effect of wide row spacings on growth, form and branching characteristics. At higher stocking densities there were more trees without form defects at closer within row spacings. There was little effect of rectangularity on most characteristics compared to stocking density.

Three-year-old *Eucalyptus dunnii* plantation that received total weed control after the first year
Photo: Geoff Smith

Spacing, thinning and pruning

A review of factors affecting the decision to pre-commercially thin in subtropical eucalypt plantations was undertaken. The main reasons for early thinning were to remove defective stems that may otherwise become dominant and redistribute growth to a small number of stems that will then achieve a target size more rapidly. Thinning needs to be considered in light of initial density, pruning and the wood quality consequences of these three interacting factors. Other management factors discussed were the use of thinning as a risk management strategy (risks such as hail, disease, etc) and as a means of more rapid site capture (saving weed control costs).

Phil Alcorn from the Australian National University has made excellent progress during the first year of an Australian Research Council Linkage Grant PhD investigating the response to pruning of two eucalypt plantation species (*Eucalyptus pilularis* and *E. cloeziana*) with contrasting crown recession behaviours. Early findings indicate photosynthesis within the crowns of the two species is very different. The ongoing project is investigating growth, tree water use and leaf area distribution in response to pruning. This process based understanding of canopy dynamics will be used to formulate guidelines for early silvicultural interventions in eucalypt plantations.

Site productivity estimation

John Grant's PhD project on the effect of soil physical properties on hardwood plantation growth has collected data from all permanent growth plots within the hardwood estate. Relationships between a range of soil characteristics and growth are being investigated. These relationships are being incorporated into the site productivity estimation system to improve estimates of productivity and aid investment decision making. Field and glasshouse work on fine root biomass and root distribution within soils of different structural characteristics is underway

Integrated growth and thinning response models for even-aged forests

H Bi

Several components of growth and yield models have been developed or refined for regrowth forests in the South-East Region. Using thinning removal data collected from a small number of plots established in the recently thinned compartments and growth data from all available sources, preliminary thinning removal and growth response functions have been developed for individual trees. Now growth, thinning and growth response following thinning can all be predicted for the relatively even-aged regrowth forests.

Software Development - *Reden* is a forest resources management information and decision support system that combines the growth and yield models with inventory data for the regrowth forests in the South-East Region. It provides a user-friendly interface for forest managers to obtain growth and yield estimates of the regrowth forests at different levels of resolution. The output from this system has already been linked with GIS and used for short-term management planning and long-term strategic yield scheduling of the regrowth forests in the Region. Over the past year, work has continued to improve and refine *Reden*. Components have been developed to implement thinning and thinning response models in *Reden*. As a part of the data pipeline to *Reden*, *Reden* DE has been developed and refined for capturing inventory data in the field on handheld computers. *Reden* has been modified to output a set of yield tables as specified by Forest Resources Branch for long-term strategic yield scheduling using Woodstock.

In addition to modeling and system development, experimental work focused on the maintenance and re-measurement of a large thinning experiment over four sites jointly

established by Forests NSW and CSIRO in regrowth forests dominated by *Eucalyptus sieberi*.

A stochastic frontier analysis of a classical self-thinning experiment first reported by Yoda *et al.* (1963) and re-analysed by other ecologists showed that the belief among many plant ecologists over the past forty years that the self-thinning boundary line was species-specific and site independent was unfounded. The results also provided a way of estimating site carrying capacity of plant stands from the self-thinning surface. In addition, our collaboration with scientists at College of Environmental Science and Forestry, State University of New York and United States Department of Agriculture (USDA) Forestry Service focused on a comprehensive comparison of statistical methods for estimating the self-thinning boundary line.

ACIAR Project - the potential of *Pinus radiata* for ecological restoration of the Yangtze River catchment in Aba, Sichuan, China

H Bi, J Simpson, R Eldridge, S Sullivan

The overall objective of the project is to carry out an assessment of the potential of *Pinus radiata* for ecological restoration and so to help to ensure the future success of the planned expansion of *P. radiata* in Aba prefecture.

The project team carried out field inspections and assessments in June/July 2004 to evaluate forest health risks to the long-term success of *P. radiata* introduction in the study area. Since *P. radiata* was only introduced to the study area about 14 years ago and has been established in widely separated small plantations for environmental purposes, the team examined selected stands to see the level of health issues occurring in these plantations. At the same time, selected stands of native species *P. armondii* and *P. tabulaeformis* were also examined because pests and pathogens of these native species were considered more likely to establish on *P. radiata*. The field inspections and assessments have identified some general and specific health risks to the long-term success of *P. radiata* introduction.

Jack Simpson at *Pinus radiata* planting site, Min River valley, China
Photo: Bob Eldridge

Our progress on climate modelling has enabled us to identify areas in Aba and other geographic areas in China suitable for *P. radiata*. The results have shown that much of the Min River valley of Aba is climatically suitable for growing *P. radiata*.

Maps have been generated to show these areas in Aba using the climatic profile already developed for *P. radiata,* together with the topographic and climatic data collected last year. Low minimum temperature and low annual rainfall are still the major constraints for radiata pine in some areas. More data from weather stations around Aba are being added to refine the estimates of climates at a local scale

A provenance experiment has been measured for the first time after successful establishment at three sites along the lower, middle and upper reaches of the Min River valley. The sites were selected and site preparation was completed in late 2003 and early 2004. Seedlings of five natural provenances (Monterey, Año Nuevo, Cambria, Guadalupe and Cedros) were planted at each site. The survival rate three months after planting is over 98% across the three sites.

The project team inspected two *P. radiata* nurseries and assessed seedling health and nursery practices. The following areas have been identified to be in need of assistance and training:

(a) Genotype/source of material, seed pre-treatment management and handling

(b) Container types, style and size, growing media composition/materials

(c) General nursery cultural practices such as Irrigation methods and mycorrhizal innoculation

(d) Seedling nutrition, fertiliser, pesticide and fungicide applications

(e) Staff training and quality control processes

(f) Specifications and grading of stock.

A training program was developed for the visit of Chinese project personnel to Australia in late 2004. This program provided them a full exposure of the *P. radiata* production system including seed treatment, nursery techniques, forest health, stand management, harvesting, timber processing, pulp and paper making.

Huiquan Bi contemplates a young *Pinus radiata* provenance trial near Li Xian, Sichuan, China
Photo: Bob Eldridge

Water quality monitoring for the Environment Protection Licences

A Webb

Forests NSW has been issued with five Environment Protection Licences (EPLs) by the NSW Department of Environment and Conservation (DEC) for the carrying out of forestry activities on State forests and Crown timber lands. The object of each licence is to require practical measures to be taken to protect the aquatic environment from water pollution potentially caused by these activities and to ensure that monitoring of the effectiveness of the licence conditions in achieving the relevant goals is undertaken. The EPL water quality monitoring program therefore forms a very important component of the licences. Specifically, the objective of the water quality monitoring program is to determine if there is an identifiable impact on water quality from licensed forestry activities and, if so, to quantify the level of that impact. To meet these objectives, Forests NSW conducts river gauging and water quality monitoring at a number of sites in both native hardwood forests and softwoods plantations.

This year clearfell pine harvesting was completed within the two impact catchments at Bago State Forest (Hume Region). A soil disturbance audit conducted at the completion of harvesting revealed that 50.5 ha (53.3%) and 45.8 ha (54.2%) of the BAGOG4 and BAGOG5 impact catchments were clearfell harvested, respectively. In both catchments, the General

Harvest Area (GHA) accounted for the majority of the harvested area, with forwarder tracks having the next greatest extent in area. Mean vegetated groundcover over the harvested area was in excess of 92% in the BAGOG4 catchment and in excess of 89% in the BAGOG5 catchment. The vegetated groundcover was dominated by "small litter" (<0.2 m diameter) with lesser amounts of "large litter" (>0.2 m diameter) and "living vegetation". The degree of soil disturbance was comparatively minor in both catchments and even lower than recorded after harvesting in the Canobolas catchments. Forests NSW will continue to monitor turbidity, total suspended sediment concentrations and streamflows within these catchments for at least 18 months post-harvest to assess if harvesting had any impact on water quality.

During 2004/2005 monitoring continued post-harvest in the Canobolas catchments (Macquarie Region) but no harvesting has occurred yet within any of the native forest catchments at Yambulla State Forest (South-East Region) or Kangaroo River State Forest (North-East Region). Harvesting of the three impact catchments at Kangaroo River is scheduled for mid-2006.

High flows in a native forest catchment, Kangaroo River State Forest, October 2004

Photo: Ashley Webb

A final report detailing outcomes of the Middle Brother State Forest (Mid North Coast) native forest paired catchment study was completed in early 2005. Water quality data were collected at Middle Brother between 1994 and 2003, with selective harvesting of the eucalypt forest (20.7% canopy removal) occurring between December 1999 and March 2000 in the impact catchment. At low-flows, for both turbidity and Total Suspended Sediment (TSS) concentration there was a statistically significant impact detected, with both variables exhibiting an increase in the immediate post-harvest period, which declined to pre-harvest levels after a period of approximately 12 months. The increases experienced were low in absolute terms and, if viewed in the context of the multiple-use Camden Haven catchment, were practically insignificant. At high flows no significant impact was detected for total event turbidity or TSS, nor was there a significant impact detected for event mean turbidity. However, event mean TSS values were higher during the post-harvest period, peaking in an event in March 2001, after which they returned to the pre-harvest levels. This observation is consistent with the expectation that forest harvesting activities could have a minor impact on in-stream turbidity and TSS levels in the immediate post-harvest period followed by an exponential decline.

Forest Health

Program Leader:
Christine Stone

Aim:

Integrated decision support and management systems developed which provide an acceptable level of forest health protection.

Objectives:

To minimise the introduction or establishment of exotic pests or diseases

A system of forest health management which minimises pest and disease impacts on managed forests

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Forest health surveillance of softwood plantations
A Carnegie, D Kent, D Waterson

The incidence, severity and extent of areas where pests, diseases, vertebrates, nutrients and weeds were limiting growth or affecting survival of pines were highlighted by the Forest Health Survey Unit. Softwoods management can use this data to determine correct predictions of pre-harvested wood volume in affected stands, adjust management regimes for "unhealthy" stands (eg bring thinning forward in drought affected stands), apply fertilisers or weed control to improve establishment, growth and survival of young trees and control spray for *Dothistroma* needle blight.

Softwood plantations in all Regions were surveyed from June to September 2004. Forest Health staff met with Regional Managers or Operations Managers at the completion of each survey to discuss the major health problems in each Region and any remedial or control actions recommended. Reports were completed and sent to Regional Managers.

The main health issues in 2004 were:

- Drought-related *Sphaeropsis* damage, more severe in un-thinned stands:
  - ~1250 ha in Hume Region (Kangaroo Vale, Nanango and Carabost State Forests)
  - ~4200 ha in Macquarie Region (Pennsylvania, Vittoria, Mount David, Vulcan, Kinross, Essington, Roseberg and Glenwwod State Forests).
  - Mostly low levels in Monaro Regionbut high in Pericoe and Craigie State Forests.
  - Low levels in Northern Region
- *Essigella californica* numbers and damage were lower than previous years in all areas.
  - Forests NSW's part of a National study investigating the impact and causality of *Essigella*. This insect pests costs the pine plantations industry in Australia $**21 million** per annum, or **$53**/ha/yr, in lost wood production. Forests NSW has approx. 150,000 ha that are at risk from *Essigella* defoliation.
  - A cost benefit analysis was conducted on several control options (May 2004), with biological control the best option, at a cost of **~$20 000** per annum over five years (contribution to a national management strategy) Forest NSW should derive a benefit of **$3-5 million**.

