



---

**STATE FORESTS OF NEW SOUTH WALES**



## **Our Mission**

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

**Research and Development Annual Report 2003/04  
is a supplement to the State Forests Annual Report and  
Social, Environmental and Economic Report 2003/04**

Front Cover: Squirrel glider feeding on flowers  
of a five-year-old blackbutt  
plantation tree  
Photo: Alison Towerton

ISSN: 1444-5441 (Online)

---

## Table of Contents

Foreword.....	1
Management Team.....	1
Research Services.....	2
State Forests Library .....	3
Tree Improvement .....	5
Vegetative propagation of eucalypts .....	5
Eucalypt species, hybrid seedling and provenance testing .....	6
Establishment and management of eucalypt breeding populations .....	8
Seed production of select eucalypt varieties .....	8
Development and testing of eucalypt clones .....	10
Australian Low Rainfall Tree Improvement Group (ALRTIG) .....	11
Softwood tree improvement – radiata pine.....	12
Softwood clonal testing.....	12
New Forests.....	14
Carbon in forests .....	14
Life cycle analysis of wood products .....	15
Benchmark salinity control and carbon sequestration in western New South Wales .....	18
Sub-catchment impacts of tree planting on salt mobilisation, stream water quality and flow.....	19
Dryland salinity trials.....	20
Maximising growth and determining preferred species for mine sites in the Hunter Valley .....	21
Nutrition, growth and wood density .....	27
Silvicultural Systems.....	28
Characterising the pine resource.....	28
Value recovery studies– an integrated approach .....	29
Silviculture spacing trials .....	30
Improving the processing of timber from plantation forests: the challenge of managing variability.....	31
Non-destructive evaluation of wood properties in planted forests .....	32
Hardwood plantations - maximising seedling survival .....	33
Hardwood plantations - matching species to site .....	34
Early plant growth of eucalypts in response to fertiliser application .....	34
Wood properties of plantation hardwoods .....	35
Water quality monitoring for the Environment Protection Licences .....	37
Forest Health Management .....	39
Forest health surveillance of softwood plantations.....	39
Forest health surveillance of hardwood plantations .....	39
Stem borers in eucalypt plantations .....	40
State Forests of NSW insect collection .....	41
Clonal eucalypts resistant to pest and diseases.....	41
Airborne assessment of forest health in pine plantations .....	42
Airborne assessment of native forest dieback in North-East Region .....	42

Soil-applied insecticides for eucalypt plantation establishment.....	43
National harmonisation of methodologies for the assessment and reporting of crown damage in eucalypt plantations .....	43
Termite and Power Pole Evaluation Research (TAPPER) Project.....	44
Forest Biodiversity .....	45
Ecology of birds and non-flying mammals in managed forests .....	45
Response to disturbance.....	47
Indicators of ecological sustainability in managed forests.....	49
Wildlife in eucalypt plantings .....	50
Bat ecology in managed forests .....	52
Response to disturbance.....	53
Effect of logging on nectar production in eucalypts.....	55
Nectar maps for flying foxes .....	55
Ecology of pygmy possums in managed forests .....	56
Managing frogs and reptiles in the forest environment.....	56
Pond requirements of frogs and effects of disturbance on frogs .....	57
Green-thighed frog monitoring program for the Roads and Traffic Authority .....	58
Wildlife Schools .....	58
Co-operation with Other Organisations .....	59
Special Purposes Permits for Research .....	65
Published Papers, Reports and Presentations .....	74
Staff List and Location (30 June 2004) .....	81



---

## Foreword

State Forests' research and development objectives are delivered primarily through its Research and Development Division. The Division provides strategic research support and scientific leadership to the organisation's operational, policy and resource Divisions. Its primary focus is on innovative scientific development in fields which can add value to the planted forests, investment services and native forests businesses of the organisation. The Research and Development Division is structured around five scientific Programs:

- **Tree Improvement**
- **New Forests**
- **Silvicultural Systems**
- **Forest Health Management**
- **Forest Biodiversity**

Research priorities and strategies are established with input from all sections of the organisation through regular planning and research delivery meetings. State Forests' goals currently focus on expansion of the State's planted forests and marketing the environmental benefits to be derived through the strategic location of planted forests in the landscape. Research emphasis has included investigation of the issues impacting the establishment, management and product quality of sustainable planted forests in lower rainfall areas as well as the traditional higher rainfall zones. Significant work has been directed at establishing the benefits of planted forests for such purposes as carbon sinks, mine-site rehabilitation, biodiversity enhancement and the development of sustainable land use practices for salinity-prone areas.

To ensure effective uptake and implementation of research outcomes we rely upon several strategies, including organisational Research and Delivery Teams. These Teams comprise representatives from the research, operational, policy and investment Divisions. Each team plays a key role in planning and prioritising projects in its area and facilitates the direct transfer of research findings to clients and stakeholders. This concept was taken further this year with the establishment of a Task Force to address the critical issues of early seedling health within State Forests' hardwood plantations. In addition, the Division's scientists actively communicate research findings through a range of other means, including scientific and technical publications, seminars and field visits.

The Division's head office at West Pennant Hills houses the State Forests' Library, which is also open to the public.

### Management Team

**Alastair Howard**  
**GENERAL MANAGER**  
Technology and Services Division

**Robert Eldridge**  
**DEPUTY GENERAL MANAGER**  
Research and Development Division

**Stephen Bryce**  
**ADMINISTRATIVE OFFICER**  
Research and Development Division

---

## Research Services

**Administrative Officer:** Stephen Bryce

*Information Management Officer:* Yen Sargan; *Human Resources Officer:* Ted Delaney; *Executive Assistant:* Margaret Caple; *Purchasing Officer:* Denize Moss; *Receptionist:* Marilyn Paskin; *Clerical Officer:* Amanda Guild; *Security/Maintenance Officer:* Paul O'Hara.

*Publications Officer:* Joy Gardner

Research Services staff provide administration and financial functions to the Division, including clerical support to Northern Research, Coffs Harbour and Tablelands Research, Tumut and Bathurst.

Its main roles include:

1. Provision of budget information to the General Manager, Deputy General Manager and the Program Leaders of the Division and financial data for externally funded projects.
2. Processing all purchasing for the Division.
3. Processing all expenditure and income transactions for the Division.
4. Processing all salaries and wages for the Division.
5. Fleet management.
6. Records management
7. Site maintenance and security.

---

## State Forests Library

**Librarian:** Narendra Anuj

**Library Technician:** Kylie Davies

State Forests' Library, based at Research and Development Division, West Pennant Hills, manages a special library collection and resources. The collection is developed and managed in the area of core business of forestry science and research including biodiversity and conservation, carbon sequestration, ecology and management, engineering, environmental sciences, forest health, nursery management, policy and planning, silviculture, soil salinity, tree breeding and research, water resources and management, wildlife research and wood products and properties. Library staff are committed to providing and improving excellence in quality information service delivery to all staff of State Forests of NSW.

- **Collection development and management** - the Library subscribes to nearly 120 core journal titles and Australian Standards to deliver up-to-date and relevant information services.
- **Current awareness services** - provided customised services to clients by establishing subject profiles on Ingenta®.
- **Reference services** - provided answers to general enquiries, complex reference enquiries, conducted comprehensive literature searches using special national and international databases and electronic resources, supplied statistical information and standards and provided links to key scientific information agencies.
- **Bibliographic database services** - all staff now have access to CAB- Abstracts (1972 - to date) on WebSpirs® who can set up personal bibliographic databases on their own subject specialisation using ProCite®, personal bibliographic management software.
- **Document supply** - provided inter-Library loan of books, photocopies of articles and electronic document delivery services from local and international sources.
- **Electronic journals** - established electronic access to 50 core full-text journals on staff desktops. We have a subscription for online access to **JSTORs** botany and ecology full-text journal archives collection.

The Library's collection can be accessed by all State Forests' staff through the Library Catalogue on the Intranet. State Forests' Library is a full participant member of Kinetica, the National Libraries network and has established links with GLINN (NSW Government Special Libraries Network Group), ALOFT (Australian Libraries of Forestry and Timber) and Agriculture and Environment Interest Group of ALIA (Australian Library and Information Association).

During the year the Library provided an extensive range of professional library and information services to all State Forests of NSW staff. Members of the public, including students from both the primary and tertiary level, have also gained from accessing our collections and services. We have trained two students from the NSW TAFE who qualified as Library Technicians.

STATE FORESTS OF NSW LIBRARY  
INTER-LIBRARY LOANS STATISTICS

JULY 2003 - JUNE 2004



	Loans	Article Requests	Internal ILL Requests	External ILL Requests	Monthly Totals
<b>Jul-03</b>	54	36	109	48	247
<b>Aug-03</b>	17	95	171	47	330
<b>Sep-03</b>	21	43	57	39	160
<b>Oct-03</b>	19	46	74	64	203
<b>Nov-03</b>	154	20	83	56	313
<b>Dec-03</b>	79	14	47	43	183
<b>Jan-04</b>	41	30	130	24	225
<b>Feb-04</b>	33	77	75	50	235
<b>Mar-04</b>	49	25	136	60	270
<b>Apr-04</b>	30	32	54	33	149
<b>May-04</b>	50	34	80	36	200
<b>Jun-04</b>	35	31	64	33	163
<b>TOTAL S</b>	<b>582</b>	<b>483</b>	<b>1080</b>	<b>533</b>	<b>2678</b>

Photo: Geoff Smith



---

## Tree Improvement

**Program Manager:** Michael Henson

*Aim: Improved softwood and hardwood genetic material available and in use throughout planted forests*

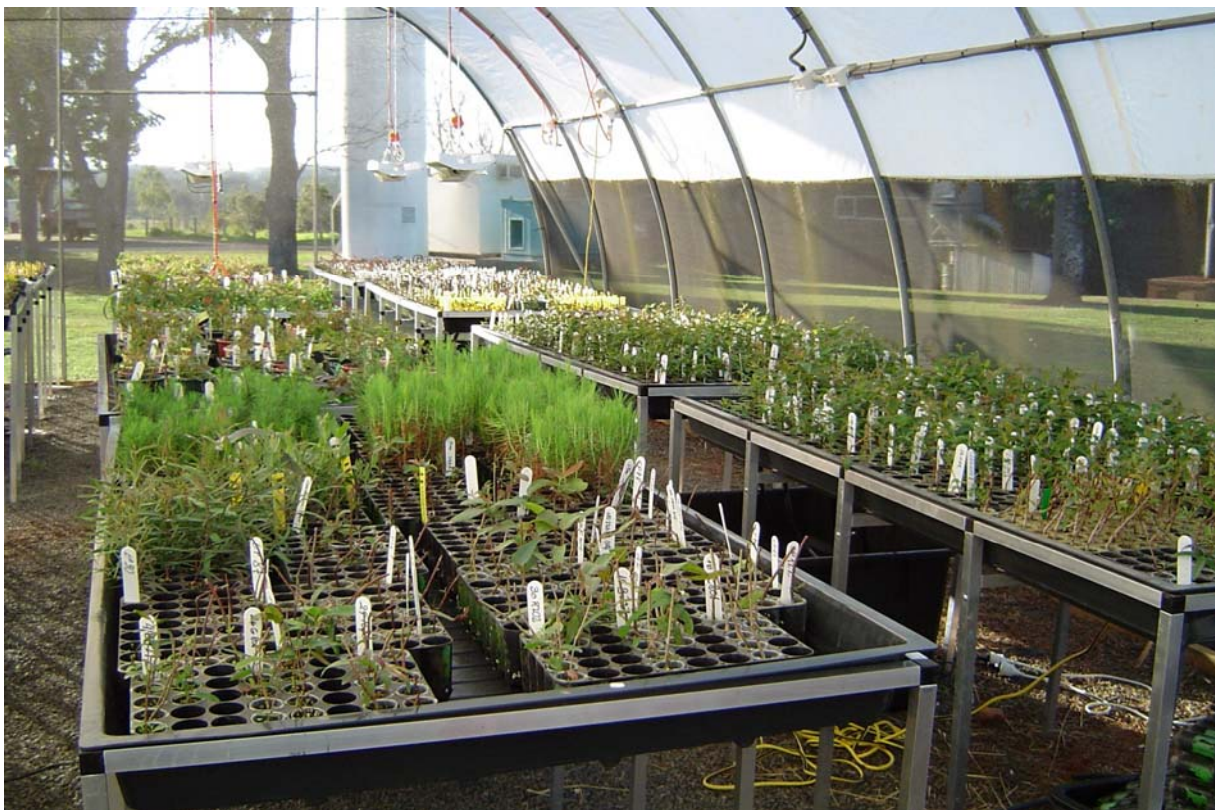
*Objectives:*

- *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*

### Vegetative propagation of eucalypts

H Smith

An efficient and effective clonal propagation system using mini-cuttings will allow rapid deployment of improved material into operational plantations. State Forests of NSW can 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. Planting of clones in both operational plantings and field trials will allow the Tree Improvement Program to 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.



*Mother plant house holding hydroponic trays containing mini-hedges for flood irrigation with defined nutrient solutions*

Photo: Helen Smith

The development and testing of a propagation system, using mini-cuttings harvested from potted mother plants (mini-hedges), has been successful for a number of eucalypt species and hybrids this year. Initial work was done on optimising the system to attain maximum mother plant productivity and rooting of mini-cuttings. Work will continue during 2004/05, to optimise the system for each key species propagated using these techniques. Clones of approximately 25 different eucalypt species and hybrids were successfully propagated using this system.

A total of over 17,000 plants of blackbutt (*Eucalyptus pilularis*) clones and hybrid (generally *E. grandis*-based) clones were propagated, using the system, for deployment in operational or field trial plantings. Material was both tested clones and seedling-based clones from plus tree seedlots. Over 1,100 plants of tested spotted gum (*Corymbia citriodora* subsp. *variegata*) clones were also propagated by tissue culture for operational deployment. It is planned to significantly increase the number of plants of improved blackbutt and spotted gum for operational deployment during 2004/05.



Young blackbutt mother plants in hydroponic flood and ebb trays ready to be harvested for mini-cuttings

Photo: Jess Scott

An international cloning workshop (Benchmarking Clonal Propagation for the Blue Gum Industry) was held at Grafton in March 2004. This was held in conjunction with the CRC for Sustainable Production Forestry and was supported by AusIndustry. During the workshop, our success with mini-cuttings propagation was showcased and input sought from highly experienced international representatives on the plans for propagation facilities.

Relocation of the clonal archive from Somersby to Grafton is underway. Semi-hardwood cuttings were taken from the outdoor hedges in the archive for most of the State Forests clones. Plants of a number of clones are ready for planting when the archive is developed. Some clones have not been successfully propagated, so they will be propagated this coming season, to complete the required complement of plants.

### **Eucalypt species, hybrid seedling and provenance testing**

H Smith

The interest by client divisions in finding eucalypt taxa suitable for planting on coastal “problem” sites has declined. However, recently established trials on drier, cooler sites north and west of Gloucester and on potentially boggy sites west of Casino, will still be of interest and need to be maintained and assessed in due course. Existing species/taxon trials are mostly too young to yield any useful results. Those in the Gloucester area may be most useful in the longer term if they confirm the superiority of one or more “traditional” species or



show a more promising alternative species or two. This will require at least five to six years of testing, including multiple episodes of insect attack. Trials on the more extreme “problem” sites are more likely to suffer high mortality and reduced growth and may identify “survivor” eucalypt species but possibly none of real commercial value. Avoiding such sites for planting of eucalypts may be the best option.

Large species trials were planted in early 2002, on three sites west of Casino. These sites are subject to periodic waterlogging, drought and frost at various times. They include 12-13 eucalypt species, as well as southern pine hybrid clones and seedlings, and *Casuarina* species. Species trials were also planted in early 2002 on two sites east of Gloucester, a cool subcoastal area with good soil drainage. Species planted included the four major coastal plantation species (spotted gum, Dunn’s white gum, flooded gum and blackbutt) and 13 miscellaneous species including southern blue gums, mahoganies and stringybarks.

Hybridising orchards of cadaghi (*Corymbia torrelliana*) and spotted gum (*Corymbia citriodora* var *variegata*) were established on two sites near Casino. Open pollinated seed will be collected from the spotted gum in these blocks; the blocks will also be used to make selections of superior individuals for controlled pollination. Genotypes produced from these crosses have potential for better disease tolerance, form and growth rates than pure spotted gum and have been found to be more easily propagated by cuttings.



Trials of imported hybrid seedlings, mostly *Eucalyptus camaldulensis* x *E. grandis* and *E. grandis* x *E. tereticornis*, in various taxon trials, have mostly grown poorly, being subject to heavy insect attack. These are now four years old. No obviously superior individuals have been found that could be cloned from coppice. Many of the larger hybrid trees have been attacked by stem borers recently. The usefulness (if any) of the trees in these trials needs to be determined.

*Hybrid (Eucalyptus grandis x E. camaldulensis) clone in trial planting, three months after planting*

Photo: Steve Boyton

The first annual meeting of the ACIAR project “High performance eucalypts and interspecific hybrids for marginal lands in south and eastern South Africa and south-eastern Australia” was held in Canberra. Representatives from CSIR in South Africa then toured the State Forests dryland trials at Quirindi and some Tree Improvement trials around Coffs Harbour with members of the Tree Improvement Program. Tasks carried out by State Forests during 2003/04 included acquisition of pollen of 10 red mahogany (*E. resinifera*) selected trees and export of aliquots of this pollen to CSIR in South Africa, to carry out controlled pollinations. Hybrid seedlots have been procured from CSIR (South Africa) and CSIRO for inclusion in hybrid trials in the south of New South Wales during 2004/05.

Existing species and provenance trials in the Riverina region were maintained. Selections were made of superior trees of Chinchilla white gum (*E. argophloia*) and river red gum (*E. camaldulensis*), for capture by grafting and coppice cuttings, from a species trial near Deniliquin and the co-operative river red gum trials with CSIRO near Albury. Plants of river red gum propagated from coppice have been transported to South Australia for the establishment of a co-operative clonal seed orchard.

A number of superior *E. camaldulensis* trees have been identified and captured from the Albury provenance trial to form a core of select parents of that species. These selections are to be used to establish a clonal seed orchard and for use in the breeding program for crossing with other species hybrid clones for testing on relevant sites.

## **Establishment and management of eucalypt breeding populations**

H Smith

Dunn's white gum (*Eucalyptus dunnii*), flooded gum (*E. grandis*), blackbutt (*E. pilularis*) and spotted gum (*Corymbia citriodora* subsp. *variegata*) breeding population plantings were established as family trials (or breeding seed orchards (BSOs)) between 1995 and 2001. They are the major sources of future select material for breeding, improved seed production and clone development.

The Dunn's white gum and blackbutt breeding populations were assessed at age three years for growth, volume and form traits and the Dunn's white gum again at age six years. This year the Dunn's white gum BSO at Boambee was comprehensively assessed for wood quality traits. This was a co-operative project with Southern Cross University (SCU), University of Canterbury (NZ) and CSIRO under funding provided by Forest and Wood Products Research and Development Corporation, Australian Centre for International Agricultural Research and SCU. Information from the study will allow selection of genetically superior individuals for growth, form and wood quality traits. These individuals will be captured, by grafting, for establishment of a clonal seed orchard to produce seed for operational deployment that is superior to that currently being planted and for use in advancing the breeding program for this species. A similar but more extensive wood quality study is planned for 2004/05 on the blackbutt breeding population at Hannam Vale.

The best families of blackbutt over the five BSOs in New South Wales and Queensland were identified and 15 of these, that had a ready supply of seed, were used to initiate family forestry plantings. Approximately 100 seedlings from each family were established as mother plants in the mini-cuttings propagation system. Approximately 9,000 plants of blackbutt were propagated for operational or trial plantings using this material. Seedling mother plants from identified superior families of blackbutt will again be used to propagate plants for operational deployment during 2004/05 (approx. 40,000 plants).

Four large scale (approx 550 families) spotted gum (*Corymbia citriodora* subsp. *variegata*) progeny trials were established on three sites in the north coast region. These will form additional breeding population resources for the spotted gum improvement program. State Forests now has the most comprehensive pedigreed trials of spotted gum in Australia.

## **Seed production of select eucalypt varieties**

H Smith

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. This is likely to be true for the key species of Dunn's white gum (*Eucalyptus dunnii*) and spotted gum (*Corymbia citriodora* subsp. *variegata*) and the emerging species of shining gum (*E. nitens*). Grafting of the first two species has proven successful, allowing

establishment of clonal seed orchards. Other minor species, that do not warrant a full tree improvement program, will also have selections of superior individuals grafted to establish clonal seed orchards (CSOs) of slightly improved material for operational deployment.

Importantly, work was continued to establish further CSOs of blackbutt (*E. pilularis*) and Dunn's white gum as the mainstay of future improved seed production. Seedlings from these should give higher gains in growth and form than extensive seedling seed orchards (ESSOs) (though at higher cost) and they can also be used as sites for future controlled pollinations.

The initial blackbutt CSO (2 ha) was planted in spring 2002 on an ex-plantation site on the north coast. The second stage of this CSO was established during March 2004. At the same time it was noted that over 25% of the trees in the Stage 1 planting were showing immature flower bud development. This has increased over the last few months with now over 64% of trees in bud. Approximately 2% of the trees in the Stage 2 planting are now also in bud.

The Dunn's white gum CSO, established in co-operation with CSIRO and a landholder on an irrigated site near Corowa, had further grafted plants planted to complete the establishment of this site. A number of the plants from the original planting are now in flower bud. Results from the autumn 2001 assessments of the two 1995 Dunn's white gum family trials at Boambee and Megan, and a supplementary wood density study, were used to select parent clones in both trials for grafting. Reanalysis of the data lead to further selections in the Boambee trial that were grafted over summer 2003/04 and will be used to establish a second CSO. The results of the Boambee wood quality study will be used to make selections for grafting in late 2004 to establish a third CSO specifically for superior wood quality traits.



