

## WESTERN AUSTRALIA

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### **Plantations**

#### ***Pinus radiata***

##### **Insect pests**

##### ***Sirex* spp.**

The Forest Products Commission (FPC) in Western Australia conducts an annual monitoring programme throughout its estate. Monitoring in WA is now done using static (panel) traps, which are effective in detecting very low numbers of *Sirex*. The traps are erected in pairs in open areas of plantations that would likely be used as flight paths for the wasp. Last year they were deployed in plantations from Perth to Esperance, as well as Albany town site and a Bunbury sawmill. It is planned to further increase the coverage of the traps outside of plantations to cover 'points of entry' such as borders, sea ports, airports, container depots and along transport corridors.

No *Sirex* wood wasps (*Sirex noctillio*) were detected in any of the traps in the 2009/10 flight season.

##### **Bark Beetles**

Bark beetle distribution and abundance were monitored in conjunction with the *Sirex* trapping programme; numbers were low and not causing problems.

##### **Five-spined Bark Beetle (*Ips grandicollis*)**

*Ips* were found in all plantation areas over the length of the trapping season. No *Ips* were detected in the Albany town site traps. Numbers were highest in the west coastal plantations of Gnangara, McLarty and Myalup as well as the pine mill near Bunbury. Numbers peaked in February for McLarty, Myalup and the pine mill and in March for Gnangara.

No significant reports outside of the trapping areas were received in 2009-10.

##### **Golden Haired Bark Beetle (*Hylurgus ligniperda*)**

*Hylurgus* distribution and abundance around the Bunbury area was monitored in conjunction with the *Sirex* trapping programme, but numbers were low and not causing problems.

##### **Monterey Pine Aphid (*Essigella californica*)**

Although *Essigella* is present it is still not regarded as a problem in WA. Ian Dumbrell (FPC) is the WA representative on the *Essigella* biocontrol project steering committee. (I. Dumbrell, FPC). WA will receive its first release of the control agent *Diaeretus essigellae* in spring 2010.

##### ***Pinus Pinaster***

##### **European House Borer (*Hylotrupes bajulus*)**

Management of this pest is ongoing and eradication is still the objective.

##### **Wingless Grasshopper (*Phaulacridium* sp.)**

No unusual activity

### **Rutherglen Bug (*Nysius vinitor*)**

Rutherglen bug is usually a problem in plantations from October to late December, but an unusually late infestation occurred in the Esperance region in February 2010. Infestations were misted in conjunction with wingless grasshopper control.

### **'Spring' beetle (*Liparetrus jenkinsi*)**

Unusal spring beetle activity was noted in mid-winter on a property north of Badgingarra (approx. 250km north of Perth).

## **Pathogens**

No major problems reported.

### ***Eucalyptus globulus***

#### **The Industry Pest Management Group (IPMG)**

Pest and pathogen research has historically been undertaken through the Industry Pest Management Group (IPMG), a collaborative body of industry companies, state government forestry agencies and institutional partners. Current members of the IPMG are; Albany Plantations Forestry Limited (APFL), Elders Forestry (EF), WA Plantation Resources (WAPRES), Forest Product Commission (FPC), Forestry SA, Murdoch University and the CRC for Forestry.

The IPMG restructured over the 2009-10 period and has appointed Francisco Tovar as its new research scientist. Relevant projects that are currently being developed by the IPMG include;

1. Publication of a field guide to aid foresters and contractors to accurately identify common pests and pathogens in the field
2. Development of mobile device software to allow foresters and contractors to report plantation pest and diseases in an accurate and timely manner
3. Development of a web-based database of records of pest and pathogen outbreaks irrespective of plantation ownership. Data will be compiled at a regional level, individual company level and at a plantation level (F. Tovar, IPMG).

In 2009-10 about 25 000 ha of the WA bluegum plantation estate was inspected frequently, comprising mostly 1- 3 year old plantations. Approximately 8 000 ha were found to have significant problems due to biotic and abiotic problems, with 200 ha having to be replanted and 1100 ha being treated or managed in some way (Table 1). The remainder were left untreated. Summaries of specific pest and disease activity are given below (F. Tovar IPMG).

## **Insect pests**

### **Weevil (*Catasarcus* sp.)**

Extensive low levels of damage (160 ha) were caused by a species of *Catasarcus* at a 1-year-old plantation in Esperance. Historically *Catasarcus* spp. have been the main weevil species causing moderate damage to the lower canopies of mid-rotation plantations in the Esperance Region.

### ***Eucalyptus* weevil (*Gonipterus scutellatus*)**

The distribution range of *G. scutellatus* has now expanded to encompass all south west WA growing areas, with the exception of Esperance. Traditionally damage has been significant in areas east of and around Albany, though this year little damage was reported. In south-western interior areas, usually unaffected, moderate damage was reported with 50 ha moderately damaged (30-50% defoliation) in Manjimup and Bridgetown. The reasons for this apparent increase in damage are unclear.

### **Lesser shoot weevil (*Myllorhinus dentiferus*)**

*M. dentiferus* is thought to be responsible for damage to growing shoots of 3-7 year-old second rotation plantations in the Boyup Brook area. Repeated damage over a number of seasons has resulted in reduced growth, highly branched trees, and poor apical dominance. There seems to be an interaction between recent reduced rainfall, weevil damage and subsequent growth of what were previously productive plantations. The extent of this emerging problem is currently being investigated.

