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8.0 WESTERN AUSTRALIA

8.1 Summary

In native forest, dieback in jarrah forest caused by *Phytophthora cinnamomi* and tree decline in tuart and wandoo woodland continues to command attention. Research on the taxonomy and ecological implications of new Phytophthora records and taxa from WA continues.

The outbreak of Gum Leaf Skeletonizer (GLS) continued in Dec-March 2011–12. It appears that the area subject to defoliation has contracted but moved into forest adjoining areas which had been defoliated the previous year. Although population levels have declined since 2010–11, they were still high compared with non outbreak periods, and some areas of forest experienced nearly 100% defoliation again.

Frost and drought damage in susceptible stands in the northern jarrah forest and coastal pine plantations continue to be monitored, and a new project has been started to examine the impact and management of Quambalaria canker in *Corymbia calophyla* (marri) trees.

A bluegum plantation industry-wide collaborative surveillance program was initiated in 2011–12. The surveys were conducted between October 2011 and January 2012 and involved the use of "mobile devices" and software to record all data. Liparetrus beetles and *Chrysomelid* species (*Paropsisterna m-fuscum* and *P. variicolis*) continue to be the species most commonly reported affecting seedlings and juvenile trees, while Heteronyx beetles, and Eucalypt weevils (*Gonipterus* spp.) continue to be the most frequently reported insect pests in +3 year-old plantations.

8.2 Plantations (*Pinus radiata* and *P. pinaster*)

8.2.1 Insect pests of *Pinus* species

a). Borers (*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. No Sirex wood wasps (*Sirex noctillio*) were detected in any of the traps in the 2011-12 flight seasons.

b). Monterey pine aphid (*Essigella californica*)

Although *Essigell*a is present it is still not regarded as a problem in WA. Ian Dumbrell (DAFWA) is the WA representative on the Essigella biocontrol project steering committee. There have been four releases in winter 2011 of the control agent *Diaeretus essigellae*. Follow up monitoring is yet to be conducted to see if the wasp has become established.

c). European house borer (*Hylotrupes bajulus*)

Eradication activities transitioned to ongoing management in 2011, which will carry an increased risk of European House Borer (EHB) spread to non-infested areas.

To date, EHB has been found mainly in dead sections of live pine trees, dead pinewood material and untreated pine structural timbers. However, there has been one confirmed case of structural timber infestation in a home, resulting from nearby EHB infested trees. This discovery was made early last year in a Brigadoon home.

There has also been one case of timber infestation in Albany, where the timber had been transported from Perth.

While the EHB Response has achieved significant progress in the past six years in reducing EHB populations, further strategies for stakeholder groups are needed to contain these populations to already affected areas.

The Department of Agriculture and Food is undertaking consultation with stakeholders to discuss the transition impact and future management strategies. Most importantly, the transition will require increased support from industry, government and communities in carrying out EHB surveillance, and embracing future containment.

Throughout 2011, the EHB Response Program will focus on:

- extension and improvement of current EHB training for pest controllers.
- development of a national communication strategy for EHB education and awareness.
- continued State communication activities to ensure uptake of risk minimisation strategies.
- development of interstate quarantine regulations for the movement of EHB host materials from Western Australia.

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

No unusual activity.

e). Rutherglen bug (*Nysius vinitor*)

No unusual activity.

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

No unusual activity.

8.2.2 Pathogens of *Pinus* species

No significant issues.

8.2.3 Abiotic factors

a). Drought

Record low rainfalls over recent years, coupled with prolonged high temperatures, have resulted in widespread tree deaths in south-west WA. This has had a significant impact on forestry production, biodiversity, and visual amenity. Additionally, the large scale deterioration of both plantation and native forests has increased future bushfire risk as the impacts of the drying climate are expected to continue. There have been extensive losses of plantation pines in recent years and the effects of the drought continue to be monitored (Ian Dumbrell, DAFWA).