Trees in Stage 1 of blackbutt CSO  
Immature flower buds on a grafted blackbutt tree  
Photos: Helen Smith

Selections of Chinchilla white gum (*E. argophloia*) were grafted to establish a small CSO.



Superior individuals have been selected in the old shining gum (*E. nitens*) trial near Batlow, which has representatives of the southern provenances of the species. Scions will be collected and grafted in winter 2004 for establishing a CSO during 2004/05. This will be a co-operative project with Hancocks' Victorian plantations.

A permit has been granted for experimental use of paclobutrazol, a growth hormone commonly used to enhance flowering on eucalypts. This permit allows experimental use on in-ground trees, containerised trees and as a flood irrigation treatment for potted ramets. This chemical will not be used in the current blackbutt and Dunn's white gum CSOs due to the natural prolific and early flowering.

## Development and testing of eucalypt clones

H Smith

Interim results from clone trials of blackbutt and spotted gum have been used to select small numbers of clones for limited operational deployment. Propagation of these plants was achieved, although some problems did occur with the rooting in tissue culture of the spotted gum propagules. Establishment of the clonal plantings was extremely successful. Large gains in growth and pest/disease tolerance are likely using superior clones for operational deployment. Larger scale plantings are planned for 2004/05.



*Blackbutt clone four months after setting mini-cutting*

Photo: Jess Scott

The testing of eucalypt clones, developed "in-house" or imported (which may come with deployment restrictions or royalty payments) is important in order to identify superior clones that are suitable for use in State Forests plantations. The ultimate goal is to develop and deploy clones that are well suited to NSW sites and conditions. Plants of highly improved clones will eventually replace seedlings as planting stock of some key eucalypt species in operational plantations, if vegetative propagation is found to be a cost-effective alternative to seedling planting stock. Currently, operational and trial planting of seedling-based clones from selected superior blackbutt (*Eucalyptus pilularis*) families (family forestry) is providing a source of improved material for operational deployment. In the case of hybrid clones, it will be necessary to develop an effective method of vegetative propagation to allow an

operational deployment strategy. Gains achieved in growth and other traits should be substantial when using well-adapted improved clones over unselected seedling material.

The program of developing clones from young field select trees of blackbutt is continuing, using coppice produced on the stump of felled selects as a source of cutting material to capture the clone. A total of 86 trees of excellent phenotypes was selected over several years. All field select clones are being propagated for establishment of field trials during 2004/05.

Coppice of 40 selected trees felled during a wood quality study of the Dunn's white gum breeding population at Boambee has been harvested and set as cuttings. Strike rate has been variable but this project is continuing. It is aimed to propagate enough plants to establish a clone trial during 2004/05.

The first small field trial of "field select" blackbutt clones, established in 1999, is growing well. It was assessed for growth and form in spring 2002 and the best five clones are currently being propagated, using mini-cuttings, for block plantings during 2004/05. Several more good-performing clones have just been added to this group of clones for commercial deployment.

Tested spotted gum clones selected from a series of trials established during 1999 have been propagated by tissue culture for operational deployment. Over 1,100 plants of three superior clones were propagated for planting. Performance of these clones on State Forests sites will be further monitored over time.

### **Australian Low Rainfall Tree Improvement Group (ALRTIG)**

H Porada

Four new ALRTIG trials were established during 2003/4:

- *Eucalyptus caldocalyx* (sugar gum) provenance - progeny seedling seed orchard near Wagga Wagga;
- *Eucalyptus occidentalis* (swamp gum) provenance - progeny seedling seed orchard near Wagga Wagga;
- *Pinus radiata* (radiata pine) provenance - progeny trial of families from parents whose phenotype suggested some adaptation to dry environments; and
- *Corymbia maculata* (spotted gum) yield trial planted near Quirindi.

These trials were part of a suite of trials established nationally to develop plantations for the reforestation of drier environments (<650 mm annual rainfall).

Apart from the new trials, two two-year-old trials, again near Wagga Wagga, were assessed for growth and vigour. One trial was a sugar gum seedling seed orchard that showed exceptional vigour even during the drought, as well as no insect or other damage, while the second trial assessed was a swamp gum trial. Of particular concern for the swamp gum was the high proliferation of insect damage caused by a stem boring moth (Xylorictidae). This damage was particularly disconcerting as no previous damage of this nature had been recorded for swamp gum in NSW. Continued damage to swamp gum by this stem borer may well jeopardise the species suitability to drier regions of NSW.

## **Softwood tree improvement – radiata pine**

H Porada

The key outcome and implication from this year's work is to continue to provide confirmation of the performance of New Zealand seedlots in Australia. This will allow State Forests to continue to move ahead in testing clonal stock derived from parents included in the seedlots tested.

Results from the Native Population Progeny Trial and the 1996 Female Tester Trial in Northern Region will provide valuable data and potential selections for the radiata breeding and production populations, as well as new material to counter the prospects of later inbreeding effects. Importantly, these data will also assist in understanding the stability of families across environmental gradients, increasing the potential for better matching planting stock to site and end product, shorter rotations or better returns on investment.

Four new trials were established as part of State Forests research program for softwood tree improvement. Two trials formed part of the GFPLUS International series of trials, while the remaining two trials were part of State Forests involvement with the Radiata Pine Breeding Company. Both sets of trials were across first and second rotation sites and will explore the impact of site and genetic improvement on a range of traits.

A key report was drafted jointly by the Radiata Pine Breeding Company [RPBC] (New Zealand) and the Southern Tree Breeding Association [STBA] (Australia) on the outcome of a series of trials established to test seedlots from a range of sources. The trial series was the culmination of a project initiated by the Forest Genetics Research Working Group (RWG1) to benchmark genetic gain across a large range of sites throughout Australasia. Seedlots of known genetic quality were provided by South Africa, New Zealand, Victoria, South Australia, Western Australia, New South Wales and Tasmania. The trials contained 20 common seedlots and up to 10 other seedlots planted over two New Zealand sites and 16 Australian sites. Seven other New Zealand sites were planted with New Zealand seedlots only. Diameter growth was the most difficult trait to interpret. Certain seedlots were significantly superior on some sites but there was usually significant replicate x seedlot interaction on individual site analyses and site x seedlot interaction in across-site analyses. The New Zealand seedlots were the top performers on New Zealand sites but were often equalled by Australian seedlots on Australian sites.

Of particular note was the consistently good ranking of the improved New Zealand material for stem and branch form. The use of multiple family seedlots will help mitigate any potential risk of genotype by environment interaction negatively impacting plantation productivity and quality. A project is currently being formulated to assess the importance of genotype by environmental interaction within the State Forests estate and between New Zealand and NSW. Results from this project will give a better understanding of the importance of genotype by environment interaction and how best to capitalise on it for the deployment of improved material.

Preliminary analysis of a number of older State Forests radiata trials this year has also shown environmental influence on some traits. These data have yet to be confirmed and written up but follow similar trends to that in the report mentioned above.

## **Softwood clonal testing**

H Porada

While capturing the premiums derived from clonal forestry is complex, productivity gains of around 20% are feasible. Such gains mean a significant reduction in the land base to meet wood supply, enhanced return on investment or both.

To date a total of 11 clonal trials have been established in collaboration with external (New Zealand) collaborators; six of these were established during the year. Although many of the trials are duplicated across the same sites, they nonetheless continue to test genotype by environment interaction as well as the performance of newly captured clones.

The key objective centres on the testing and selection of genotypes matched to sites for specific end-use. The attainment of this objective will have a considerable impact on State Forests capability to achieve desired return on investment through the trees themselves (growth, stem form, wood quality) and to enhance the opportunity for plantation expansion into more marginal (drier or colder) environments.

---

## 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

### Carbon in forests

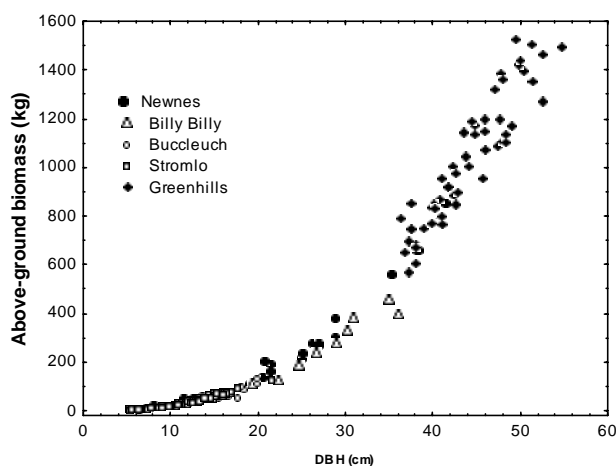
K Montagu

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.

#### **Providing relationships for *Pinus radiata* to estimate above- and below-ground carbon**

Allometric relationships, which relate an easily measured tree variable (e.g. stem diameter) to biomass carbon, are an efficient method for estimating carbon sequestration when combined with inventory data. For above-ground biomass, such relationships have been shown to be independent of site factors - environment, age and stand management. As a result above-ground biomass across stands can be estimated from a single relationship without increasing the uncertainty of the estimate.

Relationships for *Pinus radiata* above- and below-ground biomass carbon have been developed for use across the *P. radiata* estate of State Forests. The relationships were built on data from 217 destructively harvested trees from five sites across NSW and ACT. Stands sampled ranged from five to 40 years old, with trees ranging from 5-55 cm diameter at breast height (DBH). An example of the relationship is given below. Similar relationships were derived for estimating below-ground biomass and stem expansion factors for estimating total above-ground biomass from stem biomass.



*Further development of the Carbon Sequestration Predictor model*



### ***Further development of the Carbon Sequestration Predictor model***

The Carbon Sequestration Predictor toolkit was developed for predicting likely changes in both biomass and soil carbon associated with a number of land use changes, predominantly in the western areas of NSW with rainfall below 800 mm/year. The model is now publicly available and can either be downloaded from ([www.forest.nsw.gov.au/env\\_services/ess/default.asp](http://www.forest.nsw.gov.au/env_services/ess/default.asp)) or run online at the CRC for Greenhouse Accounting website [www.greenhouse.crc.org.au/calculators/cseq/](http://www.greenhouse.crc.org.au/calculators/cseq/)). Further development of the model is occurring to incorporate land clearing in the land-use change scenarios and increase the commercial forestry options.

### **Life cycle analysis of wood products**

WD Gardner, F Ximenes

The aim of this 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 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 from carbon trading and may make other land acquisition and management options viable. 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, developed within the CRC for Greenhouse Accounting (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.

### ***Studies of total biomass at three sites***

This research was a collaborative project co-funded by AGO and CRCGA. The research aim was to determine the total biomass at three sites of differing productivity, close to or at maximum carbon carrying capacity, in forests dominated by spotted gum. The research results will be used by AGO to calibrate productivity models used to estimate the carbon

sequestered in Australian forests. Three sites (low, medium and high productivity) were identified by State Forests personnel in forests in the Batemans Bay area. The sites ranged in area from 5,000 to 6,000 m<sup>2</sup>.

All trees on each site were identified to species and measured by State Forests' personnel prior to harvest. The trees were then harvested and weighed. The tallest tree sampled was 48.5 m and the heaviest tree weighed 28.1 tonnes. Trees were sampled to determine moisture content and basic density. A summary of the total biomass data is given in the following table.

*Summary of total spotted gum biomass data at three sites of different productivity*

Productivity	Number of trees weighed	Total biomass, tonnes/ha	
		Green basis	Oven dry basis
Low	207	352	210
Medium	156	492	263
High	162	691	389

### **Sawmill conversion studies of spotted gum from two productivity sites**

This research was a collaborative project co-funded by AGO and CRCGA. Spotted gum logs from the low productivity site and the high productivity site were processed to green sawn products at Batemans Bay Timbers. A summary of the conversion data are given in the following table.

*Summary of spotted gum conversion data from two sites*

Site productivity	Weight, tonnes, of logs processed	Percentage of logs converted to green sawn products	Percentage of logs converted to residues	Average moisture content of logs (wet basis)
Low	15	60	40	37
High	63	54	46	41

### **Decay of coarse roots**

This research was a collaborative project co-funded by AGO and CRCGA. The aim 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. Hardwood stumps have been excavated at the three sites where the total biomass studies were conducted. State Forests 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. The area around the stumps was excavated and the stumps removed with an excavator. Larger stumps required additional assistance from a bulldozer.



*Excavating stump for coarse root decomposition study*

Photo: David Gardner



*Fabiano Ximenes weighing above-ground biomass on weighing trailer*

Photo: David Gardner

The excavated stumps were photographed and sampled for laboratory analysis. The studies to date indicate that the main deterioration after 25 years is decay of the sapwood on the roots. The heartwood section of all 25-year old stumps appears to be in sound condition. There is some deterioration of the heartwood in the coarse roots after 50 years. There was one 27-year old stump excavated in the low productivity site that had grafted to the roots of



other living trees and hence the root system of the stump was still fully functional and there was no degradation. A summary of moisture content and basic density data are given in the following table for the 25 and 50 year old stumps from the high productivity site.

*Summary of moisture content and basic density data for 25 and 50 year old stumps from the high productivity site*

Stump age, years	Range of moisture contents, % (wet basis)	Range of basic densities, kg/m <sup>3</sup>
25	28-34.3	807 - 935
50	27.3- 34.3	673 - 905

### **Calibration of Australian Greenhouse Office wood products model**

The Australian Greenhouse Office has developed a model for accounting for carbon storage in wood products. The model assigns wood products to one of five service lives and allows for transition of the products through three age pools within each assigned service life. The model also accounts for the fate of all products that leave each age pool - they may be recycled, used for energy, placed in landfill or oxidised to atmosphere. Data from several of our projects, including basic density of trees and wood products, service life survey, waste audits and landfill research were used to develop a set of Australian default values for the model.

### **Benchmark salinity control and carbon sequestration in western New South Wales**

C Barton, P Walsh, S Roberts

Results from this project will provide information about likely growth rates and the water use of trees in catchment recharge areas of dryland salinity prone regions and give an indication of which species are most suited to the region. This information is required to develop sustainable land use systems and to design market based solutions to dryland salinity.

Objectives are being met through a combination of activities, including establishment of trial forests in low rainfall zones, measurements of tree growth, water use and water balance in existing forests, sampling of above ground and below ground biomass in planted forests, soil carbon sampling and collaboration with other state agencies and universities.

Data collection was completed in May 2003 with soil sampling at three sites comparing eight to 12-year-old plantations with neighbouring pasture. Data analysis is nearing completion and a report is in preparation.

### **Tree water use measurements**

For tree water use to be a suitable trading unit for salinity it needs to be quantifiable and linked to a salinity benefit. State Forests has collected tree water use data at four sites with a view to refining field techniques and developing or calibrating models for the prediction of water use by trees in low rainfall zones.

Four sites have been used for tree water use measurements. At a property near Quirindi, ongoing measurements of all forest water balance components are being taken in a *Eucalyptus sideroxylon* plantation in collaboration with Department of Infrastructure Planning and Natural Resources (DIPNR) and NSW Agriculture. University of Technology Sydney and NSW Agriculture are measuring the water balance of adjacent remnant forest and improved native pasture to allow comparison of evapotranspiration among the various land uses.

Transpiration has been measured in a sample of trees planted on private properties near Albury in 12-year-old *Pinus radiata* and *Corymbia maculata* and near Murrumbateman in 14 year-old *Eucalyptus polyanthemos*. At the property near Murrumbateman the landholder has extensive records of soil and water salinity and the depth to the water table that can be utilised in determining the effect of the trees on salinity.

At these four sites, water use has been measured for six tree species (*Eucalyptus sideroxylon*, *E. melliodora*, *E. polyanthemos*, *Corymbia maculata*, *E. camaldulensis* and *Pinus radiata*).

### **Tree growth rates**

Over the last three years more than 85 trees at seven sites have been destructively sampled to determine the biomass of various tree components (including roots). Allometric relationships have been developed that relate biomass to easily measured tree size parameters such as stem diameter.

Measurements of stem diameter and height have been collected from ca. 7,000 trees growing in plantations of varying age and species across a range of landscape settings in the 500-700 mm rainfall regions of NSW. These data will be used to model potential productivity of planted forests in dryland salinity prone landscapes.

### **Soil carbon**

Soil sampling to assess the impact of reforestation of agricultural land has been completed at three paired sites. The first site, near Quirindi, was sampled in late March where the soil carbon stock in the *Eucalyptus sideroxylon* plantation will be compared with that of adjacent pasture and the neighbouring remnant native vegetation. The site near Albury was sampled in early April to compare soil carbon under the spotted gum, pine and neighbouring pasture. A third site near Wagga Wagga compares soil carbon under a 10 year-old eucalypt plantation with that under a neighbouring pasture. Samples have been sent for chemical analysis and have been scanned with an MIR system to give fractionation of carbon between various pools.

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

**P Walsh, C Barton**

Continued monitoring of the Baldry site, within a subcatchment of the Little River, will enable State Forests to predict the impacts of plantations on salt mobilisation, water yield and water quality in dryland salinity prone landscapes as well as the potential growth rates of plantations in low rainfall environments. The project will also underpin the development of expertise within State Forests in the environmental services provided by plantations to support market-based solutions to dryland salinity management.

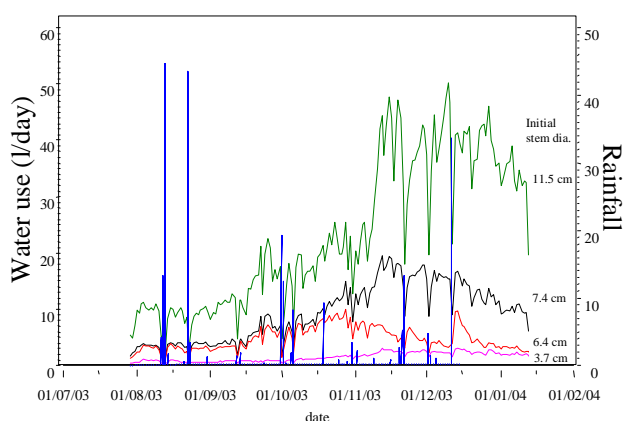
The project received one year of funding in 2003 under the National Action Plan (NAP) for Dryland Salinity. All of the agreed milestones for that year were completed and include:

- characterising the site (resistivity survey, topographic survey);
- installing instrumentation (weir, sap flow sensors, soil moisture monitoring equipment, piezometers, weatherstation); and
- provide baseline measurements of summer transpiration rates of the plantation; watertable levels beneath the plantation and adjacent pasture, salt load and salt composition of stream above weir for validating salt export and recharge models being developed by Department of Infrastructure Planning and Natural Resources (DIPNR).



A further six months of funding for the site was secured by DIPNR in 2004, under a project called Recharge Model Validation. Under this project, Baldry is one of four sites being used by DIPNR to validate their suite of salinity models. A further three years funding for the Recharge Validation Project will be sought later in 2004.

Over the ensuing six months (August 2004-January 2005) biophysical data will continue to be collected and interpreted. Early estimates of individual tree water use are provided below. The daily water use of four trees and the rainfall events during the first six months are also shown. As would be expected, large trees used more water than small trees. Daily water use increased from winter through spring to summer primarily in response to increased evaporative demand but in part due to increased tree size. Interestingly the smaller trees showed an increase in water use after rain but the larger trees didn't. This indicates the small trees were more water limited and may explain part of the variation in growth rates across the site, even between neighbouring trees. The day to day variation in tree water use between rain events is in response to daily weather and gradual soil moisture depletion.



Daily water use of four of the 16 trees between 28 July 2003 and 12 January 2004. Vertical lines show rainfall events

## 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 these trees has been measured annually since their establishment.

This year a subset of nine of the sites was measured while next year, when the trees reach five years old, all sites will be measured. During the first two years the black wattle (*Acacia mearnsii*) outgrew the other species with the hybrid eucalypts following closely. 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. These species consistently carried a large leaf area and were generally unaffected by pests and diseases. *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.

A joint project has been initiated with CSIRO Forestry and Forest Products to provide detailed characterisation of 12 of the sites. This will assist in determining the causes of site to site variation and site/species interactions.

### **Plantation 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. Last year, measurement plots were established and 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-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.

### **Maximising growth and determining preferred species for mine sites in the Hunter Valley**

G Kelly

Is a commercial plantation hardwood industry possible in the Hunter Valley? This work will help Planted Forests Division, Power Generators and Coal Mines determine if trees can be grown at commercially viable rates on Hunter Valley coal mine buffer and overburden lands. The results will indicate appropriate species and determine if amending the soil with organic wastes significantly improves survival and growth.

### **Use of soil - amendments on mine sites**

At Macquarie Generation Bayswater Power Station a 30 ha trial is established to examine the response to three soil amendments (biosolids, greenwaste and flyash) by six eucalypt species (*Eucalyptus sideroxylon*, *E. argophloia*, *E. punctata*, *E. mollucana*, *E. benthamii* and *Corymbia maculata*). The site was planted in October 2000.



Soil amendment trial (*Corymbia maculata*): Bayswater Power Station

Photo: Georgina Kelly

The formal requirements for Natural Heritage Trust and Department of Infrastructure Planning and Natural Resources concluded in October 2002. However the plantation will continue to be monitored (soil and growth) until it reaches five to six years of age (next measurement October 2005/06). In addition, thinning will be considered in October 2004 with subsequent monitoring.

Results for all species trialled are very similar on biosolids and fertilizer. *Eucalyptus molluccana*, *C. maculata* and *E. punctata* are all doing reasonably well. On the buffer land at Macquarie Generation there is no significant difference between trees with biosolids and those with fertiliser (100 g DAP/tree)



The Hon. Michael Costa MLC, Robin Bragg, Environmental Manager, Bulga Coal and Georgina Kelly inspect the Tomen/Chubu plantation trial at Bulga Coal

Photo: Ministerial staffer

There has been no statistically significant difference in the *C. maculata* grown on the different treatments. This holds for both height and diameter assessment. This may be because the trees are only three years old and we know that treatment trends only become clear after about four years. More likely the data support the current thesis that amendment with recycled organics is more productive on overburden sites but equal to fertiliser treatment on buffer sites.