- *Dothistroma* severity was lower than previous years in Northern Region.
- Possum damage was significantly lower than previous years in Monaro Region but wallabies are now a problem in some of the younger age classes.
- Mortality from *Armillaria* was still a continuing problem at Acacia Plateau (Northern Region).
- There were only localised and low level mortality associated with Sirex. The management strategy (biological control and surveillance) has been very effective.
- Snow damage was a significant problem in Monaro Region, with a total of 6755 ha affected. However, only 1700 ha had moderate to severe damage, where broken branches or broken tops occurred.
- Hail damage caused localised damage in Northern and Monaro Regions.

Forest health surveillance of hardwood plantations

A Carnegie, D Kent, G Price

Forest health surveys identify important pests and diseases that may be limiting to growth and establishment of eucalypt plantations and that may need further research, as well as certain sites/areas that may have increased health problems. Continued forest health surveys are essential to increase our knowledge of known pests and diseases and what factors influence damaging outbreaks of these, as well as increase our ability to detect new pests and diseases early (including exotics). Forest Health reports provide owners/managers with a summary of important pests and disease in their plantations, with recommendations on remedial/control action where appropriate. In most cases, these are discussed with relevant field staff soon after the survey.

Mistletoe in young spotted gum plantation, showing severe infestation and two species of mistletoe
Photos: Angus Carnegie

Routine forest health surveys were conducted during the early part of summer-autumn 2005. This included aerial surveys for *Creiis* psyllid in *Eucalyptus dunnii* plantations in April and May.

- *Creiis* was again a significant problem in *E. dunnii,* however, only a few plantations were severely affected. Some of these may not recover. No control operations were conduced. Low numbers of *Creiis* were observed in many plantations.
- Chrysomelid leave beetles were common but mostly at low levels of severity, and most commonly in *E. dunnii*. One exception was very severe defoliation by Chrysomelids in the *E. dunnii* at a plantation near Dorrigo, where 95% defoliation had occured. Dead-topping was observed here, with a range of stem fungi identified (*Tubercularis lateritia, Botryosphaeria* sp.*, Cryphonectria eucalypti*). Severe insect damage was also observed in the adjacent native forest.
- Severe stem canker resulting in dead-topping and tree mortality was again observed near Dorrigo. This damage is associated with several stem and root fungi, including an undescribed species of *Caliciopsis* and several commonly found canker fungi (*Botryosphaeria* sp.*, Cryphonectria eucalypti). Caliciopsis* sp. is normally only associated with localised cankers and mostly on branches. Further work is required on this disease problem to determine exactly why this plantation is affected and not others.
- Low levels of damage and mortality associated with stem canker fungi (*Botryosphaeria* sp.*, Cryphonectria eucalypti*) were observed in several older plantations. It is expected that these fungi may become a bigger problem as plantations age.
- Continued severe defoliation of *E. nitens* near Dorrigo was again observed. Trees had 95% defoliation, caused mostly by *Phaeophleospora eucalypti* (same genus as the “red tide” fungus) and this has resulted in dead-topping of some trees. Continual infection will result in further dead-topping and tree mortality.
- Levels of mistletoe were alarmingly high (65%) in several *Corymbia variegata* plantations and at lower levels in up to 15% of spotted gum plantations. The impact of mistletoe is currently being examined, with significant growth reductions and mortality observed in mature paddock trees.
- Stem borers were a continuing problem in the older plantations, especially *E. grandis.*
- The Gunnedah plantations were surveyed this year for the first time. A limited range of insects and fungi were observed, as well as nutrient deficiencies and most likely frost damage symptoms, but none at severe levels.
- Damage from a range of insects and fungi, including *Phaeophleospora epicoccoides* (red tide) and Chrysomelids, caused continual severe damage to *E. grandis* at several sites. It is obvious that these blocks are not well suited to *E. grandis.* It is expected that many trees will not recover, with dead-topping and mortality observed.
- *Quambalaria (=Ramularia) eucalypti* was observed for the first time in *E. grandis*. This fungus acts in a similar manner to *Q. pitereka,* which is the most common and damaging fungus in spotted gum plantations. At present *Q. eucalypti* is not causing significant damage and is rare (although endemic to Australia).

In February staff from Queensland Department of Primary Industries and Forestry, Forest Research joined the Forest Health Surveillance Unit to survey a selection of plantations in north-eastern NSW. The aim of this collaboration was to gain a better understanding of the pests and diseases that occur in plantations across the border, such that a “heads up” may be gained on potentially new and important insect and fungi that may cause damage to our plantations. This is the second year this has been done, with several new species of fungi identified during these surveys.

Forest health database

A Carnegie

The majority of data (including 2004 data) has been entered into the Forest Health database. These data have been checked for integrity and are in the process of being "cleaned". Layers for other data, including climatic data, soil map data and digital elevation data, have been obtained or calculated. These datasets will be "merged" with spatial data (from GIS) and inventory/forest data (from Total Forest Management). Analysis will then begin to produce a *Sphaeropsis* model.

The model will enable forest managers, at their "desk top", to reduce the chances of further mortality by drought-related *Sphaeropsis* in *Pinus radiata* stands. By producing a hazard-rating map of compartments at risk of further damage, forest managers can alter silvicultural regimes to suite individual cases. These could include bringing thinning forward or not pruning in high risk areas.

Stem degrade in eucalypt plantations

A Carnegie

Current research in hardwood plantations has focused on foliar and shoot pests and diseases. These mostly affect trees up to around age five years and, in most cases, only result in growth losses. Since these plantations are being grown for sawn timber products, with a rotation of up to 40 years, it is likely that the greatest impact on marketable yield will be caused by stem degrade. These agents are stem borers and stem decay fungi. An understanding of what agents are present in the plantations, and which are causing the most impact, is necessary to determine whether management strategies are possible and/or viable.

Severe stem borer damage to young spotted gum

Canker on *Eucalyptus cloeziana* causing staining and tree death

Photos: Angus Carnegie

Data on the extent, incidence and host susceptibility to stem borers was collected from regular forest health surveys as well as tree improvement assessments. Long-term trials examining the history of stem borer damage and associated stem degrade are continuing. It is hoped that further assessments of these can be incorporated into the new Sub-tropical Forest Health Alliance projects, in collaboration with Queensland Department of Primary Industries and Forestry.

The stem fungi associated with wounds caused by stem borers have been examined. Stem fungi in general were surveyed for in hardwood plantations in early 2005. Most of these have been identified, and most are common stem fungi found in Australia. Several are either new to eucalypts (*Tubercularia lateritia*) or new to NSW (*Caliciopsis* sp.). This latter fungus is a new species and is currently being described. It is associated with localised cankers on a range of species.

Forests NSW insect collection

D Kent

Forests NSW, through NSW Department of Primary Industries, Science and Research, maintains a significant collection of Australian forest and forest product insects. The collection provides an important identification service to Forests NSW staff, other government agencies (including Australian Quarantine Inspection Service), the pest control industry and the general public. To enhance the day-to-day and long-term management of the insect collection we have adopted Biolink, a CSIRO software database specifically designed for collections.

Forest Health has been successful in obtaining $60,000 of Commonwealth funding since 2002 for a data capture program from the Australian Plant Pest Database project. The Australian Plant Pest Database project has been developed by Plant Health Australia and Agriculture, Fisheries and Forestry – Australia, as a national, web interfaced tool, linking reference collection databases of pests and diseases of economically important crops and plant-derived commodities in Australia.

Debbie Kent with some of the 50 000 insects in the collection
Photo: Emma McMahon

Access to reliable data on the distribution, host range and economic status of pests and diseases is essential to Australia, as it seeks to meet the quarantine requirements of overseas markets and to justify phytosanitary measures that it imposes on imported commodities.

Nearly 50% of the Forests NSW Insect Collection, 23 000 specimens, is now available to be searched in-house for distribution data and host plant information, while a small percentage, mainly termites, is currently available via the Internet using Australian Plant Pest Database web site.

Clonal eucalypts resistant to pest and diseases

C Stone

Identification and propagation of clonal material from select resistant trees is an important initial stage to improving the insect resistance of eucalypt plantations. If the clones are found to perform well on certain sites, this genetic material can then be introduced into the hardwood plantations planting program.

The Forest Health Surveillance Unit and hardwood plantation officers continue their vigilance in looking out for any trees that appear to exhibit some degree of resistance to insect herbivory;

A significant contribution to this project has came from two Australian Research Council Linkage PhD projects. Christine Stone is a supervisor for both projects.

Insect resistance traits of Eucalyptus *for the NSW forest plantation industry* - is in its third and final year. Mr Martin Henery, the PhD candidate is based in the phytochemistry laboratory managed by Dr Bill Foley, Australian National University, Canberra, and is working towards the following aims: a) to characterise the chemical and physical parameters (eg leaf toughness) of foliage from susceptible and resistant *Eucalyptus grandis* trees; b) to undertake laboratory bioassays and field trials on clonal material propagated from selected resistant trees. Mr Henery has completed a series of bioassays testing *Paropsis atomaria* larvae (Chrysomelidae) on several *E. grandis* clones progated by the Forests NSW Tree Breeding Unit and identified two clones presenting significant toxic effects on young feeding *P. atomaria* larvae. Examiniation of the foliar biochemistry of these two *E. grandis* clones has commenced.

Pest status and management of a Creiis *psyllid in* Eucalyptus *plantations in northern New South Wales* - has just been completed. Mr Paul Angel, a PhD candidate, expects to submit his thesis shortly. As part of his studies, Mr Angel obtained *Eucalyptus dunnii* clonal seedlings from the Tree Improvement Program, Grafton. The clonal seedlings were propagated either from an individual tree that was exhibiting strong partial resistance to *Creiis* damage and defoliation in a plantation near Bonalbo and from similar but susceptible trees. A series of choice experiments were conducted using the propagated seedlings in screened cages. The resistant material was significantly less preferred by ovipositing *Creiis* females resulting in significantly lower psyllid egg densities on the leaves compared to the susceptible seedlings. Also the juveniles that subsequently developed on the resistant clonal stock experienced significantly higher levels of mortality in the predator free environment. Figures 1, 2, 3 and 4 presents some of the results obtained from this experiment.

