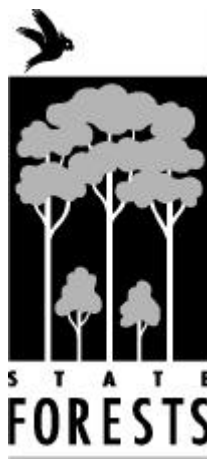


**State Forests of NSW**  
**FOREST RESEARCH AND DEVELOPMENT DIVISION**  
**ANNUAL REPORT**  
**1998/99**



# ***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***

State Forests' research and development programs

are carried out by the

Forest Research and Development Division.

Its headquarters are in Cumberland State Forest, West Pennant Hills

with Regional Research Units at

Coffs Harbour, Eden, Tumut, Bathurst and Deniliquin.

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## Foreword

Forest Research and Development Division (FR&DD) provides research support and scientific leadership for State Forests' operational and policy divisions, and a range of technical and research and development (R&D) services. The Division also houses State Forests' library, which serves as an important reference for all State Forests' personnel and programs and is open to the public.

Funding for the 1998/99 financial year totalled nearly \$7.2 million. State Forests' operational and policy divisions contributed \$5.0 million, community service obligation \$1.5 million and external clients \$0.7 million.

After consultation with research users and clients across State Forests, the Division published a strategic plan comprising research initiatives for the three financial years 1998 to 2001. The initiatives include *key research themes*, listed in this report, which are critical to sustainable forest management.

The Division is structured around two main scientific programs:

- Plantations and Forest Products
- Native Forest Management Systems.

These programs are aligned with State Forests' corporate plan and the research requirements of operational divisions, which manage the State's plantations and native forests for a wide variety of commercial and environmental values.

The Division focuses on forest carbon dynamics research, biomass and bioenergy research, mine site rehabilitation, and catchment revegetation and afforestation in the Murray–Darling Basin.

Dr Alastair Grieve

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## **Management Team**

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# Annual Report 1998–99

## **Innovation in research and development**

### **Key research theme:**

- *Identifying emerging trends and new market opportunities for State Forests and underpinning them with scientific knowledge*

### **Forest carbon dynamics**

Carbon sequestration in planted forests and forest products will play a significant role in reducing net greenhouse gas emissions. The Kyoto Protocol established carbon as a commodity, and there is a growing interest in investment in forestry projects to offset carbon emitted from other sources. To underpin carbon trading, cost-effective systems for measuring and forecasting carbon sequestered in planted forests are required.

Monitoring of carbon sequestration has begun for Pacific Power's carbon trade. The project will develop a method for estimating total biomass of NSW hardwood species, including canopy and roots, from non-destructive measurements such as stem diameter and tree height. An equation relating volume to whole-tree biomass will be linked to current inventory methods to provide a procedure for estimating stand biomass for carbon accounting purposes.

### **Forest biomass for charcoal and bioenergy**

Forestry will have a major role in reducing emissions of greenhouse gases through the use of forest biomass to substitute for fossil fuels in energy generation and industrial processes.

In a joint project with BHP, funded by the NSW Sustainable Energy Research and Development Fund, work has begun on the use of charcoal produced from biomass as a reducing agent for steel-making. FR&DD will examine the effects of species, silviculture and environment on the quality of wood for charcoal; assess forest management options for producing forest biomass for charcoal; and study options for harvesting, processing and transporting wood for charcoal.

## **CRC for Greenhouse Accounting**

Further research into forest carbon dynamics and carbon accounting will be done through the new Co-operative Research Centre for Greenhouse Accounting. FR&DD will collaborate with researchers from the Australian National University, the Bureau of Resource Sciences, CSIRO, the Queensland Department of Natural Resources and Primary Industry and the WA Department of Conservation and Land Management. FR&DD staff will lead projects on:

- refining methods for carbon accounting in above- and below-ground biomass at the project scale;
- developing sustainable forest management systems that optimise forest values, including carbon sequestration;
- life-cycle analysis of forest products.

## **Reuse of organic waste and effluent**

Research into the use of biosolids in plantations continues. The results are very encouraging, showing more than 30% increased growth when biosolids are used. Importantly, results show no adverse effects of the biosolids on surrounding soil and stream water.

The government initiative to reduce solid waste to landfill may be supported by the use of composted municipal waste in plantations on marginal or degraded sites. Discussions continue with private companies and councils on developing research.

Effluent is a resource. State Forests, in conjunction with local councils and private companies, is designing research programs that may help develop low-cost techniques for effluent application. This would increase the viability of reusing effluent in plantations for smaller coastal councils. We are also investigating projects that will determine the most efficient use of effluent in the establishment of plantations.

## **Rehabilitation of degraded lands**

In the Hunter Valley alone, there is potentially 20 000 ha of land requiring rehabilitation that is available for the establishment of hardwood plantations. These include mined lands and some marginal agricultural lands which are typically poor in organic matter and nutrients. The use of organic

wastes as fertilisers, topsoil substitutes or soil amendments has been successful in the rehabilitation of such land, and the wastes are a possible adjunct to current proposals to expand plantations.

FR&DD is working closely with the Organic Waste Recycling Unit of NSW Agriculture, the Department of Agricultural Economics at the University of Sydney and private sector companies. Our aim is to provide scientific support for developing a comprehensive package for forest land management for degraded sites. The package will include information on current land rehabilitation practices and how wastes may fit into this process, the availability of wastes in the Hunter Valley region, and the potential of different wastes for use in establishing hardwood plantations on poor sites.

### **Heartlands project**

The CSIRO Heartlands project (Sustainable Land Management for the Murray–Darling Basin) is run in co-operation with State Forests, the CRC for Catchment Hydrology and others. Its aim is to develop realistic options for long-term improvement in land management, from the paddock scale to the catchment scale. The Red Hill hydrology catchment trial (high rainfall) and the Yaven subcatchment trial (medium rainfall) will be used to monitor the effects of commercial planted forests on catchment hydrology, the ecology and regional socioeconomics.

## **More cost-effective establishment and management of sustainable hardwood plantations**

### **Key research themes:**

- *Increasing the availability of improved genetic material*
- *Developing best available silvicultural practices for stand establishment and management*
- *Establishing information on wood properties of selected species for marketing plantations to investors*
- *Developing information on soil- and water-related issues*

## **Technologies for viable plantation establishment**

The identification of new opportunities for the establishment and planting of trees is an important business strategy. Opportunities exist in low-rainfall areas, especially in farming catchments and in more traditional (coastal) forested markets.

**Acid sulphate soils** (ASSs) are a serious environmental concern in coastal Australia. There is significant opportunity for State Forests to develop broad-scale planting for wood and non-wood products in ASSs. Recent Department of Land and Water Conservation estimates indicate nearly 500 000 ha of potential ASSs in NSW alone. These soil areas are generally low-lying and often have a low economic return to farmers through existing grazing systems. In 1998–99, research was concentrated on understanding the ASS situation and exploring the potential for the establishment of eucalypt and melaleuca species to reduce the acid production and downstream effects of ASSs. Collaborative studies are under way with Southern Cross University, NSW Agriculture, the University of NSW, private industry and Tweed Shire Council.

**Water use efficiency.** The Millewa plantation (37 ha of *Eucalyptus camaldulensis*) is now incorporated into a Natural Heritage Trust program concentrating on investigating irrigated plantations in the southern Murray–Darling Basin. Field measurements of tree growth, soil moisture and weather are concentrated during summer. Irrigation practices and delivery mechanisms were reviewed, and links have now been established with Charles Sturt University.

**Salinity.** Preparation for the 15+ ha Xylonova trial site at Deniliquin has continued. The site will be planted in October 1999. This trial will investigate genetically adapted, salt-tolerant species in a saline landscape irrigated with saline water. A small trial area was established in October 1998 in northern Victoria; initial measurements indicated 2 m growth at six months of age.

**Effluent irrigation.** After a review of environmental factors, a management plan was developed for an effluent-irrigated plantation at the Holsworthy army base in Sydney. Further work now depends on the Department of Defence and Sydney Water.

**Soil water stress.** Glasshouse trials were used to determine the ability of soil additives to improve seedling survival in moisture-stressed conditions. Results showed a significant improvement in seedling survival in some treatments. Field trials are now warranted to determine the applicability of additives in operational plantings.

## **Insect-resistant clones**

The identification, propagation and screening of clonal material from select insect-resistant field trees are important components of the corporate objective of acquiring genetically improved planting stock.

The two phases of this program are a bioassay of the resistance of clonal material to key pest insects and a comparison of biochemical (e.g. essential oil profiles) and physical parameters (e.g. leaf toughness) of foliage from susceptible and resistant trees.

A series of bioassays on clonal *E. grandis* using Christmas beetles (*Anoplognathus* spp.) and three chrysomelid species has been completed in co-operation with Macquarie University. The foliar monoterpene content was also obtained from gas chromatograph analysis. The results reveal a varying level of resistance associated with levels of alpha-pinene. The Christmas beetles and *Paropsis atomaria* larvae ate significantly less foliage from the 'resistant' clonal plants than from the 'susceptible' clonal material. However, another *Paropsis* species, *P. variolosa*, showed no preference for either type of foliage. In contrast, herbivory in *E. camaldulensis* is correlated with the foliar concentration of cineole.

The project will be repeated next year and will include clonal material from a *E. dunnii* tree exhibiting resistance to psyllid attack.

Once the range and degree of insect resistance of this clonal material have been more fully characterised, the material will then be available for introduction into the eucalypt genetic improvement program. The incorporation of insect-resistant material into plantation stock will reduce the effect of herbivorous insects on tree growth, the reliance on chemical insecticides and the costs of insect pest management, providing an environmentally benign solution.

## **Development of enhanced genetic material**

**Genetic improvement of eucalypts** is proceeding along three main avenues:

- Establishing breeding populations of major plantation species with broad genetic bases for long-term cumulative improvement
- Testing alternative species and hybrids that may be better adapted for planting on new or 'problem' plantation sites

- Developing various seed-propagated and vegetatively propagated populations to rapidly deliver the best available improved material to plantations.

