Termite and Power Pole Evaluation Research Project

M Horwood

Termite damage to wood power poles in Australia costs around $20 million each year. A long-term study known as the Termite and Power Pole Research (TAPPER) trial is seeking to reduce the damage bill by identifying the most effective methods for eradicating termites from infested poles and protecting new poles from attack. Another aim of the study is to identify effective alternatives to highly toxic treatments such as arsenic trioxide, currently used by the electricity networks. Work on the trial began in 2000 and is being funded by the Electricity Association of NSW and the Forest and Wood Products Research and Development Corporation.

There are two parts to the TAPPER trial:

- **a service trial** to evaluate the performance of termiticidal treatments, including toxic dusts, chemical soil barriers, and a residual timber fumigant for eradicating termite infestations from infested power poles
- **a field trial** to evaluate the performance of termiticidal soil barriers and a physical barrier for protecting new poles from termite attack.

The service trial was established during 2000–2002. Treatments were applied to over 450 termite-infested poles located throughout urban and rural NSW. Since treatment, poles have been monitored regularly to assess treatment performance.

The field trial was established in 2002 in a State Forest near Narrandera in southwestern NSW. A large number of timber posts were placed in the ground and treated with a combination of one of a selection of chemical barriers and a physical barrier system. Posts were then monitored to determine the period of protection given by the various treatments. Inspections were planned to occur after one, three, five, seven, 10 and 20 years. The one- and three-year inspections have been conducted. The five-year inspection is due towards the end of 2007.

This trial has identified a number of highly effective termite treatments (see figure and table below), some of which are not currently used by the power supply industry in Australia. They represent effective alternatives to conventional chemicals such as arsenic trioxide, should the continued use of this chemical become undesirable and replacement chemicals be needed.

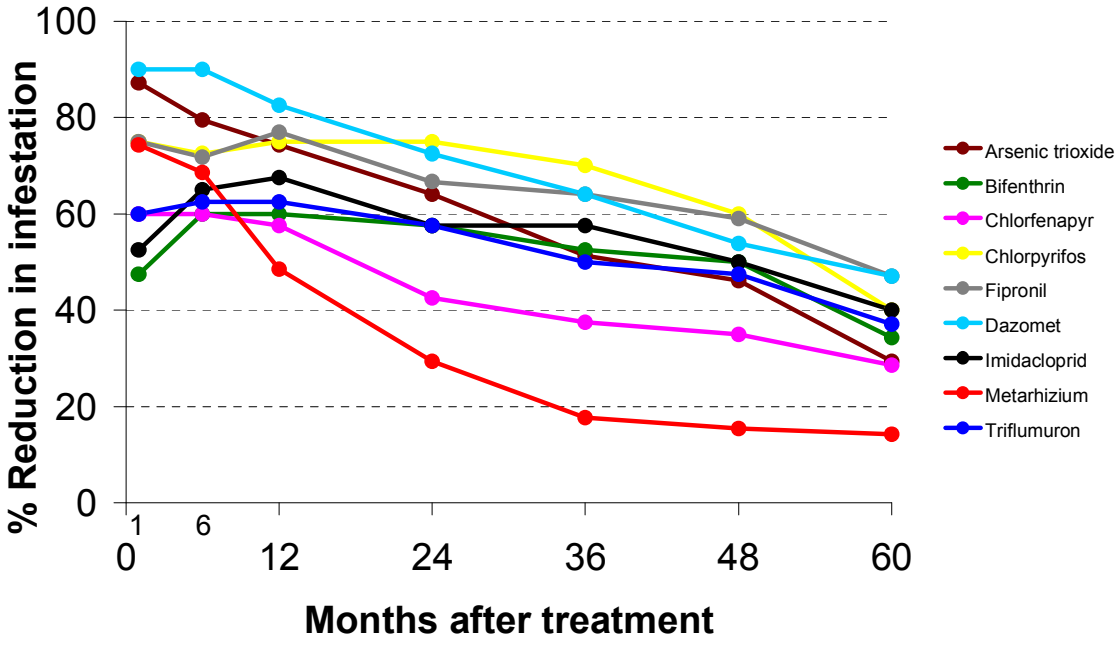
Mean termite damage scores to wooden posts in plots with control, chemical barrier and physical barrier treatments, 1 and 3 years after installation of the field trial

	Mean Damage Score[a, b] (SE)			
	Year 1		Year 3	
	Full Barriers [c]	Partial Barriers[c]	Full Barriers	Partial Barriers
Treatment Set 1				
Control	1.2 (0.20)		2 (0.45)	
Bifenthrin	1 (0)	1 (0)	1 (0)	2 (0.45)
Chlorpyrifos	1 (0)	1 (0)	1 (0)	2.6 (0.81)
Imidacloprid	1 (0)	1 (0)	1 (0)	1 (0)
Stainless steel mesh	1 (0)	-	1 (0)	-
Treatment Set 2				
Control	4.2 (1.2)		2.8 (0.20)	
Chlorpyrifos	1 (0)	1.2 (0.20)	1 (0)	1 (0)
Fipronil	1 (0)	1 (0)	1 (0)	1.2 (0.20)
Treatment Set 3				
Control	2.2 (0.37)		2.2 (0.20)	
Chlorfenapyr	1 (0)	1.2 (0.24)	1 (0)	2 (0.40)
Chlorpyrifos	1 (0)	1.4 (0.20)	1 (0)	2.4 (0.32)

[a] 1 = Sound (no attack), 2 = Superficial attack or grazing by termites, 3 = Surface attack by termites >5mm in depth, 4 = Attack (slight) 10-25% mass loss, 5 = Attack (moderate) 25-50% mass loss, 6 = Attack (severe) 50-75% mass loss, 7 = Attack (destroyed) 75-100% mass loss.

[b] Values represent the mean of five replicates.

[c] Full barrier = treatment surrounds the entire post where it is in contact with the ground. Partial barrier = treatment surrounds only that part of the post in contact with the upper 9say 30 cm) part of the ground.



Percentage reductions in termite infestation in service trial poles up to 5 years after treatment.

The trial is due for completion in December 2007.

The main implication of the research for Forests NSW is its contribution to the maintenance of wood pole cost effectiveness in an increasingly competitive marketplace. Forests NSW's share of the pole market has declined in recent years. Poles made from spun concrete and steel are becoming increasingly popular . Although it is not the only factor responsible for the change, the difficulty experienced by pole owners in controlling termites in wood poles has contributed to the increasing attractiveness of poles made from alternative materials that are immune to termite attack.

The research has provided pole owners with knowledge of the efficacy and reliability of termite control products. They no longer have to rely on marketing information from product suppliers when selecting treatments but can now base their judgements on sound, independently derived information with wide applicability. This places them in a good position to bring about reductions in treatment costs and pole replacement due to termite attack. They also now know about suitable replacements for older chemicals such as arsenic trioxide—knowledge that will be extremely valuable should the use of these chemicals become undesirable.

A number of electricity networks in Australia are known to have altered their treatment practices in response to the findings of the research.

Preschem Bioguard Bandage Trial

M. Horwood

All of the approximately two million hardwood power poles in NSW require remedial groundline maintenance at some time to protect them from fungal degrade. These procedures cost pole-using authorities approximately $15 million per annum. The most commonly used maintenance treatment is to install a bandage containing fungicidal chemicals to the underground inspection zone of the pole. This zone extends from the surface to a depth of 35-40 cm and is the area most prone to fungal degrade.