8.3 *Eucalyptus globulus* (Private Eucalypt plantations summary)

In most areas insect pests and disease levels reported over 2011–12 were generally low to moderate. The weather conditions over the spring and summer of 2011–12 were generally mild; with rainfall being average to slightly above average in most areas. These conditions allowed many trees to recover from spring defoliation of crown tops. Notably, pest damage and defoliation levels were greater in growing regions away from the coast (Manjimup to Collie and Mt Barker to Rocky Gully) that received below average rainfall. Liparetrus beetles and *Chrysomelid* species (*Paropsisterna m-fuscum* and *P. variicolis*) continue to be the species most commonly affecting seedlings and juvenile trees. The increased treatment of seedlings with systemic insecticides has seen a marked reduction in reports of seedling defoliation and pest related deaths throughout the estate. Heteronyx beetles, and eucalypt weevils (*Gonipterus* spp.) continue to be the most frequently reported insect pests in +3 year old plantations.

In the past there has been no formalised estate-wide surveillance and monitoring program for pests and diseases in Western Australian plantations. However, in 2011–12 for the first time, an industry-wide collaborative surveillance program was undertaken. The surveys were conducted between October 2011 and January 2012 (the peak pest season). The surveys involved:

(i) Stratification of the WA estate into 12 growing areas and 3 target age classes (1–3 yr-old, 4–7 yr-old and +7 yr-old),
(ii) Standardisation of survey methodology across companies to ensure comparable data sets and
(iii) The use of "mobile devices" and software to record all data.

Individual companies collected data for regions they had been allocated and all data was subsequently pooled into one database and results shared across industry. At present, reports and data are still mostly of a general nature as the system is still under development in most companies.

8.3.1 Insect pests

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

Generally low levels of damage were observed throughout the estate. Moderate to severe damage was reported for western interior areas (Manjimup-Collie). Similarly a number of plantations between Mount Barker and Rocky Gully also experienced moderate to severe damage. While collaborative surveillance was undertaken from October to January (2011), in western interior areas further damage was caused in February and March (2012). Defoliation levels in these areas went from low-moderate to severe (>50%). Monitoring in these regions may need to be extended over a longer period than in other areas.

b). Eucalypt leaf beetles (*Chrysomelidae* spp.):

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). Beetle *(Heteronyx* spp):

Heteronyx beetles continue to cause repeated damage to the tops of trees in young to mid rotation plantations from January to March (2012). Due to the large areas affected, the lack of resources and effective control options, formal surveys for this pest are not currently conducted. Plantations affected are east of Albany from Cheyne Beach to Wellstead and Esperance. It is estimated that around 3000-5000ha are affected annually.

d). Spring Beetle (*Liparetrus jenkinsi*):

Greater vigilance from foresters and the application of systemic insecticides to seedlings has led to fewer incidences of seedling defoliation by spring beetles when compared to previous years. Only one plantation near Rocky gully (about 500ha) was reported as being moderately damaged.

e). Birds:

Less damage caused by Port Lincoln parrots (commonly termed 28s) was reported in 2011–12 than in the previous year. Plantations west of Mt Barker and north of Donnybrook were reported as having moderate levels of damage.

8.3.2 Pathogens

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

Although *Tetratosphaeria* spp. damage is observed throughout the WA estate, plantations in the southern growing districts are most affected, particularly, around Denbarker, Mount Barker and the "Great Southern" coast (Wellstead to Walpole) **(**F. Tovar, Integrated Pest Management Group).

Table 2: Area of *E. globulus* plantation estate monitored and area affected by pests and pathogens in Western Australia in 2011-2012.*

Pest	**Area with moderate damage (ha)**					**Area with severe damage (ha)**					**Approx. area inspected (ha)#**	**Area treated (ha)#**	**Hosts**
	<10	**10-100**	**100-500**	**500-1000**	**>1000**	**<10**	**10-100**	**100-500**	**500-1000**	**>1000**			
Eucalypt weevil (*Gonipterus scutellatus)*					✓				✓				*E. globulus*
Heteronyx spp. **					✓					✓			*E. globulus*
Chrysomelid beetles			✓										*E. globulus*
"Spring" beetles (*Liparetrus* spp.)			✓										*E. globulus*
Wingless grasshopper (*Phaulacridium vittatum*)			✓										*E. globulus*
Parrots (*Banardius zonarius*)			✓										*E. globulus*
Rabbits		✓											*E. globulus*
PATHOGEN													

Teratosphaeria spp.										✓			*E. globulus*
WEEDS													
Kikuya grass				✓									*E. globulus*

* Data contained in the table is of a general nature and incomplete as a number of companies are still coming to terms with the new survey methods and others were unable to collect the necessary data.
** Data concerning *Heteronyx* spp. damage is an estimate based on anecdotal observations from foresters over many years.
# No information was provided to IPMG regarding areas inspected or treated **(**F. Tovar, Integrated Pest Management Group).

