

FOREWORD

The Research and Development Division provides strategic research support and scientific leadership for State Forests' operational and policy divisions, and a range of technical and research and development services. The Division also houses State Forests' library, which serves as an important resource for all State Forests' personnel and programs and which is open to the public.

Through consultation with research users and clients across State Forests, the Division published a Strategic Plan in 1998 comprising a number of research initiatives to be undertaken during the three years 1998 to 2001. These initiatives include key research themes, which are critical to sustainable forest management. This report details progress with these initiatives during 1999-2000.

The Division was structured for some of this period around two main scientific programs:

- Planted Forests
- Native Forest Management Systems

These programs were 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.

In November 1999, the Division was restructured to focus more strongly on several new areas and to discontinue research in other fields, including wood products and various aspects of native forest management. The major new strategic focus of the Division is on forest carbon dynamics research, biomass and bioenergy research, mine site rehabilitation, and salinity mitigation through catchment afforestation in the Murray-Darling Basin.

MANAGEMENT TEAM

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INNOVATION IN RESEARCH AND DEVELOPMENT

Key research theme:

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

COOPERATIVE RESEARCH CENTRE FOR GREENHOUSE ACCOUNTING

State Forests is contributing to three projects in the CRC for Greenhouse Accounting.

Biomass in forests

The project involves participants from State Forests, the WA Department of Conservation and Land Management, the Queensland Department of Primary Industry, the Queensland Department of Natural Resources, the Bureau of Resource Sciences and the Australian National University.

State Forest researchers contributed to a biomass sampling workshop held in Western Australia. The workshop brought together CRC project partners and others to develop standard forest biomass sampling techniques to ensure estimates of carbon stored in forests are comparable across the collaborating groups.

Improving techniques for measuring above- and below-ground carbon pools in a range of forest types. Large trees contain a substantial store of carbon but the amount is difficult to quantify. A new method of weighing large trees with a load cell suspended from a harvester was developed. This is being compared with a sub-sampling method (randomised branch sampling) to determine the best techniques for measuring above-ground biomass of large trees.

Development of techniques for measuring root biomass. Twenty to fifty per cent of biomass carbon can be stored in the tree root system. Field work began in June 2000, looking at the use of non-destructive methods (such as ground-penetrating radar) for measuring coarse root biomass.

Quantification of measurement error. Measurement of biomass involves sampling at a number of scales, from single trees (to develop allometric relationships) to whole forests (to estimate populations). This sub-project is looking at efficient sampling strategies for both extremes.

Ground-truthing data for remote-sensing platforms.

Sampling of each of the forest biomass pools (foliage, branches, trunk and roots of dominant trees and understorey, and litter and slash) is being used to develop complete biomass budgets for several native forest and plantation sites. These sites will be used for ground-truthing several remote-sensing platforms that have potential to provide direct estimates of forest biomass.

Life cycle analysis

In this collaborative project between State Forests and the WA Department of Conservation and Land Management, State Forests continues to develop inventories of forest product manufacture and use. The outcomes of this research will define the carbon storage in forest products manufactured and used in Australia. The data generated will provide a firm basis from which to extend the term of carbon credits from the harvesting of the tree to the ultimate return to the atmosphere of the carbon stored in the products. This should result in an increase in the value of carbon credits for planted forests.

Forest management options for carbon sequestration

A workshop on 'Policy-relevant analysis of management options for carbon sequestration in agricultural, forest and rangeland ecosystems' brought together CRC project participants and other Australian experts in this field. A new research officer is based at the Bureau of Resource Sciences.

FOREST BIOMASS FOR CHARCOAL AND BIOENERGY

Work on sustainable steel-making using renewable forest biomass has been undertaken in conjunction with BHP Research and the Department of Energy. This collaborative project, funded by the NSW State Energy Research and Development Fund, has explored the use of plantation species for charcoal production

EFFECTIVE



BULGA COAL MINE
TREE SPECIES X TREATMENT TRIAL

Chubu Electric Power Co., Inc. TOMEN

HUNTER VALLEY
NEW SOUTH WALES
NOVEMBER 1800

and steel-making. The wood properties of 32 timber species across 50 sites have been characterised. The outcomes will provide biological, logistical and economic information for a more complete evaluation of the use of forest biomass for charcoal production and bioenergy.

PROJECT

PLANTATION

REUSE OF ORGANIC WASTE AND EFFLUENT

Eleven demonstration trials have been established since 1993, nine in the Moss Vale area and two near Lithgow, along with ten research projects. Their purpose is to demonstrate the benefits of the application of dewatered biosolids as a forest fertiliser while minimising environmental impacts. Sites continue to be monitored for changes in growth and in soil and leaf chemistry. The database generated by research and demonstration trials shows that biosolids are a very effective fertiliser for plantation pine: increases in basal area of up to 30% are not uncommon, with no significant loss of wood density.

Representatives of Tomen Australia and Chubu Electric Power Company at planting at Bulga Coal Mine. Photo: Copyright SFNSW

Macquarie Generation - mounds amended with organic waste. Photo: Georgina Kelly

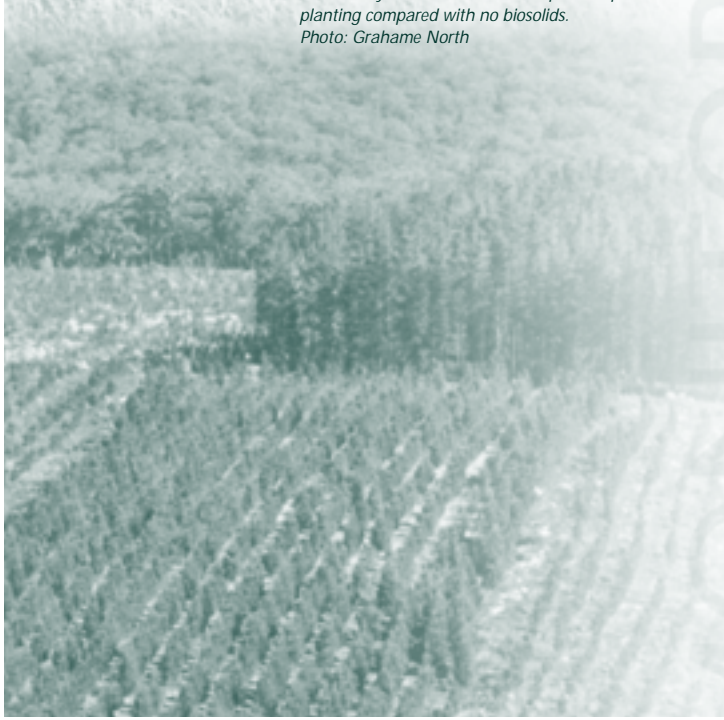
Establishment trial, Belanglo State Forest - areas with 20 dry t/ha of biosolids incorporated prior to planting compared with no biosolids. Photo: Grahame North

REHABILITATION OF DEGRADED LANDS AT HUNTER VALLEY MINE SITES

Macquarie Generation. This collaborative project, partly funded by National Heritage Trust, aims to study the value of recycled wastes as soil amendments for the rehabilitation of mine site overburden. The sites have been measured and pegged out. Site preparation and amendment incorporation are planned for July 2000. The amendments are all locally sourced – greenwaste (from power line clearing), flyash (from coal processing for power generation) and biosolids from Hunter Waste. The seedlings have been prepared and are hardening off in State Forests' Muswellbrook nursery.

Tomen Australia Ltd, in partnership with Chubu Electric Power Co. Int. Biosolids were spread in August 1999 at the Bulga mine overburden site. Seedlings were planted in November 1999. A month after planting they were measured for height, basal diameter and survival. At this early stage, incorporated biosolids (50 dry t/ha) seems to be the best treatment. Clonal material (*E. camaldulensis* x *E. grandis* crosses) seems to be the best so far.

BIOSOLIDS



MORE COST-EFFECTIVE ESTABLISHMENT AND MANAGEMENT OF SUSTAINABLE HARDWOOD PLANTATIONS

Key research themes:

- Increasing 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 issues related to soil and water

TECHNOLOGIES FOR VIABLE PLANTATION ESTABLISHMENT

Site preparation and ripping optimisation

Plantation establishment costs may be influenced by the considerable variation in the costs of using different ripping tine arrangements. Indications are that establishment success is not sensitive to ripping depth or even the overall volume of loosened soil. Later age effects will be monitored.