**Clonal forestry** with some species or hybrids is the aim, if technically and economically feasible. To this end, and to produce effective propagation populations, research and development in vegetative propagation is closely integrated with the breeding and testing of genotypes.

The breeding population of *E. pilularis* is well established in three large family trials in north-eastern NSW, augmented by similar plantings in Queensland. Co-operation and seed exchanges with the Queensland Forest Research Institute have ensured that these plantings include more than 300 select seedlots, with a large overlap of common seedlots at all sites such that genotype performance can be compared across sites in both States. In early 1999, similar extensive trials were established for *E. grandis* and *Corymbia variegata* (spotted gum) in northern NSW with both NSW and Queensland seedlots.

A large provenance–progeny test and a seed orchard of *E. camaldulensis* were planted on a Joint Venture plantation site near Albury in late 1998, under an agreement between State Forests, CSIRO and Albury City Council. These plantings form a valuable, long-term breeding resource and a potential source of improved seed of this important plantation species. Outstanding individuals identified from later assessments may be cloned for direct use or as parents for hybrid crosses.

Data for growth and form of provenances and progenies in older trials of *E. nitens* and *E. dunnii* have been analysed. The results show superior provenances to target for future seed collection, and individuals that may be cloned for seed orchards or cutting production. Heritability levels for growth in both series of trials show the likelihood of gains through selection and breeding.

**South African hybrid seedlots** of *E. grandis* × *E. camaldulensis* and *E. grandis* × *E. tereticornis* and seedlings of *E. grandis* and *E. maculata* were planted in five new trials near Casino and Grafton in early 1999. These trials complement four smaller trials with similar taxa planted a year earlier and extend the range of ‘difficult’ planting sites sampled. If the hybrids prove to be more promising than pure species after a few years, we aim to clone select individuals for more intensive testing. In adapting successfully to planting sites, hybrids need to be able to maintain growth over time in the presence of insect attack. One-year-old seedlings and clonea were assessed for insect damage after a severe attack. Although damage levels were mostly high, there were clonal differences, which gives hope that some clones may be able to recover rapidly.

About 100 select trees each of *E. grandis* and *E. pilularis*, selected in plantations on the North Coast in autumn 1998, were felled in early summer to produce coppice shoots. Most trees produced abundant coppice within two to three months, aided by the very wet season. Coppice was harvested and used to produce cuttings of the parent clones. Rooted cuttings of several *E. pilularis* clones are available to establish an early clonal trial. Replicated field trials were established in north-eastern NSW in early 1999, with 70 clones of *C. variegata* (produced by micropropagation from plus-tree seedlings) and 65 clones of *E. grandis* (rooted cuttings from seed orchard families). This material was produced as part of the vegetative propagation program.

**Vegetative propagation** techniques are used mainly as tools to increase the rate of incorporation of improved material into eucalypt plantations. Clonal forestry involves the testing of clones of select individual trees and mass production of the best clones for planting. Limited amounts of select material may be multiplied to produce plants, by cuttings or micropropagation, for field-testing.

There is great variation between species and clones in their ability to form roots on cuttings and in their productivity in culture during micropropagation. Seedlings from seedlots of mature plus trees of *E. grandis* and *E. pilularis* have been screened for root production by cuttings, and clones with good rooting ability have been selected. These will be multiplied and field-tested to identify clones with superior attributes. Plants were grown for one clonal trial of *E. grandis* planted in May 1999. Protocols developed for the micropropagation of *Corymbia variegata* were used to produce plants for clonal trials planted in April 1999 on four sites in northern NSW.

**Clonal archive** site development has begun at Somersby on the central coast of NSW. This archive will store genetic material while it is being field-tested. The plants will be intensively managed as hedges to maintain them in a juvenile state. Cuttings will be harvested to propagate plants for field trials. In three to four years when the field trials are assessed, the superior-performing clones will be recovered by taking cuttings from the hedges. These clones will then be available to establish operational hedges for mass propagation of planting stock for plantations.

Trees of superior growth, form and health were selected in plantations of *E. grandis* and *E. pilularis* at age three to five years. The trees were felled and the developing coppice was harvested for cuttings. Clones of both species were successfully grown, but the cuttings of *E. pilularis* had a better strike rate. Development of protocols for setting cuttings from *E. grandis* coppice is continuing. The plants grown from the field-selected trees will hasten the use of select material in plantations.

**Grafting** is another technique that is used to include genetic material from mature trees into the tree improvement program. Grafting may be used to produce ramets of mature select individuals for seed production (in seed orchards or as parents for controlled crossing in advanced breeding populations) or to ‘capture’ them for later propagation by cuttings. It is a non-destructive technique that allows the retention of the parent tree as a genetic resource for future use. Scions from mature plus trees of *E. dunnii*, *E. grandis* and *E. pilularis* were grafted onto juvenile rootstocks. The most successful species was *E. pilularis*. Some grafted plants will be used for experimental work to induce early prolific flowering by application of paclobutrazol. Controlled pollination of flowers on these plants could produce superior hybrid seed.

**Micropropagation** of select field material has been limited in success by contamination of cultures from high levels of endogenous fungi and bacteria associated with field material. Research has begun into protocols to produce viable, contamination-free cultures that produce vigorous shoots in initiation culture. These protocols will be used to establish cultures of select field material by grafted plants or coppice.

### **Technologies for optimum stand management**

Understanding how trees grow can help tree breeding programs. State Forests and the University of NSW investigated the use of specific leaf area as a selection parameter.

**Pruning and thinning** involve the manipulation of the tree canopy. A research strategy was devised involving both experimental and modelling work. Research into the branching characteristic of *E. grandis* and *E. pilularis* under different spacing regimes was done in conjunction with the Australian National University. Modelling options have been pursued in collaboration with the Queensland Forest Research Institute through a workshop on the forest model 3-PG.

The awarding of a grant from the Joint Venture Agroforestry Program will enhance national research into the pruning of eucalypts for clearwood.

### **Technologies to enhance environmental values**

**Paddock trees** were surveyed for wildlife on farms in 1997–98 before plantation establishment. The results have been analysed and submitted for scientific publication. Funds have been applied for to allow a resurvey of the same sites in 1999–2000, one year after plantation establishment. Continued

monitoring at these sites will allow State Forests to track changes in biodiversity levels in eucalypt plantations and to assess the role of paddock trees in enhancing this process.

## **Expanded and more efficient softwood plantations**

### **Key research themes:**

- *Developing resource-wide wood properties information*
- *Developing information on impacts of silviculture on wood quality*
- *Compiling and developing information contributing to a system of site-specific management*
- *Further improving genetic material*
- *Identifying causes of water pollution and developing strategies to minimise problems*
- *Refining the use of wastes in softwood plantations*

### **Technologies to optimise management systems and enhance productivity**

**A new trigonometric, variable-form taper model** was developed for *Pinus radiata* using data from 3251 trees sampled across plantations in NSW. The model predicts relative stem diameter with little local bias within any stem sections, and the 90% confidence interval of prediction is within  $\pm 0.1$  over the entire stem. There was little bias in the estimation of merchantable height at any specified top-end under-bark diameter ranging from 5 cm to 50 cm. Compared with nine site-specific polynomial taper equations currently in use, the trigonometric variable-form model predicts relative diameter generally more accurately. The model can be used to predict tree diameter at any height or to predict height at any diameter for ages ranging from 10 to 45 years.

**Tree nutrition.** Pine silvicultural trials, including fertiliser trials, were reviewed, and a future research strategy was prepared. This work led to the development of a research layer in the Softwood Plantations Division geographical information system. A collaborative grant application was submitted to the Strategic Partnership with Industry—Research and Training Scheme for a project to understand the effect of nutrition and other environmental factors on wood density.

**‘Expert systems’ for pine management.** Work has begun on developing expert systems for pine management. Research information will be collated and analysed in an attempt to develop growth and yield models and future silvicultural regimes (e.g. establishment and tending practices, rotation

age, thinning and pruning). For example, the radius of economic haulage distance from the major forest industries in Albury, Wagga Wagga, Tumut and Bombala includes a large area of country receiving less than 600 mm of rainfall per year. Below this threshold, *P. radiata* is barely productive. Consequently, there is a need to explore the potential of other species (such as *P. pinaster*) and silvicultural regimes better suited to these lower-rainfall areas. A trial design has been completed, and three trial sites have been selected.

**Cooperative sawing studies** (CSIRO and Forest and Wood Products R&D Corporation). The first of two studies included trees from a first-generation *P. radiata* progeny trial growing in Tallaganda State Forest. Its aim was to measure the wood volume gains from first-generation radiata pine seed orchards. Individual logs were sawn, and individual boards were tracked through the mill. The sawn lumber was dried and stress-graded, and degradation ranks were recorded.

The aim of the second study is to measure the relationships between *P. radiata* tree growth, wood properties measured with a Silvi Scan image analyser, and lumber recovery and strength. The strength and stiffness of the dried boards are currently being measured. Two non-destructive evaluation tools for predicting the wood quality of both logs and sawn boards were studied: a stress wave device and an acoustic device. The log data will be related to the strength and stiffness data for the boards to assess the predictive capability of these tools.

### **Development of enhanced genetic material**

A new breeding strategy to further improve radiata pine was developed and is already being implemented. The main aim is to improve wood quality to meet customer requirements. Major processing industries were surveyed to ensure that their needs were taken into account. The new strategy includes breeding objectives for both solid wood and reconstituted wood fibre products. Disease resistance—especially to the needle cast fungus *Dothistroma pini*—is the focus of work by CSIRO's Forests and Forest Products Division and the New Zealand Radiata Pine Breeding Cooperative at the New Zealand Forest Research Institute.

**Conservation of radiata pine.** State Forests was a major contributor to the Conserve Workshop run by CSIRO. The theme of the workshop was the conservation of genetic material of radiata pine within its native range in California, USA, and Baja California, Mexico, and in Australia and New

Zealand. Organisations from across Australia and New Zealand considered how best to conserve radiata pine, especially in light of the threat from pine pitch canker to the remaining native stands.

