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9.0 Annual Forest Health and Biosecurity Status Report of Western Australia

9.1 Surveillance activities

9.1.1 Dieback mapping and management

Mapping the presence of symptoms of the plant disease caused by *P. cinnamomi* was carried out by certified 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 the Department of Parks and Wildlife (DPaW). A total area of 19,620 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 8,454 ha of previous mapping that was checked for further spread. Mapping and hygiene planning were undertaken on a further 206 ha for the Parks and Visitor Services, Nature Conservation Service and Sustainable Forest Management Service of DPaW, and 165 ha for external parties. Training programs were carried out in disease mapping and hygiene management. A new manual for disease mapping was compiled for review by a range of stakeholders. A review of disease spread models indicated a slowing of the rates of disease spread across most zones and predictions of future disease extent were modified (G. Strelein, DPaW).

In the year to 30th June 2013, a total of 1,937 samples were tested for the presence of phytophthora at the DPaW 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 phytophthora in the DEC culture collection, and from other projects, from a range of WA locations and ecosystems. This has led to the discovery of an unexpectedly large number of new phytophthora taxa (eleven of which have now been formally described), as well as new records for WA of several *Phytophthora* taxa known from elsewhere, and also a swarm of *Phytophthora* hybrids (see details under *Phytophthora* in natural ecosystems, above). 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 of these soil-borne phytophthoras to new areas is minimised. Hygiene practices should be applied in the same way as for *P. cinnamomi* (M. Stukely, DPaW).

9.1.2 Softwood plantation survey and monitoring

Monitoring for sirex wasp (*Sirex noctillio*) in WA was undertaken by the Forest Products Commission (FPC) 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. No sirex wood wasps were detected in any of the traps in the 2012/13 flight season.

Eradication activities for European house borer (*Hylotrupes bajulus*, EHB) transitioned to ongoing management in 2011. There has been minimal activity since the transition with an emphasis on awareness and self-management (see 'Research and Development' section) (I. Dumbrell, FPC).

9.1.3 Private eucalypt plantations survey summary

Recent plantation company failures or restructuring has seen the WA bluegum plantation estate undergo a contraction both geographically and in terms of net area planted. Many plantations that are harvested in areas with marginal rainfall or distant from woodchip processing ports have been deemed uneconomic and not replanted. Further, approximately half of those plantations deemed suitable for a second rotation have been left to coppice (i.e. re-sprout from stump) rather than replanted with improved genetic material.

The industry-wide collaborative surveillance program commenced in 2011–12 was repeated in 2012–13. This year all the major companies not only collaborated in gathering crown damage data (Dec–March), but also undertook a series of pest population surveys (Sept–Nov). Target pest for population counts included chrysomelid species (*Paropsisterna m-fuscum* and *P. variicolis*) within young stands (seedlings—2 yr.) and *Gonipterus* spp. within 3–4 year-old stands. Population counts demonstrated that is possible to capture region-wide differences in pest populations. For example, *Gonipterus* spp. egg counts were 2–3 time higher in interior west coast regions than in other parts of the estate. It is hoped that in the near future, collaborative collection of population data will aid with industry co-operation with regards to area-wide management of pests, rather than individual companies conducting their own discrete pest management activities.

Liparetrus beetles and chrysomelid species (*Paropsisterna m-fuscum* and *P. variicolis*) continue to be the species most commonly affecting seedlings and juvenile trees. However, the current industry trend to treat seedlings shortly after planting with systemic insecticides (clothianidin and imidacloprid) has seen a marked reduction in reports of defoliation and pest related deaths of seedlings throughout the estate. *Heteronyx* beetles and eucalypt weevils (*Gonipterus* spp.) continue to be the most frequently reported insect pests in +3 year-old plantations (F. Tovar, Integrated Pest Management Group).

9.2 Plantations (Softwood)

(*Pinus* spp.)

9.2.1 Insect pests

a). *Sirex* spp.

No sirex wood wasps (*Sirex noctillio*) detected in any traps in the 2012/13 flight season.

b). Monterey Pine Aphid (*Essigella californica*)

Although essigella is present in WA, it is not regarded as a problem. The biocontrol project has been finalised and no new releases of the biocontrol agent *Diaeretus essigellae* took place in 2012–13. Follow up monitoring has yet to determine if the wasp has become established.

c). European House Borer (*Hylotrupes bajulus*)

European house borer continues to be restricted to dead sections of live pine trees, dead pinewood material and untreated pine structural timbers (see also 'Built Environment' section)

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

No unusual activity.

e). Rutherglen Bug (*Nysius vinitor*)

No unusual activity.

f). 'Spring' beetle (*Liparetrus jenkinsi*)

No unusual activity.

9.2.2 Pathogens

No significant issues.

9.2.3 Climatic disorders

a). Drought

No significant issues this year although soil water volumes beneath plantations were very low again. Summer and early autumn rainfall events prevented potential mortality. Until significant recharge events occur the risk of mortality will be high each year over the Summer/Autumn period (Ian Dumbrell, FPC).

9.3 Plantations (Hardwood)

9.3.1 Insect pests

(*Eucalyptus globulus*)

a). Eucalyptus weevil (*Gonipterus* spp.)

The average weather conditions experienced in most areas of the south coast during 2012–13 allowed many trees to recover from annual weevil spring defoliation and reports of severe damage were reduced from past years. Contrastingly, in western interior regions (Collie to Manjimup) there have been more reports of severe to extreme damage due to weevils. This is supported by high egg counts being recorded in this area (see map below). Damage to trees in this region is thought to be caused by a "new" species of weevil to WA temporarily termed *Gonipterus* sp. nov. 2 (**Fig. 16 & 17**). Its phenology is different to *G. platensis* (previously the more common species found in WA), it is thought to reproduce at least twice during spring and summer and most damage is done by adults feeding throughout the year and on the entire canopy, not just juvenile shoots. Work is currently underway to determine its phenology, behaviour and distribution within WA.