This industry-funded research project is assessing a range of chemical and delivery system variations to the standard Bioguard® pole bandage to optimise transfer of chemicals into poles and reduce losses of chemicals to the environment.

The project was established in the first half of 1999. At specified intervals since then a set number of poles have been inspected. At each inspection, bandages are removed from poles and core samples taken from the bandaged section. Bandages are weighed to determine the extent of losses of active materials and timber cores are analysed to determine the quantities of active materials that have been transferred from bandages into poles.

Inspections have been carried out at one (2000), two (2001), four (2003) and six (2005) years after treatment. Further inspections are planned for eight (2007) and 10 (2009) years post treatment.

The research has provided the sponsor with the necessary information for them to improve the efficiency and efficacy of the product. These improvements have been used to support product marketing in Australia, South Africa, Brazil and most recently, the USA. Improving the product also helps enhance the cost effectiveness and reliability of wood poles relative to alternative materials because the improved product provides an effective and acceptable means of protecting poles in service from fungal degrade.

Forest Biodiversity and Ecology

Program Leader: **Rod Kavanagh**

Aim: A scientific basis for maximising biodiversity values in managed forests.

Objectives:

- Enhance understanding of managed forests ecosystems
- Develop integrated landscape models of wildlife habitat and timber production

Ecology of birds and non-flying mammals in managed forests

R Kavanagh

Koala ecology and response to selective logging in mixed *Callitris Eucalyptus* forest

In this study, we posed the hypothesis that, in the short term (one year), selective logging does not adversely affect the conservation of koalas in the Pilliga forests in northwestern NSW. We examined this hypothesis in terms of koala survival and fecundity, home-range size and fidelity, movements, and tree preferences, in a planned logging experiment that incorporated a before-after control-impact design, with replication.

Thirty koalas, five in each of six areas available for logging within a mixed white cypress pine (*Callitris glaucophylla*) and *Eucalyptus* forest, were radio-tracked for one year to determine their movements, home-range sizes and tree preferences. Five months after the study began, three of these areas were logged selectively for sawlogs and thinnings of the white cypress pine, a tree that is important to koalas for daytime shelter. This removed about one quarter of the stand basal area, but the eucalypt component was unaffected. The remaining three areas were left undisturbed as controls. Radio tracking continued in all six areas for another seven months.

The Pilliga koala project was the first experimental study of the effect of a logging operation on koala populations. The principal findings were that koalas continued to occupy all or part of their previous home ranges after selective logging, and that the size of home ranges in logged and unlogged areas remained similar. The strong preferences displayed by the koala for Pilliga box and for one or more of the available Red Gums demonstrate the need to carefully manage numbers of these tree species in future logging operations. Within these mixed-species forests, where white cypress pine forms the principal commercial species it is important to maintain a minimum number of eucalypt trees per hectare for koala habitat. Preliminary findings from this study, in which all koala home ranges contained at least one preferred (primary food) tree species, suggest a minimum threshold of 20 eucalypt trees larger than 20 cm diameter at breast height (DBH) be retained per hectare to maintain habitat quality for koalas. More work is needed in other regions to

determine thresholds in the level of retention of koala food trees. Existing harvesting protocols, as applied during cypress logging operations in the Pilliga forests, do not appear to adversely affect koala populations, at least in the short term.

Review of the status of the Barking Owl in Southern Australia

The southern form of the barking owl, *Ninox connivens connivens*, is listed as vulnerable in NSW, endangered in Victoria and rare in South Australia, but is not listed in Western Australia or Queensland. Surveys over the past 20 years (in NSW, Victoria and Western Australia) have shown that this species is rarely encountered in the publicly owned tall, wet forests of the coast and adjacent mountain ranges. Instead, they appear to favour dry sclerophyll forests and woodlands on low lying, relatively fertile country, especially near rivers and swamps. These woodlands are poorly represented in the conservation reserve system.

Potentially threatening factors that limit populations of the barking owl were reviewed, particularly with reference to a recent field study in the Pilliga forests of northwestern NSW. Information about owl diet, habitat, spatial requirements, responses to logging, wildfire and drought, breeding success and predation, were considered. Food availability was hypothesised as the key limiting resource for barking owls in southern Australia, a factor that has been exacerbated by the continuing loss, fragmentation and degradation of habitat in the rural landscapes where this species now mainly occurs. Predation on nestlings was also identified as a significant factor in some areas. Systematic surveys for barking owls are urgently needed throughout rural areas to better understand the conservation status of this species. Incentive payments for landholders may be required to protect and regenerate habitat in key areas.

Impact of forest management strategies on plant species diversity and richness

R Kavanagh and T Penman

This project examines the effects of the two primary forest disturbances, fire and logging, on both understorey and overstorey vegetation. Data has been collected within the Eden Burning Study Area over a 20-year period. Funding has been provided by the Bushfire Cooperative Research Centre to analyse and publish the results of this study.

Prescribed burning and logging operations affect understorey plants differently. However, the typically patchy nature of these management procedures, at least in the dry sclerophyll forests in south-eastern NSW, means that some refuges are likely to be available for species that are more sensitive to fire and logging. The final product of this research will be a decision support tool for managers to determine the impact of various management strategies on plant communities. It is envisaged that this management tool will be applicable on a regional scale.

Prescribed burn in the Eden Burning Study Area

Research Officer Trent Penman sampling the soil seed bank in the Eden Burning Study Area

Soil seed bank

The Bushfire Cooperative Research Centre (CRC) provided funding for a student scholarship to assist in the establishment of a study of the soil seed bank in the Eden Burning Study Area. Soil samples were collected from the site in April 2006 and germinated over a 12-month period. The data identifies which species are fire responsive and require active fire management. The data will be compared with data

on above ground plant communities in order to develop landscape-scale fire management practices that conserve biodiversity in the medium to long term.

Natural responses to wildfire

The Bushfire CRC and Forests NSW provided funding for a retrospective study of the influence on understorey vegetation communities of time since wildfire. Long-term study sites in the Yambulla Hydrology catchment areas were re-established and re-sampled in October 2006. This data will be used to verify models developed from the Eden Burning Study Area and predict changes relating to an increasing time since wildfire. This information will be used to develop landscape-scale fire management practices that conserve biodiversity in the medium to long term.

Biodiversity in eucalypt plantations established to reduce salinity

R Kavanagh

This project builds upon existing knowledge from a large number of sites planted for environmental benefits in the Albury-Wodonga region and extends the geographical relevance of the work to include the Liverpool Plains region near Gunnedah. Significantly, it also broadens the scope of the earlier studies to include eucalypt plantations established for commercial wood production as well as for multiple environmental benefits, including salinity control and biodiversity conservation. The main objectives of this project are to:

- calibrate forestry-type plantings (those with typically fewer, and non-local tree species, and with fewer or no shrubs) with eucalypt plantings established primarily for habitat restoration (most of those sampled in the Albury-Wodonga region)
- investigate the capacity of eucalypt plantations to provide the critical resources needed for breeding and year-round occupancy by wildlife
- explore the opportunities for improving habitat for fauna in commercial eucalypt (agro-forestry) plantations.

Plantation patches were selected for study within the available size range (2–50 ha) and compared with similar-sized patches of remnant native vegetation, much larger remnants in the landscape, and sites typical of the surrounding agricultural matrix. Counts of the breeding season and non-breeding season populations of birds, bats, possums, gliders, reptiles and amphibians were conducted during the year using standardized, formal survey methods. Nest searches were made on all sites during the breeding season.