State Forests has some of the most extensive areas of native-provenance radiata pine and is therefore a major contributor to its conservation worldwide. It may also be a major supplier of pine germplasm back to California to replant native provenances destroyed by pine pitch canker.

**Propagation research.** Research techniques were developed to propagate radiata pine from needle fascicles. The use of needle fascicles provides an efficient way of multiplying genetic material in radiata pine, providing 80 to 100 fascicle cuttings per mother plant, compared with 10 to 20 conventional stem cuttings per mother plant.

Other research investigated ways of maintaining juvenility of radiata pine germplasm. Under normal growth and development, radiata pine remains juvenile for three to five years; this period is the only time during which cuttings can be taken and grown. However, this short period does not allow sufficient time for testing of select clones, especially for the important wood property traits. The ability to store genetic material and maintain juvenility during testing would dramatically increase the efficiency of genetic improvement and contribute to cost-effective clonal forestry. The research examined two pathways for maintaining juvenility:

- By growing mother plants in a hedge kept as low as possible—this is effective but resource-intensive and is limited to a juvenile ‘storage time’ of around 10 years.
- By storing germplasm in liquid nitrogen—tissue of selected clones was stored, removed and successfully propagated a number of times. Juvenile tissue can be stored indefinitely, allowing field testing of clonal material before operational deployment. The technique may also prove effective for long-term storage of germplasm of rare or endangered plants.

**Genetic material for the afforestation of dryland or degraded farms.** State Forests is a founding member of the Australian Low Rainfall Tree Improvement Group, funded by the Commonwealth Government. The objectives of the program include providing improved genetic material of pines, eucalypts and oil mallees for planting on dryland farms. State Forests established three field trials of *Pinus pinaster* in Junee, Wagga Wagga and Bombala as part of a broader, longer-term improvement strategy.

## **Technologies to prevent adverse effects on soil and water**

**Red Hill hydrology project.** Measurements of rainfall, stream height and water quality have continued.

- The cross-section of the streambed at the weir in Saw Mill Creek was surveyed to heights above the greatest expected stream height, and some measurements of stream velocity have been taken. More measurements at a range of stream heights are required to improve the estimation of discharge.
- By 1998, when the trees were 9–10 years old and canopy cover became complete, the annual run-off from the Red Hill catchment had declined by 250 mm from before planting.
- The project's Establishment Report has been printed and distributed.

## **Increased use and value of timber products**

### **Key research themes:**

- *Establishing cooperative research and development projects with industry in adding value*
- *Providing information on expected product performance*
- *Developing information to increase industry acceptance of underused hardwoods, particularly tableland species*
- *Developing information on pole durability, including information on non-traditional species*
- *Identifying and developing new wood products and new uses for wood products*

## **Technologies to increase market and community acceptance of preservative-treated timber**

**Power poles.** Field and laboratory studies are evaluating the performance of plantation-grown eucalypt power poles, groundline maintenance techniques for in-service eucalypt poles, and termiticidal treatments for sawn *P. radiata* timber.

In 1974, a long-term trial was established on the central coast of NSW to compare the performance of plantation-grown *Eucalyptus agglomerata* (blue-leaved stringybark) poles with that of accepted *E. pilularis* (blackbutt) and *E. maculata* (spotted gum) poles. The poles were surveyed in 1998 to compare their performance after 24 years in the field.

Field inspections and laboratory examinations of sampled material were used to assess performance. There was some variability in performance between species for some criteria. Nonetheless, all species were in good condition after 24 years. Overall, *E. agglomerata* performed as well as *E. pilularis* and *E. maculata*.

These results confirm the suitability of plantation-grown *E. agglomerata* as a pole species and will support the development of a market for plantation-grown *E. agglomerata* poles.

**Groundline maintenance.** In NSW, all of the approximately two million hardwood poles in service require remedial groundline maintenance at some time to protect them from fungal degradation. Long-term field and laboratory trials of maintenance treatments for preventing and arresting fungal decay in wood poles have been established in collaboration with commercial timber preservation companies and state electricity authorities. Research is assessing a range of chemical and delivery options to maximise transfer of chemicals to the poles and minimise the loss of chemicals to the environment.

Existing maintenance procedures cost pole-owners approximately \$15 million a year. The research will help reduce these costs. By lessening the loss of active ingredients from treatments, it will also improve the environmental acceptability of groundline maintenance treatments. Results will improve the cost-effectiveness of wood poles and keep them competitive with poles made from other materials.

**Termites** pose a major hazard to susceptible building materials such as softwood timbers. For many years, organochlorine soil barriers were used to protect buildings from termites. Their banning in 1994 placed reliance on other barrier systems without the longevity or track record of the organochlorines.

Preservative treatment is an alternative method for protecting susceptible timber. The effectiveness of experimental preservative treatments for *P. radiata* sapwood is under investigation in collaboration with commercial timber preservation companies and the Queensland Forest Research Institute.

Treated timbers will be exposed to termite attack for 12 months in above-ground simulations. If the new treatments are effective, the results will influence preservative treatment requirements for *P. radiata* sapwood and improve the cost-effectiveness and consumer acceptance of preservative-treated timber.

**Effect of CCA treatment and re-drying temperature on the strength and stiffness of *Pinus radiata*.** Re-drying of timber after copper-chrome-arsenate treatment is a normal part of the process. Although raising the temperature can accelerate the process, it can reduce timber strength. Minimising this reduction was the subject of an industry-funded project aimed at producing data to aid drying decisions in Australia. The results showed that re-drying CCA-treated *P. radiata* above 90°C had no effect on stiffness but caused a significant reduction in strength and thus grade.

### **Wood quality research**

**Developing information on wood properties of plantation hardwoods.** A draft strategy and protocol to assess the wood properties of plantation hardwoods was prepared. The immediate need is to gather information on wood quality and sawn recovery to enable better understanding of the linkages between silvicultural practice, the quality of the material available to the processor, and the consequent economic implications. Mill recovery will be studied routinely for twelve months. Trees will be felled and the logs will be tracked from the forest to the sawmill and the subsequent sawn timber. Information on product recovery and physical and mechanical properties will be collected and related to site-specific factors, breed, age and silviculture. State Forests will collaborate with the Queensland Forest Research Institute.

**Developing resource-wide information on wood properties of *P. radiata*.** Information on *P. radiata* wood properties affected by silviculture, site and genetic material is critical to improved allocation of logs for various uses, and hence to maximising the value recovered from the planted forests. A strategic document was prepared reviewing current wood quality issues faced by processors and how these may be managed through forest management.

In collaboration with the New Zealand Forest Research Institute, an operational working plan was developed to measure basic wood density across the softwood pine estate. The information gathered will be used to predict product quality and out-turn and then validated from mill studies.

**Non-destructive evaluation of intrinsic wood quality within on-farm woodlots.** FR&DD has obtained Forest and Wood Products R&D Corporation funding to establish the capability of non-destructive evaluation tools, compared with conventional assessment methods, to predict the intrinsic wood quality of standing trees. The work is being done in conjunction with CSIRO Forestry and Forest Products Division, CSR Softwoods and J. Notaras and Sons.

The intention is to develop technology that will improve log merchandising and segregation operations and in turn maximise the value recovered from planted forests. The technology could quantify the intrinsic wood quality of farm woodlots and plantations either before or during harvest. The knowledge gained from this research should strongly link growers with processors and enable them to relate product performance to wood properties and thus to identify high-value markets.

## **Ecologically sustainable forest management systems in native forests**

### **Key research themes:**

- *Native forest silviculture and tree growth modelling*
- *Regrowth forest dynamics and forest health*
- *Management impacts on biodiversity and key flora and fauna*
- *Impacts of native forest management on soil erosion, water yield and quality*
- *Forest ecosystem modelling at scales up to landscape level*

### **Technologies to optimise timber yield**

**Native regrowth forests** constitute a substantial and increasing proportion of the forest estate under the management of State Forests. Hence, there is major continuing research involving long-term measurement of managed eucalypt forests in the south-east of the State. Results of tree growth and yield modelling have not only enabled managers to schedule future yield of regrowth forests more reliably than hitherto, but also given them tools to manage forests for multiple uses, including biomass accumulation, carbon storage and water yield.

Collaborative research with CSIRO investigated the incorporation of remote sensing into growth and yield predictions. Results showed the potential use of satellite imagery from the Landsat Multi Spectral Scanner in improving the precision of forest growth and yield predictions.

Equations for stem volume, sectional volume and taper predictions have been developed and refined for more than 30 hardwood species in NSW. These equations have been incorporated in State Forests' MARVL software system. The system is being used for forest inventories and planning statewide. Improvements in stand forecasting and yield prediction have provided a quantitative basis for comparing future forest management options during the current Comprehensive Regional

Assessment/Regional Forest Agreement processes for the south-eastern and north-eastern forests of NSW.

Our understanding of stand dynamics is important to forest growth and yield modelling. A major achievement in this area is the development of a theoretical framework for evaluating the density-dependent upper boundary of stand volume and the site occupancy of even-aged forest stands, two factors governing the growth and mortality of trees in the stands.

**Optimum regeneration strategies** for ecologically sustainable management of native eucalypt forests continues to be a major research and forest management issue in commercially productive coastal forests. Results from several long-term research plots investigating diverse aspects of stand dynamics—such as thinning response, interspecific competition and recovery following different silvicultural treatments—are being prepared for publication. Collaborative research into national standards for assessment of forest regeneration has begun. The research will investigate the utility of different methods for measuring regeneration success in different forest types and study indicators of seed availability.

### **Systems to protect ecological values**

**Frogs** remain an important group in considerations of forestry operations. Work has continued on tracking the giant barred frog to confirm its habit of remaining within 20 m of larger streams and that it does not move significantly further afield during winter.

Radio-tracking studies have begun on the giant burrowing frog. This species is known to move well away from water bodies on wet nights, but how often it moves and for how long it stays away from the riparian zone are not known. Results so far indicate that it only rarely uses the riparian zone.

