

## Wungong Catchment Trial

# Tree deaths in native forests and rehabilitated minesites in the Wungong Catchment



Report on field visits in May and June 2011

**Tree deaths in native forest and rehabilitated minesites  
in the Wungong Catchment,  
Northern Jarrah Forest**

**Report on a field visits in May and June 2011**

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Aerial photograph of Site N4 looking south east, 15 April 2011. Jarrahdale Road is in the foreground.

Photo: courtesy of the Water Corporation.

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<sup>1</sup> The view expressed in this report are those of the author, and not those of Curtin University

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## Summary

Field observations and aerial reconnaissance by employees of, and consultants to the Water Corporation noted many patches of dying and dead trees in the Wungong Catchment during the 2010/11 summer. The following observations were made on two visits to several affected sites in May and June 2011.

- Patches of dead trees are not distributed uniformly throughout the Catchment. Many patches are clustered, and are associated with rocky outcrops.
- Deaths are occurring in both native forest and on rehabilitated minesites, however the patches of dead trees in native forest are larger and may be more numerous than those on rehabilitated minesites.
- Few or deaths were seen in thinned forest.
- Tree deaths are not restricted to a single species, jarrah (*Eucalyptus marginata*), marri (*Corymbia calophylla*), casuarina (*Allocasuarina fraseriana*), bullich (*E. megacarpa*) spotted gum (*C. maculata*), red mahogany (*E. resinifera*) and bull banksia (*Banksia grandis*) are all affected.
- There is considerable abscission of small branches with attached leaves from dying eucalypts in native forest; on the rehabilitated minesites there has been considerable abscission of leaves rather than whole branches.
- Understorey plants do not appear to be affected.
- Tree deaths are occurring in all size classes and ages in native forest.
- Basal areas of affected stands are from 24 to 34 m<sup>2</sup>/ha in native forest, and from 13 to 32 m<sup>2</sup>/ha on rehabilitated minesites.
- Occasional tree deaths have occurred previously on affected sites but not to the same extent as has happened in 2010/2011.
- Deaths do not necessarily appear to be associated with very shallow soil. Soil depth on some sites was greater than 80 cm.
- Preliminary examination of trees with dead crowns showed that the inner bark and sapwood was still moist, so some trees may produce coppice shoots in the coming months.
- Many of the dying trees in native forest sites had insect borers in them, indicating that the trees had been under moisture stress for several months before the foliage had died.

As the aim of the Wungong Catchment Trial is to determine whether silvicultural treatments will increase winter streamflow and run-off into the Wungong Dam, one recommendation is to determine whether streamflow from the most severely affected sub catchments will be greater than would be expected if there had not been any tree deaths.

## Introduction

The Wungong Catchment covers an area of 12,845 ha about 60 km south east of Perth. It is being intensively researched by the Water Corporation to determine whether silvicultural treatments will increase streamflow and run-off into the Wungong Dam ([http://www.watercorporation.com.au/W/wungong\\_index.cfm](http://www.watercorporation.com.au/W/wungong_index.cfm)). The catchment is in the northern jarrah forest, and comprises both cut-over native forest and rehabilitated mine sites. The area has been monitored by the Water Corporation and its consultants since 2005, so a considerable amount of background information is available.

In the summer of 2010/2011 trees started dying on many sites throughout the catchment. Although most deaths were in patches there were also some isolated ones. Aerial reconnaissance on 15 April 2011 observed that these deaths covered 5-10 % of the total catchment area ([http://www.watercorporation.com.au/\\_files/Wungong/Wungong\\_Whispers\\_Newsletters/Wungong\\_Whispers\\_May\\_2011\\_Vol\\_12\\_online.pdf](http://www.watercorporation.com.au/_files/Wungong/Wungong_Whispers_Newsletters/Wungong_Whispers_May_2011_Vol_12_online.pdf)). An initial field visit was made to some affected sites in native forest on 10 May, with Michael Loh (Water Corporation), Frank Batini (consultant) and Phil Shedley (Institute of Foresters of Australia). A second field visit was made to patches of dying trees on rehabilitated minesites on 10 June with Michael Loh, Frank Batini, Keith Barratt (consultant) and Peter Davison. The aim of these visits was to determine whether there were any obvious causes of tree death. Eleven sites were visited in total, five affected and one unaffected in native forest, and five affected sites on rehabilitated minesites (Fig. 1). Similar observations and measurements were made at each site, including species affected, basal area, stocking, soil type and depth to 80 cm, whether there had been deaths previously, and whether there were any obvious signs of pests and pathogens in the affected trees. A tree was categorized as being dead when there were no green leaves in the crown. This may be an underestimate of the number of trees which will eventually die.