At a second site (Coal and Allied) in the Hunter Valley, further research is examining a range of species and soil amendments on a variety of land types (river flats, typical buffer land and mine overburden).

Trees continue to grow well on the buffer site but there has been severe insect defoliation on the overburden and river site (particularly of *E. camaldulensis x grandis*). An insecticide trial has been super-imposed on one species trial to determine if it is effective in providing protection against leaf blister sawfly, thus allowing the trees to regenerate. A full growth assessment was completed in October 2003 with foliage samples taken from the buffer and overburden blocks to assess the nutritional status of the trees with respect to treatment.





While early growth is good (despite the 530 mm rain received last year) there is no significant difference between treatments on the buffer for *E. camaldulensis x grandis* (9). This same trend holds for *C. maculata*. At Coal and Allied the buffer vs overburden trends are similar to those elsewhere in the Hunter. On the overburden site biosolids and biosolids in combination had a significant effect on the diameter and height of the *E. camaldulensis x grandis* (9). The effect was similar for *C. maculata* (though not significant at this stage - which is consistent with other data).

Coal & Allied treatment trial - overburden site  
 Photo: Georgina Kelly

The River block is a good example of the need for appropriate species/site matching. On this alluvial site, the *E. camaldulensis x globulus* clone 44 has shown spectacular growth with some individuals reaching 5.6 m at 20 months of age. However, being slightly in a dip compared to the buffer and overburden sites, frost does occur resulting in the death of the majority of *C. maculata* (even though the frost tolerant Curryall provenance was used).

Inspection by Australian Coal Association  
 Research Program industry monitors  
 of the Coal & Allied overburden site



Photo: Georgina Kelly



## ***New opportunities for recycled organic materials***

In October 2001, a number of legislative changes to the NSW Government's waste policy and regulatory regime came into effect. The Waste Avoidance and Resource Recovery Act 2001 (WARRA) replaced the Waste Minimisation and Management Act 1995 and amended the waste provisions of the Protection of the Environment Operations Act.

Mine site rehabilitation potentially presents a significant market opportunity for the recycled organics industry, especially for the lower grades of product. Furthermore there are potential synergies for mine-site owners, where some fly ash products could beneficially be mixed with composts.

State Forests of NSW won the tender to conduct a trial to compare the cost/benefit of various types of compost in rehabilitating old mining sites. The trial site, Narama mine (owned by ExStrata) was chosen, in conjunction with the Department of Mineral Resources (DMR).



*Narama - overburden site*



Photos: Georgina Kelly

Resource NSW will use the cost/benefit analyses of the various treatments to:

1. publicise the use of recycled organics to the minesite rehabilitation 'industry';
2. commence development of product specifications.

State Forests will gain further insight into the benefits of recycled organics on minesites (and other low nutrient/low rainfall sites) and further enhance our reputation as plantation providers in the Hunter Valley. By trialing recycled organics it may be possible to promote greater growth at lower costs thus making plantations in the Hunter more commercially viable.

A literature review, to inform trial design, has been completed and will be published by Department of Environment and Conservation (DEC). Site selection and trial design was completed with input from DMR and DEC. The treatment amendments chosen conformed to Australian standards and other guideline documents. The amendments are biosolids, mulch (100% greenwaste), soil condition (100% greenwaste), municipal solid waste (ex Bedminster), with mulch + biosolids, mulch + fertiliser, fertiliser and control. The trial was established the first rains in March 2004.

*Narama* - *Eucalyptus camaldulensis* x *grandis* hybrid; *C. maculata* (ex seed orchard)



*Contract planter*



*Joe Chandler (right) briefing contract planters*





Narama

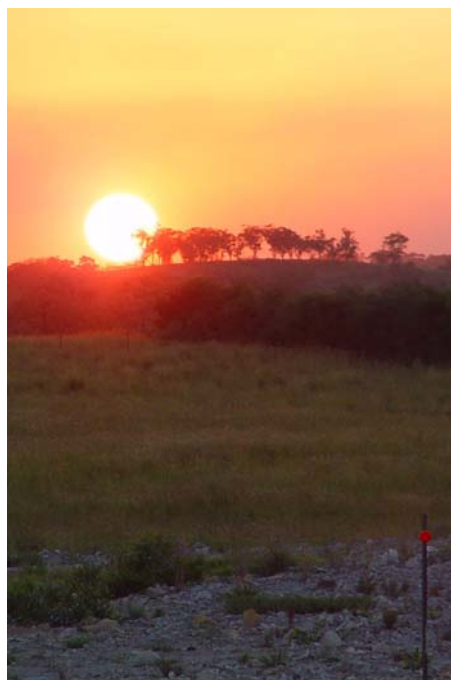


*Joe Chandler inspects the planters' work*

*Photos: Georgina Kelly*



*Amendments in randomised blocks (above and below)*



***JOB DONE!***

## **Nutrition, growth and wood density**

K Montagu

### ***Effect of the environment on tree growth and density***

This subproject is jointly funded under the Strategic Partnerships with Industry for Research and Training (SPIRT) in collaboration with the University of Western Sydney. Wood density is emerging as a major issue as Australia becomes more reliant on wood sourced from short rotation plantations of pines and eucalypts.

The general aim of this project is to investigate the relationship between CO<sub>2</sub> assimilation rates of leaves tissue and development of wood under different environmental conditions. Dr Dane Thomas commenced employment on this grant in October 2000 and later took up a position with State Forests. To complete the project Dr Thomas returned to the University of Western Sydney for six months.

A number of publications have been prepared which systematically examine the influence of growing environment of eucalypt wood density. The influence of soil drought on the relationship between wood density and xylem size and, therefore, ability of the stems to transport water, is being investigated in several eucalypt species by Mr Matthew Season, a PhD student at University of Western Sydney. Wood density was increased by soil drought, although the response in xeric species was small. Matthew is also examining the effect of increased carbon supply, during soil drought, on wood development.



---

## Silvicultural Systems

Program Leader: 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*

### Characterising the pine resource

C Raymond, W Joe, R Dickson

This project aims to gather information on the intrinsic wood properties and product quality of *Pinus radiata* as affected by silviculture, site and genetics within the NSW softwood plantations estate. Initially, the project focused on gathering information on the variation of wood density with the intent to quantify the resource into distinct strata. The project has since been expanded to include several studies on the influence of prior land use on a range of wood and fibre properties relevant for Medium Density Fibreboard (MDF) and kraft pulp manufacture including wood density, wood stiffness, fibre length and kraft pulp yield.

The initial study indicated consistent differences in wood and fibre properties between the paired ex-pasture and second rotation (2R) sites. Overall, the ex-pasture sites produced lower density wood with shorter fibres, lower fibre coarseness, higher pH and higher microfibril angle leading to a decrease in calculated modulus of elasticity (MOE). However, when results are examined across all pairs of sites, large differences were also apparent within forest areas, with some ex-pasture sites producing better quality wood than some 2R sites. Despite differences in growth patterns with prior land use, the age of change from juvenile to mature type wood was the same for the two site types. In the growth rings closest to the pith, wood density was similar for the ex-pasture and 2R sites. However, from ring six onwards, density was consistently higher for the 2R sites. There was little effect of site type on patterns of change for microfibril angle. The major effect of site type would appear to come from an increase in the volume of juvenile corewood on the ex-pasture sites.

A second, larger, study was then commenced looking at 33 sites across 11 forest areas and age classes to determine differences in wood properties, branch quality and tree taper between ex-forest, ex-pasture and ex-cleared land uses. Issues being addressed include whether all ex-pasture sites are the same, what are the differences between improved ex-pasture and non-improved ex-cleared sites, what is the variability across the forest estate and what will these stands produce at second thinning or mature clearfall in terms of MDF/pulp, sawn timber grades or other products.

The data base being established will assist with strategic decision making relating to future land purchases, site selection, silvicultural treatments, forest management and marketing options. The data will also allow for the development of tools and methods for predicting wood quality for new sites, identifying and matching the resource to product requirements and result in increased revenue to State Forests and their clients.

## Value recovery studies– an integrated approach

R Dickson, W Joe

Log length, diameter, sweep and branch size and habit greatly impact on grade yield and end-use performance. Stand history and tree assessments of the above parameters do not necessarily reflect intrinsic wood properties. Further, many of the known and evolving tools for assessing and measuring intrinsic wood quality require testing and validation. Generally, this is achieved through processing studies. 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.

This project comprised four parts, namely:

- log segregation for structural timber
- production thinning experiment - *Eucalyptus dunnii*
- hardwood wood utilisation
- pulpwood testing

### Log segregation for structural timber

This operational study on mature clearfell (MCF) *Pinus radiata* was one of three mill studies undertaken with Weyerhaeuser at Tumut. The other two studies were on second thinnings (T2) and overmature clearfell (OCF) with the intent to examine sawn wood value in relation to grade output from three operation types. The MCF trees in this study were harvested from Buccleuch State Forest and had a mean outerwood basic density of 457 kg/m<sup>3</sup> (range 368-507), which was within the expected range for this age class and site. The average size of the logs was 40.7 cm (small end diameter) and branch index (BIX) was around 3.8 cm. Overall grade yield of structural timber from these logs was in excess of 60% for MGP10 or better (MGP10 being the minimum grade for structural pine).

Branch size was a key driver of machine grade values. The smaller the branch index, the higher the grades recovered. The lower quality juvenile corewood in butt logs also had an impact on grade yield. It would appear that log size and, in turn, corewood:outerwood ratios impacted on grade yield. As a result of this study, Weyerhaeuser is looking at changing cutting pattern to bolster return on log. For State Forests, this study afforded some market intelligence of our plantation resource at minimal cost.

### Production thinning experiment – *Eucalyptus dunnii*

A production thinning operation of six year-old *Eucalyptus dunnii* on a reasonably high quality site at Moonmerri State Forest afforded an opportunity to characterise the wood quality of this young resource. The study also helped build our knowledge in the use of acoustic tools for rapid field assessment of wood properties and to examine the strength of relationships amongst wood properties and field measurements.

Field measurements included non-destructive tests (Fakopp and Pilodyn), tree size (DBH) and height. Wood samples were collected from ten trees for more intensive laboratory tests. The following were observed in this study:

- The strength rating or Strength Group for this young resource was S6 and SD7 for unseasoned and seasoned material respectively. The current classification for mature wood is S3 and SD4 for unseasoned and seasoned timber respectively. The thinnings were slightly inferior to mature radiata pine classification. F11 would theoretically be the top grade possible.
- Hardness (Janka) was low (3.6kN) or about 50% of the mature value. For flooring, a hardness value of around 5.0kN (eg. alpine ash) or more would be desirable.

- High differential shrinkage near to the pith will lead to more distortion in boards.
- Internal checking and collapse would impede quality of final product.
- The correlation between tree size (DBH) and wood properties was poor. However, the correlation between acoustic velocity as measured on the standing tree and green clearwood stiffness was significant. There was also significant correlation between Pilodyn penetration and several key wood properties including clearwood stiffness, bending strength, compression strength, basic density and hardness. Basic density was also significantly correlated with bending strength and stiffness, compression strength and hardness.

The results are so far encouraging, at least from the view point of applying rapid assessment tools for wood quality. These tools can be useful for providing information not only to manage forest silviculture for wood quality but to assist in selection trees for breeding purposes.

### **Hardwood resource utilisation**

Currently market development work is being planned to explore ways of improving the utilisation of wood fibre from the southern pine and plantation hardwood resources. This work will focus on technologies and methods to better describe the wood properties of the hardwood resource to assist with processing options and ultimately value recovery. An immediate project investigated ways to describe the hardness of mature plantation *Eucalyptus grandis* to ensure that the milled timber from this resource performs well in service. This project evaluated the potential of acoustics and a Pilodyn apparatus to measure the radial hardness of logs. The outcomes indicated that the Pilodyn readings are a good estimator of radial hardness. Similarly, the acoustic measurements were found to be reasonable predictors of the stiffness of hardwood corewood. These results may assist with the future implementation of log and/or board segregation protocols to manage variability in the stiffness and hardness of the board mill and ply mill outturn.

### **Silviculture spacing trials**

R. Dickson

With the development of new processing capacity on the south west slopes of NSW there is 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 being developed.

Work focussed on the south-western slopes will demonstrate the impact of species, stocking and planting configuration (intra-row spacing and inter-row spacing) on wood fibre yield and quality across farm sites and second rotation forest sites. This will support 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, are also considered. There has, however, been limited consideration given to the impact of espacement on radial wood quality variation.

Early data indicate that *Pinus pinaster* can perform as well as *Pinus radiata* in the 600-700 mm rainfall zone. However, *Pinus radiata* at higher stockings did not survive past summer drought events. In mid 2004, two new spacing trials comprising various improved and unimproved seedlots of *Pinus radiata* were established across ex-pasture and second rotation land in Tumut and Bathurst.

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

R Dickson, W Joe

Drying is a key step in processing and adding value to timber. Plantation hardwood timber is becoming more available but has greater property variability than in previous resources. This presents an opportunity to develop better mathematical techniques for process optimisation. This includes better drying and mechanical models for the timber. This collaborative project, with the University of Sydney and the timber industry, will produce optimised drying schedules to more effectively dry variable plantation timber, producing timber for high-value and appearance-grade end uses, such as flooring and furniture.



*Testing of blackbutt elastic wood properties for incorporation into drying model*

Photo: Bill Joe

The project is undertaken under an Australian Research Council Linkage Grant through PhD candidate, Ms Sherryn Cabardo, led by Associate Professor Tim Langrish from the University of Sydney and co-supervised by Mr Bill Joe and Dr Ross Dickson from State Forests.

The project seeks to add value to plantation timber from State Forests. A specific outcome is optimal drying conditions that meet market requirements. Blackbutt (*Eucalyptus pilularis*) is investigated in this study.

Preliminary investigations on drying parameters have been partly completed. Using test material from two logs supplied by Notaras, four sets of experiments have been completed, giving some early indications of the variations that exist within, along and between trees.

The next stage of the work will focus on:

- Developing drying schedule/s that will take into account the above variabilities.
- Accounting for variations in mechanical behaviour, and finding correlations between initial moisture content, basic density, transport parameters, and mechanical behaviour.



## Non-destructive evaluation of wood properties in planted forests

W Joe, R Dickson

For State Forests, the application of acoustics will enhance the supply of logs to specific markets or products with exacting specifications, ie matching log wood quality with final product specifications, whilst commanding a premium price royalty for the logs. For the processor, the use of acoustics would provide an objective way to sort logs that are not meeting product requirements with a degree of certainty, whilst processing only those logs capable of producing high grade recovery and value.

This project encompassed a number of sub-projects seeking to assess the applicability of non-destructive testing tools for evaluating intrinsic wood properties on standing trees and logs of plantation grown *Pinus* and *Eucalyptus* species and also to assist in selecting young trees for breeding programs. The information gathered will enable development of non-destructive tools and approaches capable of identifying and matching the resource to product requirements. It will also assist with strategic decisions on forest management, such as establishment of new planting sites, genotype and silviculture.



Ross Dickson and Darrel Johnstone using an acoustic tool (Director HM200) to segregate slash pine (*E. elliottii*) logs prior to peeling in an operational study at Norply in Kyogle

Photo: Bill Joe

The project objectives have been met through the successful completion of two operational studies with industry, which looked at the predicting the wood quality of plantation grown peeler logs prior to processing. The first of these studies was carried out with Norply at Kyogle on slash pine (*Pinus elliottii*), and the second study with Big River Timbers at Grafton on loblolly pine (*P. teada*) and Sydney blue gum (*Eucalyptus saligna*). All logs were acoustically sorted into three wood stiffness classes before being peeled and used to manufacture plywood boards. Stiffness is the key determinant of grade for machine stress graded plywood in Australia. A significant finding was that, regardless of species, the stiffness of the plywood boards was found to be closely related to the average recorded

acoustic sound speeds of logs batches. The average stiffness ranking of the plywood boards across species was *E. saligna* > *P. elliotii* > *P. taeda*. Regardless of species, sound speed along logs was reflected in corresponding peeler cores, suggesting the corewood acoustic signature may be a means for managing problematic corewood stiffness.

Acoustic tools offer real potential solutions to minimise product fall down during manufacture. In turn, forest growers have the opportunity to use wood quality information from both non-destructive stress wave technology and micro-processing studies on the current crop to assist with silvicultural decisions for either future or replacement crops. Growers and processors should explore ways to integrate wood quality data into forest management information systems linked to differential pricing arrangements.

In a separate study, acoustic tools (Director and Fakopp) were used to characterise the wood properties of a nine year-old *E. dunnii* in a family trial near Coffs Harbour. Standing tree and log measurements were used to provide information on heritability and genetic correlations. Samples were collected for further testing of wood properties (including bending strength, stiffness and hardness) in the laboratory. The study is expected provide the basis for selecting material for the next generation seed orchard.

### **Hardwood plantations - maximising seedling survival**

D Thomas

Seedling survival post planting can be low and an economic cost due to both replanting/refilling and also reduced selection options for thinning. Enhancing seedling survival is therefore of high importance to plantation forestry. This project seeks to enhance survival by:

1. Providing better advice on suitable soil and weather conditions for planting to plantation officers. Understanding of critical soil moisture and weather conditions that are necessary for high seedling survival enables better decisions about when to plant and reduces seedling losses, leading to better site capture.
2. Producing hardier seedlings better able to withstand the harsher conditions in the field compared to the nursery that will further increase the likelihood of seedling survival and site capture.
3. Exploring post nursery practices that may reduce seedling deaths. In severe conditions such as dark soil or north western slopes the benefits of moisture retention gels or leaf coatings may enhance survival and provide a further option to plantation officers.

The project has so far provided a decision support system for planting based on soil moisture and predicted weather soon after the planting operation. An associated system will soon incorporate the added benefit of using moisture retention gels.

Work demonstrated that drought hardening seedlings did not reduce growth or increase deaths in the nursery. The drought hardened seedlings also survived for longer periods between planting and a high rainfall event. This has been demonstrated in a rainshelter (glasshouse) but unfortunately rain events caused high survival of all experimental seedlings in the field experiment. The continued growth and form of the seedlings is being evaluated.

## Hardwood plantations - matching species to site

D Thomas

The suitability of land for new plantations requires knowledge of the potential tree growth on the site, typically ex-agricultural sites. Potential growth often has to be estimated as historical tree growth data is not available for ex-agricultural sites. This project seeks to refine land site selection by predicting the potential growth of several species for a particular site using an eco-physiological model and multivariate analysis of existing growth data. These tasks are immense as tree growth will be determined by a variety of factors such as soil type, climate, localised geography and species. An understanding of the many factors that contribute to either soil type (eg. depth, texture, fertility), climate (annual and seasonal variability in rainfall, temperature, humidity, and sunshine) or local geography (slope, aspect) are required to gauge the suitability for plantation forestry. An additional factor is that different species will respond to each of these component factors in a unique manner with varying degrees of magnitude. An aim is to combine the detailed understanding of cause-effect found in the ecophysiology/modelling approach with the mapping abilities within GIS systems.

This research has so far remained in its inception stage. A research grant in collaboration with University of NSW to study the eco-physiological model is under review. Data for the multivariate analysis is being collated.

## Early plant growth of eucalypts in response to fertiliser application

K Weggler, D Thomas

Plant nutrition is a management tool that can be utilised to great advantage in silviculture as it can promote plant growth and site capture. An effective fertiliser regime should be tailored to the site and the species planted to avoid over- or under fertilisation. The timing of fertiliser application, zero to six weeks after planting, may also be a crucial factor which determines the potential effect of fertiliser application.

The effect of macronutrients (N, P, K) and micronutrients (Zn, Mn, Fe, B, Cu) on early eucalypt growth were tested in factorial fertiliser trials, which included two different eucalypt species (*Eucalyptus pilularis* and *E. dunnii*). The effectiveness of micronutrients or trace elements (TE) on eucalypt growth has not been widely examined in NSW but evidence from other countries suggests there can be tremendous growth responses of eucalypts to applied micronutrients.

Although in 2002/3 the NPK/TE factorial trials suffered some seedling mortality due to frost and herbicide drift, the data still yielded useful information. Trends in the data indicated that there may be important differences in fertiliser needs of *E. dunnii* and *E. pilularis*. Results suggested a positive effect of macronutrients on the growth of *E. pilularis* and a potential positive effect of trace element application on the growth of *E. pilularis* but not for *E. dunnii*. In a number of treatments the application of trace elements had a negative effect on growth and these issues need to be considered and further refined in the future.

The fertiliser-timing trials have shown that seedling survival is not affected by the time that fertiliser is applied (zero to six weeks after planting but earlier fertiliser application enhances plant growth more effectively than late fertiliser application).

The effect of micro-nutrient application (Zn, B) was tested in an established two year-old plantation of *E. pilularis* and showed that boron and zinc increased height growth moderately but significantly. Growth gains were achieved, although no visible signs of boron or zinc deficiency were originally observed in these trees, which suffered from some growth impediment. The important message of the trial is that trace element nutrition of *E. pilularis* probably did not get sufficient attention in the past. At least moderate growth gains after

trace element application for this and maybe other species at a number of plantations seem to be possible.

Pot trials were established testing the effect of specific nutrients on the growth of three eucalypt species (*E. pilularis*, *E. dunnii*, *E. grandis*, *Corymbia variegata*). The trials, although still running, confirm the importance of trace element application for *E. pilularis*. Severe growth impediments due to trace element deficiency, Zn and Mn, were recorded when grown in a plantation soil. The results explain the chlorotic (yellow) appearance of *E. pilularis* at that particular property. Trace element application is a cost effective tool that could avoid those problems in the future.