Instead, it appears to spend most of the year some distance into the forests, where it moves around within a limited area. It may also establish 'home' burrow complexes and use several different established sites over several months. Rather than burrowing to substantial depths (30 cm or more), individuals have consistently been found to be no more than 1–2 cm below the ground. Individuals have also been found to shelter under logs and even under logging debris after having moved into recently logged areas. This information indicates that it will be difficult to determine whether any standard prescriptions should be applied for the protection of this species. However, the finding that frogs move into logged forest indicates that they are willing to use disturbed habitats.

The long-term success of corridors of native vegetation in maintaining populations of frogs within an otherwise inappropriate landscape has been little investigated, particularly over the longer term. Surveys have been done in 15–20 year-old corridors within pine plantations in south-eastern NSW to determine what frog species remained present within the corridors after this time. All species found within areas of native forest were also found within corridors extending into and through pine plantations. This indicates that frogs are quite capable of maintaining populations within only narrow strips of remnant native vegetation, and so corridors can be used as an important conservation tool for frogs.

Monitoring of frogs has continued in the Dorrigo area. This study will provide information on the nature of the natural fluctuations that frog populations go through. It has also provided information on those species that appear to be more predictable in their detectability and so are more suitable as indicators of ecologically sustainable forest management. Identifying these species will enable State Forests and other groups to more quickly detect when declines are happening and whether those declines are within the range of natural fluctuations. This is important given the continued serious decline in frog populations throughout the world.

**Bats.** Research on threatened species of bats continued with studies on the fishing bat and the greater broad-nosed bat. Fishing bats forage over water for aquatic invertebrates and small fish. A population roosting beneath a log bridge in Kerewong State Forest on the mid north coast has now been banded for three consecutive years. Banding reveals a stable population of about 60 bats. The catchment upstream of the roost is to be logged in 1999, and continued monitoring and banding will provide an important test of State Forests' management prescriptions for this species.

The greater broad-nosed bat is a large species that is a significant consumer of beetles, an important pest of eucalypt plantations and young regrowth forest. Preliminary results from radio-tracking found a maternity roost in a large *Eucalyptus grandis* adjacent to a stream in forest, but showed that the farmland–forest interface is likely to be important foraging habitat for this poorly known species. Its continued presence in the landscape may have considerable benefits for eucalypt plantations.

In 1998, research on all bat species, their sensitivity to logging and the time taken to recover began at two sites. The first, at Banskia Road in Eden, is part of a larger study of birds in an alternate coupe logging system. Bats were sampled in replicate logged and unlogged coupes. They will continue to be sampled after the unlogged coupes are logged in the coming year. Logging will follow

the same practices carried out in the early 1970s, when there were minimal prescriptions for wildlife. This worst-case disturbance scenario will help to identify the sensitivity of bats to an extreme intensity of logging.

The second study, at the Karuah Hydrology Research Catchments, is located on the mid-north coast in Chichester State Forest. In these experimental catchments, riparian buffer strips have been retained. Again, bats were sampled in both regrowth (logged in 1983) and unlogged catchments. More than 200 bats were individually banded so that population sizes under different management treatments can be estimated. The pioneering nature of this work is highly significant, as no experimental logging studies of bats have been done previously.

External funding from the National Parks and Wildlife Service was received in 1998 to write a draft recovery plan for 18 species of threatened forest bats. Under threatened species legislation it is a requirement for NPWS to prepare recovery plans for all threatened species. The purpose of the plan is to summarise key information on each species with a view to assessing its species conservation status, reviewing threats to its viability and outlining actions that are considered essential to its recovery.

**Koala ecology.** The first experimental study of the effects of logging on koalas began in October 1997. The setting was the forests of the Pilliga region, which have had a long history of wood production, but which also contain a large and previously unstudied population of koalas. The principal aim was to determine the response of koalas to selective logging for white cypress pine (*Callitris columellaris*) within a mixed white cypress – eucalypt forest. Thirty koalas, five in each of six areas, were radio-tracked for a year to determine their movements, home-range sizes and tree preferences. Three of these areas were logged selectively after four months; the remaining areas were left undisturbed as controls. Home-range sizes for males and females were similar (approximately 15 ha). Koalas used white cypress pine extensively for daytime shelter but displayed strong preferences for the foliage of red gums (2–3 species) and Pilliga box as a food source. Koalas continued to occupy all or part of their previous home ranges following selective logging, and home-range sizes remained similar between logged and unlogged areas. Similar proportions of breeding females were recorded in logged and unlogged areas. Research collaborators from a range of institutions, including the Australian Koala Foundation, the University of Queensland, the Queensland University of Technology, the University of Sydney and the University of NSW, are documenting

koala health and disease status, the genetic composition of the population and the effectiveness of different survey procedures, estimating population size, and predicting the distribution of suitable habitat for koalas in the region.

**Effects of variable-intensity logging on mammals, reptiles and amphibians.** In another experimental logging study in south-eastern NSW, populations of arboreal marsupials, small ground-dwelling mammals, reptiles and amphibians were assessed in forest before and after logging at different levels of canopy retention. The objectives of the study were to determine the sensitivity of species to the intensity of logging and the time to recovery following disturbance. The arboreal marsupials, in particular the greater glider *Petauroides volans*, were among the species more sensitive to logging disturbance. The small ground-dwelling mammals and the reptiles that were sampled adequately in this study either appeared to be relatively unaffected by logging or recovered quickly (most within eight years, and probably all within 10–15 years) following logging. Despite a large survey effort, insufficient data were available to assess the effects of logging on most species of frogs, although two species may have been advantaged. The persistence of the large gliding possums was attributed to the retention of unlogged forest within and adjacent to logged areas. This highlights the important role played by riparian reserves (wildlife corridors) and filter strips in retaining residual populations of the greater glider and the yellow-bellied glider, *Petaurus australis*, until the logged areas become suitable for recolonisation.

**Early warning of environmental changes.** A collaborative study between State Forests, the Victorian Department of Natural Resources and Environment, the Queensland Department of Natural Resources, Forestry Tasmania and the CSIRO Division of Wildlife and Ecology has begun to identify particular species and functional groups that can be monitored cost-effectively to provide early warning of major environmental changes caused by forest management. The project will analyse large sets of existing data for a broad range of species, all of which were sampled at the same locations. The objectives are to identify the sensitivity of species or species groups to major classes of forestry operational activity, in particular logging. Also, any similarities in the responses to disturbance between species and species groups will be determined. The potential value of species and species groups to serve as indicators or ‘umbrellas’ to protect the habitat requirements of other species will be assessed.

**Flowering eucalypts.** Speeding up the analysis and reporting of unpublished State Forests' data helped the Regional Forest Agreement process. The data were collected over 10 years on flowering phenology for 20 species of myrtaceous trees on the mid-north coast of NSW. The results indicated that flowering periodicity and intensity were highly variable between species and sites, ranging from annual flowering to no flowering over the 10-year period. The period of greatest flowering for all species combined occurred nine months after the highest monthly rainfall recorded in the survey (March 1985). An extreme 18-month drought led to poor flowering in *Corymbia variegata*, *Eucalyptus acmenoides*, *E. grandis* and *E. resinifera*, but recovery after the drought broke was rapid. The remaining 16 species continued to bud and flower during drought. Site disturbance from logging at two sites during the survey did not reduce the percentage of the canopy in flower over following years. No species showed a negative correlation with a history of recent logging, and direct comparisons of the percentage of foliage in flower between large and medium trees did not differ for any species. At the production forest scale, the negligible effect of tree size and high stem density would leave about two-thirds of the net harvestable area producing flowers at a similar density as unlogged forest. However, larger *C. variegata* trees flowered more frequently than medium trees (every 2.3 years versus every 5.9 years), and there was also a trend in this direction for 13 other species. This result supports the current prescription for the retention of some large individuals of important nectar- and pollen-producing species.

**Fire.** The occurrence of planned and unplanned fires has been a major factor in determining the structure, floristic composition and timber characteristics of forests in the Eden region. The impact of these practices on the forest environment remains subject to considerable debate.

To consider environmental concerns and assess forest management practices, the Eden Burning Study was established between 1985 and 1988. This is a major, long-term experiment conducted on an operational scale and is envisaged to run for at least 50 years. Situated in dry-ash forest in the Yambulla State Forest, south-west of Eden, the experiment covers a total core experimental area of 835 hectares.

Over the last 12 years, detailed measurements have been made of understorey floristic composition, forest structure, composition and regeneration, tree growth rates and fuel weights. Fauna (ground mammals and diurnal birds) was also initially recorded. Although numerous small-scale studies have

been made of fire effects, the operational scale of this experiment is important to the transfer of information to practical applications in forest management.

Immediate priorities are the amalgamation and standardisation of data into a centralised database. The data will provide empirical evidence to help determine optimum burning regimes to maximise hazard reduction and post-disturbance regeneration and to minimise ecological impacts. Such analyses will be valuable not only to State Forests but also to other land management agencies. The known fire history and extensive base data from this experiment will continue make the area valuable as a reference site for other related studies.

**Endangered plant species.** Research into endangered plant species within forests is continuing. Data are being collected on life cycle characteristics, particularly responses to different agents of disturbance. For example, *Boronia umbellata* appears to gradually die out from the forest understorey as other taller species grow above it. A study has begun that involves monitoring mortality and recruitment in populations of several ages, seed production, and germination from the soil seed bank. The results will indicate an appropriate disturbance regime for management.

### **Systems to protect soil and water values**

Research and technical investigations are being undertaken at a range of scales to quantify and enhance the effects of forest management on soil and water values within the State's native forests. Research projects range from long-term studies with experimental treatments imposed over small catchments (10–100 ha) to short-term detailed investigation of localised run-off, erosion and sediment impacts.