This report presents some general observations about the sites where these deaths have occurred, the tree species and other plants affected, and the possible cause of these deaths. Details about each site visited are presented in appendices. It also makes some suggestions for more detailed work that would better define the sites where trees have died, and why these deaths had occurred.

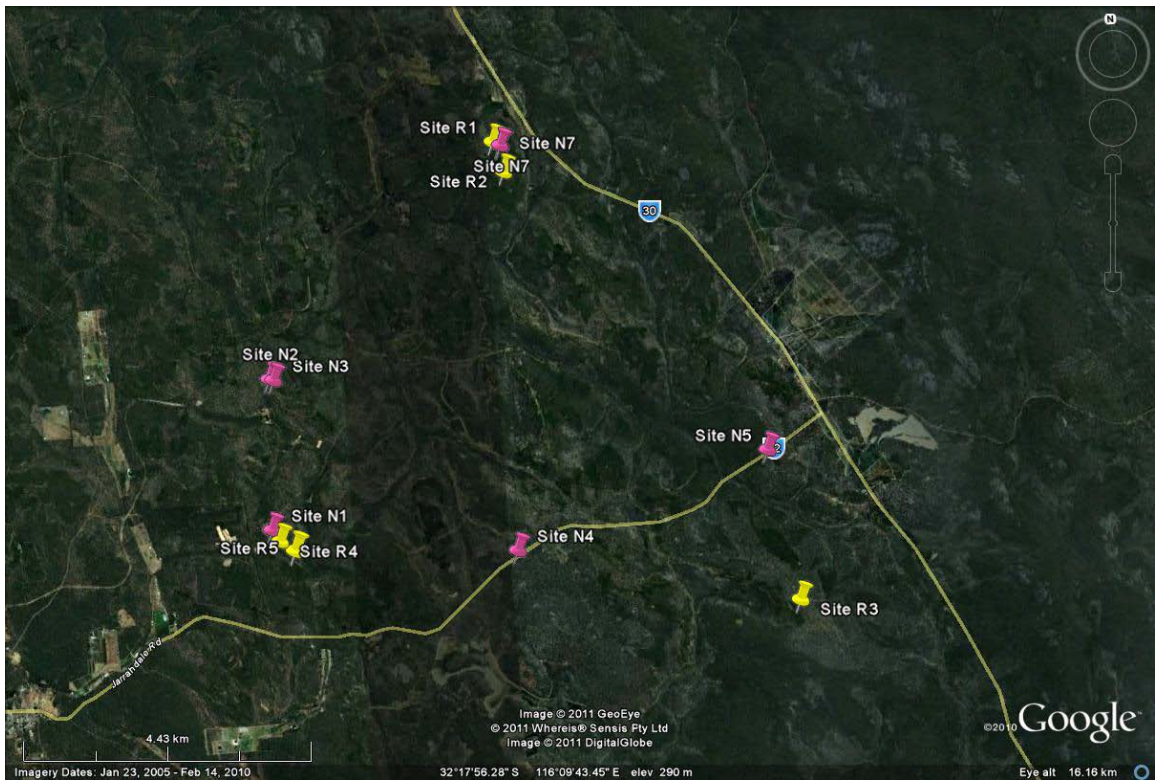


Figure 1. Location of sites in native forest (pink markers) and on rehabilitated minesites (yellow markers) visited in May and June 2011.

## General observations

### General description of the sites and of the affected trees

Aerial photography from 15 April 2011 shows that the patches of dead trees were not evenly distributed throughout the catchment. Many of these patches, but not all, were clustered, and were associated with rocky outcrops (Fig. 2 and 3). These deaths had occurred in both native forest and on the even aged stands on minesites that had been rehabilitated between 29 and 11 years earlier (Fig. 1), however the patches of dead trees in native forest appeared to be larger (up to 5 ha in area) than those on the rehabilitated minesites where the patches were less than 1 ha in extent. Few or no deaths have occurred on thinned sites (F. Batini pers. comm.).