Eucalypt plantations lack certain attributes of habitat that are important for many species (e.g. old trees, which are an important source of nest hollows; low levels of ground cover for shelter). Accordingly, landowner consent was sought and obtained to augment the habitat for fauna within half of the study sites in each plantation size class category. Preparations are underway to put in place a large number of nest boxes of varying sizes and to provide artificial ground cover at half of the plantation study sites. Other forms of habitat augmentation are being considered.

A short-list of focal species will be identified for more detailed study, based on the results of the above surveys. These species will include those that may play a role in controlling important agricultural pests, as well as some species considered to have special conservation significance in the region.

Ground-truthing biodiversity benefits toolkits

R. Kavanagh, B. Law and A. Weinberg

In the past five years, state government agencies across Australia have rapidly developed "biodiversity toolkits" as devices for estimating the locations of species-rich areas. Biodiversity toolkits work by combining a number of key vegetation and landscape attributes into a single index which, when properly constructed, represents the habitat requirements of a broad range of species. However, to date, there has been insufficient testing of the ecological basis that underlies the toolkits.

We compared the predictions from four toolkits, based on measurements collected at 120 sites throughout the South West Slopes (NSW) Region, against an existing data set of vertebrate species collected at the same sites. Using Spearman's rank correlations, we assessed whether sites with high toolkit scores corresponded to sites with the greatest vertebrate species richness. Using generalised linear models and sensitivity analyses, we looked at ways to improve toolkits by adding attributes and adjusting weightings. Overall, we found that biodiversity toolkits gave an inadequate representation of vertebrate species richness. While their performance was better in remnant vegetation, toolkits were very poor at representing vertebrate species in planted sites because the types of attributes included were unsuitable and the use of reference sites (mature and unmodified vegetation communities) were inappropriate for assessing vertebrate species in plantings. Biodiversity toolkits gave better predictions for fauna groups that depend on structurally complex vegetation, such as woodland-dependent birds, arboreal mammals and reptiles. Conversely, bats and non-woodland dependent birds were poorly represented.

We identified five key site-vegetation and landscape attributes (presence of water, canopy cover, number of hollow-bearing trees, total log length, and the amount of surrounding native vegetation cover), some of which were not included in some of the toolkits (e.g. presence of water, amount of surrounding native vegetation cover). We found that specific adjustments to the weightings of certain attributes can improve the overall performance of all toolkits examined. This research is intended to inform toolkit developers and users of their toolkits' limitations and reliability, and to identify practical ways of improving their design.

Goonoo Lands Fox Project

R Kavanagh and A Towerton

This project, which was begun in 2005, examines the habitat preferences and movements of foxes in the Goonoo Lands, a forested area northeast of Dubbo, NSW. The results of this study will provide details on potential target areas for fox control and hence effective bait placement. The results will also help to promote the

landscape management approach where agencies and landholders work together to address the problem of predation by foxes on livestock and native fauna in this area. Recommendations will be provided on the continued monitoring of the feral pest species in the forest.

Data has been collected on a number of aspects of fox distribution in this area using the methods described below.

Home range analysis. To date, thirteen foxes and one cat have been collared and tracked to provide information on home range size, habitat preferences and movement patterns. Four foxes had failed transmitters or left the area, one fox was shot on a neighbouring property, six foxes were found, presumed poisoned, following pest control operations in the forest and on surrounding properties, and two animals remain alive. Three animals were fitted with global positioning system (GPS) collars, which had not been used on foxes previously in Australia. The GPS records a location every hour, allowing a more detailed look at the fox's movements in the forest. Analysis so far has suggested that home range sizes in the forest are generally larger than those recorded for foxes elsewhere in Australia.

A fox with a global positioning system collar attached

Sand plot surveys. Some 38 sand plots were surveyed for animal tracks before and after baiting programs in order to assess fox activity. The first two baiting programs (November 2005, March 2006) had shown a significant reduction in the number of sandplots recording fox activity, while the July and November 2006 baiting programs show a non-significant increase. This may possibly be explained by July being the mating season for the foxes, when they may move about more, while in November staff were busy with fires and only half the forest was baited.

Scat searches. A total of 82 scats were collected in the area and are currently being analysed to provide information on the diet of foxes in this region.

Remote camera systems. During a period of five months, three infra-red triggered digital cameras were set up at malleefowl mounds to monitor malleefowl activity and mound visitation, particularly by potential predators. The animals photographed were the red fox, lace monitor, sand monitor, echidna, feral goats, swamp wallaby, raven, common bronzewing and a dunnart. No photos of malleefowl were recorded at the mounds.

A fox on a malleefowl mound (photographed using a remote camera system)

The study so far has demonstrated that the home range areas that foxes use in this forest and surrounding landscape are surprisingly large. Sand plot surveys have demonstrated changes in fox activity, showing a significant decrease following baiting.

Bat ecology in managed forests

B Law

The improving knowledge of forest bat ecology is allowing predictions to be made about changes in bat communities resulting from changes in forest management practices and thus will be integral to demonstrating ecological sustainability.

Improved tools have been produced for surveying bats and bats have been monitored using novel methods such as banding and infra-red counters at known roosts. The information gathered from long-term monitoring is extremely valuable.

Response of bats to disturbance

Bats in the Pilliga

Data from a major study of bats (and other fauna) in the Pilliga region was analysed and presented at scientific conferences. The aim of the study was to establish the "biological width" of streams (the minimum undisturbed corridor width necessary for biological conservation, in this case of bats) in the Pilliga in order to establish a

scientific basis for buffer widths surrounding streams. The study sampled three different-sized streams replicated across the region. Ultrasonic detectors were used to record bat calls at four distances from the stream—over the streambed (0 m), at 50 m, 100 m and 200 m from the stream. There was no distinct bat assemblage characteristic of the riparian zone (the stream bank area). However, there was a significant interaction between distance and stream size, with large streams supporting three times more activity over the channels than adjacent woodland. These results provided a scientific underpinning for recently negotiated buffer widths for these forests.

Bats in the Karuah Research Area

Bats were banded for the ninth consecutive year in March 2007, with 137 banded and 73 recaptured from previous years. The study will provide the first estimates of bat population sizes and survival rates in forests, which will enable us to compare results for regrowth and unlogged catchments. To maximise the precision of our estimates data will continue to be collected for this comparison until regrowth catchments are thinned, which is expected to occur in the next year. Annual banding is also providing extensive pre-thinning data on bat populations that will allow comparison with post-thinning data in years to come. In preparation for thinning, additional Anabat (a system designed to help users identify and survey bats by detecting and analysing their echolocation calls) surveys were conducted concurrently with trapping in the catchments, which will allow comparison of bat activity between thinned, unthinned and mature forest.

Bats in Southern Cypress

At the request of Forests NSW, Western Region, we undertook a pilot survey of bats in the southern cypress forests near Forbes. Across seven State Forests, 187 bats were captured. Threatened species were only captured at Manna State Forest, where overall capture rates were very high. About 200 reference calls were also collected. These can be used to build an identification key to bat calls for future work.