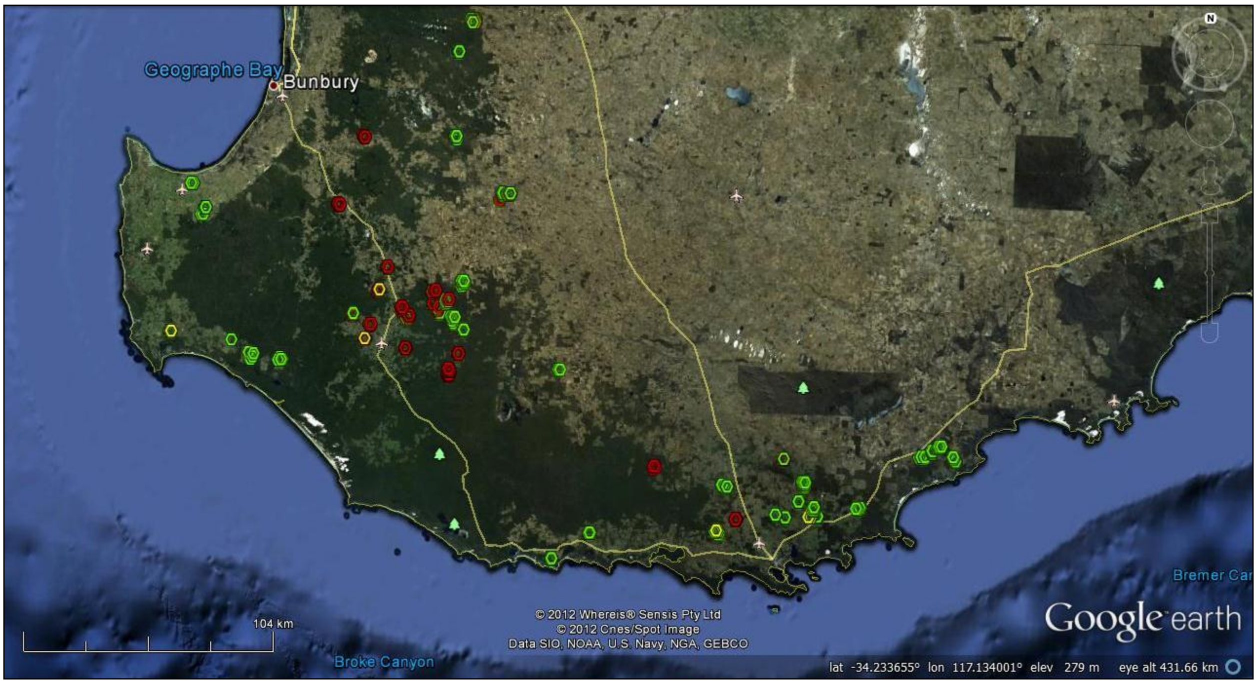

Figure 16: Map showing *Gonipterus* spp. egg population counts. Greatest weevil egg populations were observed in western interior areas (Donnybrook to Manjimup). Green <1 egg/30cm branch; Yellow 1-2.5 egg/30cm branch; Red >2.5 egg/30cm branch

Figure 17: *Gonipterus platensis* (left), *Gonipterus* sp.nov.2 (right); note the distinct X marking over the elytra and the white 'patch' between the elytra and the pronotum

b). Eucalypt leaf beetles (Chrysomelidae)

Chrysomelid species (*Paropsisterna m-fuscum and P. variicolis)* were observed causing low levels of damage to seedlings and saplings throughout the WA estate. Treatment of seedlings with systemic insecticides has greatly reduced damage reported by these insects.

c). *Heteronyx* spp.

Reports of significant *Heteronyx* spp. damage have decreased when compared to past years; especially in the south coast (Augusta to East Albany) where they are most active.

Eucalyptus (*E. cadocalyx, E. botryoides, E. loxophleba* ssp. *lissophloia, E. grandis, E. saligna*) and *Corymbia* (*C. maculata*) spp.

a). *Phylacteopohaga* spp.

An outbreak of Leaf blister sawfly (*Phylacteopohaga* spp.) in *E. botryoides* and *E. saligna* plantations on farmland south-east of Collie was reported—both these species have been heavily impacted by both adults and larvae. In addition gum leaf skeletoniser (*Uraba lugens*) was also found (in association with LBS) on *E. rudis* in an area of remnant vegetation within the plantation. Chemical spraying had limited success so plantations were thinned early which, it is assumed, may have prevented a further outbreak.

b). Autumn gum moth (*Mnesampela privita*)

This pest was identified in the low rainfall region of Salmon Gums (approx. 100 km north of Esperance) have been persistent since 2010 within the young York gum (*E. loxophleba* spp. *lissophloia*) plantations. Early chemical spraying operations did not eradicate the pest. In 2013 the Salmon Gums region along with the South Coast region has experienced well above average rainfall allowing the suppressed York gums to put on extensive new growth and it appears the impact of autumn gum moth is much reduced.

c). Brown basket lerp (*Cardiaspina fiscella*)

A severe outbreak of brown basket lerp (*Cardiaspina fiscella*) occurred on both *E. saligna* and *E. grandis* at a property near Nannup. *C. maculata* and *E. diversicolour* at the same site were unaffected. It is not known when the outbreak began but indications suggest it may have been associated with the 2010/11 drought event.

At the time of writing a high prevalence of a number of different galls on different plantation species across the south of the state have been noted, including two different forms (one on *E. saligna* the other on *C. maculata*) from this property with the outbreak of brown basket lerp (I. Dumbrell, FPC).

d). Case moth (*Hyalarcta heubneri*)

The damage was reported on *E. polybractea* in a plantation near Lake Magenta. *E. polybractea* is not noted to support insect pests (A. Wills, Department of Parks and Wildlife – DPaW).

9.3.2 Pathogens

Eucalyptus globulus:

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

Reports are increasing of young stands (<3-years-old) in Denbarker and Manypeaks being affected by outbreaks of teratosphaeria leaf disease. This is thought to be a result of a combination of:

1. Most stands in this area being at the susceptible juvenile leaf stage (1-4 year-old).
2. Mild winters and wet springs/summers in the last 2 years creating unusually warm moist conditions conducive to *Teratosphaeria* spp.
3. Poor soil nutrition being a contributing factor.