Pest and disease management

Granular insecticides. Insect damage before canopy closure can reduce growth, affect tree form or even kill trees, forcing replanting or restocking. A successful cost-



Actual acid sulphate soil exposed in a drain underlying sugar cane in northern New South Wales. The iron rich (pyritic) layer is exposed, yellow in colour, above the water table. Photo: Brendan George

effective granular insecticide applied at planting would protect trees and eliminate the need for spray application of insecticides during establishment years. Initial results from insect bioassays on young potted *Eucalyptus grandis* trees treated with a soil drench of imidacloprid SC appear encouraging.

Ramularia disease of Corymbia. The pathogen *Ramularia pitereka* continues to be the major disease impediment in plantations of spotted gums, *Corymbia* spp. Spray trials using copper oxchloride, copper sulphate, thiabendazole, benomyl, triforine, mancozeb and difolatan gave no effective control of *R. pitereka* when applied monthly. Other fungicides will be assessed. A variety of *C. variegata* with possibly much greater tolerance or resistance to *R. pitereka* is being assessed in field trials.

Acid sulphate soil

Acid sulphate soil is a major environmental problem, especially in coastal areas. Recently the Department of Land and Water Conservation identified nearly 400 000 ha of potential acid sulphate soil in coastal NSW.



Trees from tissue cultures of *Corymbia maculata*. Photo: Ian Johnson

Generally, acid sulphate soil occurs in low-lying areas that are poorly drained and return low income to farmers. Alternative land uses maintaining hydrological conditions and increasing income are preferred. Reforestation of areas with acid sulphate soil is currently viewed as a potential alternative to existing practices. A project is now under way to investigate this option, with the assistance of a Coasts and Clean Seas (Natural Heritage Trust) grant for two years.

Water use efficiency

Irrigated plantation forestry in low-rainfall areas. The future of plantation forestry in low-rainfall areas depends on the availability of information on water use in irrigated plantations and low-rainfall areas, the development of optimum irrigation management techniques, and a better understanding of some silvicultural practices such as fertiliser application and tree spacing. In conjunction with Murray Riverina Farm Forestry and the Commonwealth Scientific and

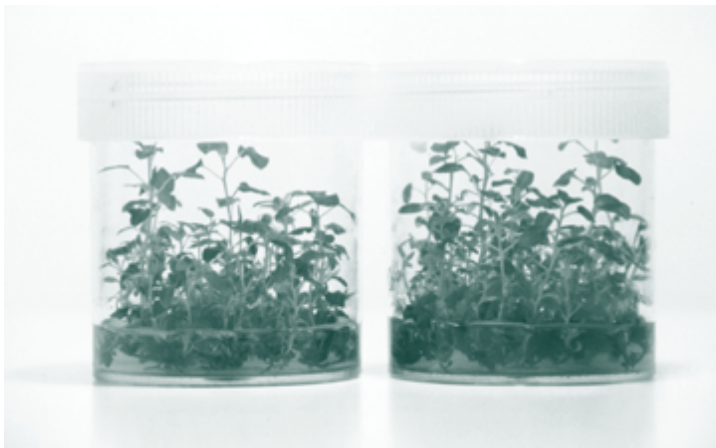
*Section of blackbutt (Eucalyptus pilularis) family trial near Taree, aged 30 months.
Photo: Ian Johnson*



Industrial Research Organization (CSIRO), State Forests has set up a local network of plantation sites to demonstrate irrigation practices and plantation silviculture to primary producers and foresters.

Salinity. The development of salinity credits is at the forefront of land management in saline areas and will be an economic inducement to planting trees in low-rainfall catchments in inland NSW. The measurement of transpiration in low-rainfall areas is being investigated. These results will be used to underpin the strategy for developing salinity credits.

As part of the 'Xylonova' project, nearly 10 000 seedlings of hybrids and select species were established 50 km west of Deniliquin in October 1999 to test their performance under saline conditions. The initial results indicate that the hybrids may offer better growth than the species. This could mean that increased growth (and water use) could be achieved even in degraded landscapes.



Tissue cultures of *Corymbia variegata*. Photo: Kerrie Bacon

Effluent irrigation. Funding was secured from Coasts and Clean Seas for a collaborative study with Hastings Shire Council at Kew and Kendall. The study is designed to assess the use of sewage effluent for a contour irrigation scheme within a hardwood plantation. The site is being prepared for planting in late August 2000.

DEVELOPMENT OF ENHANCED GENETIC MATERIAL

Genetic improvement of eucalypts

A Memorandum of Understanding was signed with the Queensland Forest Research Institute to cement an existing collaboration. The Memorandum will enhance the range of improved material and knowledge available to both parties for a more efficient applied

improvement program. State Forests continued to participate in the Australian Low Rainfall Tree Improvement Group's technical committee for hardwoods improvement. Site selection and preparation commenced for a seedling seed orchard for *Eucalyptus tricarpa* (ironbark) on private property near Culcairn.

A range of trials of species and hybrids were established or assessed during the year. These included inspection of the CSIRO collaborative *E. camaldulensis* trial near Albury and establishment of trials of various *E. camaldulensis* x *E. grandis* crosses (clones and seedlings).

An extensive range of breeding population plantings (family trials) and seedling seed orchards of *E. grandis*,

E. pilularis, *E. dunnii* and *Corymbia variegata* continued to be maintained, established or assessed during the year. Severe frosts during June took their toll in some of the younger trials, with damage most severe in *C. variegata*.

A growth and form assessment of the oldest of the large

E. pilularis family trials (age three years) identified superior families, giving information for "backwards selection" among the original parents for seed collection and later clonal seed orchards. A wide range of young *C. variegata* families in a field trial were assessed for *Ramularia* shoot blight, showing certain provenances in north-east NSW and south-east Queensland to be less severely affected. Seed from these provenances will be used preferentially, pending further assessments.

Clonal forestry

The screening of seedlings from plus-tree seedlots for root production by cuttings has continued. The aim of this work is to develop clones with good rooting ability from selected trees for plantations on the north coast of

NSW. Plants of selected clones of *E. grandis* (and hybrids), *E. pilularis*, *E. dunnii* and *Corymbia* spp. are planted in a eucalypt clonal archive at Somersby. These hedged plants will be the source of cuttings to produce plants for the establishment of clonal trials over a range of sites. Clonal trial plantings established from cuttings and micropropagated select material in 1997 and early 1999 were assessed for growth and form at age one year. The growth and form of trees in most trials is good to excellent. Uniformity within clones and variation between clones are often striking, particularly in *Corymbia*.

Clones resistant to biological agents

Significant differences between eucalypt species, varieties and individual trees in susceptibility to insect attack have long been recognised. Identification and propagation of clonal material from select resistant trees for possible incorporation into future improved breeding stock may become one avenue for improving the level of insect resistance of eucalypt plantations. This is a highly desirable long-term approach towards reducing the expensive and environmentally unfriendly requirement of controlling pest insects by spraying insecticides. The identification and assessment of a range of select resistant trees have continued.

Clonal archive site

The establishment and planting of the eucalypt clonal archive and cutting hedges facility has been a major project this financial year. The archive is located on NSW Agriculture's Horticultural Research and Advisory Station at Somersby on the central coast of NSW. The site comprises three adjacent blocks of a total area of approximately 0.75 hectare of land. The largest block has been planted with hedge plants; one end will be planted with archived grafted plants.

Accelerated seed production

Work has continued on assessing the potential benefits of paclobutrazol for early seed production from seed orchards of *E. grandis*, *E. pilularis* and *E. dunnii*. There was some evidence that paclobutrazol stimulated flower production in two- to three-year-old *E. grandis* and *E. pilularis*. A trial on potted blackbutt grafts of four clones showed promising results. Further trials using pots and root restriction bags were established for grafted ramets of *E. pilularis*, *E. dunnii* and *E. grandis* plus-tree clones.

Micropropagation

Research continued on the establishment of tissue cultures from field-grown trees. Grafted plants with scions from select mature trees of *E. grandis*, *E. pilularis* and *Corymbia variegata* were used. Results show that the problem of fungal contamination of tissue cultures from field-selected trees may be overcome, however growth of these cultures is slower than those from juvenile explants. Other work has shown that clonal cultures can be archived as rooted plants for 12 months and then revived and recultured.

Seedling selection

A project was begun to develop selection methods for the early identification of promising genotypes. Work was confined to seedling studies within a few eucalypt species. Field studies have also been conducted to evaluate the range of variation in field populations. Further support for the development of early screening methods is being pursued in conjunction with the Queensland Forest Research Institute and the University of Queensland.