The threatened greater long-eared bat, Nyctophilus timoriensis, captured at Manna State Forest during a pilot bat survey at Forbes

Improved tools for monitoring and surveying bats

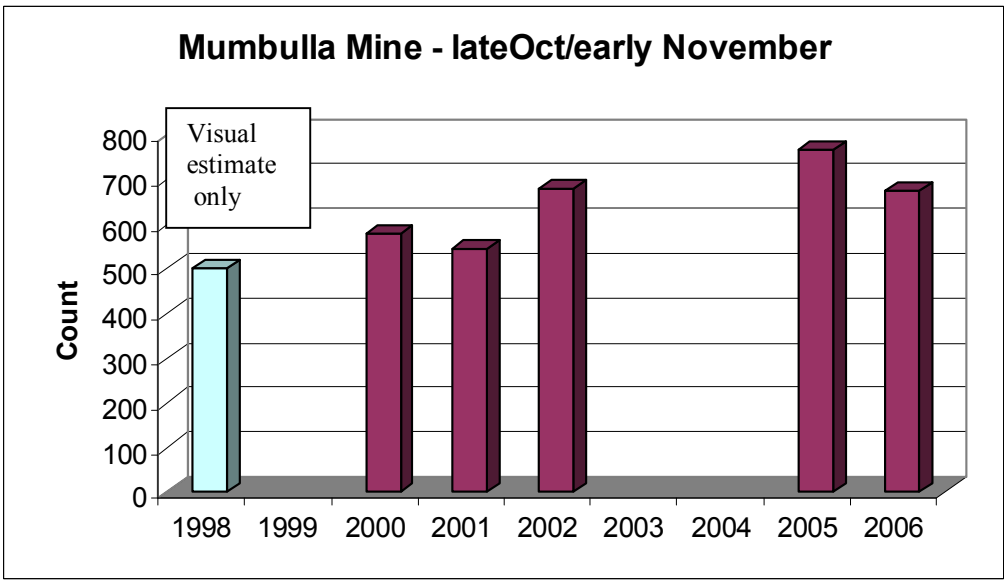
The Large-footed Myotis, a water-way dependent bat, was banded for the eleventh consecutive year at Kerewong State Forest. Forty-eight bats, including 30 recaptures, were caught there in 2007. In January 2006, the half of the bridge under which this colony of bat roosts, collapsed. The rest of the bridge collapsed in late 2006, prior to banding in 2007. The capture of banded bats indicates that some proportion of the population survived the destruction of the roost. Radio tracking of two individuals at the time of banding resulted in the discovery of a natural roost in the hollow trunk of a large water gum on Upsalls Creek, about 500 m downstream of the collapsed bridge.

We plan to install nest boxes in the vicinity of the collapsed bridge so that monitoring of this important population may continue. A full analysis of population trends over 10 years will take place to assess changes both before and after logging in surrounding catchments from 2000–2003 and over changing weather conditions. This data will provide a strong test for the effectiveness of riparian buffers in mitigating any potential short-term effects of logging.

Monitoring also continued at two key subterranean roost sites for eastern horseshoe and eastern bent-wing bats. An infra-red gate and data-logger were used for this. At Mumbulla mine near Eden, 674 $\pm$ 19 (n=4 nights) were counted in November 2006. In December 2006, the sixth annual population census was carried out at Ourimbah bat cave on the central coast (the largest known roost of Horseshoe bats in

Australia). An uncorrected count of 5,271 bats (n=1 night) was made as they exited their cave.

Counts at both Mumbulla and Ourimbah were similar to those of previous years and a stable population pattern, with no large fluctuations, is beginning to appear. Continued monitoring of these important bat populations will allow Forests NSW to track the changing status of these bats and especially to assess changes due to forest management practices imposed on the surrounding environment.



Population census of bats at Mumbulla Mine, near Eden, NSW. The population is made up of eastern horseshoe and eastern bent wing bats.

Effect of logging on nectar production in eucalypts

B Law

This project was completed in 2006–07 and a final report was submitted to the external funding body—the Honeybee Program of the Rural Industries Research and Development Corporation.

The focus of the research was on nectar production by spotted gum *Corymbia maculata* and grey ironbark *Eucalyptus paniculata*, both tree species of prime importance to the timber industry, beekeepers and nectarivorous wildlife.

State Forests provide the major honey resource for the beekeeping industry in NSW. While Forests NSW has a number of management practices already in place to retain nectar-producing trees during logging operations, there is no information on how much nectar is produced by retained trees or young trees re-growing after logging. Indeed, beekeepers have expressed concern about the effects of logging on nectar production. They are especially concerned because there is a perception that young trees do not produce as much nectar as mature trees.

The view from a crane used to access the canopy of mature spotted gum to measure nectar in flowers

The research concluded that nectar production in spotted gum on a per flower basis was not affected by logging history or tree size. When individual flowers are scaled up to the forest stand, mature forest with large trees and many more flowers produced almost ten times as much sugar per hectare as recently logged forest, with regrowth being intermediate. However, at the compartment scale, the difference between mature forest and recently logged forest was reduced to a factor of two times when the extent of areas left unlogged under current logging practices was considered. Most importantly, nectar was not a limiting resource in 2005 as extensive flowering was recorded across the south coast of NSW.

We surveyed local beekeepers with questionnaires and found that honey yields in 2005 (54 – 83 kg/hive over 7 months of flowering) were above the typical range for the south coast of NSW. Honey productivity was similar across the three different logging histories. This appears to contradict the views expressed by some beekeepers that small trees in recently logged forest do not produce much nectar. But not every year is as good as 2005, with flowers measured in 2003 providing a strong contrast. Few trees were in flower and nectarivores, especially birds and honeybees, left virtually no nectar behind by mid-morning. Beekeepers reported that hive bees were not producing honey under these conditions.

Results for grey ironbark showed similarities to those for spotted gum with regard to the impact of logging, but the species differed markedly in other aspects of nectar production.

The results of this study will help to promote sustainability by raising the awareness of forestry organisations about the importance of the nectar resource and that of beekeepers about current forest management. To improve communication between apiarists and foresters it was recommended that formal guidelines be established on the management of apiary sites and the nectar resource in forests. Further research on how climate change will affect flowering levels and subsequent nectar production could be critical to the apiary industry and the conservation of nectarivorous fauna.

Nectar maps for flying foxes

B Law

Grey-headed flying foxes have recently been listed is a threatened species. This project aims to improve our understanding of this species and provide mapping tools for describing the distribution of their food resources. Our collaborative role in preparing digital maps of the distribution of flying fox food (nectar and fruit) is fully funded by the NSW Department of Environment and Climate Change (DECC). Progress this year has been slow because of delays in accessing the latest vegetation maps for various regions. Using the latest maps available will ensure the best quality information is used in the project.

Ecology of pygmy possums in managed forests

B Law

This project is investigating the ecology of the eastern pygmy possum and any impact that logging in forests might have on it. The research will aim to provide a scientific underpinning for the management of pygmy possums, a recently listed endangered species, by aiding the development of sensible and effective wildlife prescriptions in forests.

Eastern pygmy possum with a freshly fitted radio-collar ready for radio tracking

The primary study at MacPherson State Forest (Hunter Region) follows a BACI experimental design with two controls and two logged sites plus a further two sites that were logged four years previously. The pre-logging phase was completed in April 2007 and resulted in 61 individual possums captured, 32 radio-collared and 22 spooled. The two sites logged previously provide us with a picture of how pygmy possums use habitat in the early stages of regrowth after logging, rather than in the immediate post-logging period. Possums at both of these sites used dens and foraged in the regenerating zone, suggesting that these possums can survive in the thick understorey regenerating after logging.

The Department of Environment and Climate Change has provided approval for logging prior to November 2007 and the next phase of the study will be begun when logging occurs.