Tree deaths were not restricted to a single species. Most deaths were of jarrah (*Eucalyptus marginata*), the dominant species. Other species that have died are marri (*Corymbia calophylla*), casuarina (*Allocasuarina fraseriana*), bullich (*E. megacarpa*) spotted gum (*C. maculata*), red mahogany (*E. resinifera*) and bull banksia (*Banksia grandis*). All ages and size classes have been affected in the native forest. The basal area of affected stands varied from 24 to 34 m<sup>2</sup>/ha in native forest and 16 to 32 m<sup>2</sup>/ha on rehabilitated minesites. The number of stems per ha varied from 300 to 500 in native forest, and from 600 to 1300 on rehabilitated minesites.

In many of the affected native forest stands there were a large number of dead leaves under the trees (Fig. 4), resulting from the clean abscission of crown units (Fig. 5). This was different from the situation on the rehabilitated minesites where abscission was mainly of leaves, rather than whole crown units (Fig. 6).

It was only the trees that appear to have been affected; in native forest stand there were no obvious deaths in the understorey (Fig. 7). On the rehabilitated minesites there were very few understorey plants (Fig. 8).

The sites where tree deaths have occurred in both native forest and on rehabilitated minesites are sites where deaths have occurred in the past, especially in 2007 (F. Batini, pers. comm.). In some cases the complete tree had died, in other cases the primary crown had died and the tree had regenerated by coppice and/or epicormic shoots at the stem base. This was particularly evident on the rehabilitated minesites (Fig. 9 and 10).

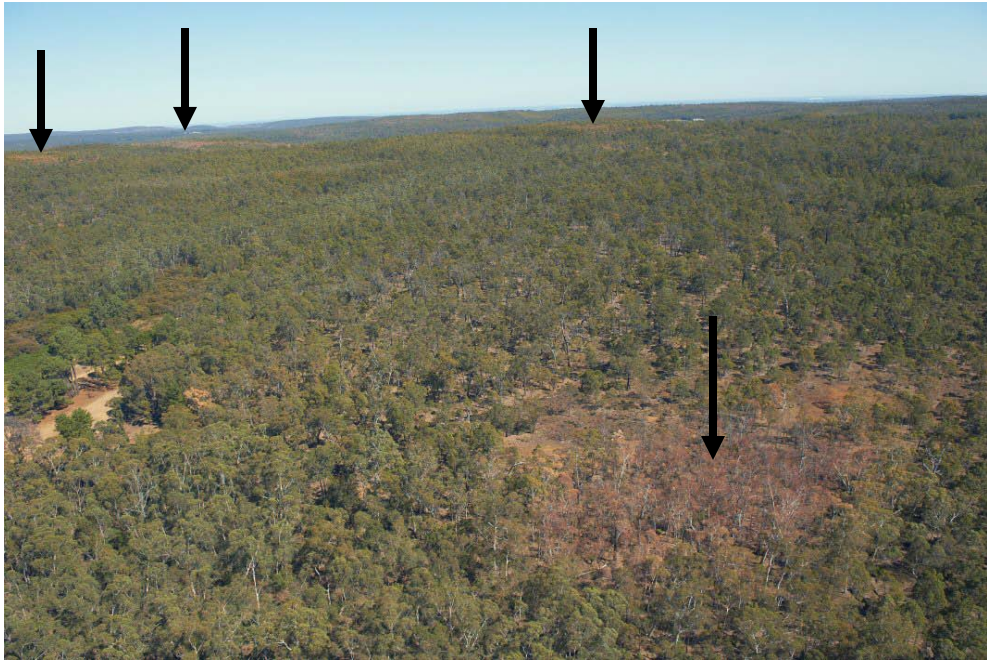


Figure 2. Aerial photograph close to Site N2, looking south. Arrows indicate patches of recent deaths. Photo: courtesy of the Water Corporation.