Grafted Dunns white gum (Eucalyptus dunnii) in root restriction bag, flower induction field trial, Somersby. Photo: Ian Johnson

RESULTS

PLANTINGS

BENEFITS

PRODUCTION

TRIALS



Studying branching patterns in Eucalyptus pilularis to improve management for the production of clear wood. Photo: Karen Faut

TECHNOLOGIES FOR OPTIMUM STAND MANAGEMENT

Eucalypt nutrition

Eleven eucalypt plantations that had been performing poorly were sampled for soil and foliage. No single nutrient deficiency was found on any site. This suggests that poor growth is a product of a combination of unfavourable soil factors that can only partially be overcome by fertiliser additions. Further monitoring is planned.

Pruning and thinning

The presence of knots in plantation eucalypts has been shown to be a major cause of downgrade. Pruning can reduce the occurrence of these knots and significantly increase the value of the log. However, the development of pruning in eucalypts is at an early stage. The current knowledge relating to eucalypt pruning was summarised in a Rural Industries Research and Development Corporation publication to provide the best available information on which to base future pruning programs.

Pruning trials of mixed eucalypt species were remeasured. Preliminary results suggest that for some species of eucalypts (not including *E. dunnii* or *E. pilularis*), decay will be a problem in sawlog and veneer rotations. Columns of incipient decay are much more extensive than white rot decay columns. No brown rot decay columns have been found. The incidence of decay and incipient decay associated with pruning of large branches was much greater than for small branches (< 15 mm diam.).

TECHNOLOGIES TO ENHANCE ENVIRONMENTAL VALUES

Paddock trees. Three case study sites used for cattle grazing were surveyed before plantation establishment for wildlife in spring 1998. In spring 1999 the first resurvey of wildlife in one-year-old eucalypt plantations and embedded remnant vegetation was completed. Early results suggest that plantations established for commercial timber harvesting will increase biodiversity as a by-product of increasing tree cover on cleared paddocks. These ecological benefits appear more obvious in plantations of eucalypts than in exotic plantations.

EXPANDED AND MORE EFFICIENT SOFTWOOD PLANTATIONS

Key research themes:

- Developing resource-wide information on wood properties
- 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 use of wastes in softwood plantations

TECHNOLOGIES TO OPTIMISE MANAGEMENT SYSTEMS AND ENHANCE PRODUCTIVITY

'Expert systems' for pine management

Site quality, nutrition, second rotation. An improved site index model was developed for *Pinus radiata* growing throughout NSW. The model was derived from mean stand top height obtained from 5545 permanent plots (17 500 plot measurements) established statewide, covering a wide range of site and stand conditions. Compared with the models currently in use, the new model gives more reliable and robust prediction of height growth and site index for stands from age 5 to 40 years.

Magnesium (Mg) deficiencies have been identified as a major problem in radiata pine grown in New Zealand. The occurrence of Mg deficiencies and its importance has not been considered in NSW. A report was prepared to examine the extent and significance of Mg deficiencies in NSW pine.

The use of process-based models in predicting the magnitude of fertiliser responses is a novel use of process models that is as yet untried. The Research and Development Division is currently developing this concept with the University of New South Wales.

Comprehensive trial review. The Division has established and maintained more than 400 pine silvicultural trials in conjunction with the Softwood Plantations Division over the past 30 to 40 years. These trials, covering fertilisation, pruning, spacing, thinning and establishment, have been established across a wide range of sites and are often within commercially managed compartments, making them directly relevant to forest managers. These trials were reviewed in consultation with the Softwood Plantations Division.

The trials were mapped for the first time with a geographical information system (GIS). Expansion of the research GIS data and its incorporation into the softwoods GIS is seen as an important method to improve the flow of information between forest managers and researchers.

Taper and volume functions. Taper models are one of the most important functions in the stand modelling system STANDPAK and the inventory system MARVL. Currently, ten polynomial taper functions are used for measurement of log volume. A new trigonometric



Pruning trial established in Blenheim State Forest - second lift pruning and measurement. Photo: Brad Jarrett

variable-form taper model was developed using the data from taper trees sampled across sites and stands throughout NSW. The model predicts relative stem diameter with little local bias across merchantable sections.

Weibull diameter distribution models are also used in STANDPAK and MARVL for log assortment and volume calculation. Significant limitations and biases have been repeatedly found in current models that were not developed with specific data from the pine growing Regions. New combined Weibull distribution models were developed using plot measurements from silvicultural trials established in Hume, Macquarie and Monaro Regions. This work has delivered new model functions that more accurately predict growth and yield of pine plantations in the Hume, Macquarie and Monaro Regions.

EARLY pruning trials. The EARLY growth models will allow the judicious scheduling of pruning and thinning operations. Three pruning and thinning trials are established across the Macquarie and Hume Regions; a fourth is planned for the Hume Region in 2000. The trials provide information to validate the New Zealand EARLY model. These trials have been regularly monitored, maintained and measured.

Compilation of information on resource-wide wood properties

Information is being gathered on wood quality (primarily wood density) of *Pinus radiata* for all significant regions, site types, silvicultural treatments, age classes and genetics within NSW. Results so far indicate there can be significant site differences in density within regions. Variation within sites can also be

considerable, but variation across sites is relatively constant. The results also show a consistent reduction in outerwood density in thinned stands relative to unthinned stands. The ability to model changes in wood density within trees throughout the growing cycle will provide a powerful tool for forest managers.

Non-destructive evaluation of intrinsic wood quality

Research work is investigating the use of acoustics to measure log quality without damaging the timber itself.

The Natural Heritage Trust, through the Joint Venture Agroforestry Program, and State Forests are funding this study to explore better ways to allocate on-farm timber to its end use. State Forests is working closely with CSIRO, Weyerhaeuser and J. Notaras and Sons to test the use of the acoustic tools. Ultimately this work should lead to a more efficient use of wood resources by directing the appropriate quality timber to the right market.



*State Forests' and CSIRO staff put bar codes on trial timber boards at the Weyerhaeuser mill, Tumut.
Photo: Sarah Chester*

DEVELOPMENT OF ENHANCED GENETIC MATERIAL

New breeds of radiata pine

New breeds of *Pinus radiata* developed in New Zealand have not been rigorously tested under the prevailing environmental conditions in NSW. Testing on a range of sites will facilitate the development of site-specific silviculture for the resource. It will enable closer modelling of growth and wood quality, and therefore more effective marketing of end-products. Fifteen seedlots representing growth and form, high wood density, and long internode length were imported from the New Zealand Radiata Pine Breeding Co-operative. Seeds were sown into stool beds to produce cuttings in preparation for a series of breed x silviculture trials.

Measurement of harvest-age traits in Pinus radiata

Quantification of the volume gains from mature genetic improvement trials is critical to justifying future investment in tree improvement programs. Research work has begun to provide genetic gain information on harvest-age traits. The timber characteristics of sawn logs were linked to the pedigrees of more than 300 radiata pine trees planted in 1973 in the Tallaganda State Forest. This work was part of the non-destructive evaluation study of intrinsic wood quality (see above) run at the Weyerhaeuser mill in Tumut. The key aim was to provide genetic-based information to both growers and processors.

Genetic material for the afforestation of dryland or degraded farmlands

Three replicated trials were established on low-rainfall ex-pasture sites to assess the performance of four different tree types (*P. pinaster* and *P. radiata*) at three different initial spacings. Survival and growth of the trial plots in the first twelve months were excellent. State Forests is also participating in a nationwide trial of genetically select families of *P. pinaster* as part of the Australian Low Rainfall Tree Improvement Group. Two trials will be established early in the new financial year.

Collection of increment cores at breast height from sample tree. Photo: Bill Joe





*The koala is listed as a threatened species in NSW yet recent research has shown that forestry operations may be compatible with long-term conservation of this species.
Photo: Rod Kavanagh*

*Checking a harp-trap for banded bats in a logged catchment at the Karuah Research Catchments.
Photo: Brad Law*

*Hip-pocket frog - subject of fire research at Dorrigo.
Photo: Frank Lemckert*

ECOLOGICAL

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

Field sampling within spotted gum related forest types in the South Coast Region has been completed. A system of equations for volume and taper predictions has been developed and published for all major commercial species in the South Coast and South East Regions. The results of this project have enabled forest managers to schedule the yield of regrowth forests of the southern regions with a high degree of accuracy.