Managing frogs and reptiles in the forest environment

F Lemckert

Current monitoring strategies for many species of frogs are likely to detect only coarse changes in numbers and only after several years because of the variability in successfully detecting frogs over only one or two surveys. Site occupancy modelling can provide a much more sensitive means of detecting population changes with minimal survey effort.

Senior Research Scientist Frank Lemckert undertaking a tadpole survey

Most species in eastern NSW have been recorded frequently enough in the reserve system for us to believe that they are in a good position for their long-term conservation. The effect that climate change may have on this does, however, need to be factored in.

Monitoring of frog populations continued to be hampered by the drought, which effectively prevented monitoring of sites at Dorrigo and Bulahdelah this year. A wet winter/spring is needed to provide data on overall drought affects.

A paper was completed in collaboration with the Federal Department of Environment and Heritage looking at the species richness and endemism patterns of frogs in Australia. A second, on the patterns of frog records in Australia relative to reserves, is almost ready for submission. This latter paper provides specific information on the rarity of Australia's frogs, particularly on those in southeastern Australia. We are determining which frogs have relatively few records and how their biology and range influence the numbers of records. We are also working on a new system of ranking the relative rarity of frogs by considering how easy they should be to detect and the range and habitats over which they are found. This work will provide a better understanding of whether some of our rare species really are rare, or just hard to find, and should be applicable to other taxonomic groups.

We have almost completed the giant burrowing frog recovery plan, which will be submitted for public comment in the second half of 2007. This will provide for better

management of this frog and demonstrate the recognised expertise of the Forest Science Centre.

Pond requirements of frogs and effects of disturbance on frogs

F Lemckert

An expanded analysis of sites to include ponds from the Dorrigo, Wauchope, Bulahdelah and Watagan Ranges areas is almost complete and appears to indicate again that whilst some variables have an influence on use of ponds by frogs, most variation is not related to habitat. Analysis has been undertaken to assess whether water quality accounts for a large part of the variation, but it too looks to be relatively unimportant to most species of frogs. The information on water quality does indicate that many of the factors vary markedly through the year, suggesting that frogs need to be relatively tolerant of change if they are to be able to use a pond successfully.

Ongoing drought conditions may be confounding the results to some degree as pond levels have dropped very low and frog numbers have declined. It is hoped that conditions during the 2007 spring will be closer to the norm and provide final data to determine whether the patterns observed are “real”, as is expected to be the case. The most likely scenario is that the species populations at ponds are determined at random by which species are lucky enough to find the pond first. Once several have, any other species are essentially excluded through competition.

Over 500 frogs have been micro-chipped for long-term monitoring of population size, health and mortality. Many Peron’s tree frogs have been recaptured and mortality rates look reasonably low. Populations overall appear to be very stable, as do community structures. That is, there is not a high population turnover as is the case in many northern hemisphere systems and the typical metapopulation structure believed to drive populations in that hemisphere is not very relevant here. This is important as it may mean that eastern Australian pond frogs are less prone to localised extinction events through disturbances. However, this may also mean that it may take longer for populations that do become locally extinct to return to breeding sites.

The 32 new ponds constructed in the Watagans as part of this project continue to be colonised and most have good numbers of Peron’s tree frogs, whistling tree frogs and common froglets. Five sites are being used by the rare heath frog, demonstrating the potential of constructed ponds in assisting rare species. The refuge provided by such ponds makes the frogs less sensitive to local disturbances, meaning that it might be possible to reduce the required buffer zones around sites for this species. Radio tracking will be used to track the frogs when they leave the breeding site.

One of the frog ponds created in the Watagan Ranges, fills up

Data gathered on the calling activity of frogs in NSW was used to more accurately define the calling seasons of frogs and remove some of the confusion evident in field guides. The data also indicates the most likely months for calling to occur.

Wildlife schools

F Lemckert

Wildlife schools, open to Forest NSW and staff from other agencies, provide continuing training in the skills needed to carry out pre-logging survey programs as efficiently as possible. As well, these training sessions promote communication and understanding between Forests NSW and other agencies regarding current forest practices and management knowledge. Regulatory agency staff training ensures efficient communication and collaboration with Forests NSW.

Maitland Office of Forests NSW ran one course over the year and Frank Lemckert, a Senior Research Scientist with the Forest Resources Research Unit, assisted in this course with presentations on reptiles, frogs and licensing and assistance in spotlighting. The course was attended by Forests NSW staff and a number of consultants. A course is planned shortly to demonstrate wildlife survey techniques to members of Animal Care and Ethics committees.

Water Quality Monitoring

A Webb

Forests NSW's water quality monitoring program is conducted in a number of native forests and pine plantations throughout NSW. It is designed so that various intensities of harvesting and road activities are monitored across a range of soil types, climates and forests. A major proportion of the catchments are instrumented (have monitoring equipment installed) as part of Forests NSW's obligations under its Environment Protection Licences issued pursuant to the *Protection of the Environment Operations Act 1997* (NSW).

The program aims to determine if there is an identifiable impact of forestry activities on water quality and, if so, to quantify the level of that impact. The project investigates potential impacts on in-stream turbidity, suspended sediment concentration levels and total sediment loads and has important implications for the quality of water available to downstream users, given that State Forests are located in the headwaters of many water supply catchments.

To date, water quality monitoring (WQM) programs have been completed in Middle Brother (native forest) and Canobolas (pine plantations) State Forests and results published. In each of the completed programs, forest harvesting activities created pulse disturbances resulting in temporary increases in suspended sediment concentrations and in-stream turbidity levels. The use of best management practices for timber harvesting coupled with appropriate road drainage and riparian zone protection measures served to reduce the level of the impacts observed.

Post-harvest monitoring is nearing completion in the Bago pine plantation catchments, whilst harvesting has commenced in the Yambulla and Kangaroo River replicated native forest catchments. It is anticipated that these programs will continue for at least the next two years, during which time any water quality impacts will be measured.

Published Papers, Reports and Presentations

1. Anderson J, **Law B** and Tidemann C. 2006. Stream use by the large-footed *Myotis macropus* in relation to environmental variables in northern New South Wales. *Australian Mammalogy* **28**: 15-26.
2. Bilney RJ, **Kavanagh RP** and Harris JM. 2007. Further observations on the diet of the Sooty Owl *Tyto tenebricosa* in the Royal National Park, Sydney. *Australian Field Ornithology* **24**, 64-69.
3. **Carnegie AJ**. 2007. Forest health condition in New South Wales, Australia, 1996-2005. I. Fungi recorded in eucalypt plantations during forest health surveys. *Australasian Plant Pathology* **36**: 213-224.
4. **Carnegie AJ**. 2007. Forest health condition in New South Wales, Australia, 1996-2005. II. Fungal damage recorded in eucalypt plantations during forest health surveys and their management. *Australasian Plant Pathology* **36**: 225-239.
5. **Cowie AL**, Kirschbaum MUF and Ward M. 2007. Options for including all lands in a future greenhouse gas accounting framework. *Environmental Science and Policy* **10**: 306-321.
6. **Cowie AL**, Pingoud K and Schlamadinger B. 2006. Stock changes or fluxes? Resolving terminological confusion in the debate on land-use change and forestry. *Climate Policy* **6**: 161-179.
7. **Cowie AL**, Schneider UA and Montanarella L. 2007. Potential synergies between existing multilateral environmental agreements in the implementation of land use, land-use change and forestry activities. *Environmental Science and Policy* **10**: 335-352.
8. **Cowie AL**, Smith P and Johnson D. 2006. Does soil carbon loss in biomass production systems negate the greenhouse benefits of bioenergy? *Mitigation and Adaptation Strategies for Global Change* **11**: 979-1002.
9. Crous PW, Summerell BA, **Carnegie AJ**, Mohammed C, Himaman W and Groenewald JZ. 2007. Follicolous *Mycosphaerella* spp. and their anamorphs on *Corymbia* and *Eucalyptus*. *Fungal Diversity* **26**: 143-185.
10. Forrester DI, Bauhus J and **Cowie AL**. 2006. Carbon allocation in a mixed-species plantation of *Eucalyptus globulus* and *Acacia mearnsii*. *Forest Ecology and Management* **233**: 275-284.
11. Forrester DI, Bauhus J and **Cowie AL**. 2005. Nutrient cycling in a mixed-species plantation of *Eucalyptus globulus* and *Acacia mearnsii*. *Canadian Journal of Forest Research* **35**: 2942-2950.