## Wood properties of plantation hardwoods

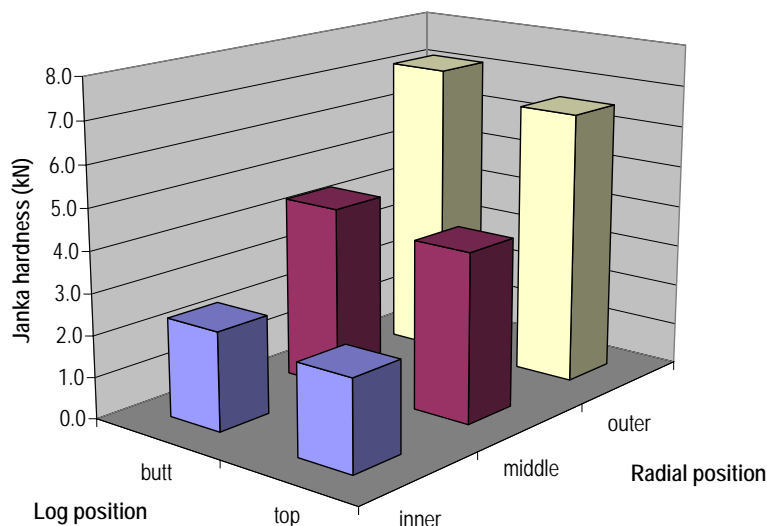
W Joe

This project is an on-going assessment of important wood properties of plantation hardwoods grown in NSW. The intent is to develop information to gauge potential for specific end uses and marketability compared with traditionally more mature wood. The information would also assist with silvicultural decisions, e.g. thinning, spacing, rotation age, etc. To meet these objectives, two studies were undertaken over the past 12 months.

### Wood quality of *Eucalyptus grandis* focusing on hardness

Wood hardness is an important quality feature for flooring and the ability to sort logs for this key attribute prior to sawing is highly desirable, particularly in the face of an increasingly variable log resource. This study attempted to demonstrate the applicability of commercially available non-destructive tools (Director HM200 and Pilodyn 12J) for segregating logs for hardness prior to sawing.

Variation in mean Janka hardness on radial face from pith-to-bark for *E. grandis*



Working with one of State Forest of NSW's customers (Notaras), run-of-the-mill 38 year-old flooded gum (*Eucalyptus grandis*) logs were tested non-destructively for acoustic velocity (Director) and Pilodyn penetration and segregated into three groups - high, medium and low - according to the Pilodyn readings. Laboratory assessment of wood properties revealed significant variation in hardness, increasing radially from pith-to-bark. Wood hardness within a third of the radius from the pith was low and will fail to meet performance requirements expected of flooring. This has implications on sawing strategies for the sawmill and consequently log value at the mill gate.



Segregating the logs into groups of low, medium and high Pilodyn penetration readings resulted in a reasonably good segregation of hardness values. The correlation between the Pilodyn reading and Janka hardness was good.

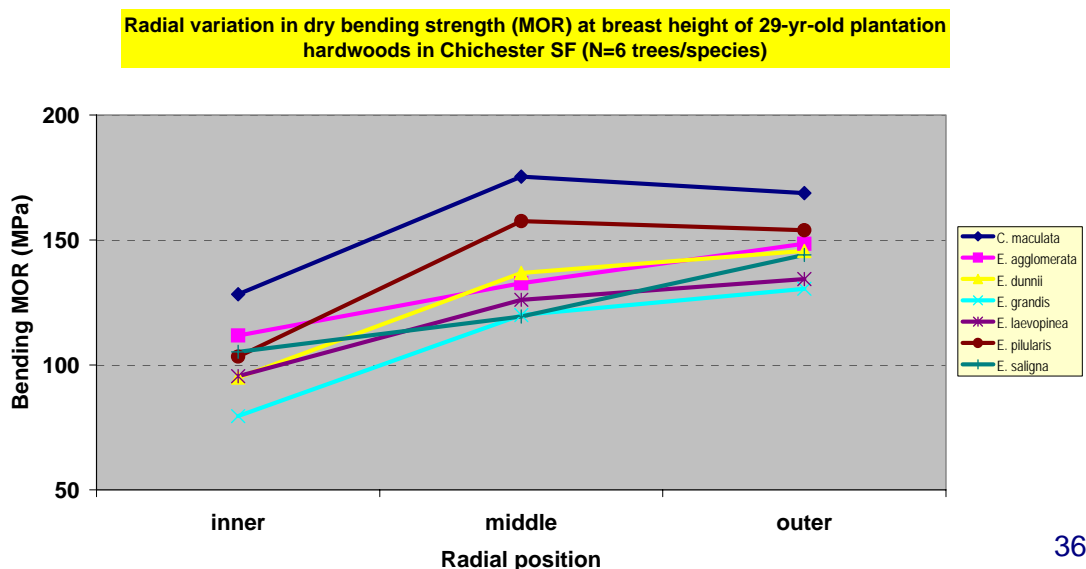
The Director HM200 was a poor predictor of hardness. However, early results from testing of other wood properties showed the Director was an excellent tool for predicting bending stiffness, which is also an important wood quality trait for plantation hardwoods. Results are in the process of being collated and a report prepared.

### Chichester species trial - mill study and wood quality

This species trial provided an excellent opportunity to assess and compare the relative processing values and wood quality of 29-year-old plantation hardwood thinnings from Chichester State Forest in the Hunter Region. The intent was to develop information on the potential of plantation hardwoods for sawn and veneer products. Of interest were Dunn's white gum (*Eucalyptus dunnii*), flooded gum (*E. grandis*), spotted gum (*Corymbia maculata*), Sydney blue gum (*E. saligna*), blackbutt (*E. pilularis*), blue-leaved stringybark (*E. agglomerata*) and silvertop stringybark (*E. laevopinea*). Standing tree measurements included those taken with non-destructive tools (Fakopp and Pilodyn), along with diameter and height. After felling, a section of the butt-log was taken for further wood property assessment in the laboratory, whilst the remaining log was transported to LG Gordon (Coolongolook) and Big River Timbers (Grafton) for sawing and peeling, respectively.

The mill studies were successfully completed and a report comparing the dry recoveries and stumpage values of the various species was prepared for the Marketing Division. The calculated residual stumpage was highest with spotted gum followed by Dunn's white gum and flooded gum and lowest with Sydney blue gum. Interestingly, blackbutt, being an important species in NSW, ranked only fourth. Blue-leaved and silvertop stringybark had similar residual values. Although the residuals derived in this study may vary from those in practice, they could still be useful for determining the relative values of species for site types similar to this trial.

The wood quality component of the study has progressed with testing of wood properties on the dry samples almost completed. Early results indicate that similar to the green wood properties, the dry wood properties at 29 years of age in general were either approaching or comparable to those of mature wood as published in "Wood in Australia" by Keith Bootle. The implication for forest management is that harvesting at this age may not affect structural utilisation. A positive outcome of this work is that the Strength Group for Dunn's white gum could be reclassified to one strength group better than that currently given in the Australian Standard (AS/NZS 2878).



## Water quality monitoring for the Environment Protection Licences

A Webb

State Forests of NSW has been issued with five Environment Protection Licences (EPLs) by the Environment Protection Authority (EPA) 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, State Forests conducts river gauging and water quality monitoring at a number of sites in both native hardwood forests and softwoods plantations.



*Dr Ashley Webb with a turbidity probe in Kangaroo River State forest. Turbidity and stream height are automatically recorded every six minutes*

Photo: Howard Spencer

During 2003/2004 clearfell pine harvesting was completed within the two impact catchments at Canobolas State Forest (Macquarie Region). A soil disturbance audit conducted at the completion of harvesting revealed that 23.9 ha (43.2%) and 22.3 ha (40.3%) of the Canobolas 5 and Canobolas 7 treatment catchments were clearfelled, respectively. Cable harvesting accounted for ~35% and 65% of the harvested area in each catchment, respectively. Total vegetated groundcover over the harvested area was in excess of 80% in both catchments. The degree of soil disturbance was comparatively minor in both catchments. State Forests 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 2003/2004 harvesting commenced within the pine plantation impact catchments at Bago State Forest (Hume 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).

In addition to the EPL water quality monitoring program State Forests maintains a series of independent water quality monitoring stations, as well as a long-term hydrology research program. The hydrology research program was initiated in the 1970s and comprises a series of replicated forest catchments, the most significant being those of the Karuah Hydrology Research Area (KHRA) in Chichester State Forest (Hunter Region).



*Station is used to monitor the integrated effects of harvesting operations within a large pine catchment*



*In small pine catchments flows and water quality are monitored within aluminium flat-v weirs*



*Automatic water samplers are activated to pump samples from each monitored stream as the water level rises and falls during floods and weekly during periods of low flow*

Of the eight native forest catchments in the KHRA, six were harvested in 1983 while two remain untouched as controls. Hardwood plantations were established in some of the harvested catchments while others now comprise native forest regrowth. In the next two years State Forests plans to thin some of the plantation and regrowth catchments. Streamflows and water quality will continue to be monitored pre- and post-thinning to assess any impacts on water yield or quality. This research is important because it will quantify the positive impacts of thinning regrowth and plantations, which is expected to increase the amount of water available for downstream users.

*Data collected at water quality monitoring sites is stored in a multi-channel datalogger*





---

## Forest Health Management

**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*

### Forest health surveillance of softwood plantations

A Carnegie, D Kent

Softwood plantations in all Regions were surveyed from June to September 2003. 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 2003 were:

- Drought-related *Sphaeropsis* damage, more severe in unthinned stands, as per previous years.
- *Essigella californica* numbers and damage was lower than previous years in Hume and elsewhere.
- *Dothistroma* severity was lower than previous years in Northern Region.
- Possum damage was again a significant problem in Monaro Region, although the levels of damage have decreased from previous years.
- Localised areas of boron deficiency on first rotation sites and boron excess in several compartments.
- Mortality from *Armillaria* still a continuing problem at Acacia Plateau (Northern Region).

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 use these 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; control spray for *Dothistroma*.

### Forest health surveillance of hardwood plantations

A Carnegie, D Kent

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 exotic species). 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.



Routine forest health surveys were conducted by the Forest Health Survey Unit (FHSU) during the early part of summer-autumn 2003, using the Crown Damage Index (CDI) for the first time. Time taken to carry out these surveys has increased but we believe the benefit is the more statistically sound nature of the CDI method.

In collaboration with Future Forests Group (FFG) staff, the FHSU set up an Indicator Plantation system, whereby a selection of plantations in defined Zones are assessed regularly by FFG staff using the CDI. The aim of this is to gain more temporal data, since the FHSU is only able to visit a particular plantation on a limited basis. There are a few problems with the new method and work continues to resolve these issues.

In February the FHSU joined with Queensland DPI, Forest Research to survey a selection of plantations in north-eastern NSW and south-eastern Queensland. The aim of this collaboration was to gain a better understanding of the pests and diseases that occur in plantations across the border and identify potentially new and important insects and fungi that may cause damage to our plantations. Several new leaf spot fungi were recorded from Queensland plantations, and these are currently being described.

A creiis psyllid outbreak in autumn-winter 2003 occupied significant FHSU time in addition to regular surveys. An initial aerial survey revealed significant and widespread damage. In conjunction with PhD student Paul Angel, the FHSU devised a monitoring method for creiis and trained FFG staff in its use. The aerial and ground surveys and monitoring were then used to determine where and when to spray. An Emergency Permit to spray for creiis, from both ground and air, was obtained. Approximately 500 ha were sprayed. Control results were variable and depended on tree size and application method. Aerial surveys for creiis were also conducted in April and June 2004, with follow-up ground surveys by FHSU and FFG. Creiis activity was significantly lower in 2004 than 2003, with only localised damage observed in 2004, with spraying conducted on several plantations.

### **Stem borers in eucalypt plantations**

A Carnegie, D Kent and M Horwood

Several 'long-term' trials have been established in commercial plantations to investigate host susceptibility, impact and the change in attack and damage by stem borers in young plantations over time. Several of these were assessed this year and data are being analysed.

A number of tree improvement trials were assessed for stem borer damage in 2004. These data are being analysed. Further trials have been identified for future assessments, including silvicultural and genetic trials, for 2004-2005. A destructive assessment methodology has been developed to determine the frequency of attack by stem borers in the life of a plantation, the extent of this damage and the volume loss attributable to this damage (including stains and decay).

Preliminary analysis of Hardacres Spacing trial has shown that several plots had significantly more damage, although there was wide variation within and between treatments. There seems to be more involved with stem borer attack than just initial stocking and diameter.

## State Forests of NSW insect collection

D Kent

State Forests of NSW maintains a significant collection of Australian forest and forest product insects. The insect collection is a major asset, providing a reliable resource of identified material that has readily accessible information, e.g. distribution and plant host interactions on insect pest species in both plantation and native forests in New South Wales.

The collection provides an important identification service to State Forests of NSW staff, other government agencies (including Australian Quarantine Inspection Service) 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. For the last two years we have successfully attracted \$54,000 of funding for data capture from a Federal government initiative from Plant Health Australia called the Australian Plant Pest Database. This funding has enabled nearly 40% (approximately 20,000 records) of the collection to be electronically captured into the database. Nearly half of the collection 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.

Participation in the Australian Plant Pest Database project has raised the profile of the State Forests Insect collection by joining an Australia wide network of affiliated organisations (i.e. other forestry institutions and Agricultural Departments) seeking to improve access to important information on pest and diseases in Australia

## Clonal eucalypts resistant to pest and diseases

C Stone

Significant differences between eucalypt species, provenances and individual trees in susceptibility to insect attack have long been recognised. 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 planting program. In general, the incorporation of insect-resistant clonal material into plantation stock will reduce the impact of herbivorous insects on tree growth as well as removing any reliance on chemical insecticides and hence reduce the costs of insect pest management.

The Forest Health Survey Unit and Planted Forests Officers continue their vigilance for trees that exhibit some degree of resistance to insect herbivory or disease.

Good progress has been made into the third year of a collaborative Strategic Partnerships with Industry for Research and Training (SPIRT)-funded PhD project (Mr Martin Henery) "Insect resistance traits of *Eucalyptus* for the NSW forest plantation industry". Mr Henery is based at Australian National University and is working towards characterisation of the chemical and physical parameters (eg leaf toughness) of foliage from susceptible and resistant trees undertaking laboratory bioassays and field trials on clonal material propagated from selected resistant trees.

The Tree Improvement Program continues to develop protocols for multiplying clones propagated from the insect-resistant field trees. For example, there are now eight clones that originated from *Eucalyptus dunnii* trees exhibiting partial resistance to the damaging *Creilis* psyllid.

## **Airborne assessment of forest health in pine plantations**

C Stone

In NSW, as elsewhere in Australia, surveillance of pine plantation health has relied on manual ground and aerial surveys and Aerial Photographic Interpretation. The increasing size of State Forest's pine estate makes the annual assessment by the Forest Health Survey Unit a laborious and hence expensive operation. Recent advances in remote sensing technologies and image analysis, however, provide a realistic alternative to the approach taken to assess the health status of pine plantations.

A collaborative State Forests/CSIRO Forests and Forest Products application to Forest and Wood Products Research and Development Corporation (FWPRDC) was successful in securing a total of \$243,400 funding for a project titled "*Application of Multispectral Imagery to the Management of Pine Plantation Condition and Productivity*". Dr Stone was principal investigator. The primary study area was in Carabost State Forest which has a history of being affected by a range of damaging agents of *Pinus radiata* including the two fungal species *Dothistroma* and *Sphaeropsis* and the *Essigella* aphid. A second study site was in the Kangaroo Vale Section of Buccleuch State Forest.

The project was completed in July 2004 and successfully addressed the following three objectives:

1. To identify and define the type of remotely sensed imagery that best defines the structure, condition and physiological status of *Pinus radiata* plantations.
2. To develop algorithms that will automatically classify the imagery into reproducible categories of canopy condition .
3. Demonstrate the potential benefits of integrating this spatial coverage with other environmental and operational GIS modules through a series of visualisation and analytical techniques.

A Handbook that presents the details associated with this project and provides recommendations for the acquisition, processing and modelling of multispectral imagery for this application will be available (after August 2004) as a PDF file on the FWPRDC web site *Remote assessment of pine plantation condition: a handbook describing the use of multi-spectral imagery to measure impacts from three damaging agents of Pinus radiata*.

## **Airborne assessment of native forest dieback in North-East Region**

C. Stone

The overall aim of this project is to identify the specifications of cost-effective imagery that will enable the accurate stratification of canopy condition in native eucalypt forests. More specifically this would contribute to the development of operational guidelines for quantitatively mapping the extent and severity of canopy dieback in native forests within NSW.

The objectives of this project are to:

- i) Acquire digital multispectral airborne imagery of native forests in the Richmond Range area of northern NSW which includes extensive areas affected by the Bell miner-associated dieback syndrome.
- ii) Conduct an analytical study of the imagery to examine the potential of 'scaling up' from high spatial, high-resolution to less expensive operational-based multispectral imagery.

The ground-based program will be undertaken by personal within Department of Environment and Conservation and State Forests. Analysis of the imagery will be done by researchers in the remote sensing unit, CSIRO Forestry and Forest Products and State Forests of NSW.

This collaborative project has just commenced (June 2004). The project has been partially funded by the National Heritage Trust (NHT2) funding process. The original research project was selected by the Northern Rivers Catchment Management Board who forwarded it on for NHT2 funding. An amount of \$50,000 of Federal funding, payable over 12 months, was secured.

### **Soil-applied insecticides for eucalypt plantation establishment**

C Stone

A range of herbivorous insects has been identified as having the potential to significantly affect plantation establishment success and productivity. At present only two chemical insecticides are registered for controlling insects on eucalypts and their effectiveness is determined by the timing of spray application with respect of susceptible life stages of the pest insects being present in the plantation canopy during insecticide application. Frequent monitoring of the plantations is therefore required to identify when to spray. The fragmented nature of the hardwood plantation estate means that the necessary level of intensive monitoring cannot be achieved. In addition, there are difficulties associated with ground-based application for adequate insecticide coverage to a crop that exceeds two meters in height within two years. Also the formal protocols (defined by the National Registration Authority) associated with the aerial application of insecticides to plantations are becoming more demanding and hence more difficult to implement. A long-acting slow-release insecticide would avoid the need to intensive monitoring over the first two years after planting.

Research and Development Division continues to field trial a Bayer, imidacloprid based, soil applied insecticide against a range of insects, including *Creiis*. A State Forests collaborative Strategic Partnerships with Industry for Research and Training (SPIRT) – funded PhD project (Mr Paul Angel), titled “Pest status and management of a *Creiis* psyllid in *Eucalyptus* plantations in northern New South Wales” has provided encouraging data on the long-term efficacy of the imidacloprid.

A series of five large field trials were established in 2003 to test the efficacy of imidacloprid pills applied at planting of either *Eucalyptus dunnii* or *E. grandis* across a range of different site conditions. If this product, when applied in the soil near the seedling at the time of planting, can provide protection and eliminate the need for spray application of insecticides during the first two seasons of plantation establishment then *E. dunnii* and other species known to be susceptible to insect herbivory can remain a species option for the future.

### **National harmonisation of methodologies for the assessment and reporting of crown damage in eucalypt plantations**

C Stone

The issue of developing harmonisation standards is discussed in Stone *et al.* (2003) *Harmonisation of methodologies for the assessment and reporting of forest health in Australia – a starting point*. In this paper the future need for integration of standardised ground-based assessments such as the Crown Damage Index (CDI) with future airborne surveillance data is discussed.

A further outcome, from consultation with forest health experts nationally, was the development of the CDI for use in young eucalypt plantations. This is a simple generic



measure for comparisons of tree crown damage irrespective of plantation location or damaging agent. The assessment methodology for the Crown Damage Index is presented in a Field Manual that also describes a standardised two-stage sampling procedure enabling statistical summaries and scaling up for reporting purposes (see Stone *et al.* (2003) *Pest and Disease Assessment in Young Eucalypt Plantations: Field Manual for Using the Crown Damage Index*). The CDI data can be entered into a *worksheet for data entry* that can be downloaded from the National Forest Inventory web site ([www.Affa.gov.au/nfi](http://www.Affa.gov.au/nfi)).

## Termite and Power Pole Evaluation Research (TAPPER) Project

M Horwood



Termite and decay damage to power poles

Photos: Martin Horwood

Termite damage to wood power poles in NSW costs around \$15 million each year. State Forests of NSW receives approximately \$5 million per annum from sales of power poles. In recent years this market has come under challenge from manufacturers of concrete and steel poles. The main implication of this work is to improve the cost effectiveness and reliability of wood poles relative to concrete and steel by identifying effective and acceptable means to protect poles in service from termite attack and eradicate infestations that have occurred.

Research and Development Division has established a long term trial to examine the effectiveness of existing and experimental methods for eradicating termites from infested poles and protecting new poles from attack. The Electricity Association of NSW and the Forest and Wood Products Research and Development Corporation are providing funding for the project, which will amount to over \$1 million in direct cash and in-kind contributions over the seven year life of the project.

The TAPPER trial was constructed in two parts:

1. The Service Trial is evaluating the performance of termiticidal treatments including toxic dusts, chemical soil barriers and a residual timber fumigant for eradicating termite infestations from infested power poles.
2. The Field Trial is evaluating the performance of termiticidal soil barriers and a physical barrier for protecting new poles from termite attack.

Both parts of the trial focus on protecting poles from *Coptotermes acinaciformis*, in economic terms Australia's most damaging termite species.

There is now up to three years of comparative chemical efficacy data from Service Trial poles, along with data for the longevity of soil residues of chemicals used in the Service and Field Trials.

---

## 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

These 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. However, there is some evidence to suggest that current procedures, which require the retention of important habitat elements and the reservation of riparian forest areas, may be adequate to ensure population recovery for many species within the time-span of a standard logging rotation. Fuel reduction burning, as practised in the dry, heathy forests near Eden, was found to result in very patchy burns that had few or no adverse consequences for most bird species. The numbers of records for some legislated threatened species may now be sufficient to argue for the de-listing of those species from Threatened Species Conservation Act schedules. This may require the development of alternative, but less onerous, management strategies to ensure the recovery and conservation of these species, should they be de-listed.