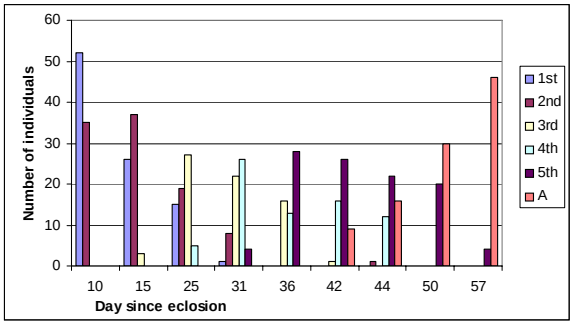


Figure 1. Development of *Creiis literatus* (Psyllidae) juveniles on three *Eucalyptus dunnii* commercial stock seedlings

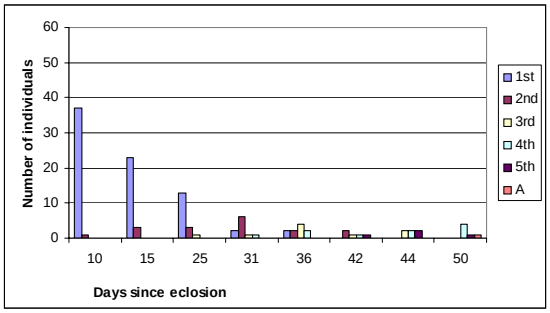


Figure 2. Development of *Creiis literatus* (Psyllidae) juveniles on three seedlings propagated from a "resistant" *Eucalyptus dunnii* tree

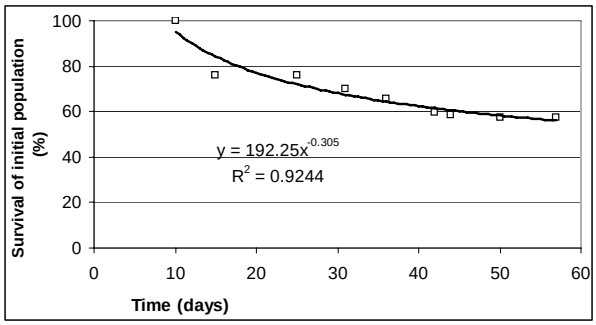


Figure 3. Survival of *Creiis lituratus* juveniles on grafted, "susceptible" *Eucalyptus dunnii* stock seedlings

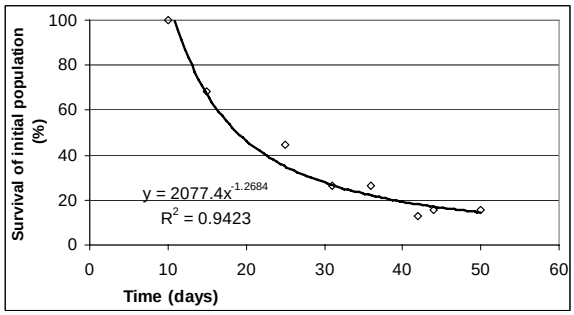


Figure 4. Survival of *Creiis lituratus* juveniles on grafted, "resistant" *Eucalyptus dunnii* stock seedlings

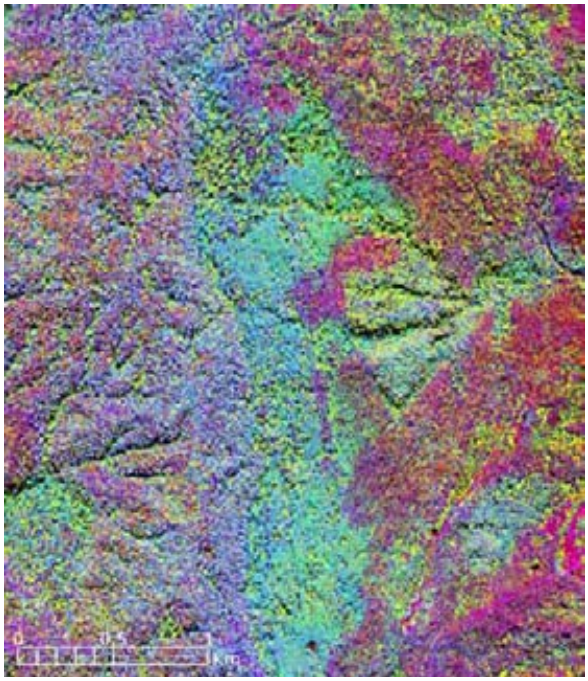
Airborne assessment of native forest dieback in North-East Region

C Stone

The aim of this project is to identify the acquisition, processing and modelling specifications of cost-effective imagery that will enable the accurate classification of canopy condition in native eucalypt forests. This will contribute to the development of operational guidelines for quantitatively mapping the extent and severity of canopy dieback in native forests within NSW.

The collaborative project, commenced in June 2004, has been partially funded by the National Heritage Trust (NHT2). The original project was supported by the Bell Miner Associated Dieback Working Group and recommended by the Northern Rivers Catchment Management Authority for NHT2 funding and $50 000 of Federal funding was secured. The participants have secured further funding of approximately $30 000 for the 2005/2006 financial year to continue this project.

A study site of 30,000 ha was selected in the Richmond Range, northern NSW which contains native forest managed by Forests NSW and Department of Environment and Conservation (NPWS) and also of private tenure. The ground-based program associated with the intensive assessment of twenty-four 20 m radius plots has been undertaken by personal within NPWS (John Hunter, Steve King and Tim Perry) and DPI (Christine Stone, Grahame Price, Russell Turner, Peter St Clair and Jamie Churchill). The plots exhibited a range of floristics, stand structure and canopy condition. Both stand and tree-level attributes were measured including floristic composition and % crown cover of both the overstorey and understorey, bell miner density, tree crown measurements, soil profile descriptions and soil chemistry analysis. A complete listing of all the flora present in 24 plots has been prepared and the floristics data analysed. The visual assessment of canopy condition of a further 99 plots has also been completed.



A section of Digital Multispecial Imagery (2.0 m, 4 bands) processed through Principal Component Analysis in order to visualise areas of BMAD affected forest within the Richmond Range

Analysis of digital imagery by researchers in the remote sensing unit, CSIRO Forestry and Forest Products (Neil Sims) and Forests NSW (Russell Turner) has commenced and is progressing well. Acquisition of a series of GIS coverages is occurring including: soil landscape maps (prepared by Dave Moran, Departrment of Infrastructure, Planning and Natural Resources, Alstonville); silvicultural history (prepared by Rob Kirwood, Forests NSW) and topographic and climatic terrain derived attributes (prepared by Alison Towerton, DPI Forest Resources Research). The spatial modelling of these GIS coverages and the ground-based data has commenced with the assistance of Andrew Haywood (Jaakko Poyry Consulting).

Key:
Yellow = mesic vegetation (understorey and rainforest)
Blue/purple = healthy eucalypt crowns
Orange/red = eucalypt crowns affected by bell miner associated dieback

Mundalla Yellows – ARC Linkage Project

C Stone

Mundulla Yellows is a fatal disease that affects a very wide range of eucalypts, including commercial eucalypt species and other native plants. It is characterised by progressive yellowing and dieback of foliage. It was first observed in the 1970s in South Australia and has been observed spreading, in varying degrees, to other States.

This study is an ARC Linkage Project (LP0454036) submitted in 2003, based at the University of Adelaide and partially funded by Forests NSW.

The project is a comparative study of the distribution and spread of potential molecular markers for Mundulla Yellows disease. During the first year of research, the application of polyacrylamide gel electrophoresis to identify individual RNA's uniquely associated with Mundulla Yellows was unable to identify consistent bands. It was concluded that RNA sequence information was required to find specific molecular disease markers. The isolation and cloning of a range of Mundulla Yellows' RNA bands is now occurring in order to identify the molecular marker molecules.

Needlecast of *Pinus radiata*

J Simpson

Cyclaneusma minus is the most common fungus associated with *Pinus radiata* in plantations in the southern hemisphere. Previous studies in NSW and New Zealand have shown it is an endophyte in living needles and can cause significant needle cast disease. Isolates of *C. minus* from plantations from N.S.W. and New Zealand have been examined using multi locus marker systems such as resistance gene analogs (RGAs), AFLP, RAPD and Microsatellites (Tagged) to study variability in the populations of the fungus.

Cyclaneusma is associated with needlecast of radiata pine but also behaves as an endophyte in living needles. The research will help Planted Forests Operations increase production through:

1. a better understanding of variation in susceptibility to needlecast
2. an understanding of variation in pathogenicity and virulence in *C. minus*
3. marker aided selection for resistance in the tree breeding population
4. determining if there is significant variation between populations of *C. minus* from different hosts and from different regions. This has important quarantine implications.

Termite and Power Pole Evaluation Research (TAPPER) Project

M Horwood

Each year Forests NSW receives approximately $5 million from sales of timber for use as power poles. In recent years this market has been challenged by manufacturers of concrete and steel poles. The main implication of the termite and power pole evaluation research is to improve the cost-effectiveness and reliability of wood poles relative to concrete and steel by identifying effective means for protecting poles from termite attack and for eradicating infestations that have occurred.

Project objectives are to:

1. Produce efficacy and reliability data on a range of termite treatment systems for wood poles. While the data will be developed on poles, it will be applicable to both hardwood and softwood timbers in a wide range of end uses.
2. Significantly reduce the estimated annual expenditure of approximately $5 000 000 on termite protection of wood poles and replacement of wood poles due to termite attack.
3. Identify effective alternatives to arsenic trioxide dust for eradicating existing termite infestations.

Service trial installation began in December 2000 and was completed in October 2002. Treatments were applied to over 450 termite infested poles located throughout urban and rural NSW. Since treatment, poles have been continuously monitored to assess treatment performance. Because pole treatment was staggered, not all poles have been monitored for the same period. All poles have been monitored for at least 24 months.

A field trial was established in November 2002 in a State Forest near Narrandera. A large number of timber posts have been placed in the ground protected by an assortment of barrier systems. Posts are being inspected at intervals to determine the effectiveness of the treatments. The first annual inspection of posts was conducted in November 2003. Levels of termite attack upon all posts were very low and no meaningful results have yet flowed from this part of the study.

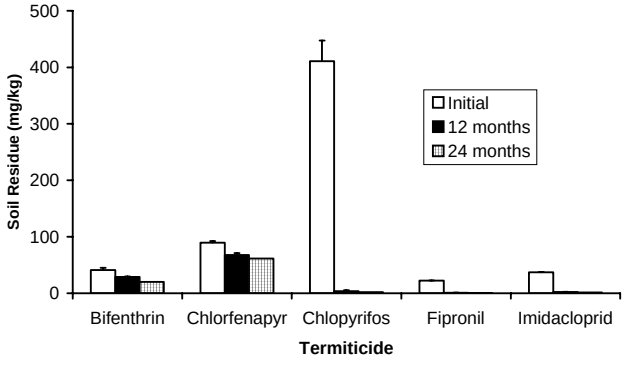


Figure 1. Termiticide residue levels in soil at the field trial site near Narrandera. Reductions in chlorpyrifos, fipronil and imidacloprid were greater than anticipated. Results are of particular relevance to efforts to police or audit the application of termiticides by the pest control industry

An ongoing program of soil testing has been carried out in conjunction with the Service and Field Trials. The aim is to determine the longevity of termiticide residues under field conditions. Results have important implications for the regulation of termiticide application by the pest control industry.

Superficial treatment alone is not sufficient protection from termites. An ongoing program of soil treatment is necessary for poles to achieve cost-effective service lives. The objective of this research is to improve the cost-effectiveness and reliability of wood poles relative to concrete and steel by identifying effective means for protecting poles from termite attack and for eradicating infestations that have occurred
Photo: Martin Horwood

Forest Biodiversity

Program Leader:
Rod Kavanagh

Aim:

A scientific basis for maximising biodiversity values in managed forests.

Objectives:

Enhance understanding of managed forests ecosystems

Integrated landscape models of wildlife habitat and timber production

Ecology of birds and non-flying mammals in managed forests
R Kavanagh

Studies show the continuing need for forest managers to carefully plan harvesting operations to minimise adverse impacts on populations of a range of common (and not so common) forest birds and mammals. About 25% of all vertebrate species recorded in north-eastern NSW were found to be clearly sensitive to logging (either advantaged or disadvantaged), while another 40% appeared to be largely unaffected. However, a further 35% of vertebrate species occur so rarely in nature that it is not possible to assess the sensitivity of these species to logging using standard fauna survey techniques. Species included in the latter group require species-specific research programmes, along the lines of that described for the barking owl, to obtain information useful for their conservation and management. In the case of the barking owl, it was necessary to undertake a radio-tracking study of a number of known individuals to determine key elements of habitat required by this species and to provide appropriate guidelines for managers.

The greatest task now facing forest managers is the need to implement species monitoring programmes at the regional scale so that ecological sustainability of forest management practices can be demonstrated. The research reported here identifies a number of species that are known, or suspected, to be sensitive to forest operations and which should be considered as candidates for long-term monitoring. Many of these species were also found to have associations with others suggesting limited support for the controversial indicator species concept in forest management. Managers should now establish regional task groups to implement robust species monitoring programmes at the regional scale.