8.4 Other *Eucalyptus* spp. (*E. cadocalyx, E. maculata* and *E. saligna*)

8.4.1 Insect pests

No new pest outbreaks reported. Leaf blister sawfly (*Phylacteophaga froggatti*) in plantations of *E. saligna* and *E. botryoide* and spring beetle (*Liparetrus jenkinsi*) at the establishment phase of *E saligna*, *E cladocalyx*, and *E maculata* plantations continue to be monitored and managed.

8.5 Sandalwood (*Santalum spicatum*) plantations

No major insect or fungal problems reported.

8.6 Managed natural forests - Jarrah forest (*Eucalyptus marginata*)

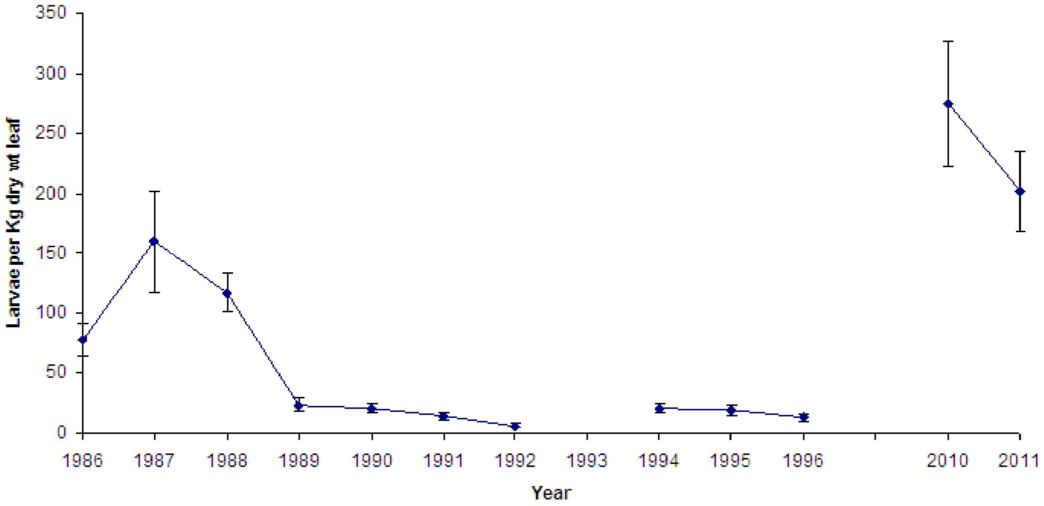
8.6.1 Insect pests

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

A survey of the JLM cut-out boundary was undertaken in October and November 2011, and results are currently being analysed (A. Wills and J. Farr, Department of Environment & Conservation).

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

The outbreak of Gum Leaf Skeletonizer (GLS) continued in Dec-March 2011–12. Population monitoring included: branch clipping at 61 sites throughout the jarrah forest (including 45 sites originally determined in the 1982-92 outbreak), and pheromone trapping using the New Zealand pheromone lure system. Areas subject to significant defoliation were not determined due to aircraft being committed fully to fire surveillance work. However, from general visual observation, area subject to defoliation had contracted and moved to forest adjoining areas which had been defoliated in the previous year. The mean larval density measured in December 2010 was 824 larvae kg^{-1} dry weight of leaf which was equivalent to a January population of 275 larvae kg^{-1} dry weight of leaf (adjusted for appropriate survival rates). Mean larval density as measured in December 2011, declined to 607.7 larvae kg^{-1} dry weight of leaf, equivalent to a January population of 202 larvae kg^{-1} dry weight of leaf (Graph 3). Therefore, although population levels declined from the 2010–11 levels, they were still high compared with non outbreak periods, such that some areas of forest again experienced nearly 100% defoliation (J. Farr, DEC).