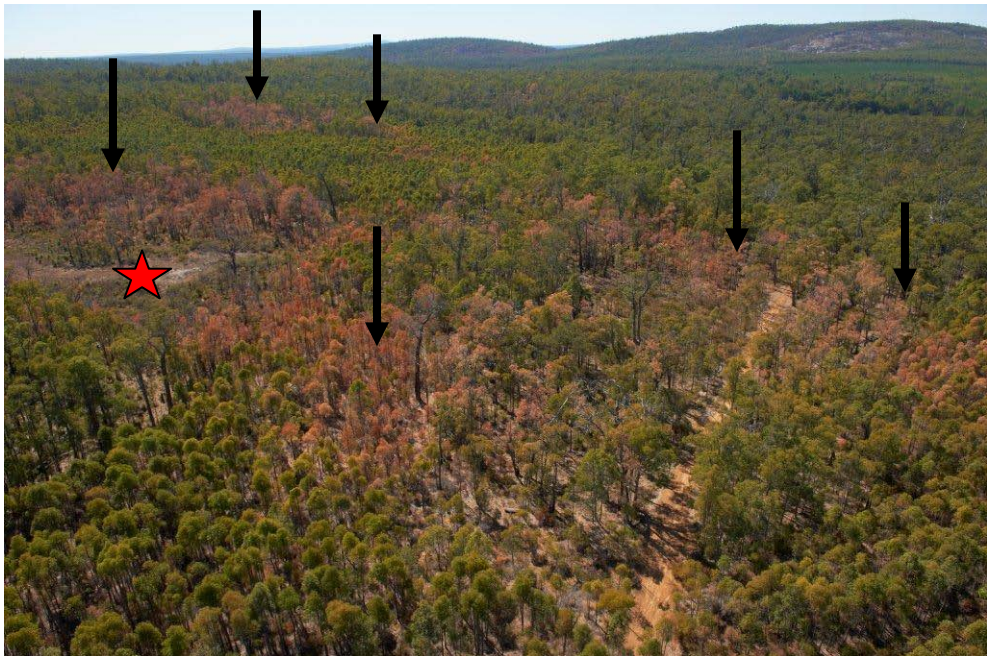


Figure 3. Aerial photograph close to Sites N7 and R1 and 2, looking north east. Arrows indicate patches of recent deaths, the star indicates a rocky outcrop. Photo: courtesy of the Water Corporation.





Figure 4. Abscised crown units under recently dead jarrah trees in native forest (Site N7).



Figure 5. The abscised end of a crown unit from jarrah, showing a clean, chalky break, rather than a ragged break



Figure 6. Leaf litter, rather than abscised crown units under recently dead jarrah on rehabilitated minesite (Site R3).



Figure 7. The understorey is unaffected in native forest even though many trees have died (Site N4).



Figure 8. On rehabilitated minesites the understorey is almost completely lacking (Site R1).



Figure 9. Jarrah tree where the primary crown has died but which has reshot from epicormic shoots at the base of the stem (Site R2).



Figure 10. Coppice shoots developing at the base of a jarrah sapling with a dead crown (Site R3).

### Possible causes of tree death

The assumption has been made that tree deaths are the result of low rainfall over the past decade, and especially in 2010, and that these deaths are on sites with shallow soil, such as Sites N1, N4, N7, R1, R2, R3, R4 and R5. The soil depth at two sites (Sites N2 and N5) is greater than 80 cm (the maximum depth that could be measured with the available equipment). On the rehabilitated minesites the soil would have been ripped to a depth of 1-1.5 m during site preparation, so that root penetration, would be greater than indicated by soil depth between the rip lines.

On all the native forest sites the trees appear to have been under moisture stress for a prolonged period because many have prematurely abscised branches from their crowns (Fig. 4 and 5). Also a number have well developed borer larvae in the cambial area, and these borers will only attack drought stressed trees.

There was no indication of death being associated with pathogenic invasion in the native forest trees, or in the majority of trees on the rehabilitated minesites. On one minesite however, several trees had large, conspicuous basal cankers at the root collar (Fig. 11). The common fungal pathogens *Cytospora* and *Endothia* were isolated from these cankers. These fungi are pathogens of stressed trees.



Figure 11. Basal canker at the on spotted gum (Site R5).

## Discussion

One of the aims of the Water Corporation is to increase streamflow by reducing stand density by thinning the forest. A reduction in stand density in unthinned areas has now happened in an uncontrolled way as a result of these extensive tree deaths. There is, however, understandable concern relating to why these deaths have occurred, and whether it would have been possible to predict the sites where mortality has been highest. Any further work to better define the sites where tree deaths have occurred needs to be done collaboratively between the Department of Environment and Conservation and the Water Corporation.