The Eucalypt plantation summary **(Table 2)** attached below provides further information associated with insect pests, pathogens and other pests for eucalyptus (contributed by F. Tovar, Industry Pest Management Group)

Table 2: Area of *E. globulus* plantation estate monitored and area affected by pests and pathogens in Western Australia in 2012–13[5]

PESTS*	Area with moderate damage (ha)					Area with severe damage (ha)					Area inspected (ha)[6]	Area treated (ha)[7]	Hosts
	<10	10-100	100-500	500-1000	>1000	<10	10-100	100-500	500-1000	>1000			
Eucalypt weevil (*Gonipterus scutellatus*)					X				X				*E. globulus*
Heteronyx spp. **[8]				X			X						*E. globulus*
Chrysomelid beetles			X										*E. globulus*
"Spring" beetles (*Liparetrus* spp.)		X											*E. globulus*
Wingless grasshopper (*Phaulacridium vittatum*)													*E. globulus*
28 Parrots (*Banardius zonarius*)			X										*E. globulus*
Rabbits		X											*E. globulus*

[5] Data contained in the table is of a general nature and incomplete as the IPMG currently only has data from collaborative surveys but is aware that companies collect more data when conducting yearly in-house audits.

[6] No information was provided to IPMG regarding areas inspected or treated (F. Tovar, Industry Pest Management Group).

[7] No information was provided to IPMG regarding areas inspected or treated (F. Tovar, Industry Pest Management Group).

[8] Data concerning *Heteronyx* spp. damage is an estimate based on anecdotal observations from foresters over many years.

PESTS*	Area with moderate damage (ha)					Area with severe damage (ha)					Area inspected (ha)[6]	Area treated (ha)[7]	Hosts
	<10	10-100	100-500	500-1000	>1000	<10	10-100	100-500	500-1000	>1000			
PATHOGEN													
Teratosphaeria spp.					X					X			*E. globulus*
WEEDS													
Kikuya grass			X										*E. globulus*
									TOTALS				

9.4 Native forests

9.4.1 Insect pests

(Native jarrah - *Eucalyptus marginata* forest)

a). Jarrah leaf miner (*Perthida glyphopa*)

A survey of jarrah leaf miner (JLM) on sites within the southern jarrah forest region was undertaken in October 2012. JLM mine densities on ground coppice leaves are presented below **(Fig. 18).** Highest population densities were found north of Collie and south of Dwellingup. Forest north of Dwellingup is free of JLM infestation while forest south of Bridgetown had low JLM population densities (A. Wills and J. Farr DPaW).

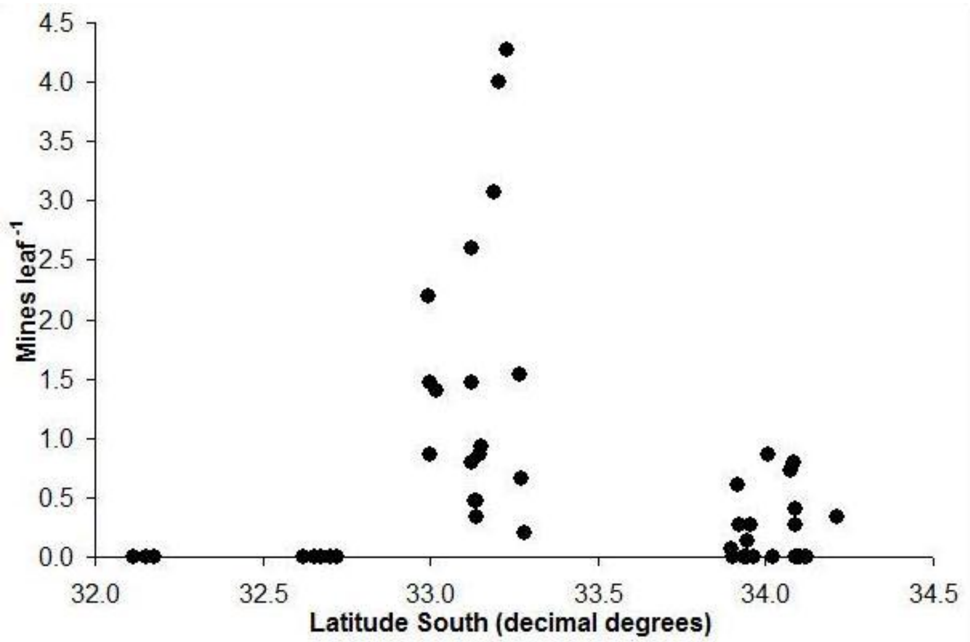

Figure 18: Jarrah leaf miner mine densities on ground coppice from FORESTCHECK sites October 2012 (15 leaves on one plant sampled per site)

b). Gum leaf skeletonizer (*Uraba lugens*)

The outbreak of gumleaf skeletonizer (GLS) continued in Dec-March 2012/13. Population monitoring used the New Zealand pheromone lure system. From ground observations, the forest area subject to defoliation had contracted and moved southeast, adjoining areas which had been defoliated the previous year. Although population levels declined from the 2011/12 levels, they were still high in some monitoring sites compared with non-outbreak periods (J. Farr and A. Wills, DPaW).

(Native Karri - *Eucalyptus diversicolor* forest)

No major insect pest problems reported.

9.4.2 Pathogens

(Native jarrah - *Eucalyptus marginata* forest)

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).

(Native Karri - *Eucalyptus diversicolor* forest)

No new major disease problems were reported. Management and survey of armillaria root disease, caused by *A. luteobubalina*, in regrowth karri forests continues to command attention.

a). Armillaria root disease

Currently, the incidence of armillaria infection in regrowth karri stands is surveyed post thinning using a visual assessment of disease symptoms on trees (**Fig. 19**). One plot is assessed for each 2 ha of thinned forest. The ability of the surveys to represent the actual level of armillaria infection on the site is being assessed by carrying out whole of coupe surveys and comparing the results to the plot surveys. Additional assessments are required before a judgment can be made, but results so far suggest that the plot based survey method provides a good estimate of the whole of coupe incidence of armillaria. However, Karri forest can be difficult to traverse and butts of trees, where armillaria-caused lesions occur, are often obscured by litter accumulation. As an alternative, surveys of logs on landings is being trialed as a rapid method for estimating the number of trees infected with armillaria (D. Wiseman, H. Tabarestani, R. Robinson, DPaW)

Figure 19: Armillaria-infected karri regrowth thinnings logs on landings. Symptoms are: white stringy rot in sapwood and bark (left), occluded scar and associated discoloured wood (centre) and white internal rot associated with occluded scars (right).