SYSTEMS TO PROTECT ECOLOGICAL VALUES

Frogs

A long-term study is attempting to quantify the effects of forestry operations on frogs. Its first aim is to supply baseline data on the population ecology and dynamics of frogs that breed at streams and pools found in forests. Its second aim is to directly assess the impacts of forestry activities on populations of frogs. Initial work has indicated that most species appear unaffected by logging in the short term, but a few species may be affected. Results are inconclusive at this time. The project is using radio-tracking as a tool to follow the movements of endangered frogs. The target species over the last year have been the giant burrowing frog (*Heleioporus australiacus*) and the giant barred frog (*Mixophyes iteratus*).

A project was begun in 1998 to determine whether the provision of corridors of native vegetation could retain native species within areas of pine plantation and, if so, the size and form these corridors should take to maximise their effectiveness. Indications are that corridors of native vegetation can serve as long-term conservation sites for native Australian frogs.

Bats

A study was initiated this year to investigate the effects of logging operations on bats. Prethinning information was collected by banding bats in the different treatment catchments of the Karuah research area. Band recaptures will be used to estimate population sizes in the different catchments each year, allowing control (unlogged) treatments to be compared with 16-year-old regrowth.

Research in the past year has clearly demonstrated the feasibility of monitoring bats at key sites. A remote data-logger using infrared beams has been developed to monitor changes in bat populations at mines and caves. Future monitoring will provide data that will feed into State Forests' annual environmental accounts.

State Forests and the Queensland Department of Natural Resources are working to identify certain features of bat calls, as recorded by Anabat detectors. This will increase the reliability of bat call identification. State Forests has submitted 260 bat calls to the Department of Natural Resources, which is analysing this collection plus its own from south-eastern Queensland.

Threatened bat ecology

Two bat species were the focus for research in the last year.

Fishing bat—*Myotis macropus*. The diet of this species was investigated from scats collected beneath a roost in Kerewong State Forest in the Macleay–Hastings Region. Aquatic prey constituted 80% of the species' diet and consisted mostly of water striders, water boatmen and diving beetles. The dominance of aquatic insects in the diet of *M. macropus* supports previous direct

observations of its foraging behaviour over still water. Annual banding continued in this population for the fourth consecutive year. An increase in population size was recorded after partial logging of their upstream catchment.

Greater broad-nosed bat—*Scoteanax rueppellii*. Two maternity roosts were located, both in tall flooded gums growing in native forest, adjacent to capture sites in young eucalypt plantation. This was consistent with roost locations from 1998.

Arboreal marsupials

The variable-intensity logging project has shown that greater glider populations can be maintained at or near prelogging levels when at least 40% of the original tree basal area is retained throughout logged areas and when the usual practice of retaining unlogged forest in riparian strips is followed.

The Pilliga koala project has identified the most important forest types and tree species for koalas and has shown that selective logging for white cypress pine has little or no deleterious effects on the koala. Research collaborators showed that the Pilliga koalas are among the healthiest, genetically diverse and vigorous of any populations in the country. The Pine Creek koala study has recorded animals using all koala management zones, including eucalypt plantation, but appears to support earlier work that multi-layered, species-diverse forests represent the best habitat for koalas.

Owl ecology, habitat modelling and population monitoring

State Forests hosted Owls 2000: The Third International Conference on the Biology, Conservation and Cultural



The powerful owl is listed as a threatened species in NSW and, as such, has been the focus of extensive survey and research by State Forests. Photo: David Hollands

Significance of Owls. Feedback from the conference about owl management in State Forests was positive.

Early warning of major environmental change

The aim of this collaborative project, funded by the Forest and Wood Products Research and Development Corporation (FWPRDC), is to give forest industry and management agencies a list of species or species groups that have potential value as indicators of major environmental change and that should be monitored long-term in particular regions. There is general acceptance that future environmental monitoring programs will need to include a suite of indicators from unrelated taxa (e.g. plants, invertebrates and vertebrates) chosen from each major trophic level and representing a range of functional groups.

SYSTEMS TO PROTECT SOIL AND WATER VALUES

State Forests is required to implement a water quality monitoring program as a condition of its environmental protection licence. Data generated by the program will enable us to assess the efficacy of measures taken to prevent sediment pollution of forest streams during harvesting.

New monitoring conditions

The Environment Protection Authority and State Forests agreed to new conditions for the monitoring program in February 2000. Monitoring will continue in the native forest sites in Yambulla and Middle Brother State Forests and in the softwood plantation sites in Bago and Canobolas State Forests. Monitoring in the native forest sites in Dampier State Forest was terminated. Five new catchments are to be identified and instrumented in north-eastern native forests by December 2000.

Hazard assessment validation of pollution control licence

A field survey of about 90 logging operations was conducted to determine their relative erosion status and to compare this with the results of the Pollution

Control Licence hazard assessment module. The project was completed in March 2000. Results were in general accord with the hazard assessment module: they revealed a difference in erosion between integrated operations and selective operations and a general increase in erosion as slopes increased and rainfall erosivity increased.

Soil erosion

The program to assess erosion on snig tracks was completed in February 2000. Results have shown that snig track erosion on steep slopes is initially quite high but declines rapidly as the surface is depleted of loose material and gains a stable cover of litter. The hydrologic features formed by snig track sections between drainage banks in steep country are generally not large enough to generate runoff discharge sufficient to transport sediment more than 10 m across undisturbed forest floor. This was shown to be true even under extreme rainfall.

Soil physical properties

A collaborative project with the Victorian Department of Natural Resources and Energy and CSIRO Forestry and Forest Products, funded by the FWPRDC, is developing a sound method of measuring and reporting Montreal sustainability indicators for soil physical properties. The major task for next year will be data analysis and reporting. There are differences after nine years in regeneration growth between logging truck access tracks and less severe classes of disturbance.

INTEGRATED SYSTEMS STUDIES FOR ECOLOGICALLY SUSTAINABLE FOREST MANAGEMENT

Flooding regimes in river red gum (Eucalyptus camaldulensis) forests

A six-year collaborative study with Charles Sturt University and the University of Melbourne has been looking at the impact of different flooding regimes on river red gum forests near Deniliquin. In the mid region of the Murray River, river regulation has reduced the

frequency and duration of spring floods and increased the frequency of summer floods. Controlled floods were used to determine how the growth of river red gums, large aquatic plants and biofilms (such as algal mats) vary with the seasonal timing and frequency of flooding. Spring flooding, while not as beneficial for tree growth, is critical for the growth of wetland plants and the maintenance of plant species richness, and favours the development of photosynthetic biofilms. Maintenance of both the timber harvest and wetland conservation values of these floodplains will require the return of more natural flood flows in spring.

A further collaborative project at this site, jointly funded by State Forests, the Murray–Darling Basin Commission and Charles Sturt University, aims to refine both the reliability and cost-effectiveness of monitoring the moisture stress of river red gums in southern NSW. Successful calibration of airborne spectral reflectance against ground-based parameters will enable the development of a customised airborne video system to provide accurate information of forest condition.

Bell miner amelioration

A trial is in place to test whether the removal of dense understorey (predominantly lantana and viny weeds) will improve the condition of canopy affected by bell miners *Manorina melanophrys*. Tree growth and canopy condition parameters were assessed for the second time during late 1999. A comprehensive set of health-related data on more than 2000 trees (consisting of several commercially important eucalypt species) has been generated. The next field assessment is scheduled for October 2000.

Rehabilitation after Bega Valley dieback

The objective of this project is to develop operational strategies that forest managers in the South East Region can adopt to manage forest decline associated with bell miners. Project sites are established throughout the Bega Valley. The Eden Bird Watchers Club conducted several bird count surveys. The second assessment of all sites was undertaken during January 2000; a third is scheduled for July 2000. All field data have been collated.

GENERAL FOREST HEALTH

Incursions of exotic pathogens and pests of forest trees and forest products are a major concern. Diseases such as pine pitch canker or blue gum leaf blight could have serious impacts if the pathogens were introduced to Australia. One of the high-risk routes for the introduction of pathogens is with germplasm. Another is with imported timber. World Trade Organisation protocols require transparent and open quarantine policies. The challenge for Research and Development Division staff has been to work with Australian Quarantine Inspection Service to develop effective quarantine procedures for forest germplasm and timber that facilitate trade but minimise the risk of incursions of unwanted organisms.