The preliminary observations in this report do no more than indicate how these deaths can be better characterized, and how the conditions that have led to these deaths can be better defined. Deaths are not confined to a single tree species, but have occurred in jarrah, marri, sheoak, bullich spotted gum, red mahogany and bull banksia. Inspection of additional sites may show that deaths have also occurred in blackbutt (*E. patens*) in native forest, and in other tree species used in the rehabilitation of mine sites.

It was not determined whether one species in the native forest was more severely affected than others, or whether all size classes were affected equally. This could be done by determining the proportion of dead to live trees of each species and size class on a number of affected sites, and this would be a worthwhile exercise. This information would be useful in better defining the impact on tree stands.

The assumption has been made that these are drought deaths. This is supported by the low rainfall over the past decade, especially in 2010, the observation that many patches of dead trees are clustered close to rocky outcrops, and many sites have shallow soil (eg soil depth was less than 80 cm on Sites N1, N4, N7, R1, R2, R3, R4 and R5). On all sites the trees appear to have been under moisture stress for a prolonged period because many have prematurely abscised leaves and/or branches from their crowns (Fig. 4, 5 and 6). Also a number have well developed borer larvae in the cambial area, and these borers will only attack drought stressed trees. The sites where deaths have occurred in 2010/2011 are sites where trees have died in the past, or where the primary crown has died and the trees have regenerated from coppice shoots (Fig. 9). Previous mortality, however does not appear to be as extensive as that which is occurring at the present. It is likely that some of the trees will produce epicormic and/or coppice shoots (Fig. 10) once there has been substantial rain, although this recovery may only be short lived, as has occurred on Site N1.

### **Recommendations**

- 1 Determine whether streamflow from the most severely affected subcatchments in the 2011 winter will be greater than would be anticipated if there had been no tree deaths. Any effects however, may be masked by the depressed water tables that have developed over the past decade, and the large annual variation in streamflow due to rainfall.
- 2 Establish by remote sensing the extent and location of dead and dying trees.
- 3 Conduct a more detailed investigation into deaths that have occurred on sites which are not adjacent to rock outcrops to determine whether these have a relatively shallow soil profile that will restrict rooting depth.
- 4 If possible, review Alcoa's drilling records of the sites detailed in this report, and other affected areas, to determine soil characteristics and depth.
- 5 Determine whether there are any sites close to rock outcrops where trees have not died, and why this has not happened.
- 6 Establish permanent plots in some affected areas to determine whether there is any recovery of trees which have dead crowns, and whether there is regeneration by seedlings.
- 7 Conduct a more extensive survey to determine whether all tree species and all size classes of tree are equally affected.

### **Acknowledgements**

I thank Mr. Michael Loh, Water Corporation, for providing aerial photographs, transport and field assistance, Mr. Frank Batini, consultant, for site selection and field assistance, Mr. Phil Shedley, Fellow Institute of Foresters of Australia, for field assistance and advice, Mr. Keith Barrett , consultant, for advice and Dr. Peter Davison for assistance with aerial photography and mapping.

## Appendix I, Sites in native forest visited 10 May 2011

### Site N1, Chandler Road

*Location:* 32° 18' 59" S 116° 6' 35" E (zone 50H 6424139 N, 416208 E), 340 m

*General site description:* a basin with a rocky outcrop close to the surface. Soil depth 10 cm in the centre of the depression, >60 cm at the margin of the depression.

*Health status:* Highly stressed with many dead trees, however the mid- and understorey are unaffected (Fig. 12). Close to a large area of dead trees (Fig. 13). Tree deaths have occurred previously on this site, particularly in the summer of 2007 following a dry winter. Many of these apparent dead trees coppiced the following year, and have died in 2010/2011 (Batini pers. comm.).

*Total area affected:* about 5 ha

*Havel vegetation type:* R with elements of S. Jarrah and marri dominant, casaurina also present.

*Basal area:* 24 m<sup>2</sup>/ha (live trees 14 m<sup>2</sup>/ha, dead trees 10 m<sup>2</sup>/ha)

*Stems/ha:* total 500 (250 live, 250 dead)

*Girth of largest dead stems:* jarrah 1.88 m, marri 2.20 m

*Pest or pathogen attack:* borer larvae in some trees, no sign of pathogenic invasion



Figure 12. Site N1. Recently dead trees around a rocky outcrop which is close to the surface.