12. Forrester DI, Bauhus J, **Cowie AL** and Vanclay JK. 2006. Mixed-species plantations of *Eucalyptus* with nitrogen fixing trees: a review. *Forest Ecology and Management* **233**: 211-230.

13. Forrester DI, **Cowie AL**, Bauhus J, Wood J and Forrester RI. 2006. Effects of changing the supply of nitrogen and phosphorus on growth and interactions between *Eucalyptus globulus* and *Acacia mearnsii* in a pot trial. *Plant and Soil* **280**: 267-277.

14. Fox J, **Bi H** and Ades PK. 2007. Spatial dependence and individual tree growth models I: Characterising spatial dependence. *Forest Ecology and Management* **245**:10-19.

15. Fox J, **Bi H** and Ades PK. 2007. Spatial dependence and individual tree growth models II: Modelling spatial dependence. *Forest Ecology and Management* **245**: 20-30.

16. Hero JM, Morrison C, Gillespie G, Roberts JD, Newell D, Meyer E, McDonald K, **Lemckert F**, Mahony M, Osborne W, Hines H, Richards S, Hoskin C, Clarke J, Doak N and Shoo L. 2006. Overview of the conservation status of Australian Frogs. *Pacific Conservation Biology* **12**: 313-320.

17. **Horwood MA**. 2007. Rapid degradation of termiticides under field conditions. *Australian Journal of Entomology* **46**: 75-78.

18. **Kavanagh, RP**, **Stanton, MA** and **Brassil TE**. 2007. Koalas continue to occupy their previous home-ranges after selective logging in *Callitris-Eucalyptus* forest. *Wildlife Research* **34**, 94-107.

19. Lloyd A, **Law B** and Goldingay R. 2006. Bat activity on riparian zones and upper slopes in Australian timber production forests and the effectiveness of riparian buffers. *Biological Conservation* **129**: 207-220.

20. **Law BS** and **Chidel M**. 2007. Bats under a hot tin roof: comparing the microclimate of eastern cave bat (*Vespadelus troughtoni*) roosts in a shed and cave overhangs. *Australian Journal of Zoology* **55**: 49-55.

21. **Law B** and **Chidel M**. 2006. Eucalypt plantings on farms: use by insectivorous bats. *Biological Conservation* **133**: 236-49.

22. **Lemckert F**, **Brassil T**, **Kavanagh R** and **Law B**. 2006. Trapping small mammals for research and management: How many die and why? *Australian Mammalogy* **28**: 201-07.

23. **Lemckert F**, Mahony M, **Brassil T** and Slatyer C. 2006. The biology of the threatened Green-thighed Frog *Litoria brevipalmata* (Anura: Hylidae) in the central and mid-north coastal areas of New South Wales. *Australian Zoologist* **33**: 337-344.

24. Li X, Li F, Rengel Z, Zhan Z and **Bhupinderpal-Singh**. 2007. Soil physical properties and their relations to organic carbon pools as affected by land use in an alpine pastureland. *Geoderma* **139**: 98–105.

25. Li X, Li F, **Bhupinderpal-Singh**, Rengel Z and Zhan Z. 2007. Soil management changes organic carbon pools in alpine pastureland soils. *Soil and Tillage Research* **93**: 186-196.

26. Li X, Rengel Z, Mapfumo E and **Bhupinderpal-Singh**. 2007. Increase in pH stimulates mineralization of 'native' organic carbon and nitrogen in naturally salt-affected sandy soils. *Plant and Soil* **290**: 269-282.

27. McNabb EG, **Kavanagh RP** and Craig SA. 2007. Further observations on the breeding biology of the Powerful Owl *Ninox strenua* in south-eastern Australia. *Corella*, **3** (1), 6-9.

28. **Penman T**, **Lemckert F**, Slade C and Mahony M. 2007. Description of breeding sites of the giant burrowing frog *Heleioporus australiacus* in south-eastern NSW. *Herpetolofauna* **36**: 102-105.

29. Radford SL, McKee J, Goldingay RL and **Kavanagh RP**. 2006. The protocols for Koala research using radio-collars: a review based on its application in a tall coastal forest in New South Wales and the implications for future research projects. *Australian Mammalogy* **28**, 187-200.

30. Richards GP, Borough C, Evans D, Reddin A, **Ximenes FA** and **Gardner WD**. 2007. Developing a carbon stocks and flows model for Australian wood products. *Australian Forestry* **70(2)**: 108-119.

31. Semeniuk M, **Lemckert FL** and Shine R. 2007. Breeding-site selection by cane toads (*Bufo marinus*) and native frogs in northern New South Wales, Australia. *Wildlife Research* **34**: 59-66.

32. **Bhupinderpal-Singh** and Rengel Z. 2007. Nutrient cycling in terrestrial ecosystems. In Marschner P, Rengel Z (Eds) *The Role of Crop Residues in Improving Soil Fertility* '. No **10** in Soil Biology series. Springer-Verlag, Berlin, 183–214.

33. Sims NC, **Stone C**, Coops NC and Ryan PJ. 2007. Assessing the health of *Pinus radiata* plantations using remote sensing data and decision tree analysis. *New Zealand Journal of Forest Science* **37(1)**: 57-80.

34. Slatyer C, Rosauer D and **Lemckert F**. 2007. An assessment of endemism and species richness patterns in the Australian Anura. *Journal of Biogeography* **34**: 583-596.

35. **Stone C** and Simpson JA. 2006. Comparison of leaf, tree and soil properties among mature *Eucalyptus saligna* in a moist sclerophyll forest exhibiting canopy decline. *Cunninghamia* **9**: 507-520.

36. Summerell BA, Groenewald JZ, **Carnegie A,** Summerbell RC and Crous PW. 2006. *Eucalyptus* microfungi known from culture. 2. *Alysidiella*, *Fusculina* and *Phlogicylindrium* genera nova, with notes on some other poorly known taxa. *Fungal Diversity* **23**: 323-350.

37. **Webb AA**, **Jarrett BW** and **Turner LM**. 2007. Effects of plantation forest harvesting on water quality and quantity: Canobolas State Forest, NSW. In:

Wilson AL, Deehan RL, Watts RJ, Page KJ, Bowmer KH and Curtis A (Eds), *Proceedings of the 5th Australian Stream Management Conference. Australian rivers: making a difference*. Charles Sturt University, Thurgoona, NSW, 443-448.