Graph 3: Population of GLS in the southern Jarrah forest (± SE) as measured from canopy samples taken in January of the respective year from 1986-96 (Farr, unpublished data) and for the current outbreak in 2010-11. Data for 2010 and 2011 adjusted to January survival levels for comparison.

c). Cerambycid woodborers (*Phoracantha semipunctata*)

(Honours Project - Interaction of drought and the outbreak of *Phoracantha semipunctata* on canopy collapse)

The Eucalyptus long horned borer *Phoracantha semipunctata* Fabricius is an endemic cerambycid beetle to the Northern Jarrah Forest (NJF) of south-western Australia that attacks stressed trees. The population dynamics, distribution and biology of *P. semipunctata* in its native habitat are poorly understood. Following a recent drought event in 2010 patches of jarrah and marri trees throughout the NJF suffered high mortality with a noticeable increase in the borer populations. The aims of the present study were to determine the effect of this drought on *P. semipunctata* populations in jarrah (*Eucalyptus marginata* Donn ex Smith) and marri (*Corymbia calophylla* Hill) trees across the NJF and to determine if they would attack healthy adjacent trees, when their population levels were high. The association between the health of trees and *P. semipunctata* infestation was determined in standing dead, dying or healthy trees located in intact and collapsed areas of forest. Life cycle stages of *P. semipunctata* in terms of egg clutches, neonate feeding galleries, mature larvae and pupae in heartwood and adult emergence holes were determined by felling jarrah and marri trees (Figure 21). Distribution of *P. semipunctata* across the NJF was investigated by counting adult emergence holes in the bark of dead standing trees, dying or healthy trees at a number of collapsed sites (Stephen Steaton, supervisors G. Hardy and G. Matusick, Murdoch University).

Figure 21: *Phorocantha semipunctata* larvae *(left*), galleries and damage (*centre and right*) in jarrah (photos by G. Matusick).

8.6.2 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).

8.6.3 Abiotic factors

a). Frost

In June/July 2010 large portions of the northern jarrah forest experienced extreme low temperatures (-4 to -6º C) resulting in rapid foliage and shoot mortality of marri and jarrah (Figs. 22 & 23). Damage was restricted to drainage lines, which likely acted as cold-air sinks. Twelve plots (6 damaged/6 undamaged, each 40m fixed radius) were installed in Wandoo National Park (Talbot Brook) to collect baseline damage and track recovery. The hardest hit areas were those pockets of jarrah/marri surrounding Darken Swamp. Trees of all size classes were affected though variation was high on each site. Some marri trees experienced 100% defoliation and shoot loss (47% average), while jarrah was slightly less affected (23% foliage damage). Marri leaves discolored, dried, and died very quickly. Affected jarrah foliage first turned purple, then eventually died in spring. Most marri trees with complete defoliation reflushed large portions of their crowns. Most affected jarrah trees simply shed their shoots, with minimal evidence of resprouting. Wandoo was not affected. Research is continuing to determine low temperature tissue thresholds. Preliminary data suggested that more cell damage occurred exponentially between -4 and -6 degrees Celsius (G.Matusick, Murdoch University).

Figure 22: Frost affected patch in April 2010 *(left)* and an affected jarrah tree in December 2010 *(right)*.

In May 2012, these stands were affected by low temperatures and frost again and re-monitoring is scheduled to help track the severity of damage and recovery. Large areas of the Monadnocks Conservation Reserve were also affected and resulted in foliage and shoot mortality in marri and jarrah. Damage was restricted to drainage lines. Two transects were established to help describe the effect of elevation on shoot mortality and to track recovery. An aerial survey was undertaken in July 2012 to determine extent of the damage and images and crown health data is currently being analyzed (G. Matusick, K. Ruthrof and N. Brouwers, Murdoch University).