9.4.3 Climatic disorders

a). Frost

During winter 2010 and 2012, frost events within the northern jarrah forest resulted in canopy dieback. Permanent monitoring plots have been established and over 700 trees are tagged. Monitoring in the Wandoo National Park suggested that:

- Canopy collapse occurred in the similar areas following both frost events.
- Species differential responses were clear, with marri *(Corymbia calophylla)* and jarrah (*Eucalyptus marginata*) being severely affected compared with wandoo (*Eucalyptus wandoo*).
- Reports are currently being prepared (G.Matusick, K. Ruthrof and G. Hardy, Murdoch University).

b). Drought

Unprecedented drought-induced deaths in the northern jarrah forest (NJF) were first observed in late February 2011 **(Fig. 20)**. Long term monitoring plots have been established to track recovery following the collapse. Re-monitoring was undertaken in 2012 and 2013 and included: resprouting, regeneration, fuel levels, canopy cover changes. Findings after monitoring 3, 6, 16 and 24 months include:

- There were contrasting patterns of recovery over time between forest experiencing different magnitudes of collapse.
- Epicormic resprouting was extensive within severely affected plots, with a much reduced response on minimally affected plots.

- A key impact was a reduced canopy height and proliferation of new stems formed from resprouting.
- Regeneration of *E. marginata* was found in higher densities in severely affected forest, predominantly as ground coppice.
- Size class distribution shifted downwards due to death of large diameter trees.

The resprouting response and high regeneration densities has led to major structural changes. However, the composition of the forest is not likely to shift away from the dominant species, *E. marginata*, thus far.

- The patterns of recovery also suggest that particular sites may be vulnerable to significant structural shifts with future drought-induced canopy dieback.

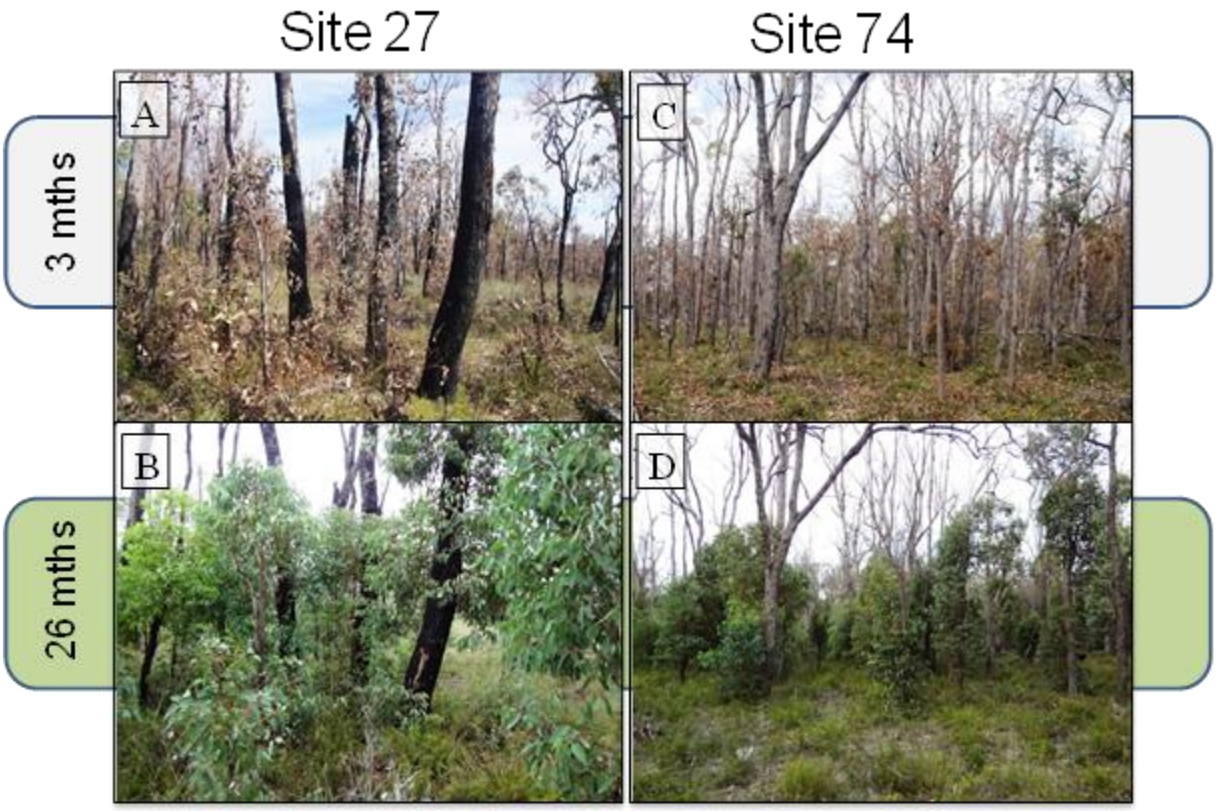

Figure 20: Recovery of trees following drought at two monitoring sites, Site 27 (A & B) and Site 74 (C & D), in the northern jarrah forest (Photos: George Matusick)

Sixteen months following the collapse, when differences in basal area were accounted for, plots severely affected by the forest collapse had significantly higher litter loads than areas minimally affected by the collapse. These increased fine surface fuel loadings (referred to as 1hr fuels) and the changed micro-meteorological conditions (temperature, relative humidity and wind speed) caused by the drought-induced canopy collapse, both of which have significant implications for fire behaviour in the short term (K. Ruthrof, G, Matusick and G. Hardy, Murdoch University).