#### **Eucalypt leaf beetles (Chrysomelidae)**

*Paropsisterna m-fuscum* was found in several plantations east of Albany in the spring of 2007-08. It had never been recorded in WA, and its identity was confirmed by Chris Reid of Australian Museum in Sydney. Current observations suggest that the species range is expanding, having been reported west of Albany, to Denmark and in south-western interior areas such as Manjimup, Bridgetown and Donnybrook. In these areas the species is found on seedlings and juvenile trees in most 1-3 year-old plantations; though at this stage damage seems minimal. In a 30 ha plantation in Bridgetown, moderate damage was caused by an unidentified chrysomelid species.

#### ***Heteronyx* spp.**

Damage by larvae and adults of *H. elongatus* caused severe damage to a P2009 plantation near Esperance with 60 ha needing to be replanted. Other species of *Heteronyx* (commonly *H. proxima*) have caused repeated damage to the tops of trees in young to mid rotation plantations from January to March. Plantations affected are east of Albany from Cheyne Beach to Wellstead and Esperance. Interior zones such as Boyup Brook and Rocky Gully are also affected. In the last season it is estimated that around 5000 ha were moderately to severely affected. Prediction of outbreaks and subsequent control is hampered by the randomness of the timing and distribution of attacks from year to year.

#### **Spring Beetle (*Liparetrus jenkinsi*)**

Less damage than in previous year was reported for this species. In total 120 ha were damaged in Rocky Gully, Manjimup and Bridgetown. Around 65 ha had to be replanted.

#### **Wingless Grasshopper**

Wingless grasshoppers caused severe damage to a number P2009 and P2008 plantations east of Albany, Rocky Gully and Mount Barker. Approximately 180 ha required replanting. In Esperance 510 ha of P2009 were moderately affected and were aerially sprayed.

#### **Vertebrate pests**

##### **Parrots**

Lake Muir Corellas, an endangered and protected *Corella* subspecies, have been reported to cause localised damage in areas east of Manjimup and around Rocky Gully. They generally pull up seedlings as they search for food resulting in deaths. Port Lincoln parrots (locally called Twenty Eights) are the most destructive and commonly reported species affecting WA bluegum plantations. They peel the bark off young trees and/or snap the tops, resulting in poor form or death. Affected areas this season were west of Albany to Denmark, Rocky gully and around Collie. Around 40 ha required replanting.

##### **Rabbits**

Browsing damage to seedlings by rabbits was reported at Manjimup, Boyup Brook, Mount Barker and east of Albany. Approximately 60 ha were affected with 35 ha having to be replanted.

**Table 1.** Area of *E. globulus* plantation estate monitored and area affected by pests and pathogens in Western Australia in 2009-10\*.

PESTS	Area with moderate damage (ha)				Area with severe damage (ha)				Area inspected (ha) †	Area treated (ha) ‡	Host
	<10	10-100	100-500	500-1000	>1000	<10	10-100	100-500			
<i>Catasarcus</i> sp.		X									<i>E. globulus</i>
Eucalypt weevil ( <i>Gonipterus Scutellatus</i> )		X									<i>E. globulus</i>
Lesser shoot weevil ( <i>Myllorhinus dentiferus</i> )				X							<i>E. globulus</i>
White fringed weevil ( <i>Naupactus leucoloma</i> )					X						<i>E. maculata</i>
Weevils (defoliating)											<i>E. globulus</i>
<i>Heteronyx</i> (establishment)		X				X					<i>E. globulus</i>
<i>Heteronyx</i> (post-establishment)									X		<i>E. globulus</i>
Chysomelid beetles		X									<i>E. globulus</i>
'Spring' beetles ( <i>Liparetrus</i> spp.)		X							X		<i>E. globulus</i>
Wingless grasshopper								X			<i>E. globulus</i>
Parrots									X		<i>E. globulus</i> , <i>E. Saligna</i>
Rabbits		X						X			<i>E. globulus</i>
<b>PATHOGEN</b>											
<i>Teratosphaeria</i> spp.								X			<i>E. globulus</i>
									<b>TOTAL</b>	15,000	1,300

\* Data contained in the above table is of a general nature and reflects the lack of a formal pest and pathogen data collection process to date. Not all companies undertook monitoring in 2009-10.

† Area inspected was roughly calculated from the known area of plantings from 2007- 2009 (1-3 years old), as plantations in this age group are known to be frequently inspected. Additionally older plantations that were reported as having damage were also counted. Again this is an underestimation

‡ Area Treated was taken to mean that some control or management action had taken place, including replanting

(F. Tovar IPMG)

## **Pathogens**

### ***Teratosphaeria* spp. (formerly *Mycosphaerella*)**

*Teratosphaeria* spp. caused moderate damage to about 500 ha of plantation in the Denbarker and Mount Barker areas as well as a single plantation east of Albany.

## **Abiotic problems**

### **Drought**

Drought stressed plantations were reported in Collie and Boddington, areas east of Albany and Esperance. Approximately 30 ha of seedlings failed due directly to drought, though some other areas thought to have succumbed to pests may have been predisposed due to drought stress.

### **Nutrient Deficiencies**

Nutrient deficiencies were reported for both first rotation plantings and second rotation. Copper (Cu) deficiency was the most commonly diagnosed, especially in first rotation plantings, with approximately 450 ha reported as needing treatment.