**Karuah hydrology project.** Detailed analyses of water yield changes revealed the following:

- Tractor harvesting of steep, moist eucalypt forest resulted in small, and generally statistically non-significant, differences in streamwater turbidity between treated and control catchments during storms. Measured values were not high and indicated that if roading and harvesting had caused any accelerated erosion, it had not resulted in significant sediment delivery to streams.
- The roaded catchment with the largest and most persistent increase in turbidity levels at low to moderate flow also experienced snig track construction and use over some minor intermittent drainage lines. This disturbance may have contributed to the observed impact, but the two effects (roading and snagging) cannot be separated.

**Yambulla hydrology project.** Water yield changes are being analysed in collaboration with Melbourne University. The following points can be made:

- Water yields increased significantly after logging or fire in catchments.
- Water yields declined slowly as regrowth became established.

**Tantawangalo hydrology project.** The analysis of water yield changes is complete.

- Water yields increased significantly after logging.
- Water yields declined as regrowth became established.
- This decline in yield has been more rapid in Wicksend Catchment, where the post-logging burn has produced a more vigorous regenerating stand.
- Yields in Wicksend Catchment have declined to below pretreatment levels after 11 years of regrowth.
- These catchments are now in National Parks, and no more forest manipulations are likely.

**Stream health assessment and indicator development.** The first stage of the national stream health assessment program (the baseline study) was completed in 1998, but the NSW Environment Protection Agency is yet to make the data available. The EPA has data on the next stage of the national program, in which a number of sites are located in State forests. All sites in this program have been included on State Forests' geographical information system, and further work has been done in determining logging and fire history in the catchments above these sites. The work will continue and will relate stream health to management history in a range of catchments with differing histories.

State Forests examined the possibility of joint macroinvertebrate investigations with the Victorian Department of Natural Resources and Environment. The DNRE established a scientific team to assess stream health in various parts of Victoria, including the north-east and Gippsland. Both agencies are considering the development of a macroinvertebrate model for north-eastern Victoria and south-eastern NSW.

**Soil erosion studies** were held over four years to quantify soil erosion and sediment redistribution processes after native forest logging.

- Erosion rates from logging tracks varied more within two monitored sites than between them.
- Erosion rates declined exponentially and by the third year after logging had returned almost to background levels.

- The severity of soil disturbance was a major determinant of observed erosion rate.
- Sediment transport distances beyond track drainage banks over undisturbed forest floor were commonly less than five metres under normal rainfall.
- Undisturbed forest floor trapped most eroded sediment over a distance of 10 m under extreme simulated rainfall.
- Ground disturbance by machines or fire increased sediment transport distance.

Field measurements have recently been completed, and the erosion research program is now winding down. Future work will involve testing of physically based erosion models under NSW forest conditions.

**Research into soil physical properties** is underway in the silvertop ash forest in south-eastern NSW to determine the impact, if any, of logging-derived soil disturbance on subsequent forest growth. Further components of the study include improving understanding of the relationship between logging machine traffic and soil impacts and identifying the best method of measuring changes in soil physical properties for sustainability criteria and indicator reporting. The study is funded partly by the Commonwealth Government's Wood and Paper Industry Strategy.

### **Integrated systems studies for sustainable forest management**

**Bell miner amelioration.** Bell miners (*Manorina melanophrys*) can cause canopy dieback and often tree death among susceptible eucalypt species. A conceptual model illustrating the relationships and feedback loops between processes that may contribute to canopy dieback associated with bell miners in moist eucalypt forests has been proposed. Bell miners interfere with the abundance and efficiency of the usual complex of birds and invertebrate natural enemies that feed on herbivorous insects present on eucalypt foliage. This results in sustained increased numbers of some damaging insects. Susceptible trees are unable to sustain repeated cycles of foliage loss and replacement, and the canopy falls into an irreversible decline once the trees' nutrient and energy reserves are depleted.

Current research has been designed to test whether the removal of dense understorey (predominantly lantana and viney weeds) will improve the condition of canopy affected by bell miners. This operation may not be suitable for all sites affected by bell miner dieback, but if successful will provide forest managers with an operational strategy to reverse this process of canopy decline.

During the 1998–99 season, as part of this work, two large plots were established in Olney State Forest, and comprehensive baseline data sets on tree condition, floral surveys and bird counts were obtained. This site is unique in Australia in terms of the opportunities it represents for future studies relating to forest ecosystem health and vitality.

### **Forest health**

Potential incursions of exotic pests and pathogens are a constant threat to our forests' production and conservation. At present, forest industries are generally not well organised to deal with serious incursions. This year, State Forests has been very active in the preparation of an Australian Forest Pest and Disease Generic Incursion Management Plan (GIMP).

A complication for management of incursions of forest pests and pathogens is that there are diverse stakeholders potentially involved: private and government production forest managers, urban forest managers, and conservation forest managers. The GIMP provides a defined framework for managing future incursions. The GIMP has been considered and endorsed by the Ministerial Council on Forestry and Fisheries and the Standing Committee on Forestry. The next step is the formation of a NSW forest health advisory committee with government and industry representatives, particularly from organisations that would be expected to contribute to incursion management.

### **Forest health surveillance**

The Forest Health Survey Unit conducted surveys of softwood and hardwood plantations, giving plantation managers recommendations for remedial or control action for pests and diseases, nutritional imbalances, vertebrate damage, weeds and environmental problems.

Aerial surveillance (by helicopter) was trialled in the larger (> 500 ha) eucalypt plantations to examine the usefulness of this method for determining the extent and severity of disorders in young plantations (2–5 years old). It proved useful in identifying problem areas and in stratifying the ground survey, thus reducing time spent doing ground surveys. The surveillance methodology for softwood plantations changed slightly in 1999, with less reliance and time spent on 'drive-through' surveys, and more 'targeted' ground surveys, concentrating on younger age classes.

**Ambrosia beetle (*Austroplatypus incompertus*).** Research into the effects of infestation continued in the Macleay–Hastings region in 1998. A trial was done to relate a visual assessment of the severity of beetle attack in living trees to the amount of timber yield in logs.

### **Pests and diseases of pine**

Ground surveys for *Sirex* wood wasp were concentrated in drought-stressed areas where last year large numbers of pines were killed by infection with the fungus *Sphaeropsis sapinea*. There were no significant increases in *Sirex* numbers this year. *Ips grandicollis* is now established in the Hume region (Tumut–Tumbarumba), transforming the situation from purely a monitoring and surveillance mode to a monitoring and management mode. The Monterey pine aphid, *Essigella californica*, is now established throughout the *Pinus radiata* regions west and south of Sydney. Further research is being conducted on the effects of this insect on tree health. After the discovery of galls in young pines in Tasmania earlier this year, surveys have been made of *P. radiata* plantations planted in NSW in 1996–98. No galls of the kind seen in Tasmania have been found as yet. The cause is still unknown.

Possoms in Bombala have caused extensive damage in recent years. The damage has increased again this year as possums move into areas previously undamaged. Other areas in NSW had only minor damage. Browsing from wallabies was a problem in young stands adjacent to native bush and retention strips in many regions in NSW.

Owing to heavy spring rains in 1998 in many *P. radiata* growing regions, damage from *Dothistroma* has increased and was greater in 1998–99 than in the previous two to three years. *Cyclaneusma minus* was widespread in the NSW *P. radiata* plantations in 1998–99. Needle symptoms associated with *Cyclaneusma* infection and Monterey pine aphid attack were observed on needles older than current-year needles in most *P. radiata* plantations surveyed.

Damage from *Armillaria* spp. was observed in the young *P. radiata* plantations planted near Urbenville in northern NSW in 1996–97. Up to 8% mortality was observed in localised areas. Elsewhere in NSW, mortality of pines due to *Armillaria* infections is rare. Widespread and severe damage from *Sphaeropsis sapinea* was observed during the forest health surveys in June–September 1998. In the worst-affected areas, up to 45% of trees were killed or had dead tops. Moderate to severe damage from *Sphaeropsis* was observed in most State Forests' *P. radiata* plantations. Infection and mortality from *Sphaeropsis* was most severe on sites with shallow soils or

a northerly or westerly aspect. Here soil moisture would be limiting (especially under the prevailing drought conditions), and there were often nutrient deficiencies too (e.g. boron). Many of the affected stands were overdue for their first thinning. Surveys in June 1999 revealed that damage from *Sphaeropsis* is much less this year. Salvage logging of affected plantations was rarely attempted. Samples of dead tops, resinous stem and branch cankers, and dead natural regeneration from *P. radiata* plantations in all pine-growing regions of NSW and ACT were collected in 1998 and 1999. Isolations from this material have yielded no *Fusarium circinatum* (pine pitch canker). The great majority of isolates were *S. sapinea*.

### **Pests and diseases of eucalypts**

An outbreak of the lerp psyllid *Creiis* sp. nr. *literalta* caused extensive damage in a three-year-old *Eucalyptus dunnii* plantation near Casino, in northern NSW. Severe damage occurred. Up to 100% of leaves were damaged and killed and up to 100 ha was affected. This is the first record of this species of psyllid causing extensive damage in eucalypt plantations. The insect was also observed at two other sites, but only at minor levels. Damage from other psyllids (e.g. *Cardiaspina* spp.) was low in most cases, only a few plantations being severely damaged. The chrysomelids *Chrysophtharta cloelia* and *Paropsis atomaria* were among the most destructive pests in young eucalypt plantations in northern NSW. In some cases trees were totally defoliated by these insects (as well as by Christmas beetles, *Anoplognathus* spp.). Christmas beetles caused defoliation in late spring to early summer in many young eucalypt plantations in northern NSW. Most of these damaged trees showed signs of recovery by late summer to early autumn. Severe outbreaks of leaf-blister sawfly larvae (*Phylacteophaga froggatti*) occurred in a few plantations in northern NSW. Damage from stem borers increased this year, in both number of plantations and number of trees in the plantations. In some cases, 45% of 3–4-year-old *E. grandis* trees in plantations on the north coast had stem borer damage (both cerambycids and cossids). Cockatoos had caused severe damage to some of the *E. grandis* trees infested with cossid moth larvae. The Forest Health Survey Unit observed that many small-diameter (< 10 cm) amenity plantings of *Eucalyptus*, *Acacia* and *Casuarina*, especially along roadsides and in parklands, had been attacked and killed by stem borers. This is a higher number than was observed in previous years.