Vertebrate species assemblages and species sensitivity to logging in the forests of north-eastern New South Wales

This study has provided one of the few opportunities to date to critically evaluate some aspects of the indicator species concept and its potential as a management shortcut for assessing changes in biodiversity in managed forest landscapes. Qualified support for the concept has been shown, based on the identification of a set of species apparently sensitive to logging and their representation across a range of species assemblages. The choice of candidate species for monitoring will depend on the integration of results from other experimental and retrospective studies and will be specific to each region depending on the composition of species assemblages and the goals of management.

The occurrences of 227 vertebrate species recorded on 487 forested sites in north-eastern New South Wales were investigated to determine the levels of association among species, the distribution of species by broad functional groups, species relations with key

environmental and disturbance variables, the sensitivity of species to intensive logging, and to list species that have potential value as direct indicators of major environmental change and which should be considered as candidates for long-term monitoring.

A total of 40 species appeared to be significantly disadvantaged by logging, another 40 species appeared to be significantly favoured by logging, while the remainder (147 species) appeared to be relatively unaffected. Most species were widely distributed throughout both logged and unlogged landscapes, albeit at possibly quite different abundances. A further 121 species were recorded so rarely in the study (based on 619 sites) that it was not possible to make any assessments of their sensitivity to logging. The study produced several unexpected results, including the failure to identify some species as sensitive to logging that had previously been identified as sensitive in experimental and other retrospective studies.

Species disadvantaged by logging were often either dependent on large old trees and/or tree hollows for nesting, roosting and foraging, such as the common brushtail possum, red-browed treecreeper, satin flycatcher and crimson rosella or they were species that inhabit open forests and woodland, such as the rufous bettong, buff-rumped thornbill, white-throated gerygone, white's skink and nobbi, that were probably disadvantaged by the increase in stem density and understorey and mid-canopy cover that usually follows logging. In contrast, species favoured by logging, such as the eastern whipbird, brown gerygone, lewin's honeyeater, wonga pigeon and land mullet, were often those species preferring wetter forest environments, particularly those with multi-layered foliage and a forest structure that includes fallen logs and a dense ground cover. No species displayed consistently strong preferences for selectively logged forest. Mammals were more likely to be disadvantaged by logging than birds but reptiles contained the largest proportion of species sensitive to logging (39%). Frogs were inadequately sampled in this study; only nine species were recorded. While each taxonomic group had some species that were apparently sensitive to logging, the time frame to population recovery following logging disturbance may differ widely between groups depending on their habitat requirements. Fire history was also strongly correlated with the occurrences of many species, indicating the need to quantify species sensitivity to regular fuel-reduction burning.

Barking owls in the Pilliga

The barking owl *(Ninox connivens)* is one of the more recent additions to the NSW Threatened Species Conservation Act (1995), where it was listed as a vulnerable species in 1998. This owl appears to have suffered a decline in abundance across southern Australia in recent decades for reasons that are not clearly understood but which may be related to habitat loss and degradation. Habitat of the barking owl includes the drier forests and woodlands near rivers and billabongs in agriculturally-dominated landscapes of the coast and inland slopes and plains. It is rare or absent from the tall, wetter forests typical of the coast and adjacent mountain ranges and, while it does occur in some State forests and National Parks, most records are from private or other unprotected lands. The recent discovery of a substantial population of barking owls in the Pilliga State Forests, an area long used for wood production, poses the question of how best to ensure conservation of this species into the future. This study was undertaken to provide guidelines for managing this species.

The main objective was to examine the importance of forest "edges" and particular forest types (tree species associations), as nesting, roosting and foraging habitat for the barking owl in the Pilliga forests. Current interim forestry prescriptions in the region were strongly influenced by the perception that barking owls need forest edges of some type, however, the owls are distributed more widely in the Pilliga. Accordingly, nine birds from eight pairs were trapped and radio-tracked for one year. Three pairs were located in an area that had major creeks (usually dry sandbeds) running through their estimated home-ranges, two pairs had substantial areas of forest with paddock edges within their estimated home ranges, and another three pairs had no creeks and no paddocks anywhere near their home-ranges (ie forest interior only). Data on reproductive success (a key variable) for these eight pairs was

augmented by the addition of nesting results from a further seven territories where we located the nest trees in 2003.

Barking owl nest tree in a large old red gum among white cypress pines
Photos: Rod Kavanagh

Barking owl roosting in white cypress pine

Preliminary results indicate that barking owl home ranges in the Pilliga forests are approximately 2000 ha per pair and include a range of forest types. While the owls often foraged near forest edges there was no strong pattern of selection for ecotones and owls occupying territories within the forest interior were no less successful in producing young. Nests were located in large old hollow trees, mainly in red gums, narrow-leaved Ironbarks and dead stags. The owls roosted among clumps of foliage, especially in rough-barked apples, white cypress pine, belah, wilga and narrow-leaved ironbarks. The diet of the owls contained a wide variety of prey items, including the Sugar Glider, microchiropteran bats, small and large birds and many types of invertebrates. Analyses are continuing to identify preferences of the owls for foraging in different forest types. This information, including data about the characteristics of nest and roost trees, will help to determine the kinds of management actions needed to conserve barking owls in the Pilliga forests.

Ecology of threatened plant species in managed forests and responses of forest litter loads and eucalypt regeneration to fuel reduction burning

This long-term project, centred around the Eden Burning Study, is providing improved understanding of the impacts of fire and logging on the population dynamics of forest trees and understorey plant species, likely effectiveness of current Conservation Protocols and identification of the most appropriate methods for monitoring long-term changes in the regional status of rare and threatened plants. Further, it is providing data to underpin the development of appropriate fuel reduction burning regimes in dry coastal eucalypt forests of southern NSW through improved understanding of fuel build-up following fuel reduction burning and regeneration characteristics following logging and burning.

Maintenance of experimental treatments (regular prescribed burning) for the site continues with on-going plot measurements of understorey floristics, eucalypt regeneration and forest fuel litter loads. Funding is to be provided through the Bushfire CRC to employ a post-

doctoral researcher to undertake assessments of the responses of understorey plant species to disturbance. This work will commence in 2005/06.

Biodiversity in eucalypt plantations established to reduce salinity

R Kavanagh, B Law, F Lemckert

Extensive areas of trees and shrubs are being planted for land rehabilitation and wood production on previously cleared agricultural land in Australia. Environmental benefits are a major selling point for this change in land management but data concerning the response of biodiversity to new plantings are scarce and needed to direct restoration efforts and to underpin policy development.

During 2004-05, we completed a large-scale study to guide future planting schemes for biodiversity recovery in agricultural landscapes. The final report from the study was submitted to the Joint Venture Agroforestry Program (administered by RIRDC) in December 2004.

Strong evidence is provided to show that eucalypt plantings improve the habitat matrix (ie the cleared and semi-cleared land around remnant forest and woodland) for many species in agricultural landscapes. Eucalypt plantings were used by many species, especially birds and bats which are more mobile and capable of traversing cleared areas. Plantings older than 10 years provided better habitat than young plantings and planted and remnant patches larger than 5 ha were significantly better than smaller patches of either vegetation type. Landscape context (ie proximity to remnant vegetation) was shown to be an important factor influencing occupancy of young plantations, especially for birds, but less so for bats. Remnant vegetation should provide the focal point for habitat restoration efforts using eucalypt plantings.

Bat ecology in managed forests

B Law

The improving knowledge of forest bat ecology is allowing predictions to be made about changes in bat communities resulting from changes in forest management practices and thus will be integral to demonstrating ecological sustainability. Studies on the biological width of streams can provide a scientific basis for setting buffer widths, most likely at widths considerably less than those suggested by external regulators.

Publication of a detailed review of bat management practices in forests and proposal of an alternative strategy that shifts emphasis away from many pre-logging surveys to more intensive monitoring at fewer sites would not only improve bat conservation but also be more cost-effective for the organisation.

Improved tools have been produced for surveying bats, such as identification keys that can be used with software for automated bat call identification, as well as monitoring bats using novel methods, such as banding and infra-red counters at known roosts. The information gathered from long-term monitoring is extremely valuable, for example riparian buffers have been demonstrated to be effective in mitigating the immediate effects of logging on the large-footed myotis. Data can be used in annual Environmental Audit Reports.

Response of bats to disturbance

Bats in the Pilliga - a major study of bats (and other fauna) in the Pilliga region was initiated in spring 2004. The aim of the study is to establish the biological width of streams in the Pilliga, so that there is a scientific basis for buffer widths surrounding streams. The study sampled three different-sized streams replicated across the region. Ultrasonic detectors

were used to record bat calls. Many thousands of calls were collected and, as part of the process of identifying these calls, an identification key was developed for the Pilliga region that is compatible with software designed to automate the process of bat call identification. Both the key and software will be a valuable tool for Western Region, allowing rapid and reliable identification of bat calls collected as part of local monitoring projects. Call identification from the stream width study will be completed in 2005/06.

Brad Law identifying bats from a bat trap during a study investigating the biological width of streams in the Pilliga region
Photo: Rod Kavanagh

Bats in the Eden Burning Study Area - no information exists on the response of bats to hazard-reduction burning. The first bat survey at this experimental area in Eden was undertaken in 1999 and was followed after the most recent experimental burns with a second survey in 2001. A third survey was completed in December 2004, scheduled in that year to allow short-term recovery from the most recent burns. On this last survey, preliminary light trapping was also undertaken across the range of burning treatments to sample flying invertebrate prey. Data on flying insects will help to disentangle any response of bats that may be due to burning-induced changes to vegetation structure and/or prey abundance. The data from these surveys have not yet been analysed but it is expected analysis will begin later in 2005.

Mark Chidel inspects a bat trap at the Karuah Research catchments, where a detailed population study of bats is being undertaken prior to thinning of catchments in 2006
Photo: Brad Law

Bats in the Karuah Research Area - a seventh consecutive year of banding bats was conducted in March 2005, with 108 banded and 56 recaptured from previous years. The study will provide the first estimates of bat population sizes and survival rates in forests, for comparison between regrowth and unlogged catchments. To maximise the precision of our estimates, data will continue to be collected until regrowth catchments are thinned, which is expected to occur in the next year or two. Annual banding is also providing extensive pre-thinning data on bat populations that will allow comparison with post-thinning data in years to come.

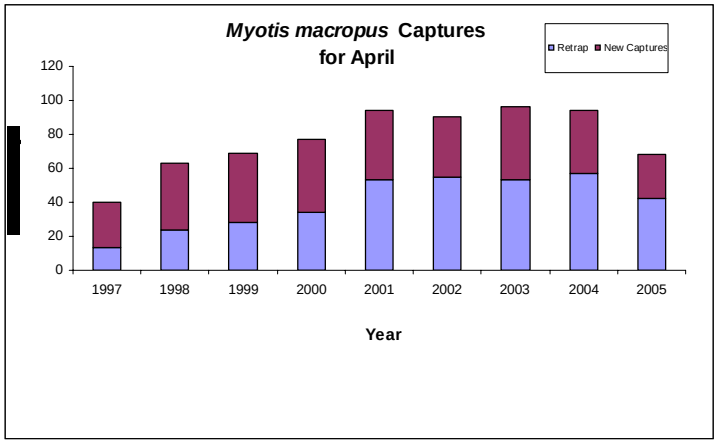
Student supervision continued for Maria Adams (PhD at Wollongong University) on the use of canopies in regrowth forests (thinned and unthinned) by bats and insects, Chris Turbill (PhD at University of Armidale) on the thermal physiology of forest bats and Rochelle Bascham (Honours at University of NSW) on Microbats in urban bushland.