Figure 13. Aerial photograph showing the area close to Site N1, with extensive deaths in native forest and rehabilitated, unthinned forest on the right of the road. There are no deaths in the thinned area, on the left of the road. The location of Figure 4 (Site 1) is indicated by the arrow, the precise location is not apparent because of changes in slope and obliquity of the aerial photograph.



**Site N2, Upstream of Chandler dam**

*Location:* 32° 17' 45" S 116° 6' 39" E (zone 50H 6426440 N, 416290 E), 300 m

*General site description:* a valley with a dense stand of bullich. Soil depth >80 cm; the soil is a lateritic loam.

*Health status:* All of the trees have died (Fig. 14); the understorey is unaffected. Occasional deaths have occurred previously on this site.

*Total area affected:* about 1 ha

*Havel vegetation type:* C

*Basal area:* 26 m<sup>2</sup>/ha (all dead)

*Stems/ha:* total 300 (all dead)

*Girth of largest stems:* bullich 1.60 m



Figure 14. Site N2, recent deaths in bullich stand, the understorey is unaffected.

**Site N3, Upstream of Chandler dam, adjacent to and downslope of Site 2**

*Location:* 32° 17' 46" S 116° 6' 41" E (zone 50H 6426397 N, 416336 E), 290 m

*General site description:* a valley with a dense bullich stand. Soil depth >80 cm; the soil is a lateritic loam.

*Health status:* No dead trees (Fig. 15); the understorey is unaffected. No deaths have occurred previously.

*Total area affected:* area unaffected

*Havel vegetation type:* C. This site has previously been a jarrah site, as indicated by several old stumps

*Basal area:* 24 m<sup>2</sup>/ha (all live)

*Stems/ha:* total 450 (all live)

*Girth of largest stems:* jarrah stump 4.12 m



Figure 15. Site N3, healthy bullich stand adjacent to the dead stand on Site N2.

**Site N4, Jarrahdale Road**

*Location:* 32° 19' 18" S 116° 8' 57" E (zone 50H 6423590 N, 419923 E), 300 m

*General site description:* upper slope. Soil depth 40 cm; the soil is lateritic gravel.

*Health status:* Very stressed with many dead trees; the mid- and understorey are unaffected (Fig. 16). No previous tree deaths on this site.

*Total area affected:* about 2 ha

*Havel vegetation type:* P. Jarrah/sheoak/marri.

*Basal area:* 28 m<sup>2</sup>/ha (live trees 6 m<sup>2</sup>/ha, dead trees 22 m<sup>2</sup>/ha)

*Stems/ha:* total 300

*Girth of largest stems:* jarrah (recent death) 2.62 m, marri 2.20 m

*Pest or pathogen attack:* borer larvae in some trees, no sign of pathogenic invasion



Figure 16. Site N4 showing deaths in the overstorey trees, with unaffected understorey.

**Site N5, Demonstration plot 1, unthinned, Jarrahdale Road**

*Location:* 32° 18' 38" S 116° 11' 26" E (zone 50H 6424840 N, 423804 E), 305 m

*General site description:* mid to lower slope. Soil depth >80 cm; the soil is a loamy gravel.

*Health status:* A few dead and dying jarrah trees; the understorey is unaffected (Fig. 17, 18).

There have been occasional tree deaths previously on this site.

*Total area affected:* < 0.5 ha

*Havel vegetation type:* S or ST. Jarrah/marri.

*Basal area:* 28 m<sup>2</sup>/ha

*Stems/ha:* total 500

*Girth of largest stems:* jarrah 2.40 m,

*Pest or pathogen attack:* Possible Armillaria infection in a dead marri



Figure 17. Site N5, Demonstration plot 1, unthinned jarrah stand showing dying crowns.



Figure 18. Aerial view of Site N5 (arrow), Demonstration plot 1, unthinned jarrah stand showing some dying crowns. A: adjacent thinned stand; B: wildfire damage in the background.

**Site N7, Adjacent to a track north of Beefarm Road**

*Location:* 32° 16' 2" S 116° 9' 5" E (zone 50H 6429638 N, 420066 E), 315 m

*General site description:* upper slope. Soil depth 30 cm; the soil is sandy gravel. General view Figure 20.