### **Other *Eucalyptus* spp. (*E. cadocalyx*, *E. maculate* & *E. saligna*)**

#### Insect pests

### **Leaf blister sawfly (*Phylacteophaga froggatti*)**

Leaf blister sawfly has been noted on stress exposed *E saligna* (G. Hodgson, FPC).

### **White fringed weevil (*Naupactus leucoloma*)**

A small experimental planting of *Eucalyptus maculata* (2 ha) was severely attacked, resulting in death of 90% of trees (F. Tovar IPMG).

### **'Spring' beetle (*Liparetrus jenkinsi*)**

Spring beetle features as a significant problem in establishment of *E saligna*, *E cladocalyx*, and *E maculata* plantations. Attacks predominate in late September/October. 2009 spring season was not an unusual season apart from one swarming approx 50km northeast of Dumbleyung (inland wheatbelt). This insect has not been reported this far from a forested area before.

### **Autumn Gum Moth (*Mnesampela privita*)**

An outbreak of *M. privita* was reported on York Gum (*E. loxophleba*) in the northern inland area of the Esperance region. This was a first time experience of *M. privita* in the area and as such staff were not prepared for it.

### **Termites**

In the Esperance region live eucalypt mallee species in plantations (young trees) have been attacked by termites (species unknown).

### **Sandalwood (*Santalum spicatum*) plantations**

No major insect or fungal problems reported.

## Managed natural forests

### Jarrah forest (*Eucalyptus marginata*)

#### Insect pests

#### **Jarrah leaf miner (*Perthida glyphopa*) (JLM)**

Surveys for jarrah leaf miner (JLM) in October & November 2009 showed that there was northwards spread of JLM outbreak into northern regions of Jarrah forest, but severe browning due to JLM was recorded in the Albany hinterland (A. Wills, DEC).

#### **Gum leaf skeletonizer (*Uraba lugens*)**

Two separate outbreaks of gumleaf skeletonizer (GLS, *Uraba lugens*), one SE and one NW of Manjimup occurred in 2009-10. Forty seven sites were inspected, with GLS identified at 12 and a further 4 showing symptoms of damage. In the NW outbreak, at 5 sites from two forest blocks, 5-40 % of trees were affected with some experiencing 80% defoliation. At 5 sites within the SE outbreak 5-70 % of trees were affected with some being 90% defoliated. Prior to 2009 and following the 1982-1992 outbreak populations of this defoliator were so low that its presence in the southern jarrah forest was rarely recorded. With the current increase in the GLS population the Department of Environment and Conservation intend to reactivate a former quantitative sampling program in summer 2010 such that comparisons with the previous outbreak can be made (J. Farr & A. Wills, DEC).



*U. lugens* at Warren NP (left) and Canopy chewing by GLS at Yanmah forest block February 2010 (right).

## Pathogens

No new major disease problems were reported. Management and survey of *Phytophthora* root disease in jarrah forests continues to command attention (see Forest Health Surveillance and Diagnosis, and Research and Development).

## **Karri forest (*Eucalyptus diversicolor*)**

### **Insect pests**

No major pest problems reported.

### **Pathogens**

No new major disease problems were reported. Management and survey of *Armillaria* root disease in karri forests continues to command attention.

### **Nurseries**

No major problems have been reported in either hardwood or conifer seedlings in nurseries.

## **Native plant communities**

### ***Phytophthora* in natural ecosystems**

For 30 years large-scale aerial photography has been used to map the extent of *Phytophthora* dieback disease in native forests in the south-west of Western Australia, with validation of the observations involving routine testing of soil and root samples for the presence of *Phytophthora cinnamomi*. In addition to *P. cinnamomi*, six morpho-species have been identified using this technique: *P. citricola*, *P. megasperma*, *P. cryptogea*, *P. drechsleri*, *P. nicotianae* and *P. boehmeriae*. In recent years many new *Phytophthora* species have been described world-wide, often with similar morphology to existing species, thus, as many of the isolates collected in Western Australia have been difficult to identify based on morphology, molecular identification of some of the morpho-species is required. Based on amplification of the internal transcribed spacer (ITS) region of the rDNA gene sequence data of over 230 isolates were compared to that of existing species and undescribed taxa. *P. inundata*, *P. asparagi* P. taxon PgChlamydo, *P. taxon personii*, and *P. taxon niederhauserii* were identified based on sequence data. Phylogenetic analysis revealed that nine potentially new and undescribed taxa can be distinguished. Several of the new taxa are morphologically indistinguishable from species such as *P. citricola*, *P. drechsleri*, *P. megasperma*.. In some cases, the new taxa are closely related to species with similar morphology (e.g. P.sp. 4 and *P. citricola*). However, the DNA sequences of other new taxa such as P.sp. 3 and P.sp. 9 show that they are not closely related to morphologically similar species, *P. drechsleri* and *P. megasperma*, respectively. Most of the new taxa have been associated with dying *Banksia* spp. while P.sp. 2 and P.sp. 4 have also been isolated from dying *Eucalyptus marginata* (jarrah). Some taxa (P.spp. 3, 6 and 7) appear to have limited distribution, while others like P.sp.4 are widespread (T. Burgess, G. Hardy, D. White, Murdoch University; J. Webster, J. Ciampini, M. Stukely, DEC).