Drought-associated vegetation declines are increasingly observed worldwide. A study was undertaken to investigate whether differences in water relations can potentially explain the distribution and vulnerability to drought-induced decline of four common tree species in Mediterranean south western Australia. It compared seasonal and daily water relations of four eucalypt species (i.e. *Corymbia calophylla, Eucalyptus accedens, E. marginata, E. wandoo*) when co-occurring as well as on nearby typical sites for each species. When co-occurring, species generally inhabiting drier regions (i.e. *E. accedens, E. wandoo*) had lower summer leaf water potentials, osmotic potential, and vulnerability to cavitation and higher stomatal conductance and relative sapflow velocity. Both wetter zone species (e.g. *C. calophylla* and E. *marginata*) had remarkably high vulnerabilities to cavitation for Mediterranean-type tree species but showed greatly improved leaf water status on nearby sites where they dominate. Using local soil moisture retention curves of saprolitic clay layers underlying south western Australia showed the large disadvantage that wetter zone species have in terms of accessing tightly bound water in these layers. This work shows that species distribution and local dominance of four dominant overstorey species in south western Australia is largely a function of plant water relations interacting with local soil profiles. The observed differences in water relations amongst species are consistent with some of the declines that have been observed in recent decades (P. Poot and E. Veneklaas, University of Western Australia).

9.5 Nurseries

No major problems have been reported in conifer seedlings in nurseries.

An infestation of *Phytophthora alticola* (previously designated *P*. aff. *arenaria*) was found in a WA wheatbelt region nursery producing oil mallee (eucalyptus spp.) seedlings, in 2012 and again in 2013. This is being investigated further, including studies on its pathogenicity and mode of transmission, as well as control methods (M. Stukely, DPaW).

9.6 Urban and Rural trees

9.6.1 Insect pests

Extensive declines of *E. rudis* (flooded gum) associated with *Creiis periculosa* (western horn lerp) sometimes in association with *Perthida* sp. leafminer and/or *Phylacteophaga froggatti* (leaf blister sawfly, LBS) continue to be monitored in the south-west.

LBS activity in areas of on remnant marri (*C. calophylla*) in the valleys of the Darling Scarp in the vicinity of Mornington Road and the Ferguson Valley were also observed in 2012/13 (A. Wills, DPaW).

9.6.2 Pathogens and Declines

a). *Armillaria luteobubalina*

Symptoms of armillaria root disease (ARD) was found in *Melaleuca rhaphiophylla*. The infected trees were in remnant swamp vegetation between the Collie River and urban development, indicating that they may be subject to nutrient rich run off from nearby houses. ARD has also been noted to affect *M. viminea* in fertilised and watered situations in the south-west (D. Wiseman and A. Webb, DPaW).

b). Phytophthora in parks and remnant bushland

Surveys of dying vegetation within remnant bushland, parks and gardens and streetscapes throughout the urban forests of Perth and the south-west of Western Australia, revealed symptoms typical of those produced by phytophthora species. A total of nine phytophthora species, including *P. alticola, P. multivora, P. litoralis, P. inundata, P. nicotianae* and *P. palmivora* were isolated. In addition, three previously undescribed species, *Phytophthora* aff. *arenaria*, *Phytophthora* aff. *humicola* and *Phytophthora* sp. '*ohioensis*' were isolated. Isolates were recovered from a wide range of native and non-native host genera, including *Agonis, Allocasuarina, Brachychiton, Calothamnus, Casuarina, Corymbia, Dracaena, Eucalyptus, Ficus, Pyrus* and *Xanthorrhoea*. *Phytophthora multivora* was the most commonly isolated species. Out of 230 samples collected 69 were found to be infected with phytophthora. Of those 69, 54% were located within parks and gardens, 36% within remnant bushland, and 10% within streetscapes. These pathogens may play a key role in the premature decline in health of the urban forest throughout Perth, and should be managed according to the precautionary principle and given high priority when considering future sustainable management strategies (P. Barber, T. Paap, T. Burgess, W. Dunstan and G. Hardy, Murdoch University).

c). 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 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 inland 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, DPaW).

9.6.3 Other

a). Canopy health of urban trees

Canopy cover of remnant urban native bush within the city of Perth has dramatically reduced over recent years, largely as a result of property development. What remains has become increasingly fragmented and is in a very poor state of health, due to a range of factors. Over the past 18 months, surveys at many sites have revealed a range of anthropogenic and biological factors contributing to the decline of these species. Within much of the urban bushland of Perth *Eucalyptus marginata, E. gomphocephala* and *Corymbia calophylla* have symptoms of severe crown decline. Diagnosis of the biological factors, including a range of pathogens, pests and nutrient disorders, has guided the selection and application of a range of systemic treatments to mitigate crown decline and improve crown health. Mitigating crown decline of mature trees in this way is much more cost-effective than annual pruning of dead wood (P. Barber, G. Hardy).

9.7 Built Environment

9.7.1 European house borer (*Hylotrupes bajulus*, EHB)

Records of EHB in timber in service remains restricted to the original house in the Perth metro area in 2005, and to one incidence of untreated timber in Albany which was transported from Perth. No recent infestations of timber in service have been recorded.

9.8 Biosecurity

9.8.1 Native plant communities

a). Phytophthora in natural ecosystems

Previously, 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, whereas currently most mapping is undertaken with intensive field survey. Validation of the observations may involve routine testing of soil and root samples for the presence of *Phytophthora cinnamomi.* In addition to *P. cinnamomi*, six morpho-species had been identified prior to 2005 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. 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, sequence data of over 850 isolates (both recent and historical, from the DPaW Vegetation Health Service collection) have now been compared to that of existing species and undescribed taxa. This work is continuing.

A total of eleven new species of phytophthora have been described from WA natural ecosystems since 2009: *Phytophthora multivora, P. elongata, P. thermophila, P. gibbosa, P. gregata, P. litoralis, P. arenaria, P. constricta, P. fluvialis, P. amnicola* and *P. bilorbang.* Pathogenicity has so far been tested and confirmed on native plants for *P. multivora*, *P. elongata*, *P. arenaria* and *P. constricta*. *P. bilorbang* is pathogenic to the agricultural and forest weed, *Rubus anglocandicans* (European blackberry). Several additional new WA *Phytophthora* taxa await formal description.