The national Generic Incursion Management Plan, sponsored by the Standing Committee on Forestry, for forest pests and diseases has been accepted by the Standing Committee on Forestry, the Standing Committee on Conservation and the Ministerial Council on Forestry and Fisheries. A NSW Forest Health Advisory Committee is being formed, as recommended in the management plan. State Forests, through this Division, was lead organisation in this process.

FOREST HEALTH SURVEILLANCE

A collaborative project under the Wood and Paper Industry Strategy of the FWPRDC aims to develop a robust and reliable indicator of eucalypt canopy condition by using remotely sensed imagery that will be suitable for integration with other planning tasks. In late 1999, a very intensive leaf sampling program was undertaken as part of the acquisition of hyper-spectral imagery by Compact Airborne Spectrographic Imager associated with the ground-truthing project in the Olney forest health study. An array of morphological and physiological assessments was made of foliage sampled from mature trees exhibiting a range of canopy decline symptoms. A similar study is planned for the *Pinus radiata* plantations in the Hume Region.

The Forest Health database is complete, and regular entry of data is now being done.

PESTS AND DISEASES OF PINE

The Forest Health Survey Unit reported the incidence, severity and extent of areas where pests, diseases, vertebrates, nutrients and weeds were limiting the growth or affecting the survival of pines. Management of the Softwood Plantations Division can use this data to predict preharvest wood volume in affected stands (e.g. trees damaged by possums or *Sphaeropsis*); to adjust management regimes for 'unhealthy' stands (e.g. bring thinning forward in drought-affected stands); to apply fertilisers or control weeds to improve the establishment, growth and survival of young trees; and to spray or thin and prune for *Dothistroma* needle blight control.

Forest health surveys of all softwood plantations were completed during winter and spring 1999. Weed regeneration and competition (mainly *Acacia* and grasses) was a problem in the younger age classes (up to four years old) in the Hume, Macquarie, Monaro and Northern (Casino) Regions. Widespread needle chlorosis and defoliation associated with the Monterey pine aphid *Essigella californica*, spring needle cast *Cyclaneusma minus* and drought were observed in the Hume and Macquarie Regions. *E. californica* was observed for the first time in the Walcha and Casino plantations in the Northern Region. *Cyclaneusma minus* was observed at higher levels than previously in the Monaro and Northern (Walcha) Regions. High levels of needle chlorosis associated with drought and natural senescence were observed in the Casino plantations, similar to previous years. There was an increase in the extent and incidence of possum damage in the Monaro Region. Studies on the impact of possums in the Monaro Region have been conducted.

There was a significant reduction in deaths related to drought and *Sphaeropsis* in all regions this year. *Dothistroma* was a significant problem in the Northern Region (*P. radiata* plantings), and was also observed at higher than previous levels in the Monaro and Hume Regions. *Sirex* was observed in Mount Topper State Forest, the farthest north this exotic pest has spread, in early June 2000. It was not significant in most regions. Establishment problems, such as poor site quality and



Christmas beetles (Anoplognathus porosus) feeding on the foliage of spotted gum (Corymbia maculata). Photo: Angus Carnegie

waterlogging, resulted in infection by *Macrophomina* and deaths of newly planted seedlings in localised areas mainly in the Hume Region. Frost damage to the lower needles of young trees was higher than previous years in the Hume and Macquarie Regions. Wallaby browsing was observed in localised areas in the Monaro and Macquarie Regions.

Recommendations on control or remedial actions for health problems were made to the Softwood Plantations Division. These included control of competing weeds (*Acacia* and grasses) in young stands, and spray or thinning control of *Dothistroma*-affected areas. Regions that requested immediate reports on specific disorders (such as areas with *Dothistroma* and weed competition or possum damage), so that control and remedial operations could be organised quickly, were supplied with maps and reports on these conditions within two weeks of the surveys. In most cases forest health reports were completed within two to three months of the ground survey.

PESTS AND DISEASES OF EUCALYPTS

Forest health surveys identified important pests and diseases that may limit the growth and establishment of eucalypt plantations, and that may need further research. They also identified sites or areas that may have increased health problems. Forest health reports

gave owners and managers a summary of important pests and disease in their plantations and recommendations on remedial or control action where appropriate.

Most joint venture and land purchase plantations were surveyed during summer and autumn. Forest Health staff met with silvicultural and plantation officers at the start of surveys to assign priorities to plantations to be surveyed. Most of the larger (> 500 ha) plantations were aerially surveyed. These surveys proved useful in highlighting health problems and stratifying ground surveys.

Overall, the levels of pests and diseases in the eucalypt plantations were lower than in previous years. In most cases, damage from leaf-feeding insects, such as Christmas beetles and chrysomelids, was much lower this year. However, several plantations of *Eucalyptus dunnii* and *Corymbia maculata* experienced high levels of defoliation. *Ramularia* leaf and shoot blight of *Corymbia* spp. was also less significant this year. There were also no new deaths due to *Phytophthora* observed this year, due probably to the drier weather on the north coast. Cankers caused by *Endothia* were also not observed this year. However, levels of *Mycosphaerella* leaf spot were higher in several *E. pilularis* plantations than in previous years, and these plantations experienced significant defoliation. Stem borers were again a significant pest in the *E. grandis* plantations,

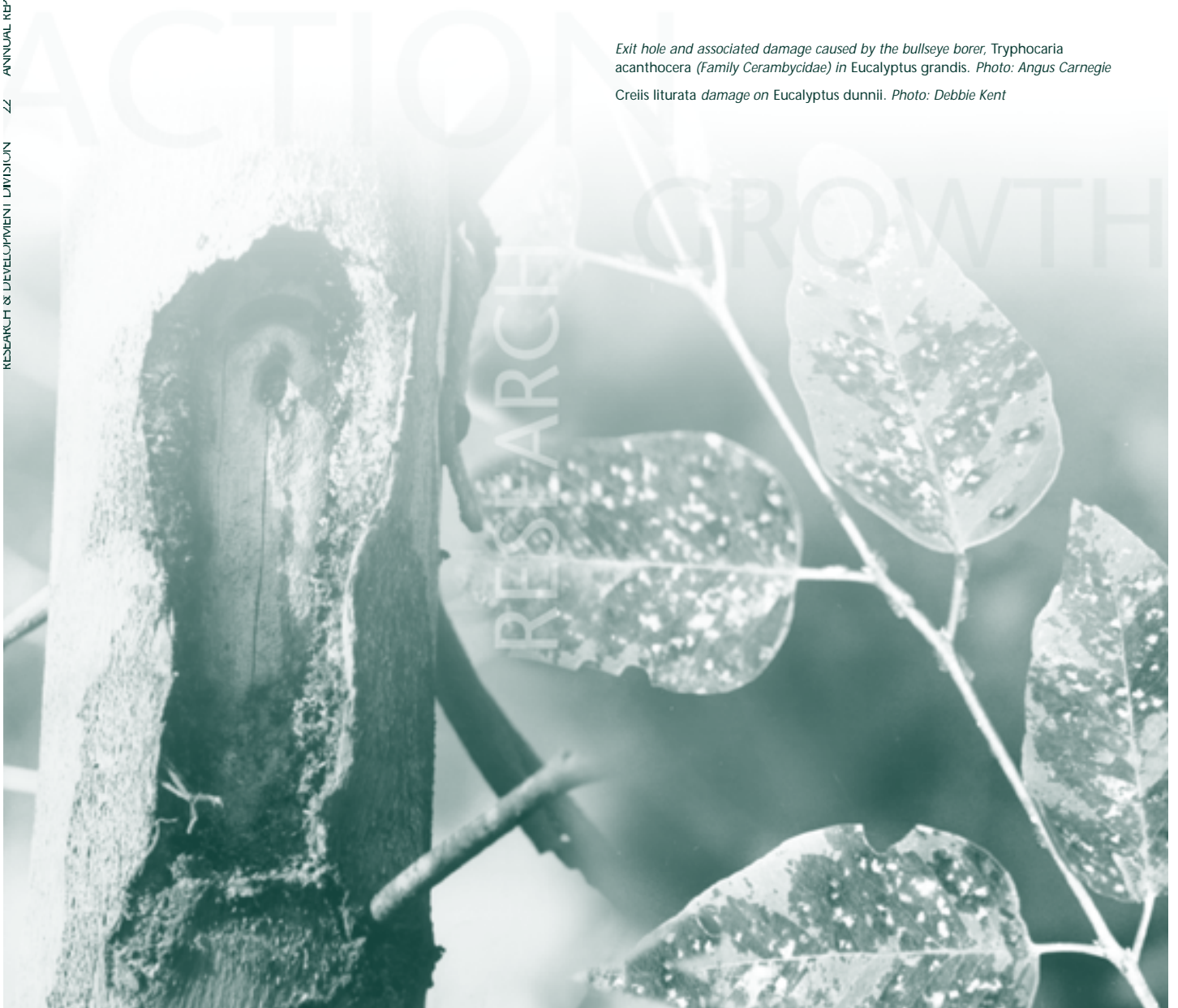
potentially reducing the value of many of these plantations. High levels of stem borers were also found in several older *C. maculata* plantations. Cankers and resin bleeding were also observed in these older *C. maculata* plantations. The cause and impact of this are being investigated.