38. **Ximenes FA** and Evans PD. 2006. "Protection of wood using oxy-aluminium compounds. *Forest Products Journal* **56(11/12)**: 116-122.
39. **Ximenes FA**, **Gardner WD** and Richards G. 2006. "Total above-ground biomass and biomass in commercial logs following the harvest of spotted gum (*Corymbia maculata*) forests of SE NSW". *Australian Forestry* **69(3)**: 213-222.
40. **Ximenes FA** and **Gardner WD**. 2006. *The decay of coarse woody roots following harvest in a range of forest types*. National Carbon Accounting System Technical Report No.49. Australian Greenhouse Office.
41. **Ximenes FA**. 2006. "Wood products in NSW: energy budget and disposal options. *Proceedings of the 5th Australian Conference on Life Cycle Assessment*, November 2006, Australian Life Cycle Assessment Society, Melbourne.
42. Yan H, **Bi H**, **Eldridge R**, Li R, Wu Z, Li Y and Simpson J. 2006. Assessing climatic suitability of *Pinus radiata* for summer rainfall environment of southwest China for ecological plantings. *Forest Ecology and Management* **234**:199-208.
43. Zhou XD, Burgess TI, de Beer ZW, Lieutier F, Yart A, Klepzig K, **Carnegie AJ**, Portales JM, Wingfield BD and Wingfield MJ. 2007. High intercontinental migration rates and population admixture in the sapstain fungus *Ophiostoma ips*. *Molecular Ecology* **16**: 89-99.

Other reports

1. **Horwood MA**. 2006. A service trial of the effect of mechanical and chemical variations to the Preschem Bioguard Bandage on efficacy and environmental performance. Year Six Report. Report prepared for Preschem Pty Ltd, August 2006.
2. **Horwood MA**. 2006. Termite and Power Pole Research (TAPPER) trial. Annual Report. Report prepared for the Energy Networks Association Power Poles and Crossarms Committee, March 2007.
3. **Kavanagh, R**. 2006. Study ensures protection for timber industry and Barking Owls. (Ed. by J. Finlay). *Science and Research Update*, NSW Department of Primary Industries website.
4. **Kavanagh, R**. 2006. Barking Owls at home on the range. *Bush Telegraph*, Autumn issue, p. 7.

5. Walsh PG, Haywood A and **Barton CVM**. 2007. Growth and carbon sequestration rates at age 10 of some Eucalypt species in the low to medium (450-700mm) rainfall areas of New South Wales, Australia. *Australian*
6. Webb A and **Kathuria A**. 2006. Discussion paper on the Yambulla power analysis and calculation of effect size for sediment-related monitoring programs. Report submitted to the Department of Environment and Conservation, 40pp, July 2006.
7. **Weinberg AZ**, **Kavanagh RP**, **Law BS** and **Penman TD**. 2007. Testing biodiversity toolkits – How well do they predict vertebrate species richness? Final report to NSW Environmental Trust. May 2007.
8. **Ximenes FA**, Robinson M and Wright B. 2006. *Forests, Wood and Australia's Carbon Balance*. Brochure prepared for the Forest and Wood Products Research and Development Corporation. http://www.fwprdc.org.au/menu.asp?id=36&lstReports=18

Conference presentations

1. Barry KM, **Stone C** and Mohammed CL. 2006. " Towards assessing stress in eucalypt plantations: Use of a single-crown system to test the effect of whole-tree attributes and background surface on spectral reflectance in eucalypts." Presented by K Barry at the 13th Australasian Conference of Remote Sensing, Canberra, November 2006.
2. **Barton CVM** and **Morgan H**. 2006. "Tree water use of a young plantation targeted at salinity control." 6th International Workshop on Measuring Xylem Sap Flow and its Application to Plant Sciences, Perth, November 2006.
3. **Barton CVM**. 2007. "Tree water use and growth in the 500-700 mm rainfall zone of NSW." CRC for Plant-based management of Dryland Salinity, Workshop on perennial vegetation, Wagga Wagga, March 2007.
4. Barry KM, Ridge S, **Stone C** and Mohammed CL. 2006. "Characterising biochemistry and structure of leaves from stressed eucalypts with reflectance spectra." Presented by K Barry at the 13th Australasian Conference of Remote Sensing, Canberra, November 2006.
5. **Cowie AL**. 2006. "A growth opportunity for energy and the environment." Oral presentation at . Bioenergy Australia Conference: Bioenergy for Reducing Greenhouse Gas Emissions , Fremantle, 5-8th December 2006.
6. **Cowie AL**. 2007. "Market-based instruments for GHG mitigation in Australia. Task 38 Workshop. Oral presentation at Policies and Instruments to Promote Bioenergy and Bioproducts for GHG Mitigation. 15th European Biomass Conference, Berlin, 7-11th May 2007. (Oral presentation)
7. **Cowie AL**. 2007. Soil carbon in agriculture, pastoral and forestry systems. Oral presentation at NSW Climate Change Impacts and Adaptation Research Summit, Sydney, 23rd February 2007.

8. **Horwood MA**. 2006. "Understanding and identifying termites". Country Energy Asset Inspection Conference, Orange, NSW, 7-9th November 2006.
9. **Horwood MA**, Westlake T and Pulham L. 2007. "Which termite treatments have proven effective?" Network Technology Forum, Meadowbank, Sydney, 14-15th June 2007.
10. **Kavanagh R**. 2007. "Why are Barking Owls so uncommon in Southern Australia?" Birds Australia Southern NSW and ACT Group Annual Seminars, Sydney Olympic Park, March 2007.
11. **Law B**, **Kavanagh R** and **Lemckert F**. 2006. "Eucalypt plantations established on farmland in NSW: use by wildlife." Presented at workshop on Plantations – Are they equivalent to native forests? Ecological Society of Australia, University of Western Sydney, Parramatta. December, 2006.
12. **Morgan H** and **Barton CVM**. 2006. "Patterns of tree and forest transpiration responses to rainfall in a *Eucalyptus sideroxylon* plantation." 6th International Workshop on Measuring Xylem Sap Flow and its Application to Plant Sciences, Perth, November 2006.
13. **Penman TD**. 2007. "Ecological issues for prescribed burning in NSW forests." Prescribed burning training course, Forests NSW. TAFE accreditation PIAFIR406A, PUAFIR407A.
14. **Penman TD**, Binns D and **Kavanagh RP**. 2006. "Effects of forest management practices on the understorey composition in the dry forests of south-eastern Australia." Oral presentation at Fire Ecology and Management Conference, San Diego, USA.
15. **Penman T**, Binns D and **Kavanagh R**. 2007. "Influence of fire on the understorey vegetation communities in south-eastern Australia." Oral presentation at Bushfire CRC, Program B conference, Melbourne.
16. **Penman T**, **Kavanagh R**, Binns D and Melick D. 2006. "Patchiness of prescribed burning in dry sclerophyll forests." Poster presentation at Bushfire CRC annual conference, Wollongong.
17. Rancic A, Acworth RI, **Kathuria A**, Salas G and Johnston B. 2006. "Effect of rainfall on groundwater trends over the past century in fractured rocks of the New England Fold Belt in the Namoi Catchment, NSW." 10th Murray-Darling Basin Groundwater Workshop, Canberra, 18-20th September, 2006.
18. Scherl T, **Penman T** and Poulton B. 2007. " Fire management in a heating world: Potential issues and actions for commercial forest areas." Oral presentation at Nature Conservation Council Conference – Bushfire in a Heating World. Sydney.
19. **Bhupinderpal-Singh**, Allen DE, Mendham DS, Wang W, **Cowie AL**, Baldock J, Dalal RC and Raison J. 2007. "Understanding the drivers of N_2O and CH_4 fluxes during the transition from pasture to plantation forests." Non-CO_2 greenhouse gas fluxes in Australian and New Zealand Landscapes' Research Forum, Melbourne, 15-16th May 2007.