New records for WA of *Phytophthora* taxa known elsewhere (identified since 2005 from recent as well as historical WA isolates) have included: *P. inundata*, *P. niederhauserii*, *P. asparagi*, *P. palmivora*, *P. rosacearum*, *P. lacustris*, *P. alticola*, *P. parvispora*, *P.* taxon personii, *P.* taxon PgChlamydo, and *P.* taxon humicola-like.

A number of naturally-occurring hybrid phytophthoras with significant genetic diversity have been identified from WA natural and plantation ecosystems: some from soil associated with dead plants, and also many from waterways in WA as well as in South Africa. Collaborative investigations of these hybrids and their origins are progressing. The presence of these hybrids (all recovered from routine soil, root and water samples being tested for *Phytophthora* spp.) shows that they are sufficiently stable and resilient to survive in the harsh WA environment. Also, it raises the possibility of hybrids with significant pathogenic capability arising in the field at any time from interactions between compatible *Phytophthora* species. The formation of *Phytophthora* hybrids is believed to be a continuing process. Movement of infested soil and/or plant material between sites will clearly facilitate these interactions, and should be minimised.

Most of the newly-described phytophthoras (and some of those yet to be described) have been associated with multiple species of native plants dying in WA natural ecosystems, with some DPaW isolations from indicator plants dating back to the 1980s. Some phytophthoras are active in a broader range of site conditions than those favouring *P. cinnamomi* (e.g. *P. multivora* in limestone soils). Some species (e.g. *P. arenaria* and *P. constricta*) are believed to be endemic in WA. Most of the new taxa have been associated with dying *Banksia* spp. while *P. elongata*, *P. multivora* and *P. thermophila* have also been isolated from dying *Eucalyptus marginata*. *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. *P. elongata* has also been isolated from dying *Corymbia calophylla* in mining rehabilitation sites. Some taxa appear to have limited distribution, while others like *P. multivora* are widespread.

The previously recorded presence in WA natural ecosystems of four *Phytophthora* species other than *P. cinnamomi* (*P. cryptogea, P. nicotianae, P. megasperma, P. boehmeriae*) has been confirmed by DNA sequencing of stored isolates. However, two species that were previously believed to be present based on morphological studies alone (*P. citricola* and *P. drechsleri*) are not present among the isolates tested todate. Land managers are being encouraged to apply the precautionary principle in dealing with all of these soil-borne *Phytophthora* species with the aim of minimising their spread (T. Burgess, G. Hardy, D. White, and A. Rea, Murdoch University; M. Stukely, J. Webster and J. Ciampini, DPaW).

b). Canker pathogens in natural ecosystems

Neofusicoccum australe, *N. macroclavatum*, *Cryptodiaporthe melanocraspeda* and *Luteocirrhus shearii*, a newly described pathogen of Proteaceae in the Cryphonectriaceae, were consistently isolated from cankers affecting *Banksia* and *Lambertia* spp. communities across the South West Australian Floristic Region. *Neofusicoccum* spp. were the most frequently isolated pathogens in *B. baxteri* and *B. coccinea. C. melanocraespeda* was associated with cankers on *B. coccinea* and *L. shearii* on *B. baxteri*. Canker severity on *B. baxteri* had positive significant correlations with average monthly, maximum and minimum temperatures at sites. For *B. coccinea* there were no significant correlations.

Effectiveness of the fungicides Rovral, Switch® and Banrot® was compared to previously tested Sportak® fungicide and controls. Growth rates *in-vitro* were used to determine effective dose rates. The two most effective, Banrot® and Switch®, were then used *in-vivo* spray treatments on *B. baxteri*, *B. occidentalis*, *B. speciosa* and *B.verticillata* seedlings to assess pathogen-host-fungicide interactions. Seedlings were treated with fungicides then challenged by stem wound inoculation with the canker fungi and lesion extension rates compared. Switch® Fungicide produced a significant control effect on all canker pathogens in *B. verticillata* but none in *B. Baxteri.* Therefore, any applied fungicide spray program needs to consider pathogen-host-fungicide interactions prior to implementation (C. Crane and B. Shearer, DPaW).

9.8.2 Other

a). South Coast Region aerial Phosphite program to mitigate *Phytophthora cinnamomi* impact

In autumn 2013, 262 ha (27 targets) were sprayed targeting 20 Threatened flora species (13 Critically Endangered) and 2 Threatened Ecological Communities (Montane Heath & Thicket of the Stirling Range, Montane Mallee Thicket of the Stirling Range). Selected populations of Critically Endangered flora within targets were monitored and data collected on survival, growth, reproduction and plant health. Phosphite was applied at 12 kg/ha (30 L/ha) using 40% phosphite. Aerial phosphite application is a critical component in a suite of recovery actions for these species that include fencing, seed collection and translocations. While phosphite in general slows population decline, the additional threats of grazing and aerial canker, caused by *Luteocirrhus shearii* (formerly *Zythiostroma* spp.), *Neofusicoccum australe and Cytospora* spp., also impact on the health and survival of several critically endangered taxa and affect management outcomes (S. Barrett, DPaW).

9.9 Research and Development activities

9.9.1 European house borer (EHB) on-line training package

A new on-line training package has been developed by the Department of Agriculture and Food WA and Challenger Institute of Technology **(http://www.challenger.wa.edu.au/courses/ShortCourses/Pages/short-course-ehb-**

european-house-borer.aspx). The course targets technicians in the pest management industry and aims to enhance knowledge about EHB including how to recognise and control EHB infestation and how to prevent damage and future spread. Participants will acquire enhanced skills in the detection of EHB, the infestation signs to look out for and how to treat and prevent further infestation (I. Dumbrell. FPC).

9.9.2 Forest health monitoring

An automated annual monitoring program has been 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, DPaW).