Several studies were completed, including one about the ecology of the greater glider, a species which is sensitive to intensive logging, and two other studies which reviewed the conservation status of owls, possums and gliders in NSW.

#### ***Home-range of the greater glider *Petauroides volans* in tall montane forest of south-eastern New South Wales, and changes following logging***

Nine greater gliders were radio-tracked intensively for up to 11 months in two areas, one of which was logged five months after the study began. Home-range size for all animals was small (median 1.0 ha) but home-ranges of males were significantly larger than those of females. Home-ranges of males and females overlapped extensively but the home-ranges of same sex individuals did not overlap. The home-ranges of gliders affected by logging were reduced in size and became restricted to the unlogged parts of the pre-logging home-range. One of these gliders was killed when its den tree was logged. There was no evidence of any gliders, including nearby untagged animals, using the heavily-logged areas and there appeared to be no significant movement of gliders into unlogged areas following logging. These data, and those from associated transect counts, indicate that the greater glider is one of the most sensitive mammals to heavy logging (as practised in 1984). Since that time, habitat management prescriptions for this species have evolved and may now be adequate to conserve this species in logged areas.

#### ***Conserving owls in Sydney's urban bushland: current status and requirements***

Distribution records for the seven species of owls, recorded in the Sydney region, made during the past decade have been compared, where possible, with records made since the beginning of the twentieth century.

The powerful owl is widely distributed, albeit at very low population density, throughout the outer suburbs of the greater metropolitan area, particularly where these suburbs adjoin

substantial areas of bushland and reserves. The sooty owl and the masked owl are restricted to a few such locations near Sydney but both are more common in the wetter and the drier forests, respectively, of the central coast. The barking owl appears to be uncommon and of concern because this species is poorly conserved in national parks of the region and its habitat is threatened by continued clearing for agriculture and urban developments. The grass owl appears to be a rare vagrant to the Sydney region. The southern boobook and the barn owl may be common in the region but their distribution and abundance appears to have been under-represented by official records.

The status of all owls is imperfectly known within the most suburban parts of the Sydney metropolitan area and on surrounding semi-rural properties. Efforts are needed to encourage broadscale community participation in voluntary surveys for owls (and several of their main prey species) throughout residential areas. The conservation of owls in the Sydney region depends on the protection of extensive bushland areas from urban and rural development, especially the major forested gully systems which provide essential nesting, roosting and core foraging habitat for most species. The role of fire frequency and weed control in Sydney's urban bushland needs to be examined in terms of its impact on populations of the common ringtail possum, and other important prey species of the owls.

### **Distribution and conservation status of possums and gliders in New South Wales**

Eleven species of possum and glider from five families occur in New South Wales. The mountain pygmy possum (*Burramys parvus*) is the most threatened possum in NSW due to its limited range, small population size, terrestrial habit and the threat posed by climate change which has the potential to significantly alter its habitat within several decades. The other ten species are primarily, or exclusively, arboreal in habit and this has enabled them to escape the widespread destruction of habitat caused by grazing by introduced herbivores and the major depredation of introduced carnivores that has so severely afflicted many small terrestrial mammal species in NSW. Instead, widespread tree clearing for primary production and urban developments has been, and remains, the major threatening process affecting most species. National parks and nature reserves have recently been substantially increased in size and extent, such that they now cover almost the entire length of the forested Great Dividing Range from Queensland to the Victorian border and include many forested areas near the coast. This reserve system is complemented on other public forest lands by the routine application of conservation protocols intended to protect habitat for possums and gliders during logging operations. These two measures are likely to ensure the security of most species in NSW. The squirrel glider (*Petaurus norfolcensis*) may require additional conservation attention because its habitat appears to occur primarily outside of public forest lands. Further work is required to develop and support incentive schemes to protect and create habitat for possums and gliders on privately-owned lands.

Over the past decade, there has been an enormous increase in the number of survey records for most species (see below). The data indicate continued occupancy by most species throughout their previously known ranges, although little information is available about changes in species abundance. The legislated status of the yellow-bellied glider (*Petaurus australis*) is in need of review, given the large increase in records for this species and the extent to which threatening processes acting on it have been controlled. The most urgent research needs are the establishment of an appropriate baseline for species population density across a range of land tenures and geographical locations, including within conservation reserves and to regularly monitor changes in species abundance. This information is needed to assess whether species status is stable, increasing or in decline, and to provide early warning of unforeseen threatening processes requiring further research.

## Numbers of records of possums and gliders in NSW



Yellow-bellied gliders sap-feeding

Photo: Ross Sigley

Species	NSW National Parks & Wildlife Service	State Forests of NSW	Australian Museum	Total
Greater glider	4025	2417	280	6722
Common ringtail possum	3098	384	232	3714
Yellow-bellied glider	2136	3811	24	5971
Squirrel glider	700	127	142	969
Sugar glider	2634	1824	304	4762
Feathertail glider	435	73	258	766
Eastern pygmy possum	285	16	67	368
Western pygmy possum	115	0	2	117
Mountain pygmy possum	33	0	7	40
Mountain brushtail possum	751	91	54	896
Common brushtail possum	3305	862	207	4374

**Source:** NSW National Parks and Wildlife Service Wildlife Atlas (May 2003)  
State Forests of NSW Fauna Database (September 2003)  
Australian Museum Fauna Database (September 2003)

## Response to disturbance

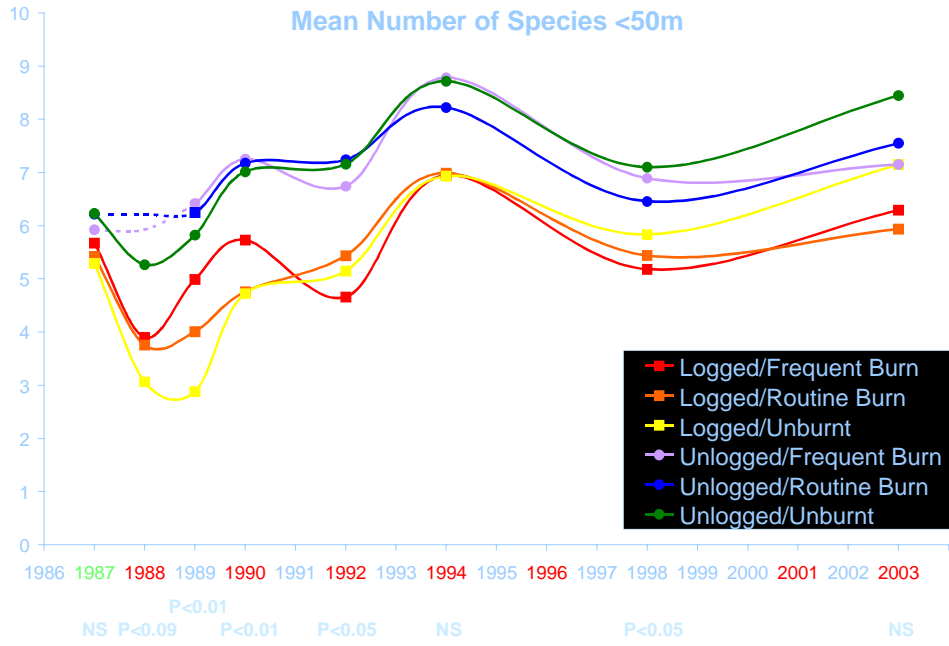
R Kavanagh

### *Effects of logging and repeated fuel reduction burning on birds in dry sclerophyll forest near Eden*

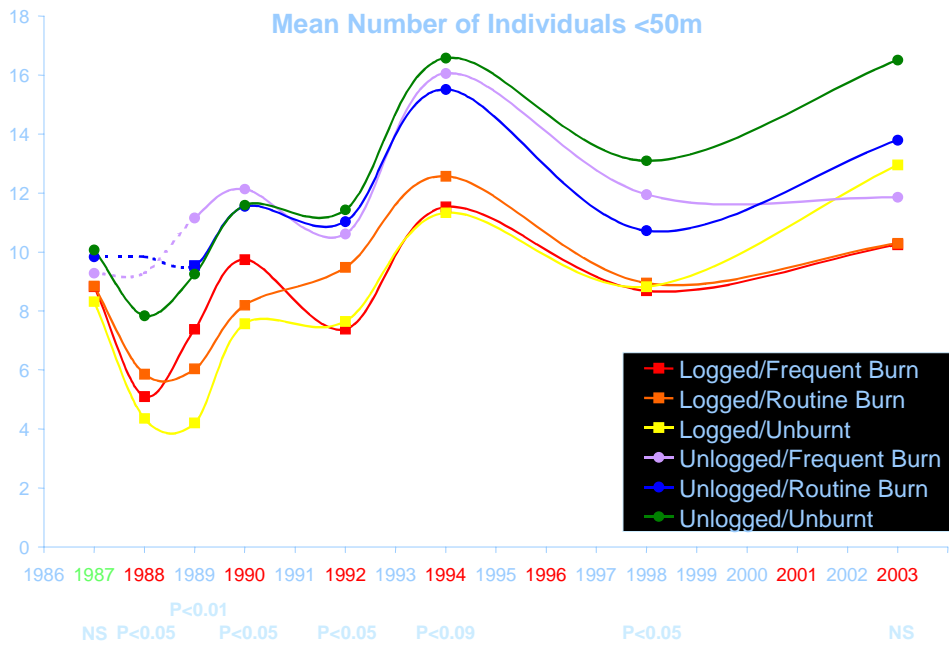
Fuel-reduction burning is a standard management practice in the forests of south-eastern Australia, yet little information is available about the effects on fauna of repeated burning and no published studies have reported the interactions between logging and fuel-reduction burning on fauna. Birds were re-sampled in 2003 in the Eden Burning Study using the same systematic methods as used in previous years. Approximately 56,000 birds from 109 species were recorded during 1987-2003 in a commercial-scale experiment involving 18 forest blocks (three replicates of six treatments: two levels of logging and three levels of burning frequency).

Logging (approximately 33% retention of the original tree basal area) caused the main impact in this study. The mean number of species and the mean number of individuals was greater on all unlogged treatments than on the logged treatments, whether burnt or unburnt, and remained so for up to 11 years after logging (see below). Burning had little effect on bird numbers, other than the temporary influx of open-country species (also found following logging), and increasing fire frequency had little or no discernible adverse effect on overall counts. Individual species displayed a wide range of responses to treatments, although few species showed lasting adverse responses to logging and/or burning. This was attributed to the spatial heterogeneity characteristic of modern logging and burning operations.





Mean number of bird species recorded in each logging and burning treatment from 1987-2003



Mean number of birds recorded in each logging and burning treatment from 1987-2003

**Effects of logging and repeated fuel reduction burning on small ground mammals in dry sclerophyll forest near Eden**

Small (<5 kg) ground mammals were also re-sampled in 2004 in the Eden Burning Study using the same systematic methods as used in previous years. Progress results of this project are still being compiled, but of interest was the occurrence of records in all treatment types for the threatened southern brown bandicoot *Isoodon obesulus*.

## **Bird population recovery 22 years after intensive logging near Eden**

Birds were re-sampled in 2003 in the Banksia Road Small Coupe Logging Study near Eden using the same systematic methods as used in previous years. This study now incorporates three treatments (logged in 1976, logged in 2001, unlogged) following the logging in 2001 of half of the previously unlogged coupes.

Intensive logging for sawlogs and woodchips in south-eastern Australia is known to cause an immediate impact on bird populations. We measured bird abundance and species turnover during the medium term (13 and 22 years) after intensive alternate-coupe logging in a forest area that had been studied previously for short term (zero to four years) impacts. The study provides a series of snapshots of bird population recovery following one of the most intensive logging operations in the region when, unlike the current practice, no old trees were retained in logged areas and no unlogged forest was retained in strips along all drainage lines. The aim was to assess the longer term effects of logging on the bird assemblage and to determine whether recovery had occurred.

We found that recovery had occurred for a large component of the avifauna within 22 years of intensive logging (as practised in 1976 when few or no old trees were retained in logged areas). Most bird species that forage among canopy foliage, in the air, among the understorey and on the ground had recovered. Five common forest birds were significantly more common on logged coupes than unlogged coupes. The bell miner *Manorina melanophrys*, a honeyeater often associated with disturbed forest and implicated in eucalypt canopy dieback, had established colonies on some logged coupes 22 years after intensive logging. However, some hollow nesting bird species (e.g. treecreepers, cockatoos) had still not fully recovered. A number of other common forest birds occurred so rarely in the study area (on both logged and unlogged coupes) that few conclusions could be made about their responses to logging. Evidence suggested that intensive logging may have had an effect at a local landscape (compartment) level as well as at the level of individual logged coupes. This was indicated by changes to the avifauna of the *unlogged* coupes over time (increasing numbers of species) as the forest regenerated on the adjacent logged coupes.

### **Indicators of ecological sustainability in managed forests**

R Kavanagh

There is a clear need, and requirement, for forest managers to begin systematic monitoring programmes for populations of selected representative species to provide confirmation that their actions are having the desired effect (i.e. maintenance of ecological sustainability in managed forests). In conjunction with routine monitoring (via remote-sensing) of broad habitat surrogates, this study has shown that it is possible to select representative species from a range of functional groups that will serve as useful indicators of sustainable forest management.

This study, which was a collaborative effort involving researchers from five State and Commonwealth agencies, investigated the feasibility of developing a practical, sensitive and cost-effective approach to the implementation of Montreal Process Indicator 1.2c for monitoring populations of representative species for forest management. Representative species include those for which a significant change in population level has a high likelihood of indicating a significant change in populations of other species. This focus on populations of individual species, in addition to habitat surrogates (as used in other indicators), is needed because managers require confirmation that their actions are having the desired effect and because factors other than habitat availability may interact to account for the size of populations.

The project included literature reviews identifying species (vertebrates, invertebrates and vascular plants) known to be, or potentially, sensitive to logging in south-eastern Australia,

and reviews of the potential for species and functional groups to serve as bioindicators in monitoring programmes. The study also categorised plant and animal species according to their known or suspected sensitivity to logging. Using large retrospective (space-for-time) datasets from Queensland, New South Wales, Victoria and Tasmania, the study analysed correlations between species across a wide range of taxa, and the frequencies of occurrence or abundance of species in relation to logging intensity or time since logging. Principles for consideration in the design of monitoring programmes were proposed and discussed, and a new method (videography) for remotely-sensing habitat (forest structure) attributes important for ground-dwelling mammals (and potentially other fauna) was demonstrated.

The task now is for regional managers to meet with conservation biologists and other stakeholders and, guided by the results of our studies and those of other retrospective and experimental studies, determine a set of key species or groups to monitor and where this monitoring should take place, over the longer term, in each region.

### ***Student supervision***

Dr Brendan Wintle from the University of Melbourne was awarded his PhD after submitting his thesis “Dealing with uncertainty in wildlife habitat models”. Sally Radford and Natasha Schedvin, from Southern Cross University (koala study) and Charles Sturt University (barking owl study) respectively, are currently writing their PhD theses.

### **Wildlife in eucalypt plantings**

R Kavanagh, B Law and F Lemckert

Little is known about the biodiversity that occurs in eucalypt plantations, on either the coast or west of the Divide, how this changes with time, and whether eucalypt plantings can augment the wildlife carrying capacity of nearby remnant vegetation. Our research is providing this information. Knowledge of changes to biodiversity will be useful to management when harvest plans are prepared, particularly in relation to threatened species. Also, research into biodiversity in plantations will provide the information necessary to aid the expansion of new business areas for State Forests in planting trees for commercial timber, salinity, carbon or purely for biodiversity. One example is feeding the new information into development of the NSW Environmental Services Scheme.

### ***Biodiversity in eucalypt plantings established to reduce salinity***

Most of the original forest and woodland cover on the western slopes of NSW and the northern plains of Victoria has been cleared for agriculture (wheat, sheep and cattle), and what remains is highly fragmented and modified by a long history of grazing and cutting for fenceposts and firewood. Extensive revegetation efforts for environmental benefits including land rehabilitation, salinity reduction and habitat restoration, as well as for improved landscape amenity and wood production, have been occurring in the Albury-Wodonga region over the past three decades. These plantings of native trees and shrubs have the potential to greatly improve the quality of the habitat matrix surrounding existing remnants of forest and woodland for a wide range of fauna, and to increase the carrying capacity of the habitat within remnants.

To guide future planting schemes for restoring biological diversity, we sampled 120 sites for birds, bats, arboreal marsupials, terrestrial mammals, reptiles and amphibians. These sites encompassed the range of available patch sizes, stand ages, floristic and structural conditions, and habitat attributes for revegetated areas, and remnants, in the region and we compared these to nearby paddocks. We also sampled birds and bats in March-April 2004 at another 16 planted sites to further consider the influence of proximity of the revegetated areas to remnants and the broader landscape context. The aim of the study was to determine the extent to which eucalypt plantings could assist farmers and regional

conservation planners to improve biological diversity in agricultural landscapes in south-eastern Australia and to identify the variables which may influence their effectiveness.

Eucalypt plantings were found to provide significant improvements in biodiversity compared to cleared or sparsely-treed paddocks, but the different fauna displayed a range of responses. Indeed, mixed eucalypt and shrub plantings contained similar numbers of birds and bats as did remnant native forest and woodland in the region. Birds and bats made the most extensive use of plantings, particularly favouring the older (> 10 years) age class. Birds showed a strong effect of patch size, with both larger eucalypt plantings and larger remnants having more species and more individuals than smaller patches of these vegetation types. Even young (<10 years old) plantings were occupied by many birds, once patch sizes were larger than 5 ha. Bats were widespread throughout all vegetation types sampled (planted areas, remnants and paddocks), although they were more common in remnant vegetation. Remnant forest and woodland was also most important for arboreal mammals and nocturnal birds, and reptiles, but the oldest (>20 years) plantings were also contributing to the habitat of these species.



*Twenty-five-year-old mixed species eucalypt plantings near Albury Wodonga. Pitfall traps for reptiles shown in the foreground.*

Photo: Tracey Brassil

Younger plantings and cleared or sparsely-treed areas provided little habitat for these species, and no reptiles were recorded in paddocks. Ground mammals were virtually absent from the region, presumably due to the widespread and long-term impacts of grazing and the abundance of introduced predators.

Plantings of native trees and shrubs of all shapes and sizes, especially those larger than 5 ha, have an important role to play in providing habitat for many species. These plantings may also contribute significantly to increasing the effective size of remnants in agricultural landscapes. Young plantings of native vegetation are used by more species of woodland-dependent birds if they are situated in landscapes having greater amounts of remnant forest and woodland.

### ***Wildlife in north coast commercial eucalypt plantations***

This project has been tracking changes in biodiversity at three large case study areas (Kungurrabar, Fletchers and Boyles) beginning at the pre-plantation stage in 1997 when sites were cleared farmland with scattered remnant vegetation. A re-survey of all sites was undertaken in spring 2003, coinciding with plantation trees being five years old. The data are yet to be analysed but the observations during our field-work suggest that biodiversity levels were increasing since plantation establishment. Some interesting observations include an apparent increase in numbers of the rufous bettong at Kungurrabah, a decline in noisy miners across all plantation areas, which appears to have coincided with an increase in small insectivorous birds, the use of plantation trees as a nectar resource by two threatened species (squirrel glider and grey-headed flying fox) and little change in small mammal numbers, possibly due to the effects of continued cattle grazing, which keeps ground cover to a minimum.





*A squirrel glider, listed as Vulnerable on the NSW Threatened Species Act 1995, feeding on flowers of a five-year-old blackbutt plantation tree, Urbenville, NSW*

*Photo: Alison Towerton*

## **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. Improved tools have been produced for surveying bats, such as guides to identifying calls and monitoring bats over time, including the use of banding or 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 have been used in annual Environmental Audit Reports.

## Response to disturbance

B Law

### *Bats in the Karuah research area*

A sixth consecutive year of banding bats was conducted in March 2004, with 75 banded and 39 recaptured from previous years. The study will provide the first estimates of bat population sizes and survival rates in forests, which we will be able to compare between regrowth and unlogged catchments. To maximise the precision of our estimates, data will continue to be collected for this comparison 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.



*A Gould's long-eared bat Nyctophilus gouldi banded at Karuah Hydrology Research catchments*

*Photo: Brad Law*

### *Buffer protection of bat roosts in mines*

Initiated in 2002, the project aims to test the effectiveness of the mine buffer exclusion by measuring microclimate in replicate mines before and after logging. The prescription arose out of concern from some bat biologists that logging could affect ground hydrology, air flow near mine entrances and penetration of solar radiation to the ground above mines, all of which potentially influence internal microclimate. Data are being collected over four seasons (12 months) prior to logging and for up to three years post-logging. With the assistance of Regional Ecologists, data-loggers have been placed in five mines that have been logged and eight control mines. Data have been collected from the first 12 months after logging and will continue to be collected to look for any long-term changes. Additional mines may be incorporated into the project if they become available.