An outbreak of phasmatids (*Didymuria violescens*) in native State forests in the Hume region (Tumut–Tumbarumba) was observed in April and aerially surveyed in June. The damage was extensive, covering approximately 8570 ha in three State forests (Buccleuch, Bago and Maragle). Total defoliation of some trees was observed. A similar outbreak in the same area occurred during the 1950s and early 1960s, causing extensive damage and loss of growth. The current outbreak will be monitored to determine whether control is needed.

A higher than usual number of plantations suffered from waterlogging this year, owing to the heavy rains on the north coast. *E. dunnii* was the most affected species, possibly owing to the low-lying sites chosen for planting. Trees that were severely affected by insects (e.g. *Creiis* sp. in *E. dunnii* and leaf-blister sawfly larvae in *C. maculata*) were situated in waterlogged areas. Mortality from *Phytophthora* was also higher in wet areas this year.

Considerable mortality caused by *Phytophthora cinnamomi* was observed in young eucalypt plantations (up to five years old) in 1998–99. In plantations on poorly drained sites, there was commonly about 10% mortality. Damage from leaf spot fungi was minimal in most cases.

*Aulographina eucalypti*, *Coniella fragariae* and *Mycosphaerella* spp. were the most commonly observed pathogens in young eucalypt plantations.

*Endothia gyrosa* stem cankers were observed causing damage and mortality in two-, three- and five-year-old *E. dunnii* plantations in northern NSW.

## Services provided

- The Forest Ecosystem Dynamics Section has continued in its role of giving wildlife training courses for staff within State Forests and for other government organisations, non-government organisations and interested members of the public. This ensures that State Forests' staff can maximise their effectiveness in doing wildlife surveys and in educating the community about wildlife management.
- The analytical laboratory is accredited by the National Association of Testing Authorities (NATA) and is certified by the Australian Soil and Plant Analysis Council. It provides a testing service to both internal and external clients. Samples analysed include wood, water, foliage and soil.

- The NATA-accredited timber engineering laboratory provides testing services to a number of timber-producing mills for the purpose of quality assurance of the final product and to evaluate engineering properties.
- Advisory services were provided to Joint Accredited Systems for Australia and New Zealand.
- Mechanical grading services were provided to ladder manufacturers.
- Strength properties of timber and timber products were assessed for external customers, and technical back-up was provided to branches within State Forests.
- FR&DD participated on committees of Standards Australia in relation to efficient use of timber and timber products.
- FR&DD has an active role in the Australian Forestry Quarantine Consultative Committee.
- Technical information was provided to the timber industry and the community.
- University, TAFE and school students were educated on wood properties and use of timber and timber products.
- Pests and diseases of forest and forest products were identified and technical advice was given.
- FR&DD hosted international delegations and individuals, including a technological mission of plant and forestry growers from Temuco in Chile; a Chinese delegation from the Liaoning Provincial Forestry Department; a Japanese delegation from the Central Committee for Promoting Wood Products Utilization; and a senior Indian delegation from the Indian Council of Forestry Research and Education.

### **Other advisory activities**

- Exhibitions at the Family Forest Fair, Cumberland State Forest; Timber and Working with Wood Show, Homebush Bay; Sydney Pet and Animal Expo, Homebush Bay; Interbuilt Australia '99, Darling Harbour; and local shows at Walcha, Tumut, Darling Harbour and Parramatta Park.
- Educational tours by university, TAFE, high school and primary school students.
- R&D page, including publications price list, on State Forests' Internet ([www.forest.nsw.gov.au](http://www.forest.nsw.gov.au)) and intranet sites.
- The *Bush Telegraph*; R&D articles in each edition.
- Items in popular media outlets, including the *Sydney Morning Herald*, local radio and television.

- Research results presented at various professional meetings and forestry industry groups; for example the NSW Apiarists' Association Annual Conference.

### **State Forests' library**

The library continued its role of collecting, conserving and communicating information for the benefit of staff in their work for State Forests. The library is committed to providing timely, relevant and accurate information from anywhere in the world to any office in the organisation.

In addition, staff willingly help members of the general public. In fact, more than 600 loans to external libraries and over 700 reference requests were completed.

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### **Patent**

Clark, T, Dickson, R.L., Albert, D. and Walker, J.C.F. (1998). Method of selecting and/or processing wood according to fibre characteristics. New Zealand Patent Application No. 331527.

## Co-operation with universities

FR&DD directly assist university post-graduate research work in State forests. Our staff assist in the joint supervision of research work and, in some cases, provides financial support to enable students to complete Ph.D, Masters or Honours degrees.

| <b>Project Title</b>  | <b>University Student</b> | <b>Co-operating University</b> | <b>University Supervisor</b> | <b>FR&amp;DD Supervisor</b>      |
|---|---------------------------|--------------------------------|------------------------------|----------------------------------|
| Ecological Study of the Endangered Stephens Banded Snake ( <i>Hoplocephalus Stephensii</i> )  | Mark Fitzgerald           | University of Sydney           | Dr Richard Shine             | Mr. Frank Lemckert               |
| Feeding Preference and Ecology of <i>Chrysoptharata cloeia</i>  | Caitlin Johns             | Macquarie University           | Dr Leslie Hughes             | Dr Christine Stone               |
| Characterisation of Branching Patterns in Response to Initial Planting Density in <i>E. grandis</i> and <i>E. pilularis</i> Plantations in the North Coast of NSW | Dean Kearney              | Australian National University | Dr Ryde James                | Dr Geoff Smith/Dr Kelvin Montagu |
| Integration of Spatial and Temporal Patterns of Habitat Suitability in Planning for Timber Harvesting   | Brendan Wintle            | University of Melbourne        | Dr Mark Burgman              | Dr Rod Kavanagh                  |
| Habitat Use, Distribution and Census Techniques for Koalas in the Pilliga Forests   | Elizabeth Barrott         | University of Sydney           | Dr Chris Dickman/Dr Ian Hume | Dr Rod Kavanagh                  |
| The Effects of Forestry Harvesting Practices and Forest Type on the Reproductive Ecology of the Koala in  | Sally Radford             | Southern Cross University      | Dr Ross Goldingay            | Dr Rod Kavanagh                  |

Pine Creek State Forest

|  |                  |                                |                   |                   |
|--|------------------|--------------------------------|-------------------|-------------------|
| The Impacts of Cattle Grazing and Associated Burning Regimes on the Biodiversity of Tableland Eucalypt Forests | Elizabeth Tasker | University of Sydney           | Dr Chris Dickman  | Dr Brad Law       |
| Stream Preferences of the Fishing Bat ( <i>Myotis macropus</i> )   | Jason Anderson   | Australian National University | Dr Chris Tidemann | Dr Brad Law       |
| Thermal Characteristics of Bat Roosts  | Chris Turbill    | University of New England      | Dr Fritz Geiser   | Dr Brad Law       |
| Assimilation and Resource Allocation for Growth in <i>Eucalyptus grandis</i>                                   | Claire Daves     | University of New South Wales  | Dr Ross McMurtrie | Dr Kelvin Montagu |
| Change in Soil Carbon Associated with the Establishment of Hardwood Plantations                                | Yura Totsuka     | University of New South Wales  | Dr Ross McMurtrie | Dr Annette Cowie  |
| Incorporating Competitive Process and Environmental Heterogeneity in Individual Tree Models                    | Julian Fox       | Melbourne University           | Dr Peter Ades     | Dr Huiquan Bi     |
| Development of a Site Classification Model for Native Forests Using GIS  | Ernst Kemmerer   | Australian National University | Dr Brian Turner   | Dr Huiquan Bi     |

## Special purpose 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.

| Title of Activity   | Principal              | Organisation   |
|---|------------------------|--|
| EIS for Pacific Highway upgrade, Moorland route   | Brockhoff, John        | Connell Wagner Pty Ltd, Neutral Bay, NSW                           |
| Distribution and status of <i>Isoodon obesulus</i> in New South Wales   | Claridge, Dr Andrew W. | NSW NPWS, Sth Zone, Queanbeyan, NSW                                |
| Soil based information for developing sustainable plantation forestry   | Snowdon, Peter         | CSIRO Forestry and Forest Products, Canberra, ACT                  |
| Vegetation survey of forest edge and core in three remnant rainforests of the Lismore region  | Lott, Dr Rosemary      | Queensland Forestry Research Institute, Gympie, Qld                |
| Systematics of the moss family <i>Calmpereaceae</i>   | Mishler, Brent         | University of California, USA                                      |
| Flower development of basal Monocotyledons  | Buzgo, Matyas          | Institute for Systematic Botany, University of Zurich, Switzerland |
| Investigation of the effect of forestry management practices on endangered snake species, Stephen's Banded Snake ( <i>Hoplocephalus stephensi</i> ) | Fitzgerald, Mark       | Private study  |
| Collection of native flora for taxonomic research and plant specimens for herbarium   | West, Dr Judy          | CSIRO, Centre for Plant Biodiversity Research, Australian National |

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|---|--------------------|--|
| collection  |                    | Herbarium, Canberra, ACT                                 |
| Dipteran communities in flower heads of some <i>Senecio</i> species – relationship to flower head morphology and anatomy                                | Terry, M.A.        | Private study  |
| Collection of leaf samples of certain native orchids for analysis for viruses and map and monitor areas where infected plants are detected              | Moye, Marcel       | Private study  |
| Distribution and abundance of ground-dwelling mammals in relation to site fertility, disturbance and forest structure                                   | Catling, Peter     | CSIRO, Wildlife and Ecology, Canberra, ACT               |
| <i>Eucalyptus camaldulensis</i> as a tool for reconstructing river flood history  | Proust, Katrina    | Private study  |
| <i>Angiosperm Phylogeny</i> with particular focus on Magnoliids and Gentianales and studies on asterids and monocots                                    | Lundberg, Johannes | Uppsala University, Department Systematic Botany, Sweden |
| Role of riparian vegetation in maintaining water quality as assessed using biological indicators  | Peters, Janice     | University of NSW, Geography Department, NSW             |
| Fauna and flora survey of part of Doona State Forest near Carroona  | Denny, Martin      | Mount Kine Ecological Surveys, Oberon, NSW               |
| Systematic study of <i>Crowea</i> ( <i>Rutaceae</i> ) to determine the pattern of variation within <i>Crowea</i> and its relationship to related genera | Gebert, Wayne      | LaTrobe University/Royal Botanical Gardens, Vic.         |
| The ecology of the white-footed dunnart ( <i>Sminthopsis leucopus</i> ) in coastal southern New South Wales   | Klomp, Nicholas    | Charles Sturt University,                                |
| Flora and fauna surveys to satisfy NPWS   | Martin, Alison     | Greenloaning Biostudies                                  |