9.9.3 Forest health modeling

Frost occurrence is being modelled for the past 15 years and 15 years into the future at 1km resolution over the whole south-west of WA. This will give indications where native forest was and will most likely be affected and contribute to understanding potential regional climate change and variability. Associated datasets can further be used for making predictions into the future (T. Lyons, J. Kala, Murdoch University).

A model that aims to provide understanding of a tree's hydraulic strategy and the impact of this on its survival in a global climate change context has been developed. The model uses cell-level changes that allow for adaptation of trees to their environment. This model using the hydraulics of a single individual tree can be used to test different strategies for water uptake, transport and transpiration. It was used to analyse some overall strategies adopted by trees and discuss them in the light of drought tolerance. Results show that optimizations for water use occurs at different scales and are interrelated. The different scales in this strategy are at leaf level (stomatal regulation and leaf capacitance), organ level (trade-off between conductance and vulnerability to embolism); and whole tree level (allocation of carbon to root, leaves or trunk). It is intended that this model be used to estimate tree survival under global climate change scenarios, to estimate the range of change required under certain climate projections and help estimate if real trees in the field can operate in this range and survive in drier and hotter climates (J. Chopard, Murdoch University).

Marri ARC Linkage - Western Australian State Centre of Excellence for Climate Change, Woodland and Forest Health.

An extensive survey of the incidence and severity of *Quambalaria coyrecup* canker disease across the entire marri range has been completed **(Fig. 21).** A total of 62 sites were examined, with 50 trees assessed for canker presence at each site. The survey targeted sites where marri canker disease was most likely to be present, e.g. roadsides and areas of high human impact. The survey shows the disease is widespread across much of the marri range; though the northern and south eastern extremities remain canker free. The Dunsborough-Margaret River-Augusta region has very high canker impact, along with other areas including parts of the south coast and the Perth hills where disease impacts up to 78% of trees. Further surveys will focus on distance from a disturbance, e.g. major road, as a predictor of canker presence, to verify that the extent of impact of the disease is strongly correlated with the level of human disturbance.

The role of phytophthora species as fine feeder root pathogens predisposing marri to canker disease continues to be investigated. Todate, a number of species including *P. cinnamomi, P. cryptogea, P. elongata, P. multivora* and *P.* sp. *ohioensis* have been isolated from marri roots and rhizosphere soil. Pathogenicity trials are underway to determine their impact on marri health.

A field trial is currently being conducted using artificially inoculated marri saplings to assess the efficacy of phosphite, Medicap (complete nutrients) implants and a range of fungicides in limiting canker development. These trials will also be replicated in stands of naturally infected trees to determine whether these single-tree treatments can slow, halt, or reverse the rate of marri decline.

Seed has been collected from marri to conduct a range-wide provenance trial. Seed will be germinated this summer for planting out next winter at field sites in Margaret River, Albany and Mundijong. These field trials and additional glasshouse trials will provide information on whether there is variation in susceptibility to *Q. coyrecup* and *Q. pitereka* in marri from different provenances, and whether susceptibility is influenced by disease condition of the parent tree, with the ultimate aim being to develop disease resistant lines for replanting in areas of high disease pressure. In addition, the trials will also assess whether genetics and environment interact to influence plant condition and disease progression, and examine the role of drought and waterlogging in predisposing marri to canker development (T. Paap, Murdoch University).

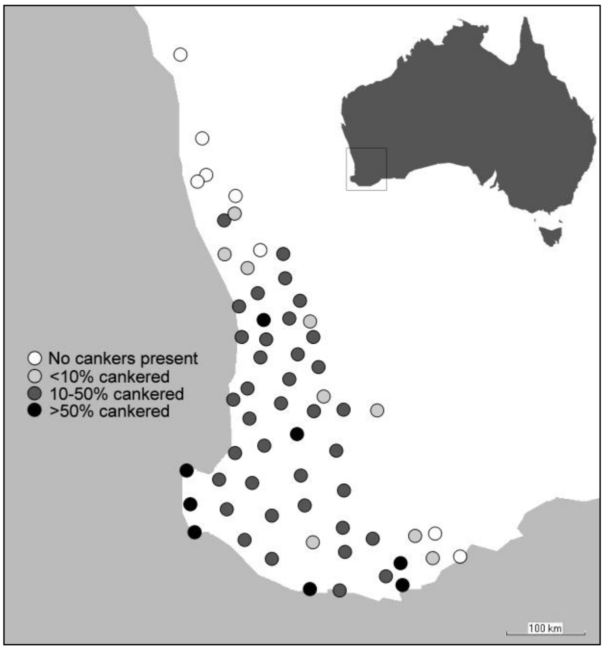

Figure 21: Incidence of marri canker across the range of marri in the south-west (above)

9.9.4 Student projects

a). PhD students

Agnes Simamora (Murdoch University) Multiple new phytophthora species from Western Australia: taxonomy, pathogenicity, and disease control (Supervisors: T. Burgess, G. Hardy, Murdoch University, M. Stukely, DPaW)

The aim of this thesis is to identify phytophthora isolates using DNA sequence data from rDNA internal transcribed spacer regions (ITS) and the mitochondrial cox1 genes in association with morphological and physiological characteristics. In addition, pathogenicity tests and the disease control of selected isolates from all the new species described will be undertaken. The outcome of this study will be to increase the knowledge about the species of phytophthora present in native plant communities in Western Australia, their pathogenicity and their potential control by phosphite.

A re-evaluation has been made for some phytophthora isolates with similar morphological characters to *P. arenaria*, but with some variation in ITS region sequences, and which have been referred to as *P.* aff. *arenaria* type I (with the vast majority of isolates coming from nurseries and urban tree plantings, and predominantly from eucalyptus) and type II (predominantly from natural vegetation on the northern sandplains). A re-evaluation of these species using morphological, physiological, and molecular characteristics using a combination of 4 gene regions, cox1, HSP90, enolase and BT, suggests that type I isolates are *P. alticola,* while type II isolates are *P. arenaria.* Thus the species that has been found in the nursery on eucalyptus is *P. alticola*.