Improved management of bats in Forests NSW

Accumulation of research data on a range issues relevant to bats over the last 10 years has led to the view that current management of this mammal group in Forests NSW is not optimal for either bat conservation or operational efficiency. A detailed review of past and current management practices affecting forest bats led to the publication (in the recently released book Conservation of Australia's Forest Fauna) of an alternative proposal for management of bats. The essence of the proposal is to shift management emphasis away from rapid, pre-logging surveys for a small suite of bat species to more intensive monitoring of the entire bat community at fewer sites. In conjunction with scientific research, monitoring would provide much needed data on the changing status of bats and a strong basis for assessing the effectiveness of management prescriptions, which is not addressed by pre-logging surveys. Although pre-logging surveys usually comprise modest survey effort, over 2 000 surveys are undertaken each year. This represents an opportunity cost that limits the introduction of monitoring. The paper was strongly supported by regionally-based Forest NSW ecologists. However, the regulation of management strategies is specified externally by the Department of Environment and Conservation within the Threatened Species License issued to Forests NSW. There is now opportunity to change management practices as a five-year review is being held in 2005. Thus a major aim of this paper was to provide a solid, scientific argument to advance the management of bats in State forests.

Improved tools for monitoring and surveying bats

The large-footed myotis, a water-way dependent bat, was banded for the ninth consecutive year at Kerewong State Forest. Sixty-eight individuals, including 42 recaptures, were caught at Kerewong State Forest in 2005. This number is a little less than that captured in previous years, most likely because of relatively poor weather conditions on the night of the survey. Sub-optimal weather conditions should have little influence on the analysis of these results, because population sizes will be estimated using mark-release-recapture models, which estimate capture probability. A full analysis of population trends will take place following the 2006 survey sample. This extensive data-set collected over 10 years, both before and after logging in surrounding catchments from 2000-2003 and over changing weather conditions, will provide a strong test for the effectiveness of riparian buffers in mitigating any potential short-term effects of logging.



Monitoring also continued at two key subterranean roost sites using an infra-red gate and data-logger. At Mumbulla mine near Eden, equipment failure prevented a successful count being made in October. At Ourimbah bat cave on the central coast (the largest known roost of horseshoe bats in Australia), an uncorrected estimate of about 6,900 bats was made as they exited their cave in January 2005. Calibration of this count by two correction factors for

bats that fly-over the infrared gate and those that simultaneously fly through (both estimated using a video) is yet to be made. This count was similar to previous years, although counts at this time of the year are quite variable, with sometimes very low counts related to either early breeding and dispersal by juveniles or poor breeding. Continued monitoring of these important bat populations will allow Forests NSW to track the changing status of these bats and especially to assess changes due to forest management practices imposed on the surrounding environment.

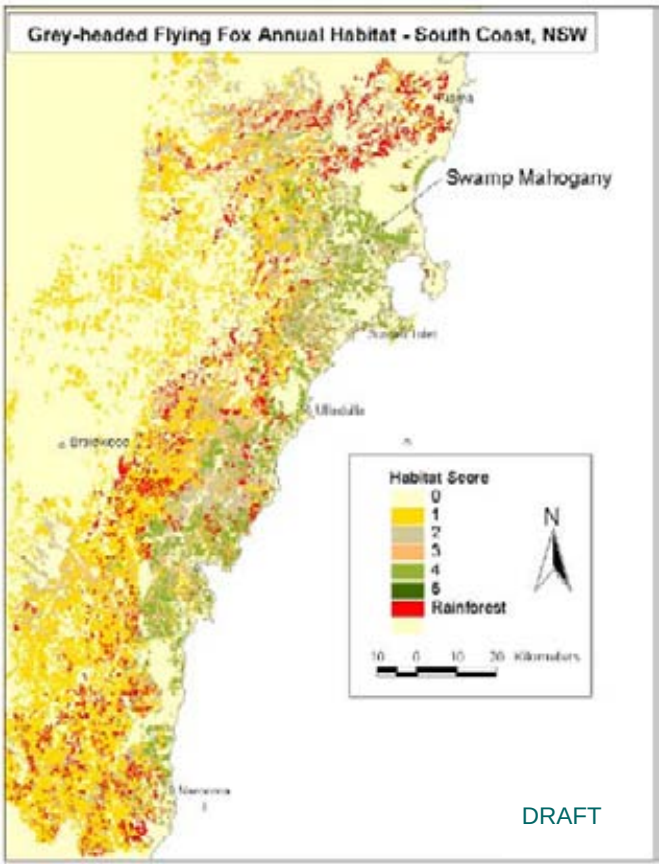
Effect of logging on nectar production in eucalypts

Research is underway that will vastly improve our understanding of nectar production after logging and will be used to make recommendations to ensure the continuing supply of this valuable resource. This project, funded by the Honey Board (RIRDC), is measuring nectar production in two tree species – spotted gum and grey ironbark. Both species are key nectar producers for beekeepers and native wildlife, as well as being important timber producing species. Progress in the last year has been limited by a lack of flowering in the target tree species. Grey ironbark did not flower in sufficient numbers on the south coast of NSW to warrant expensive nectar measurements with a cherry-picker.

Spotted gum has been well budded since the end of 2003 and began flowering in profusion in April 2005. Extensive field measurements of nectar were undertaken in May and June 2005, with completion of the field work expected by the end of winter 2005.

Nectar maps for flying foxes

This new collaborative project, fully funded by Department of Environment and Conservation, was initiated in 2004. It aims to improve our understanding and provide mapping tools for describing the distribution of food resources of grey-headed flying foxes, a recently listed threatened species. Digital maps will be prepared of the distribution of flying fox food (ie nectar and fruit). Significant progress has been made in devising a method to rank the diet species of grey-headed flying foxes for their productivity and reliability. Vegetation associations in different geographic regions are allocated a nectar score based on the presence and abundance of diet species. Where possible, local experts have been consulted to score diet species for flowering phenology, productivity and reliability. Vegetation associations are then mapped by region using GIS. Draft maps have been completed for Victoria, south east Queensland, Eden and southern NSW.



Ecology of pygmy possums in managed forests

The pygmy possum has recently been listed as threatened and little is known about its ecology in forests. This project is investigating the ecology of the Eastern Pygmy Possum and the impact of logging in forests. The research will aim to provide a scientific underpinning for the management of pygmy possums by aiding the development of sensible and effective wildlife prescriptions in forests.

Routine surveys for the species are problematic as pygmy possums are notoriously difficult to catch in elliott traps, although labour intensive pitfall traps have moderate success. Rather than focusing on surveys of this cryptic species, targeted research should be more effective for the species conservation by identifying its key habitat requirements in forests subject to timber harvesting and using these data to inform management.

The project is being undertaken on two fronts. The first at Eden is radio-tracking individuals to identify diurnal dens and parts of the landscape regularly used by pygmy possums (eg riparian vs ridge habitat). In collaboration with Chris Slade (Forests NSW, South-East Region, Eden), just one pygmy possum was caught and tracked in 2005, despite three weeks of pit-fall trapping. Hollows in trees (especially bloodwoods) but sometimes exposed stumps were the primary retreats for this species.

The second study site is located at McPherson State Forest, Hunter Region where logging is scheduled in a number of compartments. Research at this site is thus being set-up to investigate the impact of logging on pygmy possums. Meetings between Department of Environment and Conservation (DEC) and Forests NSW staff resulted in approval for sites to be logged without the inclusion of exclusion zones around records. In conjunction with local ecologists and field staff, five lines of pitfall traps were established in different sites to sample young regrowth forest, forest to be logged and control (no disturbance) forest. Traps will opened for the first time early in 2005/06.

Managing frogs and reptiles in the forest environment

F Lemckert

Different species of threatened frogs have different habitat requirements and habitat use patterns, hence no one set of protective prescriptions adequately covers all species. However, stream side buffer strips are critical in protecting both calling sites and the water quality of the tadpole habitat. Giant burrowing frogs usually remain outside these buffers and their conservation requires a different approach. Logging appears likely to be highly detrimental to resident frogs and is recommended to be excluded from sites determined to require protection. Prescribed fire however, appears to represent no significant threat and should be allowed into currently excluded areas.

The types of habitat trees selected for retention appear to be suitable for Stephen's banded snakes and should form a suitable management strategy for this species. The major concern is the development of replacement habitat trees and the hollows that they will develop.

Populations of permanent pond breeding frogs appear to be highly resilient to drought and most are relatively stable compared to some systems studied in North America and Europe. Hence, monitoring of numbers appears to be an effective strategy to assess long-term impacts of disturbances.

A PhD student with the University of Newcastle, Trent Penman, has completed his study of the giant burrowing frog near Eden and published, or has in press, several papers from this work. He has developed a bioclimatic model and geographic information systems based model of its range within the region to guide future surveys and has developed a potential conservation approach for the species in consultation with the Department of Environment and Conservation and South-East Region. Fine detail in habitat requirements has been produced in a paper based on radio-tracking movements of these frogs. Fire is not likely to be a serious threat to this frog and can be undertaken at sites where it is known but machinery disturbance during logging is likely to cause high levels of mortality and is recommended to be excluded where populations are determined to require protection. He has submitted the thesis.

A PhD student from the University of Newcastle, Harko Werkman, is completing analysis of data for his study into the impacts of logging on stream breeding frogs in areas between Gosford and Coffs Harbour in NSW. He has data on the growth and survivorship of frogs on streams with differing disturbance histories and is comparing them to assess if there are differences that correlate with management history. Analysis of this data will be completed by the end of August 2005.

A threatened species being monitored - the giant barred frog
Photo: Frank Lemckert

Beth Mott, a PhD student at the University of Wollongong, has submitted her thesis looking at fauna within plantations near Wauchope. She assessed the differences in fauna in remnant forest compared to both young and older plantations and considered why differences might exist. Her work has indicated that structural complexity and solar radiation are important variables that determine the presence or absence of some species. Young plantations are very open to wind and sun effects. Older plantations are more like regrowth forest until thinnings occur, when they again become very open and offer poorer quality or at least simplified habitat.

Monitoring of frog populations continues to be hampered by the major drought. Numbers for some frogs appeared to remain relatively high but several species were very difficult to locate. However, this may simply have been due to a lack of activity by these frogs rather than a decrease in their numbers.

Pond requirements of frogs and effects of disturbance on frogs

Populations of permanent pond breeding frogs appear to be highly resilient to drought and most are relatively stable. Data have been collected on the attributes of 42 ponds in the Watagans and the frog communities breeding at them. No single factor is of outstanding importance with regard to the overall number of frogs and number of species that will use a pond. Larger more complex ponds are overall likely to be better to maximise their potential as frog breeding habitat but rare species need specific attributes of a pond before they will use it. This work is being expanded to include ponds from the Dorrigo, Wauchope and Bulahdelah areas.

Over 200 frogs have been micro-chipped for long-term monitoring of population size, health and mortality. Populations overall appear to be very stable.

Thirty-two new ponds have been constructed in the Watagans and are being monitored to determine colonisation rates and test predictions as to the species that will colonise them. All sites have already been colonised by at least one species and four sites are being used by the rare heath frog, providing a good demonstration as to the potential of constructing ponds to assist rare species.

Green thighed frog monitoring for the Roads and Traffic Authority

Surveys for green-thighed frogs in Nerong were undertaken at the request of the Roads and Traffic Authority. This was to fulfil requirements for licensing of the Karuah-Bulahdelah upgrade and to determine if previously located populations were still extant. Our surveys were successful at locating two of these populations and provided indications that the frogs immediately adjacent to the upgrade were present in the same numbers as previously recorded.