An outbreak of the damaging *Creilis* psyllid was observed in a young *E. dunnii* plantation near Bonalbo in late April. Staff of the Hardwood Plantations Division and the Forest Health Survey Unit surveyed the extent and severity of damage, and insecticide spraying and monitoring were begun. The effectiveness of this control is yet to be assessed. This 'new' psyllid was observed in more plantations this year (> 6), and also in

E. grandis. Damage to lower leaves of *E. dunnii* and *E. grandis*, resulting in defoliation, was observed at high levels in several plantations near Kyogle. The damage was similar to that caused by herbicide spray, but there was no evidence of this. The leaf fungus *Pestalotiopsis* sp. was consistently isolated from damaged leaves but is not normally a significant problem. This is being further studied.

A selection of the eucalypt tree-improvement trials was assessed for pests and diseases. Results were forwarded quickly to the Hardwood Plantations Division to aid in the selection of suitable planting stock for the coming planting season.

Exit hole and associated damage caused by the bullseye borer, Tryphocaria acanthocera (Family Cerambycidae) in Eucalyptus grandis. Photo: Angus Carnegie
Creilis liturata damage on Eucalyptus dunnii. Photo: Debbie Kent



SERVICES PROVIDED

- The Biodiversity Group has continued to give wildlife training courses to State Forests staff and to other government and non-government organisations and interested members of the public. This ensures that State Forests staff can maximise their effectiveness in performing wildlife surveys and in educating the community about wildlife management.
- The analytical laboratory, accredited by the National Association of Testing Authorities (NATA) and certified by the Australian Soil and Plant Analysis Council, provides a testing service for both internal and external clients. Samples analysed include wood, water, foliage and soil.
- The NATA-accredited Timber Engineering Laboratory provided testing services to a number of timber mills for quality assurance of the final product and to evaluate engineering properties. The provision of this service is under review.

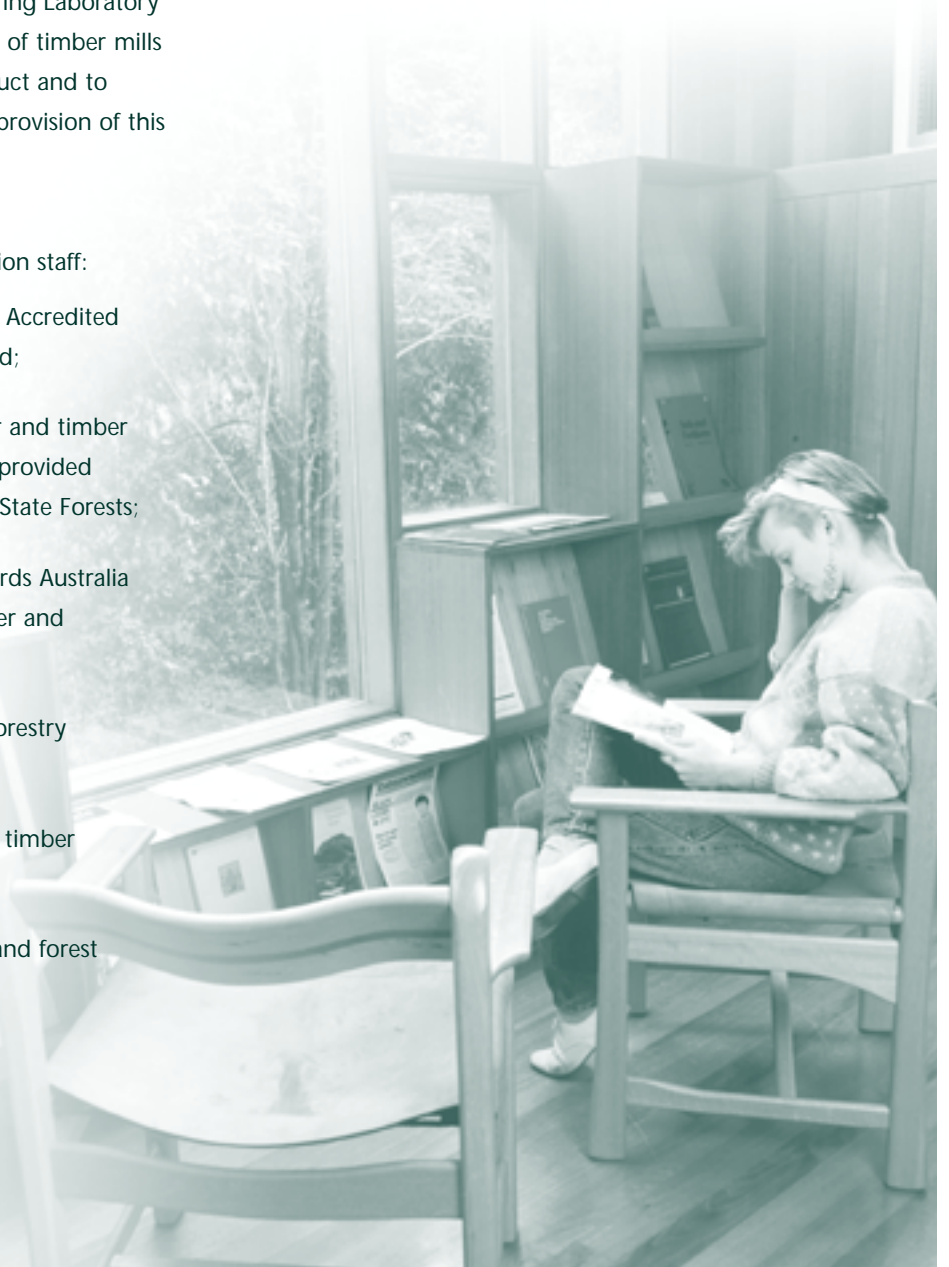
Further, Research & Development Division staff:

- provided consultancy services to Joint Accredited Systems for Australia and New Zealand;
- assessed strength properties of timber and timber products for external customers, and provided technical back-up to branches within State Forests;
- participated on committees of Standards Australia in relation to the efficient use of timber and timber products;
- took an active role in the Australian Forestry Quarantine Consultative Committee;
- provided technical information to the timber industry and community;
- identified pests and diseases of trees and forest products and gave technical advice.

STATE FORESTS' LIBRARY

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

In addition, the librarians willingly help members of the general public. The library made more than 720 loans to external libraries and completed more than 840 reference requests.



COOPERATION WITH UNIVERSITIES

The Research and Development Division directly assists university postgraduate research work in State forests. Our staff help in the joint supervision of research students. In some cases State Forests also provides financial support to enable students to complete PhD, masters or honours degrees.