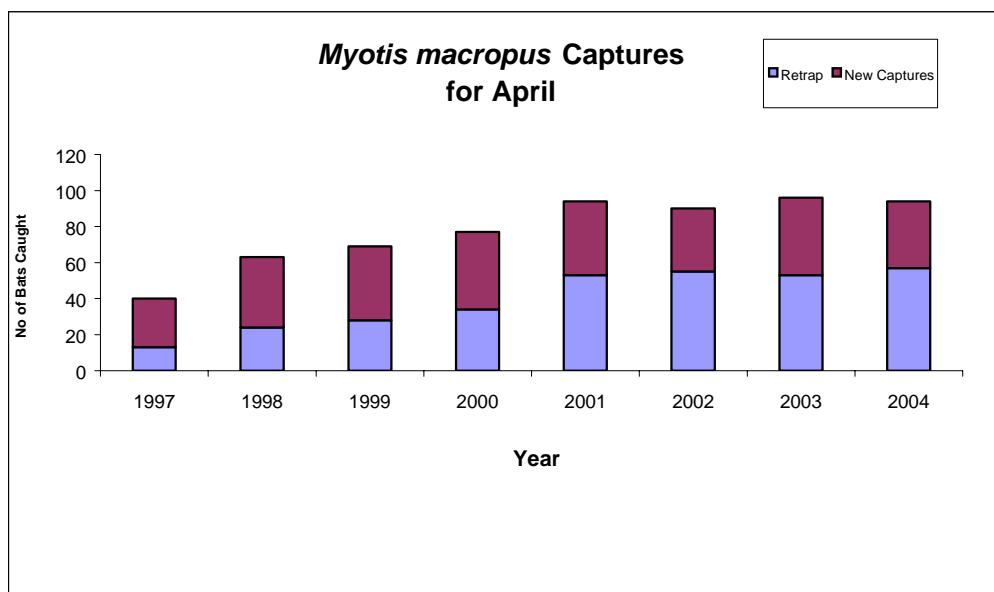
### *Student supervision*

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. Supervision was completed for three other projects - Anna Lloyd received first class Honours for investigating the importance of riparian areas for foraging bats, Chris Slade received his Masters of Natural Resources for investigating the effect of gating derelict mines on bats and

Craig Grabham submitted his Honours thesis on investigating the use of revegetated areas by bats near Albury.

### Monitoring of bats

The large-footed myotis, a water-way dependent bat, was banded for the eighth consecutive year at Kerewong State Forest. Data collection covers before and after logging. Ninety-four individuals, including 57 recaptures, were caught in 2004. This number is almost identical to that caught in recent years, indicating that after an early increase in population size, the number of bats has remained stable, despite the fact that logging occurred in surrounding catchments from 2000 to 2003. These results continue to provide support for the effectiveness of riparian buffers in mitigating any potential short term effects of logging. Of particular interest was the high number of bats caught in our last two samples, which followed the first severe El Nino event experienced in the study. This suggests some flexibility in the bat's foraging strategy to cope with dry conditions.



At a cave in Ourimbah on the central coast (the largest known roost of Horseshoe bats in Australia), about 6,500 bats were counted as they exited their cave in January 2004. 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) gave a final count of 15,600. 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 State Forests to track the changing status of these bats and especially to assess changes due to forest management practices imposed on the surrounding environment.

External funding was received to use Research and Development's infra-red gate to count the maternity population of the eastern bent-wing bat *Miniopterus schreibersii* at Bungonia Caves for Department of Environment and Conservation (DEC). These bats breed at just four caves in NSW, so obtaining reliable and repeatable counts is critical for monitoring their conservation status. A summer (2003/04) count of the breeding population of these bats was estimated at 20,500 bats.

### Improved tools for surveying bats

A guide to the regional identification of bat calls in NSW was completed in 2004. The use of ultrasonic detectors is an integral component of any adequate survey for bats. This



technique allows bat species to be identified by their calls. However, the use of bat detectors has been hampered by inadequate call reference libraries for identifying species and a lack of guides that describe call characteristics and regional variation. This project was a collaborative effort with DEC, with the resulting guide being posted on both Department's web-sites. An integral part of this project was the collation of an extensive library of over 1,000 reference calls from across NSW, which can also be directly downloaded from the internet.

### **Effect of logging on nectar production in eucalypts**

**B Law**

Outcomes from measuring eucalypt nectar in logged forests will have relevance for managing the nectar resource for both native wildlife and beekeepers using State Forests.



*Using a cherry-picker to access the forest canopy for nectar measurements in southern New South Wales*

Photo: Brad Law

This project, supported with funding from the Honey Board (Rural Industries Research and Development Corporation), 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.

A severe drought year and recent bushfires resulted in extremely poor flowering during 2003/04. Limited measurements at a sub-set of sites were made on grey ironbark in Nowra and Currumbene State Forests on the south coast. For this species, both nectar production and standing crops were measured. Standing crops were almost zero, even at dawn, indicating pollinators depleted nectar as fast as it was produced.

Bagged flowers produced much more nectar and like spotted gum, production per flower was not related to tree size. However, large trees produced many more flowers than smaller trees, resulting in greater overall sugar standing crops. Our estimates of nectar produced per hectare, found that one site clearly stood out with the most sugar produced. This was a stand of old regrowth that was thinned in the year prior to our measurements – it was probably the best flowering stand that we found. Conclusions are not yet possible about differences in sugar production at the stand level, because flowering across the forest was poor.

### **Nectar maps for flying foxes**

**B Law**

This new project 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. This project is fully funded by Department of



Environment and Conservation for a collaborative role in preparing digital maps of the distribution of flying fox food (ie nectar and fruit). The project's outcome will have relevance to State Forests in that it will identify areas that provide food for flying foxes during annual bottleneck periods and thus areas which are most sensitive to the species. State Forests will provide expertise on flying foxes (B. Law) and GIS support for the preparation of nectar maps. In 2003/04 dietary lists were collated and data-layers of vegetation types were reviewed across the full range of the species distribution (including Victoria and south-east Queensland).

### **Ecology of pygmy possums in managed forests**

**B Law**

This project is investigating the ecology of the eastern pygmy possum as it has also recently been listed as a threatened species. Little is known about its ecology in forests and State Forests have little knowledge on which to base prescriptions for the species. The project is taking advantage of recent captures near Eden and is collaborating with this Region to obtain data to better inform management. In 2004, three pygmy possums were radio-tracked by Trent Penman in association with Chris Slade (both based at Eden). Data collection focused on identifying the diurnal dens of the animals and identifying parts of the landscape regularly used by pygmy possums (eg riparian vs ridge habitat). Hollows in trees (especially bloodwoods) but sometimes exposed stumps were the primary retreats for this species. This stage of the project was treated as a pilot study to investigate the success of radio-tracking in the forest. The expectation is that a greater sample of animals will be radio-tracked in the coming year, with an additional focus of identifying foraging areas at night.

### **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 standard set of protective prescriptions adequately cover all species. Stream side buffer strips remain as very important components of the strategy to ameliorate the impacts of logging on frogs, by protecting 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.

### ***Student supervision***

A PhD student with the University of Newcastle (Trent Penman) is completing his work on the giant burrowing frog near Eden. He has developed a bioclimatic model of its range within the region and is developing a GIS based model, both of which will be available to guide future surveys. Fine detail in habitat requirements is being produced through a paper on radio-tracking movements of these frogs.

Another PhD student, Harko Werkman (University of Newcastle) has almost completed his study into the impacts of logging on some stream breeding frogs. He has a large data set on growth and survivorship of frogs on streams of differing disturbance histories which will enable him to determine if there are differences in population structures at the different sites that match with the known impacts. Final analysis of this data will be by the end of August 2004.

The PhD study of Mark Fitzgerald on the ecology and management of Stephen's banded snake has been completed and accepted. Two additional papers have been published and a further one is in review. The indications are that current habitat tree retention is usually quite good for this snake. The long-term recruitment of habitat trees is a major issue to address and data is being collected to see how well this is likely to be achieved.

A PhD student at the University of Wollongong, Beth Mott, is being assisted with advice on fauna occurring within plantations near Wauchope. She is assessing the differences in fauna at young and older plantations and in native forest and trying to determine why these differences 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 limited habitat.

## **Pond requirements of frogs and effects of disturbance on frogs**

**F Lemckert**

This work is investigating possible development of fire-fighting ponds that also maximise frog breeding habitat value. At the same time it will provide a better understanding of fire impacts on frogs. It will also deliver a set of parameters for undertaking frog surveys that will reduce the number of non-productive surveys. New survey methodology will ensure that more robust data can be collected on our frog populations and their response to disturbance.



*New pond - Traeey Brassil showing scale - Olney State Forest*  
Photo: Frank Lemckert

Data have been collected on the attributes of 45 ponds in the Watagans (Central Coast) 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. Different factors are important to different individual species in their pond requirements and abundance. Larger more complex ponds are, overall, likely to be better as frog breeding habitat but rare species need specific attributes of a pond before they will use it. This may exclude many other species from using the pond.

Over 100 frogs have been micro-chipped for long-term monitoring of population size, health and mortality.

Thirty-two new ponds have now been constructed in the same general forest area and these are being monitored to determine colonisation rates and to test predictions of species that will colonise them. Half of these sites are proposed to be disturbed with fire to see how this changes the frog communities present at them.



*Established spring-filled pond with vegetation, Olney State Forest*

Photo: Frank Lemckert

## **Green-thighed frog monitoring program for the Roads and Traffic Authority**

F Lemckert

Occasional advice has been sought by the Roads and Traffic Authority over the last year and an additional survey for green-thighed frogs in Nerong was undertaken at their request. This was to fulfil requirements for licensing of the Karuah-Bulahdelah upgrade and were requested 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. This species appears to be relatively robust to disturbances posed by the installation of unsealed roads. Roothing, therefore, is unlikely to be a problem within State Forests.

## **Wildlife Schools**

F Lemckert and R Kavanagh

Wildlife Schools continue to provide training to staff to carry out pre-logging survey programs as efficiently as possible. The schools also engender better communications and understanding between State Forests and other agencies regarding current forest practices and management knowledge.

One mammal and nocturnal bird course was run during the year. This was held at Eden in June and was led by Rod Kavanagh, with assistance from Matthew Stanton, Chris Slade and Jim Shields. The course was attended by staff from State Forests of NSW, from the Federal Department of Environment and Heritage and staff from private environmental consultancies. The course was highly successful in locating rare fauna of interest and in demonstrating appropriate methods for their detection and field identification in surveys.



## 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	R&DD 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
Comparative water use by different vegetation types	NSW Agriculture	Mr Rick Young	Dr Craig Barton	Ms Melanie Zeppel PhD student
Assessment of the potential of <i>Pinus radiata</i> for ecological restoration of the Yangtse 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	
Thinning responses of regrowth <i>Eucalyptus seibergii</i>	CSIRO Forestry and Forest Products Natural Resources and Environment, Victoria	Mr Mike Connell Ms Fiona Hamilton Dr Yue Wang	Dr Huiquan Bi	
Modelling spatial variation in tree diameter-height relationships	Faculty of Forest and Natural Resources Management, State University of New York, USA	Professor Lianjun Zhang Mr Pengfei Cheng Professor Craig Davis	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	
Stem degrade in eucalypt plantations	Queensland Forestry Research Institute	Dr Simon Lawson	Dr Angus Carnegie Dr Deborah Kent	
Assessment of the causality of <i>Essigella</i> -ascribed defoliation of mid-rotation <i>Radiata pine</i> and its national impact in terms of cost of lost wood production	CSIRO Forestry and Forest Products CSIRO Entomology Forestry SA Hancocks Auspine Green Triangle Forest Products Sidewind Tree Injectors	Dr Clive Carlyle Dr Barrie May Dr Paul DeBarro Dr Chalma Phillips Mr Steven Elms Mr Phill Loyd Mr Andrew Moore Mr Geoff Elderidge	Dr Angus Carnegie	
Dynamics of mixed species plantations	Australian National University	Professor Jürgen Bauhus	Dr Annette Cowie	Mr David Forrester PhD student
Greenhouse gas balances of bioenergy systems	CRC Greenhouse Accounting Bureau of Rural Sciences IEA Bioenergy Joanneum Research, Austria Bioenergy Australia	Ms Holly Ainslie Dr Bernhard Schlamadinger Dr Stephen Schuck	Dr Annette Cowie	
Log segregation for structural timber	Weyerhaeuser, Tumut	Mr Peter Stiles	Dr Ross Dickson	



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 – determination of total above-ground biomass at three sites	State Forests of New South Wales Australian Greenhouse Office	Mr Ian Barnes Dr Gary Richards	Mr David Gardner	
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 – development of TimberCAM	Australian National University/CRC for Greenhouse Accounting	Dr Stephen Roxburgh	Mr David Gardner	
Life cycle analysis of wood products – sawmill conversion studies of spotted gum	Batemans Bay Timbers	Mr Richard Harris	Mr David Gardner	
Life cycle analysis of wood products – decomposition of wood products in landfill	Australian Greenhouse Office	Ms Alice Akrill	Mr David Gardner	
<i>Eucalyptus dunnii</i> genetic trial in Boambee State Forest	Australian Centre for International Agricultural Research - <ul style="list-style-type: none"> <li>▪ University of Canterbury, New Zealand</li> <li>▪ Southern Cross University, Lismore</li> <li>▪ CSIRO</li> <li>▪ Oji Paper</li> </ul>	Professor John Walker Mr Frank Ripton-Turner Dr Russell Washusen Dr Allie Muneri		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 - <ul style="list-style-type: none"> <li>▪ Department of Forestry, Australian National University</li> <li>▪ CSIRO Forestry &amp; Forest Products</li> <li>▪ CSIR, South Africa</li> <li>▪ Department of Forest Science, University of Stellenbosch</li> </ul>	Professor Peter Kanowski Dr Chris Harwood Dr Steve Verryn Professor Gerrit van Wyk		Mr Michael Henson
Transforming sawnwood properties of plantation-grown <i>Eucalyptus dunnii</i> (Dunn's white gum)	Southern Cross University	Dr Jerome Vanclay	Mr Michael Henson	
Genetic variation in wood properties of <i>Eucalyptus dunnii</i> relevant to solid-wood properties	CSIRO Forestry and Forest Products	Dr Chris Harwood	Mr Michael Henson	
ALRTIG genetic gain trials (low rainfall eucalypt species) - Phase II	Australian Low Rainfall Tree Improvement Group	Ms Brioni Brammall	Mr Michael Henson	
Identifying optimal treatments for termite infested power poles	EnergyAustralia INTEGRAL energy countryenergy	Mr Terry Westlake Mr Martin Healey Mr Ray Worboys	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	Preschem Pty Ltd INTEGRAL energy	Mr Chris McEvoy Mr Martin Healey	Mr Martin Horwood	
Wood quality of <i>Eucalyptus grandis</i> focusing on hardness	J Notaras and Sons, Grafton	Mr Brunos Notaras Mr Spiros Notaras	Mr Bill Joe	
Chichester species trial - mill study and wood quality	LG Gordon, Coolongolook Big River Timbers, Grafton Queensland Forest Research Institute	Mr Leo Gordon Mr Stuart Austin Mr Matt Armstrong	Mr Bill Joe	
Peeling studies	Norply, Kyogle Big River Timbers, Grafton	Mr Frank Ripton-Turner Mr Stuart Austin	Mr Bill Joe	
Identification of species and functional groups that give early warning of major environmental change	Parks & Wildlife Service, Qld Department of Sustainability and Environment, Vic Forestry Tasmania CSIRO Department of Wildlife and Ecology	Dr Geoffrey Smith Mr Richard Loyn  Dr Robert Taylor Dr Peter Catling	Dr Rod Kavanagh	
Monitoring biological diversity as indicators of sustainable forest management	Melbourne University  NSW 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 ( <i>Phascolarctos cinereus</i> ) 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
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 ( <i>Kaohona</i> spp.) from <i>Eucalyptus</i>	NSW Agriculture, Orange	Dr Murray Fletcher	Dr Deborah Kent	

Characterisation of <i>Kahaono</i> leafhopper (Hemiptera) silk	University of Sydney NSW Agriculture, Orange	A/Professor Geoff Gurr Professor Robert Gilbert Dr Murray Fletcher	Dr Deborah Kent	Mr Jung-Chi Chang MSc student
Studies of the life cycle, host susceptibility and distribution of <i>Thaumastocoris australicus</i> attacking urban trees in Sydney	University of Sydney	Professor Harley Rose	Dr Deborah Kent	Ms Annie Noack PhD student
Vertical stratification of bats and insects in regrowth forests	University of Wollongong	A/Professor Kris French	Dr Brad Law	Ms Maria Adams PhD student
Bats in areas of revegetation	Charles Sturt University	Dr Nick Klomp	Dr Brad Law	Mr Craig Grabham Honours student
The importance of riparian areas for foraging bats	Southern Cross University	Dr Ross Goldingay	Dr Brad Law	Ms Anna Lloyd Honours student
The effect of gating derelict mines on bats	University of New England	Professor Peter Jarman	Dr Brad Law	Mr Chris Slade Masters 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	
Estimating maternity population size for the eastern bent-wing bat at Bungonia Caves	Dept of Environment and Conservation	Mr Phil Craven	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
The use of LIDAR to estimate aboveground biomass of <i>Eucalyptus pilularis</i>	University of New South Wales	A/Professor Tony Milne	Dr Kelvin Montagu	Mr Russell Turner PhD student
Eucalypt wood density under water limitation	University of Western Sydney	A/Professor Jann Conroy	Dr Kelvin Montagu	Mr Matt Searson PhD student
Developmental processes controlling wood density under different environments	University of Western Sydney	Dr Dane Thomas	Dr Kelvin Montagu	ARC – SPIRT grant
Carbon sequestration predictor for land use change in inland areas of New South Wales	Department of Infrastructure, Planning and Natural Resources	Dr Andrew Rawson Dr Brian Wilson	Dr Kelvin Montagu	
Carbon sequestration predictor for land use change in inland areas of New South Wales	Agroforestry Unit, NSW Agriculture	Mr Brendan George	Dr Kelvin Montagu	

<i>Pinus radiata</i> 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 <i>Eucalyptus populnea</i> 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 <i>Pinus radiata</i> plantations	CSIRO, Plant Industries, Canberra	Dr LanBin Guo Dr RM Gifford	Dr Kelvin Montagu Dr Ayalsew Zerihun Dr Annette Cowie	
Carbon in forests	Forest Products Commission, Western Australia	Mr Peter Ritson	Dr Kelvin Montagu	
Molecular studies of mundulla yellows in eucalypts	University of Adelaide	Dr Dagmar Hanold	Mr Jack Simpson	
Studies of the genus <i>Quambalaria</i>	CSIRO Forest 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 <i>Corymbia citriodora</i> , <i>Eucalyptus dunnii</i> , <i>E. pilularis</i> and <i>E. cloeziana</i>	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	Mr Phil Alcorn PhD student
Clonal seed orchard of <i>Eucalyptus dunnii</i>	CSIRO Forestry & Forest Products	Dr Chris Harwood	Ms Helen Smith	
Airborne assessment of forest health in pine plantations	CSIRO Forestry & Forest Products School of Geosciences, University of Wollongong	Dr Nicholas Coops Dr Ken Old Dr Darius Culvenor Dr Laurie Chisholm	Dr Christine Stone	
Eucalypt biological agent resistant clones - insect resistance traits of <i>Eucalyptus</i> 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 <i>Creis</i> psyllid in <i>Eucalyptus</i> plantations in northern New South Wales	School of Environmental Science and Management, Southern Cross University	Dr Doland Nicholas	Dr Christine Stone	Mr Paul Angel PhD student



Risk mapping and remote sensing of <i>Mycosphaerella</i> 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 National Parks and Wildlife Service CSIRO Forestry and Forest Products	Mr John Hunter Dr Neil Sims	Dr Christine Stone	
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 and 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 State Forests' staff of the pursuit of *bona fide* scientific research into the forest ecosystems managed by State Forests of NSW. During 2003/2004 State Forests supported 111 Permits.