20. **Bhupinderpal-Singh** and **Cowie AL**. 2007. "Quantifying char-C turnover in soil, and implications for greenhouse balance." Poster presentation at International Agrichar Initiative Conference, Terrigal, 30th April-2nd May 2007.
21. **Stone C**, **Turner R** and Haywood A. 2007. " Landscape assessment of native forest health – A case study in the Jilliby catchment, central coast NSW." Poster presentation at Institute of Foresters Australia Conference, Coffs Harbour, June 2007.
22. **Webb AA**. 2006. "Effects of sustainable plantation forestry practices on water quality and quantity. International Geographical Union Conference, Queensland University of Technology, Brisbane, 3rd-7th July 2006.
23. **Webb AA**, **Jarrett BW** and **Turner LM**. 2007. Effects of plantation forest harvesting on water quality and quantity: Canobolas State forest, NSW." 5th Australian Stream Management Conference, Albury, 21st-25th May 2007.
24. **Ximenes FA**. 2007. "Carbon, forests and wood products." Australian Timber Design Workshops, Brisbane, Sydney and Perth, June 2007.
25. **Ximenes FA**. 2007. "Forestry in Australia and climate change." National Association of Forest Industries (NAFI) Conference: The future of trees, Canberra, March 2007.
26. **Ximenes FA**. 2007. "From the log dump to the rubbish dump: Forestry's Carbon Balance in Australia." Forest Resources Research Seminar Series, West Pennant Hills, Sydney, May 2007.
27. **Ximenes FA**. 2007. "The greenhouse footprint of wood products in Australia." Australian Plantation Products and Paper Industry Council (A3P) Forum: What's our environment in the year 2030?, Brisbane, June 2007.
28. **Ximenes FA**. 2006. "Wood products in NSW: energy budget and disposal options." 5th Australian Conference on Life Cycle Assessment, Melbourne, November 2006.

Staff List and Location (30 June 2007)

DPI Forest Science Centre

121 - 131 Oratava Avenue, West Pennant Hills, NSW 2125

PO Box 100, Beecroft, NSW 2119

Telephone 02 9872 0111

Facsimile 02 9871 6941

Anuj	Mr	Narendra	Librarian	9872 0110
Bacon	Ms	Kerrie	Technical Officer, Forest Health Management	9872 0167
Barton	Dr	Craig	Research Scientist, New Forests	9872 0199
Bawa	Dr	Satvinder	Technical Officer, New Forests	9872 0103
Bi	Dr	Huiquan	Principal Research Scientist, New Forests	9872 0168
Brassil	Ms	Traecey	Technical Officer, Forest Biodiversity	9872 0194
Brooks	Mr	Paul	Technical Officer, New Forests	9872 0181
Carnegie	Dr	Angus	Senior Research Scientist, Forest Health	9872 0131
Carney	Ms	Catherine	Technical Officer, Scientific Services	9872 0196
Chaffey	Mr	Darryl	Technical Officer, Forest Health Management	
Chidel	Mr	Mark	Technical Officer, Forest Biodiversity	9872 0169
Cowie	**Dr**	**Annette**	**Program Leader, Senior Research Scientist, New Forests**	**9872 0138**
Eldridge	**Mr**	**Robert**	**Research Leader/Centre Director**	**9872 0126**

Giles	Mr	David	Technical Officer, New Forests	9872 0141
Horwood	Mr	Martin	Research Officer, Forest Health Management	9872 0149
Johnson	Mr	Ian	Research Officer, New Forests	9872 0161
Kathuria	Dr	Amrit	Biometrician, Scientific Services	9872 0146
Kavanagh	**Dr**	**Rod**	**Program Leader, Principal Research Scientist, Forest Biodiversity**	**9872 0160**
Kelly	Dr	Georgina	Research Officer, New Forests	9872 0151
Kent	Dr	Debbie	Project Officer, Forest Health Management	9872 0133
Law	Dr	Brad	Senior Research Scientist, Forest Biodiversity	9872 0162
Lemckert	Mr	Frank	Senior Research Scientist, Forest Biodiversity	9872 0159
Morgan	Dr	Huw	Research Officer, New Forests	9872 0154
Parekh	Ms	Jagrutee	Technical Officer, New Forests	9872 0140
Paskin	Ms	Marilyne	Clerical Officer/Receptionist	9872 0111
Penman	Dr	Trent	Research Officer, Forest Biodiversity	9872 0157
Price	Mr	Grahame	Technical Officer, Forest Health Management	
Sargan	Ms	Yen	Management Information Officer	
Seslija	Ms	Jovanka	Library Technician	9872 0109
Singh	Dr	Bhupinderpal	Research Scientist, New Forests	9872 0148
Stanton	Mr	Matthew	Technical Officer, Forest Biodiversity	9872 0182

Stone	**Dr**	**Christine**	**Program Leader, Principal Research Scientist, Forest Health Management**	**9872 0132**
Tornquist	Mr	Steve	Technical Officer, Scientific Services	9872 0158
Towerton	Ms	Alison	Technical Officer, Scientific Services	9872 0166
Weinberg	Mr	Anthony	Project Officer, Forest Biodiversity	
Wood	Mr	Sam	Technical Officer, New Forests	
Ximenes	Mr	Fabiano	Research Officer, New Forests	9872 0143

Southern Research

13B Bass Street, Eden, NSW 2551

PO Box 273, Eden, NSW 2551

Telephone 02 6496 1500

Facsimile 02 6496 3258

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

Orange Agricultural Institute

Forest Road, Orange, NSW 2800

Telephone 02 6391 3800

Facsimile 02 6391 3899

Wilson	Mr	Brett	Technical Officer, New Forests	6391 3974

List of Shortened Forms used in the Report

ACARP	Australian Coal Association Research Program
ACIAR	Australian Centre for International Agricultural Research
BACI	Ben-Ari Concurrent Interpreter, computer program that simulates the operation of concurrent processing
BMAD	bell miner associated dieback
C	Carbon
CH_4	methane
CMA	catchment management authorities
CO_2	carbon dioxide
CO_2e	carbon dioxide equivalent
CRC	Cooperative Research Centre
DBH	diameter at breast height
DECC	Department of Environment and Climate Change
DMSI	digital multi spectral imagery
DPI	NSW Department of Primary Industries
Ensis	CSIRO's partnership with New Zealand's forest research organisation, Scion
FHSU	Forest Health Survey Unit
FCNI	Forestry Commission of NSW Insect Collection
FNSW	Forestry NSW
FRR	Forest Resources Research
GARA	Greenhouse Action in Regional Australia
GGAS	NSW Greenhouse Gas Abatement Scheme
GHG	greenhouse gas
GIS	geographic information system
LIDAR	light detecting and ranging
MWC	municipal waste compost
NAP	National Action Plan for Salinity and Water Quality
NHT	National Heritage Trust
N_2O	nitrous oxide

NLBAR	Nitrogen Limiting Biosolids Application Rate
NPK	nitrogen, phosphorus and potassium (fertilizer)
NSCC	National Sirex Coordination Committee
ROs	recycled organics
SE	standard error
TAPPER	Termite and Power Pole Evaluation Research Project
QDNR&W	Queensland Department of Natural Resources and Water

Forest Science Centre

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

Telephone **02 9872 0111** Facsimile 02 9871 6941

www.forest.nsw.gov.au