A new *Phytophthora* species (previously known as P. sp.4), isolated from rhizosphere soil of declining or dead trees of *Eucalyptus gomphocephala*, *E. marginata*, *Agonis flexuosa*, and another 13 plant species, and from fine roots of *E. marginata* and collar lesions of *Banksia attenuata* in Western Australia, is described as *Phytophthora multivora* sp. nov. It is homothallic and produces semipapillate sporangia, smooth-

walled oogonia containing thick-walled oospores, and paragynous antheridia. Although morphologically similar to *P. citricola*, phylogenetic analyses of the ITS and *coxI* gene regions demonstrate that *P. multivora* is unique. *Phytophthora multivora* is pathogenic to bark and cambium of *E. gomphocephala* and *E. marginata* and is believed to be involved in the decline syndrome of both eucalypt species within the tuart woodland in south-west Western Australia. (P. Scott, T. Burgess, P. Barber, G. Hardy, T. Jung, Murdoch University; B. Shearer, M. Stukely, DEC).

#### **ARC Linkage Project. Susceptibility to *Phytophthora cinnamomi* and sensitivity to phosphate in native Australian plants: why are they linked?**

Currently, phosphite is the most effective and economically viable treatment available to prevent the spread of *P. cinnamomi*. Phosphite is applied to infested areas in state forests, national parks and urban bushland. The use of phosphite, whilst being of great benefit to control the spread of *P. cinnamomi*, may inadvertently be driving ecological change by disrupting the natural process of phosphorus (P)-sensing in Australian native plants. Phosphite disrupts normal root responses to plant P status. However, phosphite is microbially oxidised to phosphate, the plant-available form of P. Long-term use of phosphite to control *P. cinnamomi* therefore has a fertilisation effect by increasing the total phosphate status of extremely low-P ecosystems in which it is used. Fertilisation of environments that are naturally extremely low in P may have undesirable effects, as it will promote invasion by weeds and plant species that perform better under conditions where P is more readily available. It may also negatively impact on P-sensitive species. It is therefore imperative that we understand how phosphite reduces plant susceptibility to *P. cinnamomi*, so that we can search for a non-P-containing chemical alternative for the management of this pathogen. It is essential that we understand the genetics of *P. cinnamomi* resistance in order to develop new tools for dealing with this pathogen. (Research Fellows: O. Berkowitz, Murdoch University; S. Pearse, Xuanli Ma, R. Jost, University of WA; PhD student Daniel Kollehn, MU; Chief Investigators H. Lambers, P. Finnegan, Yan, UWA; G. Hardy, P O'Brien, MU).

#### **DEC Phytophthora Research Project**

A research project, funded through a State Government Specific Nature Conservation Project, to study the epidemiology and control of *P. cinnamomi* on the south coast of WA was initiated in late 2006. The project is investigating the seasonal disease dynamics of *P. cinnamomi* including the mechanisms to disease centre extension and survival. In addition the project is also investigating the effect of phosphite basal stem application on the epidemiology of *P. cinnamomi* to test whether it will prevent disease centre expansion. The initial results from high intensity phosphite application (HIPA) (ie basal stem application) field trials using 30% active ingredient seems has been promising. After three years of monitoring at the Gull Rock, Stirling Ranges and Fitzgerald River National Parks, HIPA has significantly reduced mortality in target species and reduces inoculum levels of the pathogen within soil. Only a minor (and not significant) reduction of disease centre expansion was recorded. Only minor, and mostly temporary, phytotoxicity was observed. The treatment appears to be most effective along disease fronts in south coast plant communities with deep sands where the main transmission is root-to-root contact. A large scale (3 km) HIPA treatment has been conducted at the Bell Track infestation within the Fitzgerald River National Park as a component of a containment strategy. Two years of monitoring using Plant



Cell Density measurements captured using Digital Multi-Spectral Imagery has shown promising results. Further, field investigations using the HIPA technique is planned for the Jarrah forest in early 2011 (C. Dunne, DEC).

### **State NRM Phytophthora Containment and Eradication Research**

In late 2009 a State NRM grant was received to undertake a number of Phytophthora dieback management initiatives. Included in this project are attempts at management scale containment and eradication of *Phytophthora cinnamomi* infestations within the Fitzgerald River and Cape Arid National Parks. Substantial project planning, hydrological modeling, pathogen occurrence mapping and development of eradication techniques have been completed. The integrated management approach plans to trial a number of new and novel techniques including: run-off diversion and treatment; use of silt membranes to prevent zoospore and inoculum movement down the catchment; host removal; soil sealants; fungicide treatment; and possible fumigation. Significant logistic and project management issues will need to be overcome if the eradication attempt is to be successful (C. Dunne, R. Hartley, P. Scott, DEC; B. Dunstan, T. Paap, N. Williams, G. Hardy, Murdoch University).

### **Canker pathogens as endophytes in endangered species**

Isolates of *Botryosphaeria* complex, a putative *Microthia*, *Cryptodiaporthe* and *Cytospora* spp. have been isolated from cankers on *Banksia baxteri*, *B. coccinea*, *B. verticillata* and *Lambertia orbifolia* in the SW of WA. All except *Cytospora* spp. have also been isolated at a low level from healthy asymptomatic tissue suggesting that they have some degree of benign endophytic role and that the environment may moderate the host-pathogen relationship. The systemic fungicides fenarimol, prochloraz and tebuconazole are being investigated as control options in *B. verticillata* and *L. orbifolia* – initially *in vitro*, then *in vivo*, for the four main canker causing pathogens (C. Crane, S. Barrett, B. Shearer, C. Dunn, DEC)

## **Urban and rural**

### **Insect pests**

See section on wandoo decline (below).

