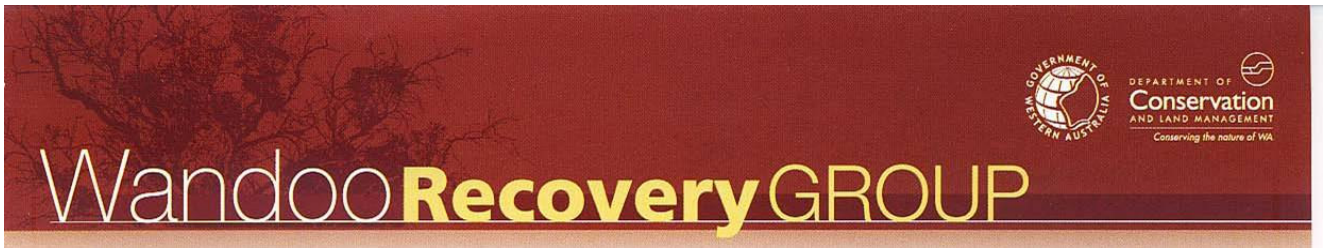

WANDOO CROWN DECLINE - SUMMARY OF RESEARCH

Background

Wandoo (*Eucalyptus wandoo* Blakely, white gum) is a widespread and ecologically valuable tree species of southwestern Australia. Wandoo occurs in valley floors of the jarrah forest belt, and in woodlands to the east of the jarrah forest, in what now constitutes the wheat belt of Western Australia. Mean annual rainfall in this region is generally 400-800 mm but can be as low as 300 and as high as 1100 mm. Wandoo grows, for Western Australian standards, on relatively fertile loamy to clayey soils, most commonly on valley slopes and floors. It usually grows in pure stands but may occur in association with several other eucalypts like jarrah (*E. marginata*), marri (*Corymbia calophylla*), powderbark wandoo (*E. accedens*), York gum (*E. loxophleba*), brown mallet (*E. astringens*) and salmon gum (*E. salmonophloia*).

Wandoo is under threat from the phenomenon of 'Wandoo Crown Decline' (WCD). In its earliest stage there is foliage death on terminal branches ('flagging'), which is often progressive, leading to tree death. Usually, affected trees produce epicormic branches, which may help to rebuild the crown, but if the condition of the tree is poor, these will also die. Wandoo crown decline was first observed in the 1980s, spread rapidly in the 1990s, and is now found throughout the species' distribution range.

Research

The Wandoo Recovery Group (WRG) was established in 2003. One of the WRG's key objectives is to promote, support and coordinate research into wandoo decline and recovery. Scientific investigations into the possible causes of decline are now underway. The WRG Research Strategy document provides guiding principles, aiming at an increased understanding of the relationships between climate, tree physiology and possible disease factors that could be contributing to wandoo decline.

The University of Western Australia (UWA) is the main research provider to the WRG. Current projects are in two main areas:
1. Tree physiology and ecology - are drought or other environmental stress factors the primary cause of poor wandoo health?; and
2. Pathology - are insects and fungi the agents responsible for the observed damage on wandoo crowns?

Tree physiology and ecology

The role of environmental stress factors in wandoo decline, in particular the impact of drought, is being investigated in UWA's School of Plant Biology. An initial survey of wandoo populations across the whole distribution range of the

species, from Three Springs to Mount Barker, and from Harvey to Merredin, revealed that there was no geographic pattern to poor health. Moreover, crown condition did not correlate with any climatic or soil factor, and chemical analysis of leaves did not point to nutritional concerns (nutrient deficiency or toxicity).