Principal	Organisation	Title of Activity
Adams, Ms Maria	University of Wollongong, NSW	Vertical stratification of bats and insects in harvested forests
Andren, Mr Michael	National Parks & Wildlife Service, Coffs Harbour, NSW	Nandewar Western Regional Assessment (NPWS Component)
Archer, Prof Michael	Australian Museum, NSW	Collection, survey and systematics of fish, birds, mammals, reptiles and amphibians, and vertebrate faunal surveys
Ayers, Ms Danielle	NPWS Woodland Ecology Unit C/- CSIRO Sustainable Ecosystems, ACT	Development of a toolkit incorporating benchmarks for assessing biodiversity benefits from vegetation managed or planted for salinity mitigation
Baldwin, Dr Darren	CSIRO/Murray-Darling Freshwater Research Centre, Albury NSW	Estimating the likelihood and impact of "blackwater" events after flooding
Barton, Mr Tim	Geoscience Australia, ACT	Experimental high resolution 3-component seismic reflection survey
Basden, Dr Alison	Department of Biological Sciences, Macquarie University, NSW	The impact of climate change on competitive plant interactions at high-altitude vegetation boundaries
Beekman, Dr Madeleine	School of Biological Sciences, The University of Sydney NSW	Honey bee foraging behaviour and information transfer
Belcher, Dr Chris	Ecosystems, Timboon, Vic	Tiger quoll study
Bennell, Mr Michael	Natural Resource Centre, Water, Land and Biodiversity Conservation, Pasadena, SA	Florasearch
Bonser, Dr Stephen	School of Biological Earth and Environmental Sciences, University of NSW	Life history and species range of Australian trees

Blackmore, Ms Caroline	Centre for Resource and Environmental Studies, Australian National University, ACT	Breeding biology and behaviour of a near-threatened species, the grey-crowned babbler
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
Blair, Dr David	School of Tropical Biology, James Cook University, Townsville Qld	The ancient symbiosis between freshwater crayfish and temnocephalan flatworms
Blair, Dr David	School of Tropical Biology, James Cook University, Townsville, Qld.	Biodiversity, biogeography and phylogeny of Australian aquatic planarians (Platyhelminthes, Tricladida, Paludicola)
Broome, Dr Linda	Threatened Species Unit 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 the Nullica area, south-east NSW
Callaghan, Mr John	Australian Koala Foundation, Brisbane, Qld	The Koala Habitat Atlas
Cameron, Mr Matt	National Parks & Wildlife Service, Dubbo, NSW	Landscape use by the glossy black cockatoo in central west New South Wales
Chesser, Dr Robert	CSIRO Sustainable Ecosystems, Australian National Wildlife Collection, ACT	Biodiversity, phylogeny, distribution and conservation of Australian vertebrate land fauna
Christie, Mr Peter	National Parks & Wildlife Service, Dubbo NSW	Superb parrot population monitoring
Claridge, Dr Andrew	Threatened Species Unit National Parks & Wildlife Service, Queanbeyan, NSW	Interactions among mycophagous (fungus-feeding) mammals and hypogean mycorrhizal fungi in eucalypt forests of south-eastern Australia
Claridge, Dr Andrew	Threatened Species Unit, National Parks & Wildlife Service, Queanbeyan, NSW	Distribution and population status of the squirrel glider ( <i>Petaurus norfolcensis</i> ) on the south-west slopes of New South Wales
Clements, Dr Anne	Anne Clements & Assoc Pty Ltd, NSW	Flora survey - State forest adjoining Coorambong aerodrome site
Collins, Ms Megan	University student	Angiosperm plant study
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

Coughran, Mr Jason	Southern Cross University, Lismore, NSW	Freshwater crayfish of north-eastern New South Wales: biology and management
Crompton, Mr Graham	CSIRO Entomology, Australian National Insect Collection, ACT	Collection of insects for the Australian Insect Collection
Dangerfield, Dr Mark	Biotrack Australia, Department of Biological Sciences, Macquarie University, NSW	Local consequences of land use for biodiversity in the Nandewar Western Regional Assessment
de Caritat, Dr Patrice	CRC LEME, Geoscience Australia, ACT	Biogeochemical dispersion pathways in landscapes of western NSW
Curran, Mr Timothy	Botany, University of New England, NSW	Phytogeography and evolutionary ecology of dry rainforest on the western slopes of NSW
Denholm, Mr Bob	Department of Land and Water Conservation, Newcastle, NSW	Native Vegetation Mapping Program
Driscoll, Mr Colin	PhD student	Reproductive strategies of two rare plants - <i>Tetratheca juncea</i> and <i>Acacia bynoeana</i> (PhD project)
Elith, Dr Jane	School of Botany, University of Melbourne, Vic.	Distribution, life history and habitat of <i>Leionema ralstonii</i> and <i>Westringia davidii</i> to build habitat models and population viability analyses
Everitt, Mr Nicholas	Conacher Travers Pty Ltd, Somersby, NSW	Preparation of a species impact statement for land adjoining Cumberland State Forest, West Pennant Hills
Fischer, Mr Joern	Centre for Resource and Environmental Studies, ANU, ACT	Landscape use by reptiles in a fragmented landscape near Tumut, NSW
Fleck, Dr Gunther	Museum Alexander Koenig Bonn, Germany	Odonata collecting for phylogenetic studies
Fleming, Ms Alison	University of New England, NSW	Native angiosperm species study
Francis, Mr Anthony	Murdoch University/CSIRO Forestry and Forest Products, WA	Australian sequestrate cortinarioid fungi
Geering, Mr David	National Parks & Wildlife Service, Dubbo, NSW	Movements and population dynamics of the regent honeyeater



Glen, Mr Alistair	Biological Sciences, University of Sydney, NSW	Competitive and predatory effects of the red fox ( <i>Vulpes vulpes</i> ) on the spotted-tailed quoll ( <i>Dasyurus maculatus</i> )
Gross, Dr Caroline	School of Environmental Science and Natural Resources, University of New England, NSW	Population surveys and monitoring of the endangered species <i>Olearia flocktoniaea</i>
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 ( <i>Santalum</i> spp. <i>Santalaceae</i> )
Hart, Dr Diana	Physical Geography Department, Macquarie University, NSW	The quarternary and recent history of the East Pilliga State Forest
Harty, Ms Julie-Anne	School of Applied Sciences, University of Newcastle, NSW	Aspects of the ecology of urban and rural frog communities in fragmented and restored riparian environments on the central coast of NSW
Hawkins, Mr Brian	University of NSW	Distribution of the yellow-bellied glider in the Gosford Local Government Area
Hilger, Dr Hartmut	Freie Universitaet Berlin - Institut fur Biologie Systematische Botanik und Pflanzengeographie, Berlin	Scientific research on <i>Boraginaceae</i> systematics worldwide
Heath, Ms Rachel	Umwelt (Aust) Pty Ltd, Toronto, NSW	Flora and fauna assessment of Marrangaroo Creek and tributaries of the Wolgan River
Hines, Mr Harry	Queensland Parks & Wildlife Service, Qld	Phylogeography of <i>Mixophyes</i> and taxonomic resolution of the <i>Litoria</i> <i>barringtonensis</i> complex and <i>Mixophyes</i> <i>balbus/fleayi</i>
Hope, Mr Ben	The University of Sydney, NSW	Modelling fine-scale patchiness of prescribed fires
Jones, Mr Nigel	Charles Sturt University, Albury, NSW	ARC research project on historical changes in tree densities and forest structures in white cypress pine and box eucalypt forests
Jones, Dr Simon	Department of Geospatial Science, RMIT University, Vic	Vegetation condition assessment: integrated remote sensing and spatial modelling
Keith, Dr Heather	CSIRO Forestry & Forest Products, ACT	Estimating greenhouse gas sources and sinks in the terrestrial biosphere

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, NSW	Impact of aerial wild dog baiting on spotted-tailed quoll populations
Kooyman, Mr Robert	Earth Process Ecological Services, Myocum, NSW	Flora surveys and threatened plant species habitat assessments in north-east New South Wales
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 <i>Antechinus flavipes</i>
Lambauer, Ms Mag Michaela	University Graz, Austria	Botanic field works on saxicolous species of the lichen genus <i>Rinodina</i> in New South Wales
Landenberger, Ms Deborah	School of Environmental and Life Sciences (Biology), University of Newcastle, NSW	Determine the habitat and growth requirements for <i>Tetratheca juncea</i>
Lebel, Dr Teresa	Royal Botanic Gardens Melbourne, Vic.	The effects of disturbance on hypogean fungal diversity in stands of different regeneration ages
Lenz, Dr Michael	CSIRO Entomology, Canberra, ACT	Termite biology and control in State forests of NSW
Liney, Mrs Jennifer	Eurobodalla Regional Botanic Gardens Herbarium, Vic.	Eurobodalla Regional Botanic Gardens
Lunney, Mr Dan	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
Martin, Ms Alison	Greenloaning Biostudies Pty Ltd, Tuncester via Lismore, NSW	Flora and fauna surveys to satisfy NPWS Conditions of Consent for Timbarra Gold Mining Projects
Miles, Ms Jacquelyn	Department of Biological Sciences, Macquarie University, NSW	Patterns of small mammal succession in response to fire
Miller, Mr Justin	National Parks & Wildlife Service, Glen Innes, NSW	Investigation of Hastings River mouse populations and habitat in the Glen Innes East area

Moody, Mr Michael	Department of Ecology and Evolutionary Biology, University of Connecticut, Storrs, USA	Phylogenetic relationships in the Angiosperm family Haloragace with an emphasis on the genus <i>Myriophyllum</i>
Morgan, Mr Huw	Department of Biological Science, Macquarie University, NSW	Comparative water-use strategies of perennial shrubs
Mott, Ms Beth	Department of Biological Sciences, University of Wollongong, NSW	Immigration of vertebrate fauna into farm forestry plantations
Mott, Ms Beth	Department of Biological Sciences, University of Wollongong, NSW	Decoupling the effects of thermal and structural environment to understand animal habitat choice
Mueller, Dr Jochen	National Research Centre for Environmental Toxicology, University of Queensland, Qld.	National Dioxins Program. Determination of ambient environmental levels of dioxins in Australia
Oberprieler, Dr Rolf	CSIRO Entomology, ACT	Cone attractants of <i>Macrozamia communis</i> cycads to pollinating <i>Tranes</i> weevils
Oliver, Dr Damon	National Parks & Wildlife Service, Dubbo, NSW	Survey of regent parrot breeding activity and foraging habitat
Peacock, Mr Lee	The University of Sydney, NSW	Roost preference of the grey-headed flying fox
Pearson, Dr Stuart	The University of Newcastle, NSW	Test <i>Callitris glaucophylla</i> tree rings for ability to detect annual variation in growth due to rainfall, thinning, species competition or fire
Pech, Dr Roger	CSIRO Sustainable Ecosystems, ACT	Conservation of threatened fauna. Rapid assessment of the benefits of fox control for remnant populations of the brush-tailed rock wallabies
Poirier, Ms Danielle	NSW Department of Environment and Conservation, NSW	Functional structure of freshwater macroinvertebrates in the Clyde River Catchment
Prestholdt, Ms Tara	University of Montana, Missoula, MT, USA	Phasmids - walking stick limb regeneration
Read, Dr David	Consultant, Wagga Wagga, NSW	Study of the Hastings River mouse
Robertson, Dr David	ERM Australia, NSW	Wyong Coal Project - threatened species surveys

Russell, Mr Ben	School of Biological, Earth and Environmental Science, University of NSW	Odour perception in the tiger quoll ( <i>Dasyurus maculatus</i> ) and the red fox ( <i>Vulpes vulpes</i> ).
Ryan, Mr Brendan	Australian Museum Business Unit, NSW	Impact of the proposed Pacific Highway upgrade, Bonville
Saunders, Ms Debbie	National Parks & Wildlife Service, Queanbeyan, nsw	Swift parrot recovery program
Schutze, Mr Mark	Queensland University of Technology, Qld,	Determining the scale at which populations of the major forest pest <i>Paropsis atomaria</i> Oliver are structured
Soderquist, Dr Todd	Threatened Species Unit, National Parks & Wildlife Service, Dubbo, NSW	Survey and population monitoring of forest owls in western New South Wales
Stauber, Mr Andrew	University of Technology, Sydney, NSW	Habitat fragmentation and disturbance in Hawkesbury sandstone inhabiting frogs <i>Pseudophryne australis</i> and <i>Heleioporus australiacus</i>
Stol, Ms Jacqui	CSIRO Sustainable Ecosystems, ACT	Sustainable harvesting of firewood in the Murray Darling Basin
Stone, Mr Brian	The University of Sydney, Orange, NSW	Integration of models of species distribution and landscape attributes across a hierarchy of scales
Stevens, Ms Tanya	Department of Biological Sciences, University of Wollongong, NSW	The ecological effect of powerline easements in coastal New South Wales
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 Macksville to Urunga Pacific Highway upgrade route selection study for the NSW Roads and Traffic Authority
Thomson, Dr Patricia	Private study	Woolgoolga Flora Reserve banding project
Thumm, Ms Karen	The University of Newcastle, NSW	Habitat utilisation and reproductive biology of the red-crowned toadlet <i>Pseudophryne australis</i>



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
van Niel, Ms Kimberly	School of Geography and Oceanography , University of NSW at Australian Defence Force Academy, ACT	Marking and resurveying "Kioloa" long-term monitoring sites
Walker, Mr John	Hon. Res. Assoc., State Forests of NSW	Study of rust fungi <i>Uredinales</i> of Australia
Ward, Ms Paula	Consultant	Monitoring amphibian response to flooding in Barmah-Millewa Forest
Wardle, Dr Glenda	School of Biological Sciences, The University of Sydney, NSW	Population biology of self-sown <i>Pinus radiata</i> outside 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
Wassens, Ms Skye	Charles Sturt University, Wagga Wagga, NSW	Frog survey - Murrumbidgee Irrigation Area for Murrumbidgee Irrigation
Waters, Ms Cathy	Agricultural Research Centre, NSW Agriculture, Trangie, NSW	Genecological study of <i>Austrodanthonia caespitosa</i> (wallaby grass)
Watson, Dr David	School of Environmental Sciences, Charles Sturt University, Thurgoona	Ecology of the painted honeyeater in Binya State Forest
West, Dr Judy	Centre for Plant Biodiversity Research, CSIRO Division of Plant Industry, ACT	Taxonomic research on native flora and invertebrate pollinators
Whyte, Dr Kelly-Anne	Forest Science Centre, University of Melbourne, Vic.	Barmah-Millewa forest monitoring project
Willan, Mr Lenard	Private study	Study of distribution, life history and host plants of Oecophorid moths
Wurtz, Mr Graham	Private study	Study of butterflies and beetles
Yalmambirra	Faculty of Science and Agriculture, Charles Sturt University, Thurgoona, NSW	Residential school field exercise for Site Survey Design

Young, Mr Michael	Private study	Research into known range of currently recognised species of <i>Macrozamia</i>
York, Dr Alan	Forest Science Centre, Creswick, Vic	Sustainability of fuel-reduction burning regimes in native forests
Zeppel, Ms Melanie	University of Technology Sydney, NSW	Tree water use and amelioration of dryland salinity

---

## Published Papers, Reports and Presentations

- Barton CVM and Walsh PG. 2004. Tree water use of a young plantation targeted at salinity control. In: Croke J, Mockler S and Takken I, eds. *Forest Management Workshop Proceedings*, Canberra 23-25 March 2004. CRC Catchment Hydrology, Monash University, Vic.
- Bi H. 2003. The self-thinning surface in relation to declining stands. In: White TCR and Jurskis V, eds. *Fundamental Causes of Eucalypt Forest Decline and Possible Management Solutions*. Proceedings of Colloquium, NSW Forest Health Advisory Committee, Batemans Bay, NSW. November 18-19, 2003.
- Bi H, Simpson J, Li R, Yan H, Wu Z, Cai S, Eldridge R. 2003. Introduction of *Pinus radiata* for afforestation - a review with particular reference to the dry river valley area in Aba, China. *Journal of Forestry Research* 14: 311-322.
- Binns DL\*\*\* and Bridges RG. 2003. Ecological impacts and sustainability of timber harvesting and burning in coastal forests of the Eden area. Establishment and progress of the Eden Burning Study. *State Forests of NSW Technical Paper No. 67*. 141 pp.
- Carnegie AJ and Keane PK. 2003. Variation in severity of target spot, caused by *Aulographina eucalypti*, in a eucalypt species and provenance trial in Victoria. *Australasian Plant Pathology* 32: 393-402.
- Cooper RD, Waterson DGE, Bangs Michael J and Beebe NW. 2000. Rediscovery of *Anopheles (Cellia) clowi* (Diptera: Culicidae), a rarely recorded member of the *Anopheles punctulatus* group. *Journal of Medical Entomology*: 37(6): 840-845.
- Cooper RD, Waterson DGE, Frances SP, Beebe NW and Sweeney AW. 2002. Speciation and distribution of the members of the *Anopheles punctulatus* (Diptera: Culicidae) group in Papua New Guinea. *Journal of Medical Entomology* 39(1): 16-27.
- Coops NC, Stone C, Culvenor DS and Chisholm L. 2004. Foliage damage and discolouration in eucalypt vegetation as assessed by red-green and red-edge remote sensing indices. *Journal of Environmental Quality* 33: 956-964.
- Dickson RL, Raymond CA, Joe B and Wilkinson CA. 2003. Segregation of *Eucalyptus dunnii* using acoustics. *Forest Ecology and Management* 179: 243- 251.
- Erskine WD\*, Beggs GW, Jolly P, Georges A, O'Grady A, Eamus D, Rea N, Dostine P, Townsend S and Padovan A. 2003. Recommended environmental streamflows for the Daly River, Northern Territory, based on ecological, hydrological and biological principles. *Supervising Scientist Report 175*. Supervising Scientist, Darwin.
- Erskine WD\* and Harris JH. 2004. Chapter 30 Australia. In: Northcote TG and Hartman GF, eds. *Fishes and Forestry. Worldwide Watershed Interactions and Management*. pp. 678-703. Blackwell Science Ltd, Oxford.
- Erskine WD\*, Mahmoudzadeh A, Browning CM and Myers C. 2003. Sediment yields and soil loss rates from different land uses on Triassic shales in western Sydney, NSW. *Australian Journal of Soil Research* 41: 127-140.
- Fitzgerald M, Shine R and Lemckert F. 2003. A reluctant heliotherm: thermal ecology of the arboreal snake *Hoplocephalus stephensii* (Elapidae) in dense forest. *Journal of Thermal Biology* 28(7): 515-524.

- Fitzgerald M, Shine R and Lemckert F. 2004. Life history attributes of a threatened Australian snake *Hoplocephalus stephensii* (Elapidae). *Biological Conservation* 119(1): 121-128.
- Fox J, Bi H and Ades P. 2004. Spatial dependence and individual tree models. In: *Proceedings of IUFRO Conference on Applications of Statistics, Information Systems and Computers in Natural Resources Monitoring and Management*. National Taiwan University, Taipei, China. 7-11 June.
- Frances SP, Waterson DGE, Beebe NW and Cooper RD. 2004. Field evaluation of repellent formulations containing deet and picaridin against mosquitoes in Northern Territory, Australia. *Journal of Medical Entomology* 41(2): 414-417.
- Gadgil P, Dick M, Simpson J, Bejakovich D, Ross M, Bain J, Horgan G and Wylie R. 2003. Management plan response to an incursion of pine pitch canker in Australia or New Zealand. Prepared and published by the Forest Health Committee on behalf of the Forestry and Forest Products Committee. August 2003. 99 pp.
- Grgurinovic Cheryl and Simpson Jack. 2003. Preliminary survey of the fungi of White Mountains National Park. *The Royal Geographical Society of Queensland Inc. Geography Monograph Series No. 9 White Mountains Scientific Study Report*. pp. 27-40.
- Jeewon Rajesh, Liew Edward CY, Simpson Jack A, Hodgkiss I John and Hyde Kevin D. 2003. Phylogenetic significance of morphological characters in the taxonomy of *Pestalotiopsis* species. *Molecular Phylogenetics and Evolution* 27: 372-383.
- Joe B, Dickson R, Raymond C, Ilic J and Matheson C. 2004. Prediction of *Eucalyptus dunnii* and *Pinus radiata* Timber Stiffness Using Acoustics. A report for the RIRDC/Land and Water Australia/FWPRDC/MDBC Joint Venture Agroforestry Program. RIRDC Publication No 04/013.
- Kavanagh RP. 2004. Conserving owls in Sydney's urban bushland: current status and requirements. In: Lunney D and Burgin S, eds. *Urban Wildlife: More than Meets the Eye*. pp. 93-108. Royal Zoological Society of New South Wales, Mosman, NSW.
- Kavanagh RP and Stanton MA. 2003. Bird population recovery 22 years after intensive logging near Eden, New South Wales. *Emu* 103: 221-231.
- Kelly, Georgina (ed.). 2003. Beneficial use of biosolids in forestry and agriculture. Proceedings of workshop held at Research and Development Division, State Forests of New South Wales. June 1998. *State Forests of NSW Technical Paper No. 66*. 39 pp.
- Law BS and Chidel M. 2004. Roosting and foraging ecology of the golden-tipped bat (*Kerivoula papuensis*) on the south coast of New South Wales. *Wildlife Research* 31: 73-82.
- Lemckert FL. 2004. Variations in anuran movements and habitat use: implications for conservation. *Applied Herpetology* 1(3): 165-181.
- Lemckert FL and Brassil T. 2003. Movements and habitat use by the giant burrowing frog, *Heleioporus australiacus*. *Amphibia-Reptilia* 24: 207-211.
- Lemckert FL, Brassil T and Haywood A. 2004. Effects of low intensity fire on pond-breeding anurans in mid-northern New South Wales, Australia. *Applied Herpetology* 1(3): 183-195.



- Moliere DR, Evans KG, Saynor MJ and Erskine WD\*. 2004. Estimation of suspended sediment loads downstream of the Jabiluka mine, Northern Territory, Australia. *Hydrological Processes* 18: 531-544.
- Montagu KD, Cowie, AL, Rawson A, Wilson, BR and George, BH. 2003. Carbon Sequestration Predictor for Land Use Change in Inland Areas of New South Wales - Background, User Notes, Assumptions and Preliminary Model Testing. Version 2.0. *State Forests of NSW Technical Paper No. 68 + CD (model)*. 35 pp.  
To use on line - [www.greenhouse.org.au](http://www.greenhouse.org.au)  
Download from - [www.forest.nsw.gov.au/env\\_services/ess/default.asp](http://www.forest.nsw.gov.au/env_services/ess/default.asp).
- Montagu K, Kearney D, Smith RGM. 2003. Pruning eucalypts - the biology and silviculture of clear wood production in planted eucalypts. A report for the RIRDC/Land and Water Australia/FWPRDC Joint Venture Agroforestry Program. RIRDC Publication No 02/152 RIRDC Project No PN.99.2011.
- Poke FS, Wright JK and Raymond CA. 2004. Predicting extractive and lignin content in *Eucalyptus globulus* using near infrared reflectance. *Journal of Wood Chemistry and Technology* 24(1): 55-67.
- Raymond CA, Dickson R, Rowell D, Blakemore P, Clark N, Williams M, Freischmidt G and Joe B. 2004. Wood and fibre properties of dryland conifers. A report for the RIRDC/Land and Water Australia/FWPRDC/MDBC Joint Venture Agroforestry Program. RIRDC Publication No 04/099.
- Saynor MJ, Erskine WD\*, Evans KG and Eliot I. 2004. Gully initiation on sandy footslopes of the Jabiluka outlier, Kakadu region, Northern Territory, Australia. *Geografiska Annaler* 86A: 191-203.
- Saynor MJ, Erskine WD\*, Smith BL, Fox GJ and Evans KG. 2003. Bank erosion in the Swift Creek (Ngarradj) catchment: results of erosion pin measurements between 1998 and 2001. *Supervising Scientist Report 176*. Supervising Scientist, Darwin.
- Searson MJ, Thomas DS, Montagu KD and Conroy JP. 2004. Leaf water use efficiency differs between *Eucalyptus* seedlings from contrasting rainfall environments. *Functional Plant Biology* 31: 441-450.
- Simpson JA and Grgurinovic CA. 2003. A new species of *Aleurodiscus* (Stereaceae) from Mt Kosciuszko, Australia. *Australasian Mycologist* 22(1): 15-19.
- Simpson JA and Grgurinovic CA. 2003. A new species of *Lanzia* (Rutstroemiaceae) from Mt Kosciuszko, Australia. *Australasian Mycologist* 22(1): 11-14.
- Smith RGB, Palmer G, Davies M and Muneri A. 2003. A method enabling the reconstruction of internal features of logs from sawn lumber: the log end template. *Forest Products Journal* 53(11/12): 95-98.
- Stone C, Coops N, Sims N, Ryan P, Loughhead A, Stanford M and Goodwin N. 2004. Remote assessment of pine plantation condition: a handbook describing the use of multi-spectral imagery to measure impacts from three damaging agents of *Pinus radiata*. Report to Forestry and Wood Products Research and Development Corporation. CSIRO Forestry and Forest Products, Clayton South, Victoria.