### **Pathogens and Declines**

#### **Cypress canker**

Branch death and flagging caused by *Pestalotiopsis* sp. (closely related to Cypress canker, *Seiridium* sp.) has been affecting Sequoia (*Sequoiadendron giganteum*, planted 1984), Moroccan juniper (*Juniperus oxycedrus*, planted 1999) and cypress (*Cyprinus macrocarpa*) hedge trees in the Golden Valley Tree Park near Balingup in the SW of WA since 2005-06. Subsequent treatment with Mancozeb and Pentrabark in March 2007 and December 2009 has allowed the cypress hedge to recover and minimised spread of the canker and recovery of other trees (B. Hingston, DEC).



Moroccan juniper showing severely affected tree (*left*) and infected and dead branch tips (*right*).



Sequoia with single infection (*left*) and close up of infected broach tip (*right*)

### **Pathogens of Boabs**

Surveys for fungi associated with boab (*Adansonia gregorii*) are underway in both South Africa and Western Australia. In this study, seven new species of the Botryosphaeriaceae are described from baobab (*Adansonia gibbosa*) and surrounding endemic tree species growing in the Kimberley region of northwestern Australia. Members of the Botryosphaeriaceae were predominant endophytes isolated from apparently healthy sapwood and bark of endemic trees; others were isolated from dying branches. Phylogenetic analyses of ITS and EF1- $\alpha$  sequence data revealed seven new species: *Dothiorella longicollis*, *Fusicoccum ramosum* *Lasiodiplodia margaritacea*, *Neoscytalidium novaehollandiae*, *Pseudofusicoccum adansoniae*, *P. ardesiacum* and *P. kimberleyense*. The most commonly isolates species was *Lasiodiplodia theobromae*. A pathogenicity test has shown that this species is highly pathogenic to boabs (Monique Sakalidis, T. Burgess, G. Hardy, Murdoch University; M. Wingfield, Tree Pathology Cooperative Program (TPCP) South Africa).

### **Marri decline**

Decline of *Corymbia calophylla* (marri) in the south-west of Western Australia (WA) has been an increasing source of concern in recent years, due to a canker disease caused by *Quambalaria coyrecup*. More recently *Q. pitereka* has been implicated in leaf and shoot blight, which has been observed over the last five years to extend to flowering parts at all stages of development. This symptomology is not typical of *Quambalaria* shoot blight (QSB) in its origin of eastern Australia, and this study is the first investigation of the disease on flowering structures. Marri flowers are invaluable to the WA beekeeping industry and to native fauna, for which reason this study was

conducted to ascertain the extent, causes and possible impacts of the disease. Six surveys conducted over a 13 month period determined that QSB was widespread over the *C. calophylla* distribution range, causing deformities and early termination of flowering structures, and was associated with three different species of *Quambalaria*. DNA sequences of 23 isolates obtained in this study confirmed the presence of *Q. cyanescens* and *Q. pitereka* with the latter identified as the primary blight pathogen of both vegetative and reproductive tissues. A third and new species is described as *Q. pseudocyanescens* C. Marbus sp. nov. and is closely associated, along with *Q. cyanescens*, with a new symptom of 'horizontal' fruit growth which is considered a separate syndrome to the traditional form of QSB and is linked to reduced seed output. The precise nature of the interactions between the diseased fruit and the *Quambalaria* spp. found has not been confirmed, and further studies are required in this area to determine the role of insects and other fungal pathogens, which in turn will shed light on possible management strategies for these pathogens in WA's native forests. (C. Marbus, T. Paap, B. Dell, G. Hardy, Murdoch University).

### **Peppermint dieback**

*Agonis flexuosa*, commonly known as the Western Australian Peppermint, is a tree native to the south-west of Western Australia, and severe dieback symptoms have been recently observed in some areas. A species of fungus was believed to be the causal agent. For this project, fungi were collected, isolated, identified and tested for pathogenicity to determine the causal agent of the decline of *A. flexuosa* in natural ecosystems in Western Australia. Fungi were isolated from symptomatic and asymptomatic material collected from *A. flexuosa*, cultured, and then identified using molecular taxonomy, microscopy and vegetative compatibility trials. Pathogenicity trials using *A. flexuosa* seedlings were carried out to prove Koch's Postulate. All isolates caused lesions in the seedlings, and there is no significant difference between lesions caused by isolates from symptomatic and asymptomatic material. This suggests that the causal agent could be an endophytic fungus which has become a pathogen (N. Dakin, BioGENIUS student, T. Burgess, D. White, G. Hardy, Murdoch University)

### **Mundulla Yellows**

Monitoring the occurrence and symptom development of Mundulla Yellows (MY) in WA continues. Symptomatic eucalypts (both planted trees and remnant native trees) have been recorded and monitored in several additional locations. Spread of symptoms within affected sites appears generally to be slow, and diseased and apparently-healthy trees can grow alongside each other. The observed distribution of MY symptoms in the south of the state is from north of Geraldton to Esperance, and it occurs on alkaline coastal sands as well as on acid soils including laterites. As in South Australia, MY in WA is only seen in vegetation in disturbed sites or modified landscapes such as road verges and medians, parks and gardens, and in parkland or paddock remnant stands where symptomatic trees can be several hundred metres from, and sometimes upslope from, any road. Symptoms have not been observed within undisturbed native forest or woodland stands in WA. Collaboration is continuing in the investigation of the cause(s) of MY with D.Hanold and J.Randles from the University of Adelaide. (M.Stukely, DEC).