Co-operation with Other Organisations

Research and Development Division participates in a number of collaborative projects with other organisations, research institutions and universities. This includes direct assistance to university post-graduate research through joint supervision of research work and, in some cases, financial support.

Project Title	Collaborating Institution	Collaborating Contact Officer	DPI Project Leader	Student Name
Tree water use and amelioration of dryland salinity	University of Technology, Sydney	Professor Derek Eamus	Dr Craig Barton	Ms Melanie Zeppel PhD student
Assessment of the potential of *Pinus radiata* for ecological restoration of the Yangtze River catchment in Aba Prefecture, Sichuan, China	Chinese Academy of Forestry Sichuan Academy of Forestry China Aba Forest Research Institute, China	Dr Rongwei Li Dr Hong Yan Mr Zhongxing Wu	Dr Huiquan Bi	
Application of an ecological framework linking scales based on self-thinning	Research School of Biological Sciences, Australian National University	Dr Belinda Barnes Dr Michael Roderick	Dr Huiquan Bi	
A comparison of alternative methods for estimating the self-thinning boundary line	Faculty of Forest and Natural Resources Management, State University of New York, USA USDA Forest Service North-eastern Research Station	Professor Lianjun Zhang Dr Jeffrey Gove Dr Linda Heath	Dr Huiquan Bi	
Molecular identification of fungi in eucalypt and pine plantations	FABI, University of Pretoria CBS, Netherlands Murdoch University, WA	Professor Mike Wingfield Professor Pedro Crous Dr Treena Burgess	Dr Angus Carnegie	
Morphological identification of fungi in eucalypt plantations	DPI Knoxfield, Vic DPI & F, Qld	Dr Vyrna Beilhartz Dr Geoff Pegg	Dr Angus Carnegie	
Insects in eucalypt plantations	DPI & F, Qld	Dr Simon Lawson	Dr Angus Carnegie	
Dynamics of mixed species plantations	Australian National University	Professor Jürgen Bauhus	Dr Annette Cowie	Mr David Forrester PhD student
Life cycle analysis of wood products - carbon sequestration and bioenergy projects	International Energy Agency Bioenergy Task 38 - Joanneum Research, Austria	Dr Bernhard Schlamadinger	Dr Annette Cowie	
Carbon sequestration potential of dryland tree species	CSIRO Forestry and Forest Products Australian Greenhouse Office	Dr John Raison Dr Matt Searson	Dr Annette Cowie	
Benchmarking wood quality of Bombala radiata pine resource	Integrated Forest Products, ACT	Mr Norm Backman	Dr Ross Dickson Mr Bill Joe	
Wood quality assessment of alpine ash	Neville Smith Timber, Laurel Hill	Mr Neil Austin	Mr Ross Dickson Mr Bill Joe	
Improving the processing of timber from plantation forests: the challenge of managing variability	University of Sydney J Notaras and Sons, Grafton	Dr Tim Languish Mr Brunos Notaras Mr Spiros Notaras	Dr Ross Dickson Mr Bill Joe	Ms Sherryn Cabardo PhD student
Life cycle analysis of wood products – decomposition of coarse roots	Australian Greenhouse Office	Dr Gary Richards	Mr David Gardner	

Life cycle analysis of wood products – landfill research	CRC for Greenhouse Accounting-Chemistry Centre, WA CSIRO Land and Water	Dr Surender Mann Mr Ken Dods Dr Jeffery Baldock	Mr David Gardner	
Life cycle analysis of wood products - landfill research	Publishers National Environment Bureau	Mr Frank Kellett	Mr David Gardner	
Life cycle analysis of wood products - landfill research	North Carolina State University, USA	Dr Morton Barlaz	Mr David Gardner	
Life cycle analysis of wood products - wood products tools - greenhouse accounting	World Business Council for Sustainable Development	Ms Gloria Godinez	Mr David Gardner	
Life cycle analysis of wood products – development of TimberCAM	CRC for Greenhouse Accounting-Australian National University	Dr Stephen Roxburgh Mr Ian Davies	Mr David Gardner	
Life cycle analysis of wood products – inputs to Australian Greenhouse Office wood products model	Australian Greenhouse Office	Dr Gary Richards	Mr David Gardner	
Life cycle analysis of wood products – development of carbon accounting for wood products	Finnish Forest Research Institute Joanneum Research, Austria	Dr Kim Pongoud Dr Bernhard Schlamadinger	Mr David Gardner Dr Annette Cowie	
Sourcing of *Eucalyptus* plantation and regrowth timber with verifiable genetic traits and silvicultural history for solid wood timber research	Forestry Tasmania WA Forest Products Commission Forest Science Centre, Vic	Mr Greg Nolan	Mr Michael Henson	
High performance eucalypts and interspecific hybrids for marginal lands in south and eastern Africa and south-eastern Australia	Australian Centre for International Agricultural Research - ▪ Department of Forestry, Australian National University ▪ CSIRO Forestry & Forest Products ▪ CSIR, South Africa ▪ Department of Forest Science, University of Stellenbosch	Professor Peter Kanowski Dr Chris Harwood Dr Steve Verryn Professor Gerrit van Wyk	Mr Michael Henson	
Transforming sawnwood properties of plantation-grown *Eucalyptus dunnii* (Dunn's white gum)	Southern Cross University University of Canterbury, NZ	Dr Jerome Vanclay	Mr Michael Henson	
Genetic variation in wood properties of *Eucalyptus dunnii* relevant to solid-wood properties	CSIRO Forestry and Forest Products Australian National University	Dr Chris Harwood	Mr Michael Henson	Ms Bandara Kangane
Review of plantation hardwood and solid wood products - FWPRDC Project	University of Tasmania	Mr Peter Volker	Mr Michael Henson	
Identifying optimal treatments for termite infested power poles	EnergyAustralia INTEGRAL energy countryenergy	Mr Terry Westlake Mr Martin Healey Mr Jody Fraser	Mr Martin Horwood	

Assessing the effectiveness of modifications to the Prechem Bioguard Pole Bandage system for protecting the inground portions of power poles from fungal decay	Prechem Pty Ltd INTEGRAL energy	Mr Chris McEvoy Mr Martin Healey	Mr Martin Horwood	
Monitoring biological diversity as indicators of sustainable forest management	Melbourne University NSW DEC (National Parks and Wildlife Service)	Dr Mark Burgman Dr Brendan Wintle Dr David Keith Dr Liz Sutherland	Dr Rod Kavanagh Mr Doug Binns	
Ecology and reproductive success of the koala *(Phascolarctos cinereus)* in Pine Creek State Forest	Southern Cross University	Dr Ross Goldingay	Dr Rod Kavanagh	Ms Sally Radford PhD student
Habitat requirements of the barking owl in north-east Victoria	Charles Sturt University	Dr Iain Taylor	Dr Rod Kavanagh	Ms Natasha Schedvin PhD student
Habitat preferences of the red fox in forests	Sydney University	Dr Chris Dickman	Dr Rod Kavanagh	Ms Alison Towerton MSc student
Use of soil amendments to maximise forest products on mine lands	Coal and Allied (Rio Tinto) ACARP (Australian Coal Association Research Program) Mineral Council of NSW Hunter Water	Dr Bruce Foster Mr Richard Jennings Mr Peter Smith Ms Deanne Pope	Dr Georgina Kelly	
Bulga mine site plantation trial	Bulga Mine Tomen Australia/ Chubu Electric Pty Ltd Hunter Water	Mr Robin Bragg Mr Anthony Bertrams Ms Deanne Pope	Dr Georgina Kelly	
Growing commercially-viable eucalypt plantations on marginal lands using wastes (Hunter Region)	Macquarie Generation Hunter Water	Mr Bob Cullen Ms Deanne Pope	Dr Georgina Kelly	
Application of recycled organics in mine site rehabilitation	Resource NSW Narama Mine (XStrata) Hunter Water Environmental Waste Technologies	Mr Mark Johnson Mr John Watson Ms Deanne Pope Mr Tony Kanak	Dr Georgina Kelly	
Studies of tent-building leafhoppers (*Kahaono* spp.) from *Eucalyptus*	NSW DPI, Orange	Dr Murray Fletcher	Dr Deborah Kent	
Characterisation of *Kahaono* leafhopper (Hemiptera) silk	University of Sydney Charles Sturt Unversity, Orange NSW DPI, Orange	Professor Robert Gilbert A/Professor Geoff Gurr Dr Murray Fletcher	Dr Deborah Kent	Mr Jung-Chi Chang PhD student
Studies of the life cycle, host susceptibility and distribution of *Thaumastocoris australicus* attacking urban trees in Sydney	University of Sydney	Professor Harley Rose	Dr Deborah Kent	Ms Annie Noack PhD student
Platypodid biocontrol studies in New Zealand.	AgResearch Lincoln, New Zealand	Dr S Reay Dr T Glare	Dr Deborah Kent	
Vertical stratification of bats and insects in regrowth forests	University of Wollongong	A/Professor Kris French	Dr Brad Law	Ms Maria Adams PhD student

Environmental physiology of free-ranging bats	University of New England	Dr Fritz Geiser	Dr Brad Law	Mr Chris Turbill PhD student
Developing nectar maps for the grey-headed flying fox	Dept of Environment and Conservation	Dr Peggy Eby	Dr Brad Law	
Bats in urban bushland - are they persisting?	University of New South Wales	Dr Peter Banks	Dr Brad Law	Ms Rochelle Baschan Hons student
Benchmark bat survey in revegetation sites	CSIRO Sustainable Ecosystems	Dr Geoff Barrett	Dr Brad Law	
Effects of forest management practices on stream frog communities	University of Newcastle	Dr Michael Mahony	Mr Frank Lemckert	Mr Harko Werkman PhD student
Applied conservation biology of a threatened forest dependent frog	University of Newcastle	Dr Michael Mahony	Mr Frank Lemckert	Mr Trent Penman PhD student
Structural differences of plantations compared to native forests and the effect on wildlife use	University of Wollongong	A/Professor Kris French A/Professor Bill Buttemer	Mr Frank Lemckert	Ms Beth Mott PhD student
Species richness, endemism and conservation of Australia's frogs and reptiles	Federal Department of Environment and Heritage	Mr Cameron Slatyer Mr Daniel Rosauer	Mr Frank Lemckert	
The use of LIDAR to estimate aboveground biomass of *Eucalyptus pilularis*	University of New South Wales	A/Professor Tony Milne	Dr Kelvin Montagu	Mr Russell Turner PhD student
Pinus radiata biomass allocation along a rainfall gradient	Greenhouse Technical Unit, Forest and Ecosystem Science Institute, Victoria	Dr Stefan Arndt	Dr Kelvin Montagu Dr Ayalsew Zerihun	
Development of generalised allometrics for northern Australia	CSIRO Sustainable Ecosystems, Darwin Charles Darwin University	Dr Dick Williams Dr Lindsey Hutley	Dr Kelvin Montagu Dr Ayalsew Zerihun	
Changes in *Eucalyptus populnea* root:shoot ratios along a rainfall gradient in eastern Australia	Queensland Department of Primary Industries and Fisheries	Ms Madonna Hoffman Mr Steven Bray	Dr Kelvin Montagu Dr Ayalsew Zerihun	
Carbon-cycling in *Pinus radiata* plantations	CSIRO, Plant Industries, Canberra	Dr LanBin Guo Dr RM Gifford	Dr Kelvin Montagu Dr Ayalsew Zerihun Dr Annette Cowie	
Studies of the genus *Quambalaria*	CSIRO Forestry and Forest Products, Western Australia	Dr Inez Tommerup	Mr Jack Simpson	
The effects of thinning and pruning on tree growth and development of plantation-grown *Corymbia citriodora, Eucalyptus dunnii, E. pilularis* and *E. cloeziana*	Queensland Forest Research, Agency for Food and Fibre Science	Mr Geoff Dickinson	Dr Geoff Smith	
Soil physical limitations to growth in sub-tropical eucalypt plantations	Southern Cross University	Dr Doland Nichols Assoc. Professor Jerry Vanclay	Dr Geoff Smith	Mr John Grant PhD student
Guiding early silvicultural interventions through predicting canopy and crown dynamics in plantations of sub-tropical eucalypts	Australian National University	Dr Ryde James Dr Adrienne Nicotra Professor Jürgen Bauhus	Dr Geoff Smith Dr Dane Thomas	Mr Phil Alcorn PhD student