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Conditions of Consent for Timbarra Gold

Mining Projects

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|---|--------------------------|---|
| Ecological communities as a basis for conservation  | Hochuli, Dr<br>Dieter    | Sydney University, School of Biological Sciences, NSW                               |
| Predicting outcomes of threatening processes and their management in multi-species assemblages  | Penn, Angela             | University of NSW, School of Biological Sciences, NSW                               |
| Thermoregulation by eastern forest bat ( <i>Vespadelus pumilus</i> ): a comparison of bats roosting in mature and regrowth forest         | Turbill,<br>Christopher  | University of New England, Zoology, Armidale, NSW                                   |
| Investigation of chemotype variation and yield in <i>Melaleuca acternifolia</i> and chemotypic variation and evolution of selected genera | Garsden, Ross            | Southern Cross University, Australian Tea Tree Oil Research Institute, Lismore, NSW |
| Investigation of brush-tail rock wallaby habitats and colony environs. Vegetation and floristic survey                                    | Cavanagh,<br>Mike        | National Parks and Wildlife Service, NSW  |
| Collecting plants for Herbarium   | Gabrielyan,<br>Eleonora  | Institute of Botany, NAS Rep Armenia  |
| Measuring the effectiveness of environmental water allocations  | Reid, Dr<br>Michael      | Monash University, Department of Biological Sciences, Vic.                          |
| Causes and consequences of variation in dispersal in Australian treecreepers  | Johnson,<br>Veronica     | Australian National University, Division of Botany and Zoology                      |
| Study of phylogenetic relationships of the bees in the genus <i>Lasioglossum</i> (Hymenoptera:Halictidae)                                 | Danforth,<br>Bryan       | Cornell University, Department of Entomology, USA                                   |
| Field work methods in SRM 204 Sustainable Resource Management: Biodiversity   | Gladstone, Dr<br>William | University of Newcastle, NSW  |

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| Field studies of lichens in the genera Caloplaca, Fulgensia, Teloschistes and Zanthoria for the <i>Flora of Australia</i> project                            | Karnefelt, Dr E<br>Ingvar | Lund University, Botanical Museum,<br>Department of System. Botany,<br>Sweden     |
| Investigation of mosquito populations in Cumberland State Forest   | Russell, Prof<br>Richard  | Sydney University, Department of<br>Medical Entomology, Westmead<br>Hospital, NSW |
| Natural history of the land mullett ( <i>Egernia major</i> )   | Klingenboeck,<br>Anja     | Sydney University, School of Biology,<br>NSW                                      |
| Environmental Assessment and Education   | Courtice, Dr<br>Gillian   | Curlew Biological Services  |
| Habitat use, distribution and census techniques for koalas in the Pilliga forests  | Barrott,<br>Elizabeth     | Sydney University, School of Biological<br>Sciences, NSW                          |
| NSW Comprehensive Regional Assessments: fauna and flora surveys  | Gott, Miranda             | National Parks and Wildlife Service,<br>NSW                                       |
| Biogeography of Australian Insect Fauna  | Keast, John               | Private study   |
| Restoration strategies for vertebrate fauna on an agricultural landscape   | Nelson, Grant             | Charles Sturt University, Bathurst,<br>NSW  |
| Systematic study of Asterolasia ( <i>Rudaceae</i> )  | Mole, Bryan               | Melbourne University, School of<br>Botany,  |
| Evaluation of effects of residential development on bird populations   | Chaffey, Brian            | Private study   |
| Determine number of flower-feeding species that can be observed or collected from Koreelah State Forest (Acacia Plateau) over a three-month period each year | Clarke,<br>Raymond        | Byron Shire Council, Suffolk Park,<br>NSW   |
| Impact of habitat fragmentation on plant-animal interactions: net effects on seed set by   | Cunningham,<br>Saul       | Macquarie University, School of<br>Biological Sciences, NSW                       |

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| understory plantations   |                     |  |
| Predicting biodiversity of woodland remnants for on-ground conservation  | Seddon, Julian      | National Parks and Wildlife Service, ACT   |
| Fauna monitoring program, Jervis Bay area  | Mitchell, Les       | National Parks and Wildlife Service, Nowra, NSW                                  |
| Domestic stock, grazing and riparian zones: research for best practice management of land and water in inland rivers               | Jansen, Amy         | Charles Sturt University, School of Science and Technology, Wagga Wagga, NSW     |
| ACT/NSW wild dog project – hydatid disease   | Jenkins, Dr David   | Australian Hydatid Control Program, Fyshwick, ACT                                |
| River bioassessment – to test and calibrate the Australian river assessment systems sensitivity to impacts caused by logging       | Sloane, Philip      | University of Canberra, Co-operative Research Centre for Freshwater Ecology, ACT |
| Upper Shoalhaven vegetation and land use mapping project   | Newham, Lachlan     | Australian National University, Forestry Department, ACT                         |
| Strategies for carbon sequestration in Australia: a comparison between <i>Pinus radiata</i> and native forests                     | Chee, Yung En       | Australian National University, Department of Geography, ACT                     |
| Lower Bellinger water supply – assessment of storage sites; flora and fauna survey for NSW Department of Public Works and Services | Kendall, Keith      | Kendall and Kendall Ecological Services  |
| Sample for small parasitic wasps of the family <i>Eucharitidac</i> (Hymenoptera:Chalcidoidea)                                      | Heraty, John        | University of California, Riverside, USA   |
| The brown barrell ( <i>Eucalyptus fastigata</i> ) community on Mt Warrawolong, Watagan Mountains, NSW                              | Fisher, Howard John | Avondale College, Coorangong, NSW  |
| Survey and collection of fauna   | Morgan, Dr          | Australian Museum, Sydney, NSW   |

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|  | Gary                    |  |
| Study and capture of Hastings River Mouse  | Read, Dr<br>David       | Private study  |
| Collecting herbarium species and seed or cutting material for propagation and documentation and display of the flora of the Hunter region at the Botanic Gardens | Tame, Dr<br>Terry       | Hunter Region Botanic Gardens, NSW   |
| Frugivory and seed dispersal of the rainforest species <i>Lauraceae</i> in north-eastern NSW   | Hackett,<br>Damian      | Southern Cross University, School of Resource Science and Management, Lismore, NSW |
| Inbreeding depression in koalas  | Houlden,<br>Bronwyn     | Taronga Zoo, Mosman, NSW   |
| Investigation of effect of natural aromatic compounds on microbial diversity   | Gillings, Dr<br>Michael | Macquarie University, Key Centre for Biodiversity and Biores, NSW                  |
| Assessment of environmental flows for the Murrumbidgee River   | Watts, Dr<br>Robyn      | Charles Sturt University, Wagga Wagga, NSW   |
| Establishment of New South Wales' recovery team for endangered and vulnerable plant species on Eden rhyolite outcrops  | Carr, Geoff             | Ecology Australia, Fairfield, Vic  |
| Test of biomass sampling strategies for forest trees   | Keith, Dr<br>Heather    | CSIRO, Forestry and Forest Products, ACT   |
| Fauna survey in Fifield State Forest for environmental impact assessment of nichel mine  | Denny, Dr<br>Martin     | Mount King Ecological Surveys, Oberon, NSW   |
| Hormonal correlates of behaviour in the highly social white-browed babbler   | Oppenheimer,<br>Suzanne | Wollongong University, Department of Biological Sciences, NSW                      |
| Boundary effects in fragmented habitat   | Martin,<br>Timothy      | Australian Museum/Charles Sturt University, Wagga Wagga, NSW                       |

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| Effects of forest harvesting practices and forest type on the reproductive ecology of the koala in north-eastern New South Wales | Radford, Sally<br>Louise       | Southern Cross University, Lismore,<br>NSW  |
| Transpiration and water yield in dry sclerophyll, mixed species eucalypt forests in south-eastern Australia                      | Roberts,<br>Sandra             | CRC for Catchment Hydrology   |
| Rock wallaby ecology - assessing the impact of foxes and evaluating control  | Rummery,<br>Catherine          | National Parks and Wildlife Service,<br>NSW   |
| Sustainability of fuel-reduction burning regimes in native forests   | York, Dr Alan                  | University of Wollongong, Department<br>of Biological Sciences                            |
| Collection of native flora for taxonomic research  | Bruhl, Dr<br>Jeremy            | University of New England/NCW<br>Beadle Herbarium, Department of<br>Botany, Armidale, NSW |
| Habitat utilisation and reproductive biology of the red-crowned toadlet ( <i>Pseudophryne australis</i> )                        | Thumm, Karen                   | University of Newcastle, NSW  |
| Undergraduate field trip in vertebrate zoology   | Shine,<br>Professor<br>Richard | University of Sydney, Department of<br>Biology  |
| Collection of herbarium specimens, seed and cuttings from trees, plants and shrubs   | Errington,<br>Graeme           | Mount Annan Botanic Gardens, NSW  |
| Ongoing study of mushrooms and toadstools in New South Wales   | Wood, Dr AE                    | University of New South Wales,<br>School of Biological Sciences, NSW                      |
| River red gum invertebrate biodiversity  | Yen, Dr Alan                   | Museum of Victoria, Vic   |
| <i>The New Atlas of Australian Birds</i>   | Barrett, Dr<br>Geoff           | Birds Australia   |
| Southern Australian study of macro fungal  | Rees, Dr                       | University of New South Wales,  |