### **Tuart Decline**

In recent years, tuart (*Eucalyptus gomphocephala*) woodland within Yalgorup National Park, south of Mandurah has suffered a severe decline in health. Results of research carried out by the Tuart Health Research Group (THRG) include:

- Survey shows that the major decline syndrome is confined to the Yalgorup region
- A new species of *Phytophthora*, *P. multivora*, associated with declining trees has been described (Scott *et al.* 2009, *Persoonia* 22: 1-19)
- A very close correlation between foliar zinc levels and crown health has been observed and demonstrated
- Trees are still showing signs of an increase in crown health five years after treatment with zinc and phosphite
- There is a strong correlation between crown health and soil microbial function and diversity (Y. Cai, Murdoch University)
- Lack of fire may be contributing to the decline of tuart, however, it is not a major factor (R. Archibald, Murdoch University).
- Botryosphaeriaceous taxa have also been implicated in the decline of *E. gomphocephala* and the potential roles of a number of other endophytic taxa are being investigated (K. Taylor, P. Barber, G. Hardy, T. Burgess, Murdoch University)

A new project is looking at restoring sites where soils have lost their tuart seed banks (Katinka Ruthrof, Murdoch University; P. Barber, THRG, Murdoch University).

### **Wandoo Decline**

Crown decline of wandoo (*Eucalyptus wandoo*) in southwest Western Australia has escalated over the last 15 years, so that very few unaffected stands remain. This decline is widespread and a cause of significant concern. The Wandoo Recovery Group's (WRG) role is to support research to identify possible causes of crown decline and communicate knowledge and information about wandoo. Management of research on wandoo decline is presently being co-ordinated by the State Centre of Excellence for Climate Change; Woodland and Forest Health. Previously research and monitoring was co-ordinated by the University of WA and DEC. Results of research and monitoring to date include:

- *Cisseis fascigera*, wood boring insect (Coleoptera: Buprestidae), has been identified as a primary contributing factor in dieback and decline of Wandoo trees (R. Hooper, A. Wills, B. Shearer, K. Sivasithamparam 2010, *Australian Journal of Entomology* 49: 234-244).
- Wandoo and powderbark wandoo (*E. accedens*) appear to be better adapted to operate at greater tensions and can lose more water before they lose turgor than jarrah and marri. Moreover wandoo and powderbark can accumulate more osmotically active compounds, allowing greater tissue dehydration and better water uptake from dry and clayey soils. Their stems are much more resistant to high tensions. Although tensions in wandoo reach higher values than the other species, they don't cause greater loss of stem functionality (E. Veneklaas, UWA).
- Broad-scale survey and mapping over the last ten years identified temporal and spatial trends in wandoo health that indicate decline patterns are broad scale, variable and not continuous across the landscape. Although crown

decline still occurs across the range for wandoo (albeit at low levels) at some sites decline has stabilised and trees have started to recover (J. Mercer, WRG, K. Whitford, DEC).

## **Forest health surveillance and diagnosis**

### **Dieback mapping and management**

Mapping the presence of symptoms of the plant disease caused by *P. cinnamomi* was carried out by accredited interpreters to determine areas suitable for protection. Hygiene requirements were specified for activities likely to result in the movement of soil (and as a consequence, *P. cinnamomi*) on lands managed by DEC. A total area of 15864 ha was mapped to assist the planning of roading and timber harvesting operations undertaken by the FPC, while FPC also arranged significant areas of mapping by private contractors. This included 7,552 ha of previous mapping that was checked for further spread. Mapping and hygiene planning were undertaken on a further 1,707 ha for the Parks and Visitor Services, Nature Conservation Service and Sustainable Forest Management Service of DEC, and 3,319 ha for external parties. Training programs were carried out in disease mapping and hygiene management (G.Strelein, DEC).

In the year to 30<sup>th</sup> June 2010, a total of 1,581 samples were tested for the presence of *Phytophthora* by DEC's Vegetation Health Service (VHS). These samples were associated with verification of dieback mapping for the above projects, as well as external requests. DNA sequencing has been carried out at the Centre for *Phytophthora* Science and Management (CPSM), at Murdoch University, on various recent and historical isolates of unidentified *Phytophthora* in the DEC culture collection, from a range of WA locations and ecosystems. This had earlier led to the identification new records for WA of *P. inundata*, *P. asparagi* and *P. niederhauserii*. At least nine new and undescribed *Phytophthora* taxa occurring in native vegetation in WA have been distinguished, based on their ITS rDNA sequences. Most of the newly identified *Phytophthoras* have been associated with multiple species of dying native plants in natural vegetation communities. Several of them are difficult to distinguish, on morphological characters, from known species such as *P. citricola*, *P. drechsleri*, or *P. megasperma*. The formal description of the first of these new WA species, *Phytophthora multivora*, was published in 2009, and the descriptions of another seven species are in preparation. A PhD project commenced in April 2007 at Murdoch University to describe several of the new *Phytophthoras*, and to test their pathogenicity (A. Rea – see Research and Development). In addition, there is now strong new evidence of naturally-occurring *Phytophthora* hybrids in WA native ecosystems; these are being further investigated. While the pathogenicity of many of the new taxa is still to be fully investigated, the precautionary principle should be applied by managers to ensure that the spread of all *Phytophthoras* to new areas is minimised. Hygiene practices should be applied in the same way as for *P. cinnamomi*. (M.Stukely, DEC).