Burning under young eucalypts. Bushfire CRC	ENSIS Australian Defence Force Academy	Mr Jim Gould A/Professor Rod Weber Dr Wendy Andersen	Dr Geoff Smith	Mr Phil Lacy PhD student
Molecular studies of mundulla yellows in eucalypts	University of Adelaide	Dr Dagmar Hanold	Dr Christine Stone	
Eucalypt biological agent resistant clones - insect resistance traits of *Eucalyptus* for the NSW forest plantation industry	School of Botany and Zoology, Australian National University	Dr Bill Foley	Dr Christine Stone	Mr Martin Henery PhD student
Soil-applied insecticides for eucalypt plantation establishment	Bayer Australia Ltd	Mr Justin McBeath	Dr Christine Stone	
Pest status and management of a *Creiis* psyllid in *Eucalyptus* plantations in northern New South Wales	School of Environmental Science and Management, Southern Cross University	Dr Doland Nichols	Dr Christine Stone	Mr Paul Angel PhD student
Risk mapping and remote sensing of *Mycosphaerella* leaf blight in a Tasmanian eucalypt plantation	CSIRO Forestry and Forest Products CRC Sustainable Production Forestry	Dr Caroline Mohammed Dr Trevor Booth Dr Elizabeth Pinkard	Dr Christine Stone	Ms Elizabeth Pietrzykowski PhD student
Remote sensing eucalypt canopy dieback in the Richmond Ranges	NSW DEC (National Parks and Wildlife Service) CSIRO Forestry and Forest Products	Mr Ron Billyard Dr Neil Sims	Dr Christine Stone	
Increasing success of tree establishment by using seasonal climate forecasts	Sustainable Ecosystems CSIRO Department of Natural Resources and Mines Greening Australia	Dr Deborah O'Connell Dr Mark Howden Ms Sonia Graham Mr Steven Crimp Mr John Carter Mr David Carr Mr Tim Emmott Mr Ron Dodds Ms Rae Talbot Ms Justine Watt Ms Anne Brown	Dr Dane Thomas Mr Paul Brennan	
Sub-catchment impacts of tree planting on salt mobilisation, stream water quality and flow	DIPNR UNSW	Dr Mark Littleboy Dr Ian Ackworth	Mr Peter Walsh Dr Craig Barton	

Special Purposes Permits for Research

Special Purpose Permits for Research are issued to authorise the conduct of various prescribed activities on State forests, timber or flora reserves. The permit system allows the orderly supervision and facilitation by Forests NSWs staff of the pursuit of *bona fide* scientific research into the forest ecosystems managed by Forests NSW. During 2004/2005 Forests NSW supported 105 Permits.

Principal	Organisation	Title of Activity
Andrew, Dr Nigel	Centre for Ecology, Evolution and Systematics, University of New England, NSW	Ecology and insect herbivore communities in the New England Region, NSW - influence of host phylogeny and plant traits
Archer, Prof Michael	Australian Museum, NSW	Collection, survey and systematics of fish, birds, mammals, reptiles and amphibians, and vertebrate faunal surveys
Baker, Mr Neville	Environmental Resource Management Australia, Pyrmont, NSW	Aboriginal archaeology surveys on mine lease sites
Balandin, Ms Margaret	Department of Commerce, Sydney, NSW	Eurobodalla regional water supply scheme, southern storages - preliminary environmental and planning overview
Baldwin, Dr Darren	CSIRO/Murray-Darling Freshwater Research Centre, Albury NSW	Estimating the likelihood and impact of "blackwater" events after flooding
Basden, Dr Alison	Department of Biological Sciences, Macquarie University, NSW	The impact of global warming on vegetation boundaries: an experimental approach
Bell, Dr Tina	School of Forest and Ecosystem Science, University of Melbourne, Vic	Barmah-Millewa forest monitoring and transect study
Benwell, Dr Andrew	Consultant, Mullumbimby, NSW	Flora survey - Kempsey by-pass
Blackwell, Dr Grant	School of Biological Sciences, The University of Sydney, NSW	The effects of predation and rainforest fragmentation on non-flying mammals of the northern rivers region of NSW
Boulton, Professor Andrew	Ecosystem Management, University of New England, NSW	How do silt and invertebrates in streams differ upstream and downstream of road crossings in areas with different land uses?
Broome, Dr Linda	Threatened Species Unit Department of Environment and Conservation (National Parks & Wildlife Service), Queanbeyan, NSW	Monitoring vegetation and small mammals in areas of logged, burnt and undisturbed known and potential smoky mouse habitat in south-east NSW
Budd, Mr Chris	Australian Bureau of Statistics, Sydney, NSW	Factors affecting the distribution and abundance of small native fish in Murrumbidgee wetlands
Callaghan, Mr John	Australian Koala Foundation, Brisbane, Qld	The Koala Habitat Atlas

Carr, Mr Geoff	Ecology Australia Pty Ltd, Fairfield, Vic.	Survey and documentation of floating swamp wallaby grass to determine distribution, conservation status, biology, ecology and threats to this species in the Riverina region in New South Wales
Catford, Ms Jane	SAGES, University of Melbourne, Vic	Response of non-indigenous riparian plant species to changes in the flooding regimes of ephemeral wetlands along the Murray River
Chesser, Dr Robert	CSIRO Sustainable Ecosystems, Australian National Wildlife Collection, ACT	Biodiversity, phylogeny, distribution and conservation of Australian vertebrate land fauna
Claridge, Dr Andrew	Threatened Species Unit, Department of Environment and Conservation (National Parks & Wildlife Service), Queanbeyan, NSW	Interactions among mycophagous (fungus-feeding) mammals and hypogeal mycorrhizal fungi in eucalypt forests of south-eastern Australia
Clifton, Ms Emma	School of Resources, Environment and Society, Australian National University, ACT	Grazing in wetlands: long-term effects of grazing intensities on soil properties and vegetation composition
Connolly, Mr Daniel	Department of Environment and Conservation (NPWS), Hurstville, NSW	Vegetation mapping of the central tablelands
Conn, Mr Barry	Royal Botanic Gardens, Sydney, NSW	Collection of Herbarium specimens, seeds and cuttings from trees, plants and shrubs for cultivation and research purposes
Cooper, Mr Endymion	School of Biological Sciences, The University of Sydney, NSW	Chemical interactions between epiphytic lichen and bark fungi
Curran, Mr Timothy	Botany, University of New England, NSW	Phytogeography and evolutionary ecology of dry rainforest on the western slopes of NSW
Crowther, Dr Mathew	School of Biological Sciences, The University of Sydney, NSW	Undergraduates study of vertebrates in Olney State Forest
Denny, Dr Martin	Mount King Ecological Surveys, Oberon, NSW	Fauna surveys of selected areas within collieries to provide baseline data for future assessment of impacts from subsidence from underground mining
Driscoll, Mr Colin	PhD student	Reproductive strategies of two rare plants - *Tetratheca juncea* and *Acacia bynoeana* (PhD project)
Elks, Mr Greg	Idyll Spaces Environmental Consultants, Bonville, NSW	Flora survey for threatened species, populations and ecological communities for coal seam gas project
Forster, Mr Ian	Cornell Wagner PPI Pty Ltd, Neutral Bay, NSW	Installation of groundwater monitoring piezometers in upland shrub swamps
Geering, Mr David	Department of Environment and Conservation (National Parks & Wildlife Service), Dubbo, NSW	Movements and population dynamics of the regent honeyeater
Gilson, Mr Tony	Hyder Consulting Pty Ltd, North Sydney, NSW	Delta Mine Dewatering Project
Glen, Mr Alistair	Biological Sciences, University of Sydney, NSW	Competitive and predatory effects of the red fox *(Vulpes vulpes)* on the spotted-tailed quoll *(Dasyurus maculatus)*

Grabham, Mr Craig	Johnstone Centre - Environmental Consulting, Albury, NSW	Moira Creek aquatic and terrestrial ecological assessment
Graham-Higgs, Mr Nicholas	Nghenvironmental, Bega, NSW	Environmental Impact Assessment for pipeline construction, Eurobodalla Shire
Graham-Higgs, Mr Nicholas	Nghenvironmental, Bega, NSW	Boydtown Species Impact Statement
Graham-Higgs, Mr Nicholas	Nghenvironmental, Bega, NSW	Survey of threatened species (flora and fauna) of proposed road completion of Batemans Bay bypass
Grimson, Mr Matthew	School of Environmental Science and Management, Southern Cross University, Lismore, NSW	The role of nest boxes in the management of Australia's arboreal marsupials
Hall, Dr Karina	Murray Darling Freshwater Research Centre, Albury, NSW	Acidification of freshwater wetlands
Hangay, Dr George	Private study	Beetle study, specifically the Scarabaeoidea
Harbaugh, Ms Danica	Uni Herbaria and Dept of Integrative Biology, University of California Berkeley, USA	Evolutionary history and systematics of sandalwoods (*Santalum* spp. *Santalaceae)*
Harrington, Dr Rhidian	Biosis Research Pty Ltd, Chippendale, NSW	Flora and fauna assessment of proposed off-river storage facility on Bowra Creek
Hart, Dr Diana	Physical Geography Department, Macquarie University, NSW	The quarternary and recent history of the East Pilliga State Forest
Hawkins, Mr Brian	University of NSW	Distribution of the yellow-bellied glider in the Gosford Local Government Area
Heywood, Ms Lynne	Private study	Surveys to determine the distribution of some nocturnal bird species and the regent honeyeater in the Dunedoo area
Hsu, Ms Tina	University of Wollongong, NSW	Population structure and dynamics of birds in plantations on the mid-north coast of NSW
Hughes, Ms Kate	Department of Biological Sciences, Macquarie University, NSW	Wood anatomy and water flow in native plants
Keith, Dr Heather	CSIRO Forestry & Forest Products, ACT	Estimating greenhouse gas sources and sinks in the terrestrial biosphere
Kendall, Mr Keith	Kendall and Kendall Ecological Consultants, West Kempsey, NSW	Fauna assessment - coal seam gas project
Kent, Ms Kylie	The Johnstone Centre Herbarium, Albury, NSW	Reference collection of flora species for Herbarium
Koertner, Dr Gerhard	National Parks & Wildlife Service/Zoology, University of New England, Armidale, NSW	Impact of aerial wild dog baiting on spotted-tailed quoll populations
Kristiansen, Dr Paul	Agronomy and soil Science, University of New England, NSW	Polygodial production in *Tasmannia stipitata*
Lada, Ms Hania	School of Biological Sciences, Monash University, Vic.	Ecological and demographic effects of flooding regimes of the Murray River on the yellow-footed antechinus *Antechinus flavipes*