Figure 23: Marri seedling (*far left*) and jarrah crown (*left)* affected by frost in the Monadnocks Conservation Park (photos: K. Ruthrof).

b). Drought

Unprecedented drought-induced deaths in the Northern Jarrah Forest (NJF) observed starting late February 2011 (Figs. 24 & 25). Most damage occurred along the Darling Scarp from northern Perth to Pinjarra and in the western forest. Mortality occurred in over storey (jarrah/marri) and mid storey (*Banksia grandis/Allocasuarina*) in noticeable patches. An aerial survey of approx. 9% of the NJF resulted in an estimate of 1.6% of the area severely affected with an additional 5% showing strong crown chlorosis in late May. The rate of progression seemingly slowed through June, however, some sites continued to lose canopies through late July. All size and age classes of trees are affected. Most canopies died very quickly (within 5-7 days), losing their shoots and leaves within a month. The Western Australian State Centre of Excellence for Climate Change, Woodland and Forest Health together with the Department of Environment Conservation's Forest Management and GIS branch undertook surveillance work to accurately map the extent of the drought affected sites across the DEC forest estate and identified that dieback occurred:

(i) In areas that received a slightly higher amount of annual rainfall compared to the surrounding landscape,

(ii) In areas that were generally slightly warmer than their surroundings,

(iii) On sites that were close to rock outcrops, and

(iv) On steep slopes.

Several papers are due to be published in 2013 on findings from research conducted following the event (K. Ruthroff and N. Brouwers, Murdoch University).

Figure 24: Jarrah canopy mortality centres near Dale (*left*) and strongly chlorotic canopies surrounding mortality centre (*right*) (Photos taken May 2011).

Figure 25: Jarrah crown collapse and leaf shed (*above*) near Dale, east of Perth (Photo taken July 2011).

Drought-induced tree mortality also was also observed in about 500ha of tuart (*Eucalyptus gomphocephala*) in February and March 2011. Tree foliage rapidly discoloured and died over this period. A combination of remote sensing and field-based approaches are being used to characterize the extent and severity of canopy dieback following the event, as well as highlighted potential pre-disposing site factors (K. Ruthroff and N. Brouwers, Murdoch University).

8.7 Karri forest (*Eucalyptus diversicolor*)

8.7.1 Insect pests

No major pest problems reported.

8.7.2 Pathogens

No new major disease problems were reported. Management and survey of Armillaria root disease in re-growth karri forests continue to command attention.

8.7.3 Nurseries

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

An infestation of an undescribed *Phytophthora* taxon, (*P*. aff. *arenaria*), was found in a WA wheat belt nursery producing oil mallee (*Eucalyptus* spp.) seedlings, in 2012. This is being investigated further, including studies on its pathogenicity and mode of transmission.

8.8 Native plant communities

8.8.1 *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 involves routine testing of soil and root samples for the presence of *Phytophthora cinnamomi.* In addition to *P. cinnamomi*, six morpho-species of *Phytophthora* had been identified prior to 2005 using this technique (i.e. *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. Therefore, 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 725 isolates (both recent and historical, from the DEC's Vegetation Health Service collection) have now been compared to that of existing species and undescribed taxa. This work is continuing.

With the descriptions of *P. amnicola* and *P. bilorbang* being published in 2012, a total of eleven new species of *Phytophthora* have been described from WA natural ecosystems since 2009. The others are: *Phytophthora multivora, P. elongata, P. thermophila, P. gibbosa, P. gregata, P. litoralis, P. arenaria, P. constricta* and *P. fluvialis.* Pathogenicity has so far been tested and confirmed on native plants for *P. multivora*, *P. elongata*, *P. arenaria* and *P. constricta*. Several additional new WA taxa await formal description. In 2012, an infestation of one of these, *P*. aff. arenaria, was found in a WA wheat belt nursery producing oil mallee (*Eucalyptus* spp.) seedlings.

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

A number of hybrid Phytophthoras, with significant genetic diversity, has been identified from WA natural and plantation ecosystems: Some of these are from soil associated with dead plants, and many are 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*) 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. 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 dying native plants in WA natural ecosystems, with some DEC 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* (jarrah). *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.

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, while management and policy documents are now being updated to include the other *Phytophthora* species in the definition of Phytophthora dieback.