### **Forest health monitoring**

An automated annual monitoring program is being developed to identify changes in satellite reflectance information over time and correlate this with known or past causes of changes in forest health and vigour. This information is then used to classify the changes, with levels of confidence, to causal factors. Those with unknown or low

levels of confidence or changes in magnitude are then targeted for further investigation including field checks to confirm causes and recalibrate the annual data updates. The system includes spatial modeling algorithms to incorporate both known datasets (harvesting, fire, mining) and surrogate datasets (landform, soils, vegetation) that can be correlated with possible causes and inform the decisions on causes that as yet have no spatial history to guide classification (G. Strelein, DEC).

## Research and Development

### General

#### **Western Australian State Centre of Excellence for Climate Change, Woodland and Forest Health.**

This new Centre was approved for funding in late 2008 is made up of four programs: Climate Change, Woodland and Forest Declines; Decline Ecology; Restoring Biodiversity Values; and Policies and Action for Woodland and Forest Restoration. Murdoch University together with the University of Western Australia and the Department of Environment and Conservation are the primary proponents, with cash and in-kind support from 27 agencies, non-government agencies and industry and collaboration with Universities and agencies in eastern Australia and overseas. Six Post-Doctoral fellows and a Manager have been appointed within the centre. The focus of this centre will initially be the decline of tuart and wandoo, however, student projects under the centre have been initiated investigating the decline of other iconic WA species including *E. marginata*, *Corymbia calophylla*, *E. rudis*, *Agonis flexuosa* and *C. ficifolia*. Further information about the Centre can be found at [www.treehealth.murdoch.edu.au](http://www.treehealth.murdoch.edu.au) (G. Hardy, Murdoch University).

#### **Molecular Diagnostic Facility at Murdoch University (MU)**

Nari Anderson (Research Associate, CPSM) has developed Real Time PCR methods to diagnose *P. cinnamomi* from soil samples. She is now developing the method for high throughput and on large (250g) soil samples in order to make the process commercially viable. (Supervisors: P. O'Brien and G. Hardy, Murdoch University).

### Plantations

Research on the incidence and new records of *Teratosphaeria* (formally *Mycosphaerella*) species within a *Eucalyptus globulus* plantation continues in Western Australia. *Eucalyptus globulus* is the predominant exotic hardwood plantation species in Western Australian (WA), and is often planted adjacent to native eucalypt forests. The increase in a number of *Teratosphaeria* species associated with Mycosphaerella Leaf Disease (MLD) in *E. globulus* plantations in WA in the past decade has raised concern about the possible movement of pathogens between the native forests and plantations. Results so far include:

- Eleven species of *Teratosphaeria* have been identified by morphology and confirmed using molecular tools
- The most frequently isolated species from juvenile foliage was *T. marksii* (77%) followed by *T. nubilosa* (33%)
- *Teratosphaeria nubilosa* was most frequently isolated from adult leaves (88%) followed by *T. parva* (7.5%)
- Thirteen species of *Teratosphaeria* have now been identified from eucalypts in WA

Monitoring of plantations continues in order to understand the dynamics of the host-pathogen interactions (A. Maxwell, AQIS; S. Jackson, T. Burgess, G. Hardy, B. Dell, Murdoch University).

**Work under the following grants is in progress at Murdoch University (MU).**

Collaborative Project - Murdoch University and the Tree Pathology Cooperative Program (TPCP) South Africa. The project 'New and emerging pathogens threatening the biodiversity of Australia's eucalypts' continues, and concentrates on some of the major eucalypt pathogens worldwide (*Kirramcyes* spp. *Teratosphaeria* spp., *Botryosphaeria* spp. *Cryphonectria* spp.). The aim is to determine their origin, movement and the risk they pose to Australia's eucalypts (T. Burgess, MU; M. Wingfield, TPCP).

**PhD Theses in progress at Murdoch University (MU)**

Francisco (Paco) Tovar: The cause of basal stem rot in second rotation *Eucalyptus globulus* plantations (Supervisors: T. Burgess, G. Hardy, MU; R. Robinson, DEC).

Katherine Taylor: A detailed study of *Teratosphaeria cryptica* and *T. nubilosa* in Western Australia, focusing on the threat to native remnants (Supervisors: T. Burgess, G. Hardy and P. Barber, MU; C. Mohammad, Forestry CRC; A. Carnegie, SF NSW).

Monique Sakalidis: Investigation and analysis of taxonomic irregularities within the fungal genus *Botryosphaeria*. This thesis is answering questions that have arisen within the genus *Botryosphaeria* relating to divisions amongst and within taxa (Supervisors T. Burgess, G. Hardy, MU; B. Wingfield University of Pretoria).

Sarah Jackson: Taxonomy and biology of *Teratosphaeria* species found on *E. globulus*. (Supervisors: G. Hardy, B. Dell, MU)

Patsy Stasikowski: An investigation into the mechanism of action of phosphite mediated resistance of plants to *P. cinnamomi* infection. Patsy is also in the process of developing a rapid analytical method to rapidly and cheaply determine the levels of phosphite in plant tissues under field conditions. We hope to be commercialising this in a kit form in the near future (Supervisors: G. Hardy, McComb, P. O'Brien, MU).