Lenz, Dr Michael	CSIRO Entomology, Canberra, ACT	Termite biology and control
Lewis, Mr Ben	Lewis Ecological Surveys, Wingham, NSW	Biology and management of *Mixophyes balbus* in northern New South Wales
Lewis, Mr Ben	Lewis Ecological Surveys, Wingham, NSW	Environmental Impact Assessment for proposed Pacific Highway upgrade
Lewis, Mr Ben	Lewis Ecological Surveys, Wingham, NSW	Baseline mammal; audit of the Murrumbidgee Irrigation Area
Liney, Mrs Jennifer	Eurobodalla Regional Botanic Gardens Herbarium,Vic.	Eurobodalla Regional Botanic Gardens
Little, Ms Fiona	University of Adelaide, SA	Analysis of microfossils within sediments to provide evidence for past wetland conditions and change
Lunney, Mr Dan	Department of Environment and Conservation (National Parks & Wildlife Service), Hurstville, NSW	Mumbulla revisited: assessing the long-term changes of native fauna in Mumbulla State Forest in the Eden region of south-eastern NSW
MacTaggart, Ms Barbara	University of Sydney, Orange, NSW	Characterising and understanding the functionality of swampy meadow and chain of ponds systems
Madden, Mr Warwick	Bayer CropScience, Pymble, NSW	Investigation into the efficacy of termite colony eradicants
Martin, Ms Alison	Greenloaning Biostudies Pty Ltd, Tuncester via Lismore, NSW	Fauna assessment for Neubecks Creek EIS
McCauley, Ms Angela	Hunter Councils Inc., Thornton, NSW	Vegetation mapping for central coast, Gloucester and Hunter catchment
Midgley, Dr David	School of Biological Sciences, University of Sydney, NSW	Diversity of ericoid mycorrhizal fungi on epacrids from semi-arid Australia
Miles, Ms Jacquelyn	Department of Biological Sciences, Macquarie University, NSW	Patterns of small mammal succession in response to fire
Miller, Ms Emily	School of Biological, Earth and Environmental Sciences, University of New South Wale, NSW	Male choice and maternal investment in brown antechinus
Miller, Mr Justin	Department of Environment and Conservation (National Parks & Wildlife Service), Glen Innes, NSW	Investigation of Hastings River mouse populations and habitat in the Glen Innes East area
Mjadwesch, Mr Raymond	Mjadwesch Environmental Service Support, Bathurst, NSW	Fauna survey, Snake Rock Reserve
Muir, Mr Glen	Australian Museum Business Services, NSW	Coleambally Irrigation Area biodiversity survey
Murray, Ms Justine	School of Integrative Biology, The University of Queensland, Qld.	The brush-tailed rock wallaby habitat
Oberprieler, Dr Rolf	CSIRO Entomology, ACT	Cone attractants of *Macrozamia communis* cycads to pollinating *Tranes* weevils
Ochieng, Mr Joel	Southern Cross University, Lismore, NSW	Using DNA variations to understand population fragmentation and secondary contact in spotted gum complex (Myrtaceae)

Parsons, Mr Jason	The University of Newcastle, Ourimbah, NSW	Define the hanging swamps of the central coast plateau
Peacock, Mr Lee	The University of Sydney, NSW	Roost preference of the grey-headed flying fox
Predavec, Dr Martin	Parsons Brinckerhoff Australia Pty Ltd, Rhodes, NSW	Baseline and ongoing flora and fauna monitoring associated with a proposed coal mine
Read, Dr David	Consultant, Wagga Wagga, NSW	Study of the Hastings River mouse
Richards, Dr Greg	Greg Richards and Associates Pty Ltd, Gungahlin, NSW	Regional targeted survey for the yellow-bellied sheathtail bat
Ryan, Mr Brendan	Australian Museum Business Unit, NSW	Impact of the proposed Pacific Highway upgrade, Bonville
Saunders, Ms Debbie	Department of Environment and Conservation (National Parks & Wildlife Service), Queanbeyan, NSW	Swift parrot recovery program
Scholz, Dr Oliver	Lower Basin Laboratory, Murray-Darling Freshwater Research Centre, Mildura, Vic	The living Murray monitoring program
Seebacher, Dr Frank	School of Biological Sciences, The University of Sydney, NSW	Is autonomic cardiovascular control important in the thermal ecology of a reptile?
Simpson, Mr Jack	Private study	Document and describe mycoflora of the forests of New South Wales
Skeen, Ms Heather	Macquarie University, NSW	Discovering the best method of grave detection using geophysics
Smallbone, Ms Lisa	Charles Sturt University, Albury, NSW	Historical changes in tree density and forest structures in cypress pine and box eucalypt forests
Soderquist, Dr Todd	Threatened Species Unit, Department of Environment and Conservation (National Parks & Wildlife Service), Dubbo, NSW	Survey and population monitoring of forest owls in western New South Wales
Spooner-Hart, Associate Professor	Centre for Horticulture and Plant Sciences, University of Western Sydney, South Penrith, NSW	Evaluation of natural oil as wood treatment against termite attack
Stocker, Professor Elfie	Organismic Biology Department, University of Salzburg, Austria	Contribution to the knowledge of the Australian lichen flora
Stone, Dr David	Australian Nuclear Science and Technical Organisation, Menai, NSW	ANSTO Isotrans Research Project
Strevens, Ms Tanya	Department of Biological Sciences, University of Wollongong, NSW	The ecological effect of powerline easements in coastal New South Wales
Sutherland, Dr Tara	CSIRO Entomology, Canberra, ACT	Onychophora studies
Tait, Dr Noel	Department of Biological Sciences, Macquarie University, NSW	Local endemism and cryptic speciation in assessment of biodiversity using genetic analysis to estimate species turnover rates in log-dwelling cryptic invertebrates

Thompson, Mr Chris	University of NSW @ Australian Defence Force Academy, ACT	Steep creeks in managed forests: effects of roads on morphology and ecology
Thomson, Mr Chris	Sinclair Knight Merz Pty Ltd, Newcastle, NSW	Flora and fauna surveys for an environmental assessment of the proposed Pacific Highway upgrade route selection study
Todarello, Mr Pino	Ourimbah Campus, The University of Newcastle, NSW	Abundance, sizes and types of cavities of hollow-bearing trees on the NSW central coast
Vernes, Dr Karl	Ecosystem Management, University of New England, NSW	The effects of aerial dog baiting on non-target small mammals at the Styx River State Forest
Walker, Mr John	Hon. Res. Assoc., Forests NSW	Study of rust fungi *Uredinates* of Australia
Wallis, Mr Ian	School of Botany and Zoology, Australian National University, ACT	Selective sap feeding and the yellow-bellied glider
Wardle, Dr Glenda	School of Biological Sciences, The University of Sydney, NSW	The invasive potential of *Pinus radiata* plantations
Warwick, Dr Nigel	Botany, School of Environmental Sciences and Natural Resources, The University of New England, NSW	Nutrient dynamics in relation to stand stability in white cypress pine forests
West, Dr Judy	Centre for Plant Biodiversity Research, CSIRO Division of Plant Industry, ACT	Taxonomic research on native flora and invertebrate pollinators
Whipp, Ms Robyn	Charles Sturt University, Albury, NSW	Historical vegetation changes in the Pilliga State forests of northern New South Wales
Wilkins, Dr Carol	Plant Biology, University of Western Australia, Crawley, WA	Revision of *Rulingia* and *Commersonia* for Flora of Australia by ABRS
Windsor, Dr Donna	Lake Cowal Foundation Limited, West Wyalong, NSW	Lake Cowal survey
Yalmambirra	Faculty of Science and Agriculture, Charles Sturt University, Thurgoona, NSW	Residential school field exercise for Site Survey Design
York, Dr Alan	Forest Science Centre, Creswick, Vic	Sustainability of fuel-reduction burning regimes in native forests
Yunusa, Dr Isa	Institute of Technology, Sydney, NSW	An exploration of neutralising potential of acid soils by coal ashes
Zhao, Mr Zengqi	Plant and Pest Science, The University of Adelaide, SA	Survey of aboveground nematode fauna of *Pinus* and related conifers in south-eastern Australia.

Published Papers, Reports and Presentations

Adams MD, **Law BS**, French KO. 2005. Effect of lights on activity levels of forest bats: increasing the efficiency of surveys and species identification. *Wildlife Research* 32: 173-182.

Arnold RJ, **Johnson IG** and Owen JV. 2005. Genetic variation in growth, stem straightness and wood properties in *Eucalyptus dunnii* trials in northern New South Wales. *Forest Genetics* 11(1): 10-12.

Barton CVM and **Montagu KD.** 2004. Detection of tree roots and determination of root diameters by ground penetrating radar under optimal conditions. *Tree Physiology* 24: 1323-1331.

Bi H. 2004. Stochastic frontier analysis of a classic self-thinning experiment. *Austral Ecology* 29: 408-417.

Bi H, Turner J and Lambert M. 2004. Additive biomass equations for native forest trees of temperate Australia. *Trees* 18: 467-479.

Bridges RG. 2005. Effects of logging and burning regimes on forest fuel in dry sclerophyll forests on south-eastern New South Wales. Initial Results (1986-1993) from the Eden Burning Study Area. *Forests NSW Research Paper No. 40*. 79 pp.

Carnegie AJ. 2004. Pest and pathogen surveillance techniques for forest plantations (Forest Health Surveillance). In: Proceedings, Asia-Pacific Forestry Commission/ACIAR/FAO Workshop: *Development of an Asia-Pacific Strategy for* Eucalyptus *Rust.* Bangkok, Thailand. October 2004.

Carnegie AJ and Angel P. 2005. *Creiis lituratus* (Froggatt) (Hemiptera: Psyllidae): a new insect pest of *Eucalyptus dunnii* plantations in sub-tropical Australia. *Australian Forestry* 68: 59-64.

Carnegie AJ and **Henson M.** 2005. Clonal variation in susceptibility of *Corymbia citriodora* subsp. *variegata* to Ramularia shoot blight and Erinose mite. Proceedings *Corymbia* Research Meeting. p. 28. Gympie, Queensland. 1-2 June 2005.

Carnegie AJ, Johnson IG and **Henson M.** 2004. Variation among provenances and families of blackbutt (*Eucalyptus pilularis*) in early growth and susceptibility to damage from leaf spot fungi. *Canadian Journal of Forest Research* 34: 2314-2326.

Cowie AL 2005. Greenhouse gas balance of bioenergy systems based on Integrated plantation forestry in north east New South Wales, Australia. Case study report and brochure - IEA Bioenergy Task 38 Greenhouse Gas Balances of Biomass and Bioenergy Systems. Available on line at: www.joanneum.at/iea-bioenergy-task38/projects/task38casestudies/aus_fullreport.pdf

Dickson RL, Joe B, Harris P, Holtorf S and **Wilkinson C.** 2004. Acoustic segregation of Australian-grown *Pinus radiata* logs for structural board production. *Australian Forestry* 67(4): 261.

Dickson RL, Matheson AC, **Joe B**, Ilic J and Owen JV. 2004. Acoustic segregation of *Pinus radiata* logs for sawmilling. *New Zealand Journal of Forestry Science* 34(2): 175-189.

Erskine W. 2005. Mass movement hazard assessment associated with harvesting of the 1962 age class of Monterey pine *(Pinus radiata* D. Don) in Canobolas State Forest New South Wales. *Forests NSW Research Paper No. 39.* 62 pp.

Fitzgerald M, Shine R, **Lemckert F** and **Towerton A.** 2005. Habitat requirements of the threatened snake species *Hoplocephalus stephensii* (Elapidae) in eastern Australia. *Austral Ecology* 30: 465-474.

Forrester DI, Bauhus J, **Cowie** AL. 2005. On the success and failure of mixed-species tree plantations: lessons learned from a model system of *Eucalyptus globulus* and *Acacia mearnsii. For Ecology and Management* 209: 147-155.

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