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| fruit bodies   | Bettye J                       | School of Biological Sciences, NSW  |
| Taxonomy and systematics of the xylariaceae (Ascomycotina)   | Smith, Dr<br>Gavin             | University of Hong Kong, Department of Ecology and Biodiversity, Hong Kong  |
| Field work skills in biodiversity and wildlife management and Australian flora and fauna                                     | Mahoney, Dr<br>Michael         | University of Newcastle, Biological Sciences, NSW                           |
| Geographic variation in <i>Pseudophryne australis</i> : morphometric and genetic differences                                 | Stauber,<br>Andrew             | University of Technology, Sydney, NSW                                       |
| Evaluation of effectiveness of the myco-insecticide <i>Metarhizium anisopliae</i> against termite <i>Coptotermes lacteus</i> | Pulsford, David                | Bio-Care Technology, Somersby, NSW  |
| Fruiting body and culture collection of Australian wild fungi  | Kearney,<br>A/Professor<br>Ray | Sydney Fungal Studies Group, NSW  |
| Palm Grove fungi forey   | O'Sullivan,<br>Pam             | Sydney Fungal Studies Group, NSW  |
| Archaeology of whaling in southern Australia and New Zealand   | Gojak, Denis                   | National Parks & Wildlife Service, Cultural Heritage Services Division, NSW |
| Effects of three stream crossings on the aquatic benthic macroinvertebrate communities of the Styx River, NSW                | Kirkman,<br>Jason              | University of New England, Armidale, NSW                                    |
| Geology of the Mt Bulga area   | Jurkiw,<br>Valodomyr           | University of Sydney, NSW   |
| Study of plant community   | Read, Jennifer                 | Private study   |
| Recovery plan for vulnerable shrub <i>Bertya</i> sp A Cobar-Colabah  | Austen, James                  | University of New England, Ecosystem Management, Armidale, NSW              |

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| River bioassessment – to test and calibrate the Australian River Assessment Systems sensitivity to impacts caused by logging   | Sloane, Philip        | University of Canberra, Co-operative Research Centre for Freshwater Ecology, ACT   |
| Survey of birds in Binya Forest  | Hutton, Dr<br>Keith   | Ricegrowers' Cooperative Ltd,<br>Leeton, NSW                                       |
| Continuing studying, photographing and illustrating members of the genus <i>Acacia</i> and preparing material for a further volume in the series <i>Acacias of Australia</i> | Simmons,<br>Marion    | Private study  |
| <i>Orchidaceae</i> of the Barrington Tops  | Dowling, Bill         | Private study  |
| Ecological impacts of cattle grazing and associated burning regimes in the native forests of northern New South Wales  | Tasker,<br>Elizabeth  | University of Sydney, School of Biological Sciences, NSW                           |
| <i>Field Guide to Flora of New South Wales South Coast</i>   | Wood, Donald          | Private study  |
| Collection of insect specimens for private collections   | Bishop, Dr<br>Bryan   | Concordia College, Moorhead, MN<br>USA   |
| Population surveys and monitoring of the endangered species <i>Olearia flocktoniaea</i>  | Gross, Dr<br>Caroline | University of New England,<br>Department of Ecosystem<br>Management, Armidale, NSW |
| The breeding of termite killing nematodes to supply the pest control industry  | Schmitzer,<br>Leigh   | Private study  |
| Distribution and abundance of forest fauna in relation to site fertility and habitat complexity  | Catling, Peter        | CSIRO, Division of Wildlife and Ecology, ACT                                       |
| Preliminary palynological assessment of the Moira Lakes  | Stone, Tim            | University of Melbourne, School of Earth Sciences, Parkville, Vic.                 |
| Ecology of the small mammal community in   | Paull, David          | University of New England, Zoology,  |

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|---|------------------------|--|
| the Pilliga State forests                                       |                        | School of Biological Sciences,<br>Armidale, NSW            |
| Survey of black-breasted button quail in New South Wales        | Milledge, Dr<br>David  | Landmark Ecological Services, Suffolk<br>Park, NSW         |
| Plant specimens – Eurobodalla Regional Botanic Gardens          | Liney, Mrs<br>Jennifer | Eurobodalla Regional Botanic Gardens,<br>NSW               |
| Biogeochemical cycling in landscapes of western New South Wales | Hill, Leanne           | Australian National University, Geology<br>Department, ACT |

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## Staff list & location

### Forest Research & Development Division Headquarters

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| Bi        | Dr  | Hui-quan  | Eucalypt Growth & Yield Senior Research Scientist |
| Bowman    | Ms  | Val       | Data Systems Management Officer                   |
| Brassil   | Ms  | Traeacey  | Ecology Technical Officer                         |
| Cai       | Mr  | Shimin    | Tree Growth Analyst                               |
| Caple     | Ms  | Margaret  | Executive and Business Support Officer            |
| Carnegie  | Mr  | Angus     | Forest Health Survey Research Officer             |
| Chidel    | Mr  | Mark      | Ecology Technical Officer                         |
| Cornish   | Dr  | Peter     | Hydrology Senior Specialist                       |
| Cowie     | Dr  | Annette   | Forest Carbon Dynamics Research Officer           |
| Delaney   | Mr  | Ted       | Human Resources and Business Support Officer      |
| Dixon     | Ms  | Leah      | Waste Utilisation Project Officer                 |
| Down      | Ms  | Stephanie | Library Technician                                |
| Eldridge  | Mr  | Robert    | Plantations and Forest Products Manager           |
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| Gardner   | Mr  | David     | Timber Preservation Research Officer              |
| Gardner   | Mrs | Joy       | Scientific Liaison Officer                        |
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| Giles     | Mr  | David     | Chemist   |
| Grieve    | Dr  | Alastair  | General Manager                                   |
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| Horwood   | Mr  | Martin    | Timber Protection Research Officer                |
| Joe       | Mr  | Bill      | Timber Engineering Research Officer               |
| Johnson   | Mr  | Ian       | Hardwood Tree Improvement Research Officer        |
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| Kavanagh  | Dr  | Rod       | Wildlife Ecology Senior Research Scientist        |
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| Kwan      | Ms  | Nancy     | Chemist   |
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| Page      | Mr  | Les       | Engineering Technical Officer                     |
| Parekh    | Ms  | Jagruitee | Soils Technical Officer                           |

|           |    |           |   |
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| Price     | Mr | Grahame   | Biologist   |
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## **Some photograph captions**

**X] Laboratory:** Photo credit P. O'Hara

Caption: Laboratory Services Manager David Sinniah, with David Giles, Nancy Kwan and Helen Engles. The Analytical Laboratory (AnLab) was extensively refurbished during the year and now offers a wide range of chemical and physical testing services to government, universities, industry and the private sector. AnLab holds National Association of Testing Authorities, Australia (**NATA**) accreditation for determinations in preservative-treated timber, groundwater and surface water, foliage and soil. Email: [anlab@sf.nsw.gov.au](mailto:anlab@sf.nsw.gov.au)

**Y] Timber and Working with Wood Show.** Photo credit B. Joe

Caption: Scientific Liaison Officer Joy Gardner representing FR&DD at the Timber and Working with Wood Show, Sydney Showground Exhibition Complex, Homebush Bay. Publications were distributed and over 4,000 enquires addressed over 3 days.

**Z] Poles. Photo credit J Marchant**

Caption: Timber Protection Research Officer Martin Horwood excavating around a pole prior to groundline inspection and maintenance treatment In NSW, approximately 2 million hardwood poles will require remedial groundline maintenance at some time to protect them from fungal degradation.

**E2] Spotted gum** Photo credit I Johnson

Caption; Select spotted gum tree in Grange State Forest near Grafton. Progeny of this and other select trees are being used in the hardwood breeding program.

**E3] Blackbutt seedlings.** Photo credit I Johnson

Caption Blackbutt seedlings raised from select blackbutt seed. Newly germinated seedlings raised at Cumberland State Forest Nursery were planted out in large family trials in 1998.

**Fishing Bats** Photo credit R Stevens/Sydney Morning Herald

Caption Wildlife Ecologist, Mark Chidel, Research Scientist, Brad Law and Regional Ecologist Justin Williams releasing banded fishing bats beneath their roost in a log bridge at Kerewong State Forest. This population of bats have been banded annually for three years before logging of their catchment (1999), with monitoring to continue over the next three years.

**Blossom Bat** Photo credit B Law and M Lean

Caption This common blossom bat has just finished feeding on the blossoms of a smooth-barked apple. Ten years of data have been analysed by State Forests' scientists to discover more about eucalypt flower patterns and the nectarivores that depend on them.

**Sooty Owl** Photo credit R Stevens/Sydney Morning Herald

Caption Sooty owls choose the darkest, gloomiest places in the forest to roost. This owl will help State Forests' scientists better understand the predators habits. The owl had a radio transmitter fitted onto her back so her moves can be monitored over the next twelve months as she hunts around central coast forests.

**Ambrosia beetle** drawing 1 credit; D. S. Kent

Caption; Adult form of Ambrosia beetle (*Austroplatypus incompertus*)

Possible (drawing 2) background drawing of the early larval stage of the Ambrosia beetle. [ credit D S Kent]

**H1** Photo credit; K Davis-Hall-Watson

Caption; Laboratory Attendant Catherine Murphy transferring tissue cultured *Corymbia variegata* to growth medium in the sterile environment of a lamina flow cabinet.

**FCD** Photo credit unknown

Caption; Carbon sequestration in planted forests and forest products will play a significant role in reducing net greenhouse gas emissions. To underpin carbon trading, cost-effective systems for measuring and forecasting carbon sequestered in planted forests are required.

**W.** Photo credit B George

Caption; Forest Assistant Geoff Heagney taking a reading with a neutron moisture meter at the Millewa irrigated river red gum plantation near Deniliquin. The trees were planted in 1992 and receive different amounts of irrigation.