Leila Eshraghi: The role of plant defense pathways in Phosphite induced protection of *Arabidopsis thaliana* from *Phytophthora cinnamomi* infection (Supervisors: P. O'Brien, McComb, G. Hardy, MU).

Kylie Ireland: Susceptibility of Australian plants to *Phytophthora ramorum*, an emerging potential threat to Australian plant industries and ecosystems. Kylie is working at the University of California Davis (UCD) screening Australian species for potential susceptibility to *P. ramorum*. She has found a large number of sporulating hosts and will start to look at 'dead-end' hosts in the near future. She will also use risk modelling to determine areas in Australia most at threat to *P. ramorum*. This project is funded by the CRC National Plant Biosecurity and The Department of Environment, Water, Rivers and Heritage (Supervisors: G. Hardy, D. Huberli, MU; I. Smith DPI Vic.; D. Rizzo, UCD).

Alexander Rea: Classical and molecular taxonomy and pathogenicity testing of *Phytophthora* species. Alex is currently describing five new *Phytophthora* species from the Department of Environment and Conservation's Vegetation Health Service culture collection. This is also including pathogenicity screening and ecological studies. This project is funded by the CRC National Plant Biosecurity (Supervisors G. Hardy, T. Burgess, MU; M. Stukely, DEC).

Papori Barua: Screening *Lambertia* species for susceptibility and resistance to *Phytophthora cinnamomi* to develop a model plant system to examine resistance mechanisms (Supervisors: G. Hardy, J. McComb, MU; B. Shearer, DEC).

Peter Scott: The potential role of *Phytophthora* species in *Eucalyptus gomphocephala* (Tuart) decline. Peter has isolated a *P. citricola*-like *Phytophthora* from the fine roots and rhizosphere of tuart. Morphological and sequence data indicate that the pathogen is undescribed and he is currently working on describing this organism. He also has field and glasshouse pathogenicity trials in place. Trees in the decline treated with phosphite respond very well in comparison to control treatments further indicating that this new *Phytophthora* species could be playing a role in the decline syndrome (Supervisors G. Hardy, P. Barber, MU; B. Shearer, DEC).

Amy Smith: The introduction, transmission and spread of plant pathogens in plant nurseries: using *Phytophthora* as a model. Amy has started to isolate *Phytophthora* species from plants obtained from a range of wholesale and retail nurseries and from substrates (e.g. sand, bark, peat) that are used to make container substrates. She is also looking at how fungicides might suppress rather than kill *Phytophthora* species and hence facilitate their movement. She also intends to look at (a) fungicide resistance and (b) the populations structures of *Phytophthora* species in nurseries. (Supervisors G. Hardy, D. Huberli, K. Baylis, MU).

Endah Yulia. Fungal pathogens affecting urban eucalypts in Western Australia: Red Flowering Gum (*Corymbia ficifolia*) case study. Endah has isolated a large range of foliar and stem fungi from across Perth and towns in the lower south-west of WA. She has also isolated from natural stands of *C. ficifolia*. She is also rating tree health to site characteristics and urban management. *Quambalaria* species in particular *Q. coyrecup* (canker causing pathogen) are widespread and causing significant loss of trees through death and removal. She is in the process of isolating soilborne pathogens in the spring and summer of 2010. Pathogenicity tests will be conducted on the most frequently isolated taxa from diseased material. (Supervisors B. Dell, P. Barber, G. Hardy, MU).

Lily Ishaq. Role of mycorrhizal fungi in tuart (*Eucalyptus gomphocephala*) health. Lily started in late 2009. The primary aim of this study is to investigate the importance of mycorrhizal fungi in the healthy functioning of *E. gomphocephala* woodlands. The following hypotheses are proposed:

- The ecto and endo-mycorrhizal inoculum potential in soil changes with *E. gomphocephala* health status
- Mycorrhizal diversity and abundance changes with changes in crown health of *E. gomphocephala*,
- Mycorrhizae can promote the health of *E. gomphocephala* seedlings on recalcitrant soils through improved nutrient acquisition, and



- Mycorrhizal abundance on roots is affected by root disease caused by *Phytophthora multivora*.  
(Supervisors B. Dell, P. Barber and G. Hardy, MU).

**Honours Theses in progress at Murdoch University (MU).**

Katherine Edwards: Phytophthoras associated with *Eucalyptus rudis*: *E. rudis* (Flooded gum) is in decline across its range in the south-west of Western Australia. It is a keystone species in riparian ecosystems and provides important ecosystem functions such as habitat provision and water quality maintenance. Symptoms of decline resemble those of dieback caused by *Phytophthora* pathogens. This study sampled several watercourses and rhizosphere soils across the south-west for species of *Phytophthora* found in association with *E. rudis* and tested their pathogenicity to *E. rudis*. Several different treatments, including phosphite, insecticide and complete nutrients, were tested on *E. rudis* in a Perth wetland to compare their effectiveness in restoring health. The health of these *E. rudis* were also assessed using aerial remote sensing imagery. Currently, two *Phytophthora* species and a number of *Pythium* species found in association with *E. rudis* are being sequenced (Supervisors: G. Hardy, W. Dunston, T. Jung, MU).

Cielito Marbus: *Quambalaria* spp. Associated with marri (*C. calophylla*)  
(Supervisors: G. Hardy, B. Dell, T. Paap, MU).