- Stone C, Coops N, Stanford M, Culvenor D, Old K and Carnegie AJ. 2003. Forest health monitoring in Australia: new tools to meet national and international reporting requirements. In: *Eighth International Congress of Plant Pathology: Solving Problems in the Real World*. Proceedings, 2-7 Feb. 2003, Christchurch, New Zealand (Published Proceedings Vol 1, Pg 67).
- Stone C, Matsuki M and Carnegie A. 2003. *Pest and Disease Assessment in Young Eucalypt Plantations: Field Manual for Using the Crown Damage Index*. (Parsons M ed.). National Forest Inventory, Bureau of Rural Sciences, Canberra.
- Stone C, Wardlaw T, Floyd R, Carnegie A, Wylie R and de Little D. 2003. Harmonisation of methodologies for the assessment and reporting of forest health in Australia - a starting point. *Australian Forestry* 66: 233-246.
- Stone C, Wardlaw T, Floyd R, Carnegie AJ, R Wylie R and de Little D. 2003. Crown Damage Index – a national standardised index for assessment of crown damage in young eucalypt plantations in Australia. In: *Eighth International Congress of Plant Pathology Pre-Congress Workshop: The Roy E. Gaunt Memorial Workshop on Disease and Crop Loss Assessment*. Proceedings, 1-2 Feb. 2003, Christchurch, New Zealand (Published Proceedings).
- Thomas DS, Montagu KD and Conroy JP. 2004. Changes in wood density of *Eucalyptus camaldulensis* due to temperature - the physiological link between water viscosity and wood anatomy. *Forest Ecology and Management* 193: 157-165.
- \*\*Walker J. 2004. *Claviceps phalaridis* in Australia: biology, pathology and taxonomy with a description of the new genus *Cepsiclava* (*Hypocreales*, *Clavicipitaceae*). *Australasian Plant Pathology* 33: 211-239.
- \*\*Walker J and Shivas RG. 2004. *Uredopeltis chevalieri* sp. nov., the rust of *Grewia* (*Tiliaceae*) formerly known as *Phakopsora* (or *Dasturella*) *grewiae*, its first record in Australia and a summary of the known rusts of *Grewia*. *Australasian Plant Pathology* 33: 41-47.
- \*\*Walker, J. and Simpson, J. 2003. An alternative view to ICBN Proposal 1584 to conserve the name *Acacia* (*Leguminosae*: *Mimosoideae*) with a conserved type. *Australian Systematic Botany Society Newsletter* 117: 17-21.
- Walsh PG, Barton CVM and Montagu KD. 2003. Macquarie catchment pilot project, New South Wales, Australia: a cost-effective, market-based approach to reducing salinity through tree planting. *Unasylva* 212: 37-39.
- Webb AA and Erskine WD\*. 2003. A practical scientific approach to riparian vegetation rehabilitation in Australia. *Journal of Environmental Management* 68: 329-341.
- Weggler, K\*\*\*\* 2004. Effect of chloride in soil solution on the plant availability of biosolid-borne cadmium. *Journal of Environmental Quality* 33(2): 496-504.
- Weggler-Beaton K\*\*\*\*, Graham RD and McLaughlin MJ. 2003. The influence of low rates of air-dried biosolids on yield and phosphorus and zinc nutrition of wheat (*Triticum durum*) and barley (*Hordeum vulgare*). *Australian Journal of Soil Research* 41(2): 293-308.
- Wintle BA, McCarthy MA, Volinsky CT and Kavanagh RP. 2003. The use of Bayesian Model Averaging to better represent uncertainty in ecological models. *Conservation Biology* 17: 1579-1590.

- Ximenes Fabiano. 2004. Wood construction wins greenhouse contest. *InWood International* Feb-March 2004.
- Zeppel MJB, Murray BR, Barton CVM and Eamus D. 2004. Seasonal responses of xylem sap velocity to VPD and solar radiation during drought in a stand of native trees in temperate Australia. *Functional Plant Biology* 31: 461-470.
- Zhang L, Bi H, Cheng P, and Davie CJ. 2003. Modelling spatial variations in tree diameter - height relationships. *Forest Ecology and Management* 189: 317-329.

\* *Dr Wayne Erskine works in the Forest Policy and Resources Division*

\*\* *Mr John Walker is Honorary Research Associate, Research and Development Division*

\*\*\* *Mr Doug Binns works in the Native Forests Division of State Forests of NSW*

\*\*\*\* *Paper published on work done prior to joining State Forests of NSW*

### **Conference Presentations**

- Barton CVM and Montagu KD. 2003. Assessing ground penetrating radar (GPR) for non-destructive measurement of tree root biomass. Third International Symposium on Dynamics of Physiological Processes in Woody Roots. Perth WA.
- Barton CVM and Walsh PG. 2004. Tree water use of a young plantation targeted at salinity control. Forest Management Workshop, Canberra. 23-25 March.
- Carnegie AJ. 2003. Forest health surveillance in young eucalypt plantations in New South Wales, Australia. In: *Eighth International Congress of Plant Pathology: Solving Problems in the Real World*. Proceedings, 2-7 February 2003, Christchurch, New Zealand (Poster presentation, Vol 2, Pg 160).
- Kavanagh R. 2003. In the Dark: About Owls. NSW WIRES State Raptor Co-ordinators meeting, Kurrajong.
- Kavanagh, R. (2004). Effects of logging and repeated fuel reduction burning on birds in dry sclerophyll forest near Eden, NSW. Seminar presentation at Research Division, State Forests of New South Wales.
- Kavanagh R. 2004. Endangered gliders and their habitat in the Sydney Region. Seminar presentation to Hawkesbury Branch of WIRES (NSW Wildlife Information and Rescue Service, Inc.), Glossodia, Sydney.
- Kavanagh R. 2004. Nocturnal forest birds and mammals: species identification and survey skills. Course leader of a three-day Wildlife Training School, Eden. 8-11 June.
- Kavanagh R and Stanton M. 2003. Role of eucalypt plantations in restoring habitat for arboreal marsupials in agricultural landscapes. Forty-ninth Scientific Meeting Australian Mammal Society, Sydney University. July.
- Kavanagh R, Stanton M and Debus S. 2003. Effects of logging and repeated fuel reduction burning on birds in dry sclerophyll forest near Eden, NSW, Australia. Third International Wildlife Management Congress, Christchurch, New Zealand.

- Kavanagh R, Stanton M and Debus S. 2003. Effects of logging and repeated fuel reduction burning on birds in dry sclerophyll forest near Eden, NSW. Australian Ornithological Conference, Australian National University, Canberra.
- Law B. 2003. Bats hanging out with birds in southern NSW. NSW Royal Zoological Society. October.
- Law B. 2004. The effect of logging on nectar production by eucalypts. Annual Meeting of Honey Board, RIRDC. May.
- Law B and Chidel M. 2003. Bats hanging out with birds in southern NSW. Forty-ninth Scientific Meeting Australian Mammal Society, Sydney University. July.
- Law B and Chidel M. 2003. Monitoring a population of the Fishing Bat *Myotis macropus*. Australian Mammal Society, Sydney University. July.
- Law B and Chidel M. 2003. A contrasting response of small ground mammals and bats to revegetation on private land. International Wildlife Management Conference. December.
- Law B and Chidel M. 2004. Bats hanging out with birds in southern NSW. Australasian Bat Society. April.
- Law B and Chidel M. 2004. Monitoring Australia's largest roost of Eastern Horseshoe Bats. Australasian Bat Society. April.
- Lemckert F, Brassil T, Kavanagh R and Law B. 2003. Trapping small mammals for research and management: How many die and why? Third International Wildlife Management Congress, Christchurch, New Zealand.
- Lemckert F and Mahony M. 2003. What makes a good frog pond? Spoken presentation at the *Australian Society of Herpetologists A.S.M.* Mary River, NT.
- Montagu K. 2004. Bringing environmental plantings into the NSW Greenhouse Gas Abatement Carbon Market. Farm Forestry for Catchment Solutions, Tamworth. 18 June.
- Montagu K. 2004. Planted forests for multiple benefits. Field Day Liverpool Plains, NSW. 21 May.
- Montagu K. 2004. Trees invade Queensland! Conflicting intelligence on the extent and motive. CRC Greenhouse Accounting Annual Science Meeting, Batemans Bay. April.
- Montagu K and Cowie A. 2004. Carbon sequestration predictor for revegetation schemes in lower-rainfall areas of NSW. The Twenty-eighth Annual Conference of the Ecological Society of Australia. UNE, Arimdale. 9 December.
- Montagu K, Zerihun A, Hoffman M, Bray S and Burrows B. 2003. Changes in eucalypt root allocation along a rainfall gradient. Sydney Ecophysiology Meeting, Macquarie University. 26 September.
- Montagu K, Zerihun A, Hoffman M, Bray S and Burrows B. 2003. Changes in *Eucalyptus populnea* root:shoot ratios along a rainfall gradient in eastern Australia. Third International symposium on dynamics of physiological processes in woody roots, Perth, Australia. 28 September - 3 October.
- Pennay M, Law B and Reinhold L. 2004. Bat calls of NSW: region based guide to the echolocation calls of microchiropteran bats. NSW Dept. Environment and Conservation, Hurstville. <http://www.forest.nsw.gov.au/research/bats/default.asp>



- Radford S, Kavanagh R and Goldingay R. 2003. Habitat utilisation by koalas in a tall coastal production forest in north eastern NSW. Forty-ninth Scientific Meeting Australian Mammal Society, Sydney University. July.
- Radford S, McKee J, Goldingay R and Kavanagh R. 2003. Koala capture and assessment procedures employed within Pine Creek State Forest, north eastern NSW. Forty-ninth Scientific Meeting Australian Mammal Society, Sydney University. July.
- Webb AA. 2004. Monitoring the potential impacts of forestry activities on water quality in New South Wales: preliminary results from the Middle Brother paired catchment program. *Third Forest Management Workshop*. CSIRO Land and Water, Canberra. 23-25 March.
- Webb AA and Erskine WD\*. 2003. Natural variability in the loading, distribution and induced scour of large woody debris in sand-bed, forest streams. Ninth International Symposium on River Research and Applications (NISORS), Albury. 6-11 July.
- Wood S, Ximenes F, Montagu K, Zerihun A and Gardner WD. 2004. Which works best? Comparing a range of biomass estimation methods using the directly measured biomass of a eucalyptus forest stand. CRC Greenhouse Accounting Annual Science Meeting, Batemans Bay. April.
- Zerihun A, Montagu K, Hoffman M and Bray S. 2004. Marked changes in root to shoot ratios of poplar box woodlands of north eastern Australia along a rainfall gradient. CRC Greenhouse Accounting Annual Science Meeting, Batemans Bay. April.

### **The Bush Telegraph Contributions**

*(The Bush Telegraph is the magazine of State Forests of NSW)*

- Birt, Dennis. 2004. Native timber banjo ... sounds unique. p. 3. Winter 2004 Edition. 19 pp.
- Dickson, Ross. 2004. Dry country pine put to the test. p.6. Autumn 2004 Edition. 19 pp. Story by Sarah Chester.
- Gardner, David and Ximenes, Fabiano. 2004. How long does it last? Looking at carbon storage in wood products. pp. 14-15. Winter 2004 Edition. 19 pp. Story by Leah Flint.
- Law, Brad 2004. Animals abound in young eucalypt plantations. p. 13. Summer 2003 Edition. 19 pp. Story by Howard Spencer.
- Lemckert, Frank. 2003. Frog conservation focus on TV documentary. p. 8. Summer 2003 Edition. 19 pp.
- Smith, Helen. 2003. Bigger straighter faster.... p. 12. Summer 2003 Edition. 19 pp.
- Stone, Christine. 2003. National approach to assessing eucalypt plantation damage. p. 5. Summer 2003 Edition. 19 pp.

### **Electronic**

- Waterson D. 2003. *Managing Sirex Workshop. 4-5 October 2000*. CD-Rom. State Forests of New South Wales.

---

## Staff List and Location (30 June 2004)

Research & Development Division Headquarters  
121 - 131 Oratava Avenue West Pennant Hills NSW 2125  
PO Box 100 Beecroft NSW 2119

Telephone 02 9872 0111  
Facsimile 02 9871 6941

Anuj	Mr	Narendra	Librarian	9872 0110
Bacon	Ms	Kerrie	Technical Officer	9872 0167
Barton	Dr	Craig	Research Scientist, New Forests	9872 0199
Bi	Dr	Hui-quan	Principal Research Scientist, Silvicultural Systems	9872 0168
Brassil	Ms	Traecey	Technical Officer, Forest Biodiversity	9872 0194
Bryce	Mr	Stephen	Administrative Officer	9872 0116
Cai	Mr	Shimin	Technical Officer, Silvicultural Systems	9872 0155
Caple	Ms	Margaret	Executive Assistant	9872 0187
Carnegie	Dr	Angus	Research Scientist, Forest Health Management	9872 0131
Chandler	Mr	Joe	Technical Officer, New Forests	
Chidel	Mr	Mark	Technical Officer, Forest Biodiversity	9872 0169
<b>Cowie</b>	<b>Dr</b>	<b>Annette</b>	<b>Program Leader, New Forests</b>	<b>9872 0138</b>
Crooks	Mr	Jason	Technical Officer, New Forests	
Davies	Ms	Kylie	Library Technican	
Delaney	Mr	Ted	Human Resources Officer	9872 0113
Düttmer	Ms	Katharine	Technical Officer, New Forests	
<b>Eldridge</b>	<b>Mr</b>	<b>Robert</b>	<b>Deputy General Manager</b>	<b>9872 0126</b>
Engel	Ms	Helen	Technical Officer, New Forests	
Gardner	Mr	David	Research Officer, New Forests	9872 0171
Gardner	Mrs	Joy	Publications Officer	9872 0122
Giles	Mr	David	Technical Officer, New Forests	9872 0141
Guild	Ms	Amanda	Clerical Officer, Research Services/Library	9872 0152/108
Haywood	Mr	Andrew	Project Officer, Statistics and Data Services	
Horwood	Mr	Martin	Research Officer, Forest Health Management	9872 0149
<b>Howard</b>	<b>Mr</b>	<b>Alastair</b>	<b>General Manager, Technology and Services</b>	<b>9872 0119</b>
Joe	Mr	Bill	Research Officer, Silvicultural Systems	9872 0174
Johnson	Mr	Ian	Research Officer, Scientific Services	9872 0161

<b>Kavanagh</b>	<b>Dr</b>	<b>Rod</b>	<b>Program Leader, Principal Research Scientist, Forest Biodiversity</b>	<b>9872 0160</b>
Kelly	Dr	Georgina	Research Officer, New Forests	9872 0151
Kent	Dr	Debbie	Project Officer, Forest Health Management	9872 0133
Law	Dr	Brad	Senior Research Scientist, Forest Biodiversity	9872 0162
Lemckert	Mr	Frank	Research Scientist, Forest Biodiversity	9872 0159
Long	Dr	Yushan	Research Officer, Silvicultural Systems	9872 0165
Major	Mr	John	Research Officer, Silvicultural Systems	
Marchant	Mr	John	Technical Officer, New Forests	
Montagu	Dr	Kelvin	Research Scientist, New Forests	
Moss	Ms	Denize	Purchasing Officer	9872 0114
Murphy	Ms	Catherine	Technical Officer, Tree Improvement	9872 0196
Nicks	Mr	Lindsay	Technical Officer, Silvicultural Systems	9872 0185
O'Hara	Mr	Paul	Site Security/Maintenance Officer	9872 0178
Parekh	Ms	Jagruitee	Technical Officer, New Forests	9872 0140
Paskin	Ms	Marilyne	Clerical Officer/Receptionist	9872 0111
Price	Mr	Grahame	Technical Officer, Forest Health Management	9872 0189
Roberts	Ms	Sandra	Research Officer, New Forests	
Sargan	Ms	Yen	Management Information Officer	9872 0121
Simpson	Mr	Jack	Research Officer, Forest Health Management	
Smith	Ms	Helen	Research Officer, Tree Improvement	6644 6158
Stanton	Mr	Matthew	Technical Officer, Forest Biodiversity	9872 0182
<b>Stone</b>	<b>Dr</b>	<b>Christine</b>	<b>Program Leader, Senior Research Scientist, Forest Health Management</b>	<b>9872 0132</b>
Tornquist	Mr	Steve	Technical Officer, Statistics and Data Services	9872 0158
Towerton	Ms	Alison	Technical Officer, Statistics and Date Services	9872 0166
Walsh	Mr	Peter	Research Officer, New Forests	9872 0148
Waterhouse	Mr	Steve	Technical Officer, Forest Health Management	
Waterson	Mr	Darren	Technical Officer, Forest Health Management	
Weggler	Dr	Karin	Research Officer, New Forests	9872 0127
Wood	Mr	Sam	Technical Officer, New Forests	
Ximenes	Mr	Fabiano	Research Officer, New Forests	9872 0143
Zerihun	Dr	Ayalsew	Research Officer, New Forests	9872 0181

### Northern Research - Coffs Harbour

357 Harbour Drive Coffs Harbour Jetty NSW 2450  
PO Box J19 Coffs Harbour Jetty NSW 2450

*Telephone 02 6650 5700*

*Facsimile 02 6651 5027*

Boyton	Mr	Steve	Technical Officer, Tree Improvement	6650 5722
Dingle	Ms	Joanne	Technical Officer, Silvicultural Systems	
Greenwood	Ms	Glenda	Technical Officer, Tree Improvement	6650 5721
Harper	Mr	Piers	Technical Officer, Silvicultural Systems	6650 5705
Heagney	Mr	Geoff	Project Officer, Silvicultural Systems	6650 5701
<b>Henson</b>	<b>Mr</b>	<b>Michael</b>	<b>Tree Improvement Manager</b>	<b>6650 5703</b>
Johnstone	Mr	Darrel	Forest Assistant, Silvicultural Systems	6650 5708
Moore	Mr	Warwick	Forest Assistant, Tree Improvement	6650 5710
O'Hara	Mr	Jim	Field Worker, Silvicultural Systems	6650 5709
Smith	Dr	Geoff	Research Officer, Silvicultural Systems	6650 5704
Thomas	Dr	Dane	Research Officer, Silvicultural Systems	6650 5702
Villalba	Ms	Liz	Technical Officer, Tree Improvement	

### Northern Research - Grafton

c/- Grafton Agricultural Research and Advisory Station  
Trenayr Road Junction Hill Grafton NSW 2640  
PO Box 1674 Junction Hill Grafton NSW 2640

*Telephone 02 6644 6158*

*Facsimile 02 6644 6134*

Moran	Mr	Chris	Technical Officer, Tree Improvement	6644 6158
Scott	Ms	Jess	Field Worker, Tree Improvement	6644 6158
Varley	Mr	Warren	Technical Officer, Tree Improvement	6644 6158

### Southern Research

13B Bass Street Eden NSW 2551  
PO Box 273 Eden NSW 2551

*Telephone 02 6496 1500*

*Facsimile 02 6496 3258*

Allen	Ms	Ruth	Field Worker, Forest Biodiversity	6496 1500
Shiels	Mr	Roy	Forest Assistant, Forest Biodiversity	6496 1500



**Tablelands Research**

Sydney Street  
Tumut State Forest  
Tumut NSW 2720  
PO Box 46  
Tumut NSW 2720

*Facsimile 02 6947 3427*

Dickson	Dr	Ross	Program Leader, Silvicultural Systems	6981 4201
Dodds	Mr	Kevin	Technical Officer, Tree Improvement	6981 4208
Hides	Mr	Ian	Field Worker, Silvicultural Systems	6981 4206
Porada	Dr	Hans	Research Officer, Tree Improvement	6981 4205
Raymond	Dr	Carolyn	Senior Research Scientist, Silvicultural Systems	6981 4204
Wilkinson	Mr	Col	Forest Assistant, Silvicultural Systems	6981 4207

**Tablelands Research**

Sunny Corner  
PO Box 143  
Bathurst NSW 2795

*Telephone 02 6337 5231*

*Facsimile 02 6337 5294*

Bell	Mr	David	Field Worker, Silvicultural Systems	6337 5231
Fisher	Mr	Brian	Field Worker, Silvicultural Systems	6337 5231
Jarrett	Mr	Brad	Forest Assistant, Water Quality Monitoring	6337 5231

**EPL Water Quality Monitoring**

PO Box 107 Dungog NSW 2420

*Telephone 02 4992 1749*

*Facsimile 02 4992 2007*

Burt	Mr	Dennis	Forest Assistant, Water Quality Monitoring	4992 1749
------	----	--------	--	-----------



## **Research and Development Division**

121-131 Oratava Avenue, West Pennant Hills NSW 2125  
PO Box 100, Beecroft NSW 2119 Australia

Telephone **02 9872 0111** Facsimile 02 9871 6941  
[www.forest.nsw.gov.au](http://www.forest.nsw.gov.au)

State Forests' research and development programs are carried out by the Research and Development Division.  
Its headquarters are in Cumberland State Forest, West Pennant Hills, with Regional Research Units at  
Coffs Harbour, Grafton, Eden, Tumut, Bathurst and Dungog