| Project title | University student | Cooperating university | University supervisor | R&DD supervisor |
|---|--------------------|------------------------|----------------------------|--------------------|
| Ecological study of the endangered Stephens banded snake (<i>Hoplocephalus stephensii</i>) | Mark Fitzgerald | Sydney | Dr Richard Shine | Mr Frank Lemckert |
| The impacts of logging on stream-breeding frogs | Harko Werkman | Newcastle | Dr Michael Mahoney | Mr Frank Lemckert |
| Feeding preference and ecology of <i>Chrysoptharata cloelia</i> | Caitlin Johns | Macquarie | Dr Leslie Hughes | Dr Christine Stone |
| The use of spatial and temporal models of wildlife habitat in planning for the management of forested landscapes | Brendan Wintle | Melbourne | Dr Mark Burgman | Dr Rod Kavanagh |
| Ecology and reproductive success of the koala (<i>Phascolarctos cinereus</i>) in Pine Creek State Forest | Sally Radford | Southern Cross | Dr Ross Goldingay | Dr Rod Kavanagh |
| The impacts of cattle grazing and associated burning regimes on the biodiversity of Tableland eucalypt forests | Elizabeth Tasker | Sydney | Dr Chris Dickman | Dr Brad Law |
| Stream preferences of the fishing bat (<i>Myotis macropus</i>) | Jason Anderson | ANU | Dr Chris Tidemann | Dr Brad Law |
| Vertical stratification of bats and insects in regrowth forests | Maria Adams | Wollongong | Dr Kris French | Dr Brad Law |
| Farm forestry plantings for carbon sequestration | Christine Sefton | UWS | Associate Prof Jann Conroy | Dr Kelvin Montagu |
| The estimation of above-ground biomass in <i>Eucalyptus pilularis</i> regrowth forests and plantations in the Hunter Region | Russell Turner | UNSW | Assoc Prof Tony Milne | Dr Kelvin Montagu |
| Change in soil carbon associated with the establishment of hardwood plantations | Yura Totsuka | UNSW | Dr Ross McMurtrie | Dr Annette Cowie |
| The development of new forest management systems which account for changes in both wood and non-wood markets | Will Evans | Sydney | Prof Gordon MacAulay | Dr Annette Cowie |
| Incorporating competitive process and environmental heterogeneity in individual tree models | Julian Fox | Melbourne | Dr Peter Ades | Dr Huiquan Bi |
| Development of a site classification model for native forests using GIS | Ernst Kemmerer | ANU | Dr Brian Turner | Dr Huiquan Bi |

SPECIAL PURPOSE PERMITS FOR RESEARCH

Special Purpose Permits for Research are issued to authorise various prescribed activities in State forests, timber reserves or flora reserves. The permit system allows the orderly supervision and facilitation by State Forests' staff of bona fide scientific research into the forest ecosystems managed by State Forests.

| Title of activity | Principal | Organisation |
|---|----------------------|---|
| Effects of fragmentation on populations of mammals | Dr David Lindenmayer | CRES, ANU, Canberra, ACT |
| Inflorescence and branch development in Australian <i>Acacia</i> | James Grimes | Royal Botanic Gardens, South Yarra, Vic |
| Impact of aerial baiting for dogs on populations of spotted-tailed quolls in forest habitats | Andrew Murray | Department of Natural Resources and Environment, Orbost, VIC |
| Variation in leaf chemistry in <i>Eucalyptus microcorys</i> | Ben Moore | Division of Botany and Zoology, ANU, Canberra, ACT |
| Collection for identification and reference of vascular and non-vascular plants, including cryptogams | Eric Whiting | Private study |
| Survey of stand structure in a range of forest types to provide information for private forest management | Dr Andrew Smith | Austeco Environmental Consultants, Armidale, NSW |
| Study of rust fungi Uredinales of Australia | John Walker | Hon Res Assoc, State Forests of NSW |
| Continuation of the phytochemical systematic study of the <i>Grevillea victoriae</i> – <i>G. miqueliana</i> species complex project | Valentino Stajsic | Private study |
| Evaluation of soil health under land use intensification gradient and the role of soil macrofauna in monitoring soil health | Nkem Johnson | Division of Ecosystem Management, UNE, Armidale, NSW |
| Enhancing ecotourism in State Forests through archaeological investigation of historical landscapes | Dr Wendy Beck | Archaeology and Palaeoanthropology UNE, Armidale, NSW |
| Moth study in Chichester State Forest | Paul Martyn | Private study |
| Collection of native flora for taxonomic research and plant specimens for herbarium collection | Dr Judy West | Centre for Plant Biodiversity Research, CSIRO, Canberra, ACT |
| Macroinvertebrate sampling and its relationships with water quality and land use in Upsalls Creek | Roger Stanley | Department of Land and Water Conservation, West Kempsey, NSW |
| Insect study | Robert Bell | Private study |
| Mushrooms and truffles of NSW | James Trappe | CSIRO Wildlife and Ecology, Canberra, ACT |
| Biology and ecology of the endangered plant species <i>Corchorus cunninghamii</i> | Julia Playford | Department of Botany, University of Queensland, St Lucia, QLD |
| Ecology and evolutionary processes associated with hybridisation in <i>Persoonia myrtilloides</i> and <i>P. levis</i> (Proteaceae) | Chris Nancarrow | Department of Biological Sciences, University of Wollongong, NSW |
| Comparison of biota between pine forest and remnant yellow box woodland | Cilla Kinross | Orange Agricultural College, University of Sydney, Orange, NSW |
| General insect collections to increase the Australian representation in Cornell University's insect collection | Louie Yang | Cornell University, New York, USA; Division of Botany and Zoology, ANU, ACT |
| Heath flora of acidic volcanic outcrops in the Moreton geological region: composition, dynamics and phytogeography | Andrew Benwell | Private study |
| Revision of the Australian Apiaceae | Dr Murray Henwood | School of Biological Sciences, University of Sydney, NSW |
| Distribution, life history and host plants of oecophorid moths | Lenard Willan | Private study |
| Collection and identification of insect specimens and Mollusca for State Forests' reference collections and the Australian Museum | Chris Ann Urquhart | State Forests; Ganwill Pty Ltd, NSW |
| Biological control of <i>Glycaspis brimblecombe</i> in California | Donald Dahlsten | University of California, Berkeley, USA |

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| Effects of predation rates on birds' nests along different edge types | Dr William Gladstone | University of Newcastle, Ourimbah, NSW |
| Flora and fauna surveys for National Parks and Wildlife Service | Alison Martin | Greenloaning Biostudies, Tuncester, NSW |
| Waterbird monitoring within Barmah–Millewa Forest | Rick Webster | Ecosurveys Pty Ltd, Deniliquin, NSW |
| Potential impacts of climate change on insect–plant interactions | Nigel Andrew | Ecology Laboratory, Macquarie University, Ryde, NSW |
| Survey of barking owl in the upper Bungawalbyn catchment | Robert McKenzie | Southern Cross University, Lismore, NSW |
| Young superb parrot habitat plan | Katrina Hudson | Young Shire Council, Young, NSW |
| The Johnstone Centre Herbarium—to provide a reference collection of species | Kylie Kent | Charles Sturt University, Albury, NSW |
| Causes and consequences of variation in dispersal in Australian treecreepers | Veronika and Erik Doerr | Division of Botany and Zoology, ANU, ACT |
| Study of warty layer of wood—black and white cypress pine | Philip Evans | ANU, ACT |
| To apply simple process model to coastal regrowth eucalypt forest and test it against empirical predictions of stand growth | David Dore | University of NSW |
| Estimating carbon in native forests | Gemma Woldendorp | Department of Geography, ANU, ACT |
| Thermoregulation by <i>Vespadelus pumilus</i> (eastern forest bat) | Christopher Turbill | Department of Zoology, ANU, Armidale |
| Integration of models of vertebrate distribution and abundance across levels of scale hierarchy | Brian Stone | Environmental Studies Unit, Charles Sturt University, Bathurst, NSW |
| Assessment of the efficacy of hair tubes for the detection of medium-sized terrestrial mammals | Michael Saxon | Southern Zone, NPWS, Queanbeyan, NSW |
| Herbarium upgrade | Alexander Floyd | North Coast Regional Botanic Garden Herbarium, Coffs Harbour, NSW |
| Genetic study as part of <i>Microtis angusii</i> recovery plan | Tanya Duratovic | NPWS, Hurstville, NSW |
| Predicting outcomes of threatening processes and their management in multi-species assemblages | Angela Penn | School of Biological Sciences, University of NSW |
| Biogeography of Australian insect fauna | J. C. Keast | Private study |
| Speciation and evolution of associations between herbivorous insects and their host plants | Dr Douglas Futuyma | State University of New York, USA; School of Botany, University of Melbourne, Vic |
| Review of environmental factors associated with design and construction of route realignments, Oxley Highway | Dr Judith Wilks | de Groot and Benson Pty Ltd |
| Study of the evolutionary biology of flies of the family Drosophilidae, genus <i>Scaptodrosophila</i> | J. S. Barker | Animal Science, ANU, Armidale, NSW |
| Survey vegetation and floristic data | Douglas Beckers | NPWS, Dubbo, NSW |
| Survey of Mt Killiekrankie – Little Wonder – Dunggir National Park wildlife corridor, focusing on remaining unprotected portion | Keith Kendall | Nambucca Valley Conservation Association, NSW |
| Monitoring of populations of great barred river frogs | Dr Michael Mahony | Department of Biological Sciences, University of Newcastle, NSW |
| Landscape evaluation—student field trip | Dr Paul Hesse | Department of Physical Geography, Macquarie University, Ryde, NSW |
| Regional forest assessment of ironbark and cypress pine forests | Gary Saunders | National Parks and Wildlife Service, Dubbo, NSW |
| Avian dynamics in the Bathurst landscape | Andrew Fisher | Environmental Studies Unit, Charles Sturt University, Bathurst, NSW |
| Field work skills in biodiversity, wildlife management and Australian flora and fauna | Dr Michael Mahony | Department of Biological Sciences, University of Newcastle, NSW |
| Targeted surveys for the stuttering frog | Garry Daly | Gaia Research Pty Ltd |