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 (T. Burgess, G. Hardy, D. White, and A. Rea, Murdoch University; M. Stukely, J. Webster and J. Ciampini, Department of Environment & Conservation).

8.9 Urban and rural

8.9.1 Pathogens and Declines

a). Mundulla Yellows (MY)

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, Department of Environment & Conservation).

8.10 Forest health surveillance and diagnosis

8.10.1 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 15,900ha was mapped to assist the planning of roading and timber harvesting operations undertaken by the Forest Products Commission (FPC), while FPC also arranged significant areas of mapping by private contractors. This included 7,815ha of previous mapping that was checked for further spread. Mapping and hygiene planning were undertaken on a further 863ha for the Parks and Visitor Services, Nature Conservation Service and Sustainable Forest Management Service of DEC, and 96ha for external parties. Training programs were carried out in disease mapping and hygiene management (G.Strelein, Department of Environment & Conservation).

In the year to 30th June 2012, a total of 2,198 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 *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, Department of Environment & Conservation).

8.11 South Coast region aerial phosphite program to mitigate *Phytophthora cinnamomi* impact

In autumn 2012, 165ha in the Stirling range and Albany coastal area were sprayed with phosphite (aerial application). The 165ha was comprised of 34 targets ranging from 1 to 72ha. The program targeted 15 threatened flora, of which 12 are critically endangered, and three threatened Ecological Communities/Priority Ecological Communities (i.e. Montane heath and thicket of the Stirling range; Montane mallee thicket of the Stirling Range and *Banksia coccinea* Shrubland/*Eucalyptus staeri*/ Sheoak woodland). Phosphite was applied at 30L/ha or 12 kg/ha using 40% phosphite. Threatened flora within targets is subject to long-term monitoring of survival and plant health. While the decline of highly susceptible taxa is ongoing, sprayed habitat continues to support threatened species and other susceptible species at higher densities than adjacent non-sprayed areas. The program has enabled the critical recovery action of ongoing collection of material for *ex-situ* conservation (S. Barrett, Department of Environment &

Conservation).

8.12 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, Department of Environment & Conservation).

8.13 Research and Development

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

A new project has been started to examine the impact and management of *Quambalaria* spp. Stem cankers were first recorded on marri in Pickering Brook in 1939–40 and by the late 1960's cankers were found to occur throughout the south west of WA. Since the 1970's mortality attributed to the pathogen has increased and by the 1990's there were recommendations that immediate attention should be given to determine its cause and to develop options for disease control. Paap (2006) showed the incidence and severity was increasing and that the large bleeding cankers on the trunk and branches were caused by a novel species, *Quambalaria coyrecup* (Paap *et al*. 2008). More than 80% of trees of all age classes are infected in some areas today. More recently, *Q. piterka* has been found causing severe shoot, bud, flower and fruit diebacks in marri (Marbus 2009). *Q. piterka* is an introduced pathogen from Queensland where it causes severe crown diebacks and death in *Corymbia maculata* (spotted gum) (Pegg *et al.* 2008). The decline and loss of marri has major economic, social and ecological implications, due to the costs associated with lost honey and pollen production, tree removal, wildlife habitats, including the critically endangered Baudin's and Carnaby's Black Cockatoos, conservation of roadside verges, amenity values such as shade, and the control of salinity and erosion by reforestation.

This project aims to:

- use and develop ground-based techniques to monitor, catalogue and understand the abiotic and biotic stress factors affecting marri throughout its range,
- experimentally confirm which biotic and abiotic factors associated with marri decline are contributors and determine their interactive effects on tree health,
- examine the biology and pathology of *Quambalaria* species currently affecting marri trees and quantify their collective role in decline,
- determine whether soil-borne plant pathogens and/or environmental (soil physical and chemical) or soil microbial factors are associated with the pre-disposition of trees to the *Quambalaria* canker and blight pathogens,
- determine whether single-tree treatments (i.e. nutrients, fungicides, insecticides, watering)

or stand-management manipulations can slow, halt, or reverse the rate of marri decline.
- develop sustainable management solutions for the long-term (T. Burgess, Murdoch University).