The focus of field research into the relationship between environmental stress and wandoo decline is on the potential impact of long-term drought. There is good evidence that rainfall in the past 2-3 decades has been below the long-term average, and that summers have become longer. Woodlands that receive less rainfall generally sustain fewer trees per hectare, and therefore long-term below-average rainfall may result in the natural thinning of tree stands. A key question is why a particular species, in this case wandoo, might be more susceptible to chronic drought than other eucalypts in the region. Pieter Poot and Erik Veneklaas at UWA aim at answering this question through field and greenhouse monitoring and experimentation. Locations were chosen in the Julimar forest, including mixed and pure stands of wandoo and powderbark wandoo, marri and jarrah. Tree water use (transpiration) and water status (tension of water in the stems and leaves) has been monitored across the seasons. Evidence thus far suggests that wandoo trees tend to be less 'economical' with water than co-occurring trees such as jarrah and marri. Wandoo trees continue to transpire when soils dry out, whereas jarrah and marri effectively reduce their transpiration. Wandoo's strategy presumably does not cause problems in years with normal rainfall, but seems risky during long-term drought.

Despite the fact that field surveys have not provided unambiguous evidence pointing to a single environmental factor that could be responsible for wandoo decline, there are two environmental stress factors that are affecting wandoo populations, to different extents depending on location, namely a decline in rainfall, and salinity. Tolerance to these stress factors is likely to differ between populations, e.g. wheat belt valley populations are more likely to have developed a degree of tolerance to salinity. Knowledge of the variation in stress tolerance among wandoo provenances is vital, for example for the purpose of selecting planting stock for revegetation. The PhD project of Eleftheria Dalmaris at the School of Plant Biology, UWA, aims at finding patterns in tolerance of wandoo to drought and salinity, and at identifying if the level of tolerance is correlated with the growing conditions or the genetic background of the population. Preliminary results, based on greenhouse screening trials, indicate that while there is variation in stress tolerance, which to some extent may be related to rainfall (moister versus drier sites), wandoo provenances are quite similar. Genetic data (collaboration with Dr Margaret Byrne, DEC) are not yet available.

Pathology

The pathology of Wandoo Crown Decline is being investigated by Ryan Hooper, as a PhD project in the School of Earth and Geographical Sciences, University of

Western Australia. The project addresses the hypothesis that: Insects and pathogens are more prevalent and damaging in recent years, due to changes in climate and subsequent alterations to landscape and site factors.

Previous work

A complex of borers and pathogenic fungi had been implicated in WCD, although the mechanisms and consistency of the relationship were not determined (Albone 1989). Brown and Tippett (1986) found 10 taxa of borer insects and two species of pathogenic fungi associated with declining *E. wandoo* in the Narrogin area, with species of Cerambycidae (longicorn beetles) causing most damage to stems. Mercer (1991, 2003) tested a wide variety of factors including rainfall deficit, fire history, "connectivity" of remnants, changes in land use, salinity, insect damage, and decomposition processes, but the role of these factors in the decline was unclear. In a reconnaissance survey of WCD conducted in 1999, three ubiquitous genera of canker fungi (*Cytospora, Botryosphaeria*, and *Harknessia*) were found associated with branch and twig cankers (defined as sunken or localized necrosis) of declining *E. wandoo*, although the incidence of branch-pruning cankers was observed to be sporadic and not always associated with "flagging" (Crane 1999; A. Wills, Department of Environment and Conservation (DEC), then known as CALM, personal communication, 2003). Instead, the recent insurgence of WCD has been linked to below-average rainfall years in 1997 and 1998 (Wills *et al*. 2001). However, anecdotal evidence suggests that the decline has been around for at least 40 years, so the role of drought is a contentious issue, as is the case with other declines (Landsberg 1985).

The long-term, progressive nature of WCD is consistent with the etiology of branch-pruning cankers, which are unlikely to cause rapid tree death. This is because internal spread of the fungus is often limited by host response, and dispersal may rely on rain splash or contact with vectors (Bathgate 1999; Old and Davison 2000). Several studies on decay processes affecting intact (living) branches of conifer hosts have also outlined the importance of latent infections in dispersal of certain fungal pathogens that are active only when conditions are favourable for pathogenesis (Boddy and Rayner 1982, 1983*b*, 1983*c*; Boddy *et al*. 1985; Chapela and Boddy 1988*a*, 1988*b*). Studies in Western Australia have focused on "opportunistic" fungal pathogens that rely primarily on wounds to gain entry into host tissues, although development of infection by these pathogens may well include a latent phase (Murray *et al*. 1994; Bathgate 1999). Initial observations of wandoo branches indicated that a characteristic "fusiform" canker and cracking was common on declining twigs and branches, and was found to be directly associated with insect borer galleries beneath surface tissue. Therefore, damage characteristics were assessed in healthy and declining stands to test the hypothesis that an interaction between wood borer(s) and fungal decay is responsible for decline of *E. wandoo* canopies. Three questions were asked:

1. Is damage caused by cankers and (or) borer(s) consistently associated with declining branches?

2. Are branch cankers causing foliage loss? and
3. Is the damage pattern widespread or are trees recovering?

Results from this work were published in the Canadian Journal of Forest Research (Hooper & Sivasithamparam (2005) 35: 2589-2602). The abstract is shown below and the full article can be accessed online: http://pubs.nrc-cnrc.gc.ca/.

Abstract: Crown decline of Wandoo, *Eucalyptus wandoo*, in southwest Western Australia has escalated over the last 10 years, so very few unaffected stands remain. To assess the canopy-damage characteristics of trees in decline a destructive, partial-harvest method was used to sample individual branches in natural mixed-age stands. Necrosis of common cankers was closely associated with type-1 borer damage, characterized by "longitudinal" gallery structure on declining trees only. Cankers were found to be consistently more severe on declining trees, with decay regions affecting a greater proportion of sapwood tissue. Several infestations causing type-1 borer damage that varied in age were found on declining branches, providing evidence of cyclical damage events. Type-2 borer damage characterized by "ring-barking" gallery structure caused extensive damage in canopies, but was not always associated with decline. Interactions between foliage density and canker score showed that 17.8% and 63.1% of the variability in foliage-density ratios was accounted for in declining intermediate-health and unhealthy classes, respectively. The relationship was negligible for the healthy class (9.9%), providing strong evidence that cankers are causing foliage loss in declining canopies. Evidence suggests that an interaction between type-1 borer infestations and decay-causing fungi is responsible for the decline in *E. wandoo* canopies.

Current work

Findings from this work provided the impetus for a PhD project commenced in 2004 investigating the influence of type-1 borer damage and associated decay-causing fungi over the region of wandoo. In particular, the taxonomy, biology, and ecology of organisms involved were to be elucidated. A combination of regular canopy sampling, molecular identification and other non-specific techniques, including pathogenicity testing are being used to fulfill this requirement. Another crucial factor is the question as to why these organisms are causing damage to such a degree at present. For this, relationships with landscape and site factors were to be tested. Various measurements were taken on reference trees in six locations across wandoo's range focusing on: tree water use, soil water balance, phenology and growth measurements. Results from these studies are due to be completed by the end of 2007.

Results thus far include:

- Quarterly surveys using a crown assessment method developed by K. Whitford and A. Wills (DEC) for use in community assessment, have shown April to May to be the peak period for decline symptoms. Comparison of nine

locations (1 sq km each) throughout the wandoo range has identified two locations as decline “hotspots”.

- By using aerial trapping and branch caging we have shown the “hotspots” to have more current borer galleries and higher populations of type-1 borer, whereas recovering stands have greater mean number of old type-1 galleries.
- Pathogenicity trials using most frequently isolated fungal species have shown five isolates out of 11 to cause significant lesions on healthy wandoo saplings. Molecular work is planned to identify fungal species and elucidate functional relationships between type-1 borer and pathogenic fungal species.

All results at this stage are preliminary and further work is being carried out by the research group.

Future research into Wandoo Crown Decline

Future research will aim to address links between environmental stress and susceptibility to pests and diseases. This hypothesis-driven research will be informed by large-scale mapping and monitoring of decline (DEC), as well as by historical research (History Department, UWA). Collaborations within the state and within Australia will further increase the volume of research and enhance synergies between tree decline scientists in different disciplines and different regions.

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