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| Species impact statement, proposed extension to Nambucca waste depot | Greg Elks | Idyll Spaces Consultants, Bonville, NSW |
| Effects of three stream crossings on the aquatic macroinvertebrate communities of the Styx River, NSW | Jason Kirkman | UNE, Armidale, NSW |
| Shoalhaven wetland survey—mammals, flora assessment and frogs | Alison Scobie | Shoalhaven City Council, NSW |
| Living and herbarium collection of a wide representative sample of flora | Terry Tame | Hunter Region Botanic Gardens, NSW |
| The role of riparian vegetation in maintaining water quality as assessed using biological indicators | Jan Peters | Department of Geography, University of NSW |
| 'Birds Australia' Bird Atlas project | Dennis Hill | Private study |
| Activity and behaviour of land snail species in Bruxner Park Flora Reserve | Michael Murphy | NPWS, Coffs Harbour |
| Spatial diversity in bats and moths | Maria Dawn Adams | University of Wollongong, NSW |
| Studies of Hastings River mouse and owls | Dr David Read | Private study |
| Northern corroboree frog recovery program | Rod Pietsch | Southern Zone, NPWS, Queanbeyan |
| Conservation genetics of the green and golden bell frog | Emma Louise Burns | Department of Biological Sciences, University of NSW |
| Collection of native flora for taxonomic research and collection of herbarium specimens | Dr Jeremy Bruhl | NCW Beadle Herbarium, UNE, Armidale, NSW |
| Relative performance of <i>Blandfordia grandiflora</i> R. Br. grown under different cultivation techniques | Dr Mike Olsen | LAMR, Oxley, Qld |
| Estimating greenhouse gas sources and sinks in the terrestrial biosphere | Dr Heather Keith | CSIRO Forestry and Forest Products, ACT |
| Biogeographic analysis of wet forest lizards and frogs within south-eastern Queensland and north-eastern NSW | Adnan Moussalli | Department of Zoology, University of Queensland, Qld |
| Nandewar bioregional assessment | Peter Richards | Northern Directorate, NPWS, Coffs Harbour, NSW |
| Inbreeding depression in koalas | Dr Bronwyn Houlden | School of Biological Science, University of NSW |
| The influence of riparian vegetation on the channel and floodplain stability of sandbed forest streams | Ashley Webb | School of Geosciences, University of Sydney, NSW |
| Macroinvertebrate assessment of Darling Mills Creek | Lee Lau | Upper Parramatta River Catchment Trust |
| Sustainability of fuel-reduction burning regimes in native forests | Dr Alan York | Biological Sciences, Wollongong University, NSW |
| Subsurface invertebrates and water quality of the Never Never River | Dr Andrew Boulton | UNE, Armidale, NSW |
| Reconciling geographical and ecological paradigms: modelling individual vegetation species distributions for dynamic mapping of vegetation | Kimberly Van Niel | Centre for Plant Biodiversity Research, CSIRO, Canberra, ACT |
| Hand collection of herbarium specimens, seeds, cuttings from trees, plants and shrubs | Peter Cuneo | Mount Annan Botanical Gardens, NSW |
| Survey and monitoring of the endangered species <i>Uromyrons australis</i> (Sch. 1 TSC ACT) | Robert Kooyman | Earth Process Ecological Services; NPWS |
| Research project contracted by National Parks and Wildlife Service into population dynamics and disturbance regime requirements of the threatened plant <i>Corchorus cunninghamii</i> | Barbara Stewart | Landmark Ecological Services Pty Ltd, Mullumbimby, NSW |
| Darling Riverine Plains and Brigalow Belt South bioregional assessments | Helen Achurch | Western Directorate, NPWS, Dubbo, NSW |

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| Bat call key to south-eastern Queensland and north-eastern NSW and bat call project (NSW) | Michael Pennay | NPWS, Hurstville, NSW |
| Undergraduate field trip in vertebrate zoology | Prof Richard Shine | Department of Biology, University of Sydney, NSW |
| The Quaternary and recent history of the East Pilliga State Forest | Dr Diane Hart | Macquarie University, NSW |
| Biodiversity survey of Woomargama State Forest | Roger Lembit | National Parks Association of NSW Inc |
| Tea tree breeding project | Gary Baker | Tea tree research team, NSW Agriculture; CSIRO |
| An analysis of how the relationship between sapwood area and leaf area changes with tree height for <i>Eucalyptus delegatensis</i> in Bago State Forest | Karel Mokany | University of NSW |
| Exotic forests: plantation style vs natural growth—which is more beneficial? | Bronwyn Haller | Department of Ecosystem Management, UNE, Armidale, NSW |
| Wiradjuri Dreaming—search for the forgotten bora grounds | Suzanne Hudson | Genaren Hill Landcare Group, NSW |
| Conservation of biodiversity on-farm in the Riverina | Dr D. Freudenberger | Department of Wildlife and Ecology, CSIRO, Canberra, ACT |
| Point-source management of carp | Ivor Stuart | Department of Natural Resources and Environment, Vic |
| Research into <i>Pomaderris queenslandica</i> (Master's thesis) | Janelle Brooks | NPWS, Coffs Harbour, NSW |
| Fire: its effects upon vegetation restoration in Goonoo State Forest | Michelle Cavallaro | UNE, Armidale, NSW |
| Flora and fauna investigations of road corridor within Barooga State Forest | Marcus Baseler | Gunninah Environmental Consultants, NSW |
| Population ecology of <i>Amanita</i> | Nicole Sawyer | University of Western Sydney Nepean, NSW |
| Field surveys to determine the locations and distribution of the threatened plant <i>Olearia flocktoniae</i> | Dr Judi Earl | Private study |
| Woolgoolga Flora Reserve banding project | Patricia Thomson | Private study |
| Eurobodalla Regional Botanic Gardens plant species | Mrs Jennifer Liney | Eurobodalla Regional Botanic Gardens |
| Systematics of Australian nepticulid moths | Dr Robert Hoare | Landcare Research Ltd, Auckland, New Zealand |
| Host specificity of mistletoes in Goonoo State Forest | Arnae Denkel | UNE, Armidale, NSW |
| Native vegetation mapping program | Bob Denholm | Department of Land and Water Conservation, Newcastle, NSW |
| Native vegetation mapping program | Paul O'Keefe | Department of Land and Water Conservation, Inverell, NSW |

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- Bi H, Wan G, Turvey ND. 2000. Estimating the self-thinning boundary line as a density-dependent stochastic biomass frontier. *Ecology* 81: 1477–83.
- Bi H. 1999. Predicting stem volume to any height for native tree species in southern New South Wales and Victoria. *New Zealand Journal of Forestry Science* 29: 318–31.
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- Collett NG, Simpson JA, Schoeborn CS, eds. 1999. A Review of the Current Status of the Monterey Pine Aphid *Essigella californica* (Essig.) in Australia. Proceedings of a workshop, 17 November 1999, Centre for Forest Tree Technology, Melbourne, Victoria. Department of Natural Resources and Environment, Heidelberg, Victoria.
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- George BH. 1999. Comparison of techniques for measuring the water content of soil and other porous media. Master of Science in Agriculture dissertation, University of Sydney.
- George BH, ed. 2000. *Commercial and Environmental Values of Farm Forestry in the Murray–Darling Basin Irrigation Areas*. Proceedings of a workshop, July 1999, Deniliquin, New South Wales. *State Forests of NSW Technical Paper No 65*. 73 pp.
- Kavanagh RP. 2000. Effects of variable-intensity logging and the influence of habitat variables on the distribution of the greater glider *Petauroides volans* in montane forest, southeastern New South Wales. *Pacific Conservation Biology* 6: 18–30.
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*Trees from tissue cultures of Corymbia variegata.
Photo: Ian Johnson*

*Turbidity probe assembly ready to be installed at the Bago monitoring site.
Photo: Dennis Burt*