Pathogenicity trials using *P. alticola*, *P. arenaria*, and *P. cinnamomi* isolates on one- and three-month-old eucalyptus seedlings (*E. polybractea*, *E. kochii* subsp. *plenissima*, *E. kochii* subsp. *borealis*, *E. loxophleba* subsp. *lissophloia,* and two seedlots of *E. loxophleba* subsp. *gratiae*) in the glass house indicated that *P. alticola* can infect all eucalyptus seedlings whilst *P. arenaria* had no/less effect. *P. cinnamomi* infected *E. kochii* subsp. *plenissima*, *E. kochii* subsp. *borealis* and *E. loxophleba* subsp. *lissophloia* (A. Simamora, Murdoch University).

Louise Croeser (Murdoch University): Is the widespread decline in the health of *Corymbia calophylla* (Marri) driven by Phytophthora root disease?

It is thought that environmental or biological factors are contributing to the decline by predisposing the trees, and *Phytophthora multivora* has been isolated routinely from the soils underneath dying marri, leading to the hypothesis that phytophthora root disease reduces the health and vigour of marri, allowing the endemic pathogen *Quambalaria. coyrecup* to take hold. Field surveys have been done to determine the extent of phytophthora infection in the soils from underneath marri. The *Phytophthora* spp. isolated from soils were used in trials such as inoculating marri branches, as well as inoculating the soil of marri seedlings in glasshouse trials. Once these experiments are concluded and the effect of *Phytophthora* spp. determined, another set of experiments will be conducted to determine the synergistic effect of dual inoculation with both *Phytophthora* spp. and *Q. coyrecup*.

Lily Ishaq (Murdoch University): The role of mycorrhizal fungi in tuart (*Eucalyptus gomphocephala*) health (Supervisors: P. Barber, M. Calver, B. Dell, Murdoch University).

The health of tuart is declining within its natural range in south-western Australia. In a pilot study to assess whether changes in mycorrhizal fungi and soil chemistry might be associated with tuart decline, we set up a containerised bioassay experiment with tuart seedlings as the trap plant using intact soil cores collected from 12 sites with tuart canopy condition ranging from healthy to declining. Adjacent soil samples were collected for chemical analysis. The type of mycorrhiza (arbuscular or ectomycorrhizal) formed in containerized seedlings predicted the canopy condition of tuart trees at the sites where the cores were taken. Ectomycorrhizal fungi colonization was higher in seedling roots in soil taken from sites with healthy canopies, whereas colonization by arbuscular mycorrhizal fungi dominated in roots in soil taken from sites with declining canopies. Furthermore, several soil chemical properties predicted canopy condition and the type of mycorrhizal fungi colonizing roots.

Other PhD projects at Murdoch University include:

- Brad Evans (Murdoch University): Climatic impacts on forest ecosystems in the south west of Western Australia
- Jason Hamer (University of Western Australia): Keeping up with climate change: the vulnerability of eucalypt species to a drying climate in south-western Australia.
- Sonja Jakob (University of Western Australia): The role of mycorrhizal fungi in healthy and declining eucalypts.
- Cielito Marbus (Murdoch University): The epidemiology and host-pathogen interactions of *Quambalaria pitereka* associated with marri (*Corymbia calophylla*).
- Tracey Moore (Murdoch University): Eucalyptus wandoo decline and its influence on wildlife.
- Emma Steel (Murdoch University): Migration of vegetation complexes in relation to the changing climate of the northern jarrah forest.

b). Honours students

Stephen Seaton (Murdoch University): The interaction of drought and the outbreak of *Phoracantha semipunctata* (Coleoptera: Cerambycidae) on tree collapse in the northern jarrah (*Eucalyptus marginata*) forest (Supervisors: G. Hardy, G. Matusick, Murdoch University).

Phoracantha semipunctata Fabricius is an endemic Cerambycid beetle to the northern jarrah forest (NJF) of south-western Australia that attacked collapsed trees following the recent drought and event in 2010/11 in the NJF. Results from this study showed that:

- There was a strong association between *P. semipunctata* infestation and the health of the trees, with the borers concentrated in trees in collapsed sites with an average of 4.5 emergence holes m^2 of *P. semipunctata* for the first 2m of the tree in collapsed areas compared to an average of 0.1 emergence holes m^{-2} in the healthy intact areas.
- *Phoracantha semipunctata* were attracted to trees that had lost all or part of their canopy or had died since the drought with 94 % of individuals in these trees and less than 1 % of *P. semipunctata* in healthy trees with an intact canopy.
- Infestation levels within trees were very high with a maximum of 429 emergence holes per tree for jarrah and 345 emergence holes per tree for marri. Averaged

across four collapsed sites, marri had higher levels of infestation with 15.42 emergence holes m^{-2} compared to jarrah with 10.55 emergence holes m^{-2} for the entire tree.

- The differences in the total *P. semipunctata* emergence holes m^{-2} between jarrah and marri was a result of a complex interaction of tree height and diameter over bark (DOB), where number of emergence holes m^{-2} decreased with height and tree species, giving a range of responses at different sites.
- However, a consistent feature of *P. semipunctata* infestation in the NJF was the occurrence of collapsed patches of various sizes and different numbers of *P. semipunctata* across the NJF (S. Seaton Murdoch University).

c). Other Honours projects at Murdoch University include:

- Briony Williams (Murdoch University): Insects as vectors of *Quambalaria pitereka* - the causal agent of shoot and flower blight on marri (*Corymbia calophylla*)

9.10 Publications

Not reported.

9.11 Forest Health Capability

Potential research/technical staffs that have expertise in areas of either Mycology or Entomology associated with forest health issues in WA.

2. Mr Ian Dumbrell (A/Manager)
   (Forest Science & Industry Development)

   Forest Products Commission, Robertson Drive
   Bunbury, WA 6230.

3. Mr Andrew Lyon
   (Principal Scientist & Manager – Science and Technical Standards)

   Forest Products Commission, 3 Baron Hay Court
   Kensington, WA 6151.

4. Dr Richard Robinson (Senior Research Scientist)
   (Science and Conservation Division)

   Department of Parks and Wildlife, Locked Bag 2
   Manjimup, WA 6258.

5. Dr Janet Farr (Research Scientist)
(Science and Conservation Division)

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