*Health status:* Many dying jarrah trees; the understorey is unaffected (Fig. 19). One previous death (more than 10 years ago) on this site.

*Total area affected:* < 1 ha

*Havel vegetation type:* S. Jarrah.

*Basal area:* 34 m<sup>2</sup>/ha (24 m<sup>2</sup>/ha live, 10 m<sup>2</sup>/ha dead)

*Stems/ha:* total 350

*Girth of largest stems:* dead jarrah 2.50 m



Figure 19. Site N7, deaths of large jarrah trees, understorey unaffected.



Figure 20. General aerial view close to Site N7, showing rocky outcrop in the foreground.

## Appendix II Sites on rehabilitated minesites visited 10 June 2011

### Site R1, Adjacent to a track north of Beefarm Road (Close to Site N7 visited on 10 May 2011)

*Location:* 32° 15' 55" S 116° 06' 00" E (zone 50H 6429837 N, 419932 E), 320 m

*General site description:* about 20 m from the edge of the pit. Site sloping down towards a rocky outcrop. Soil depth 65 cm, sandy gravel.

*Rehabilitation date:* P 1995; 16 years old

*Health status:* some dead jarrah (Fig. 21) and casuarinas trees, but the majority are healthy, although there were some past deaths in 2007 (F. Batini pers. comm.).

*Total area affected:* less than 1 ha

*Vegetation:* mainly jarrah with occasional marri, casaurina, bull banksias, water-bush and acacia.

*Basal area:* 21 m<sup>2</sup>/ha (live trees 11 m<sup>2</sup>/ha, old deaths 6 m<sup>2</sup>/ha, recent deaths 4 m<sup>2</sup>/ha)

*Stems/ha:* total 1250 (650 live, 350 old deaths, 250 recent deaths)

*Stand height:* 8-12 m

*Pest or pathogen attack:* borer larvae in some trees, no sign of pathogenic invasion



Figure 21. Site R1. Showing a small area of recent jarrah deaths.



## Site R2

*Location:* 32° 16' 10" S 116° 09' 06" E (zone 50H 6429380 N, 420109 E), 320 m

*General site description:* about 30 m from the edge of the pit. Soil depth 55 cm, sandy gravel.

*Rehabilitation date:* P 1995; 16 years old

*Health status:* small patch of dead jarrah trees (Fig. 22), but the majority appear healthy, although there were past deaths in 2007 (F. Batini pers. comm.).

*Total area affected:* less than 1 ha

*Vegetation:* mainly jarrah with occasional marri, and acacia.

*Basal area:* 32 m<sup>2</sup>/ha (live trees 11 m<sup>2</sup>/ha, old deaths 16 m<sup>2</sup>/ha, recent deaths 5 m<sup>2</sup>/ha)

*Stems/ha:* total 1300 (350 live, 900 old deaths, 50 recent deaths)

*Stand height:* 10-12 m

*Pest or pathogen attack:* no borer larvae seen, no sign of pathogenic invasion



Figure 22. Site R2. Small area of dead jarrah crowns in an area where deaths had occurred in the past.

### Site R3

*Location:* 32° 19' 52" S 116° 11' 39" E (zone 50H 6422581 N, 424157 E), 340 m

*General site description:* about 70 m from the top of the pit. Upper slope, sloping steeply down the centre of the old pit. Soil depth 30 cm, sandy gravel, frequent large boulders.

*Rehabilitation date:* P 2000: 11 years old

*Health status:* some dead jarrah trees (Fig. 23), but the majority are healthy, although there have been some past deaths.

*Total area affected:* less than 1 ha

*Vegetation:* mainly jarrah with occasional marri and casaurina.

*Basal area:* 17 m<sup>2</sup>/ha (live trees 8 m<sup>2</sup>/ha, old deaths 3 m<sup>2</sup>/ha, recent deaths 6 m<sup>2</sup>/ha)

*Stems/ha:* total 750 (450 live, 150 old deaths, 150 recent deaths)

*Stand height:* 8-10 m

*Pest or pathogen attack:* no borer larvae seen, no sign of pathogenic invasion. One tree reshooting at the base.



Figure 23. Site R3. Recent jarrah deaths.