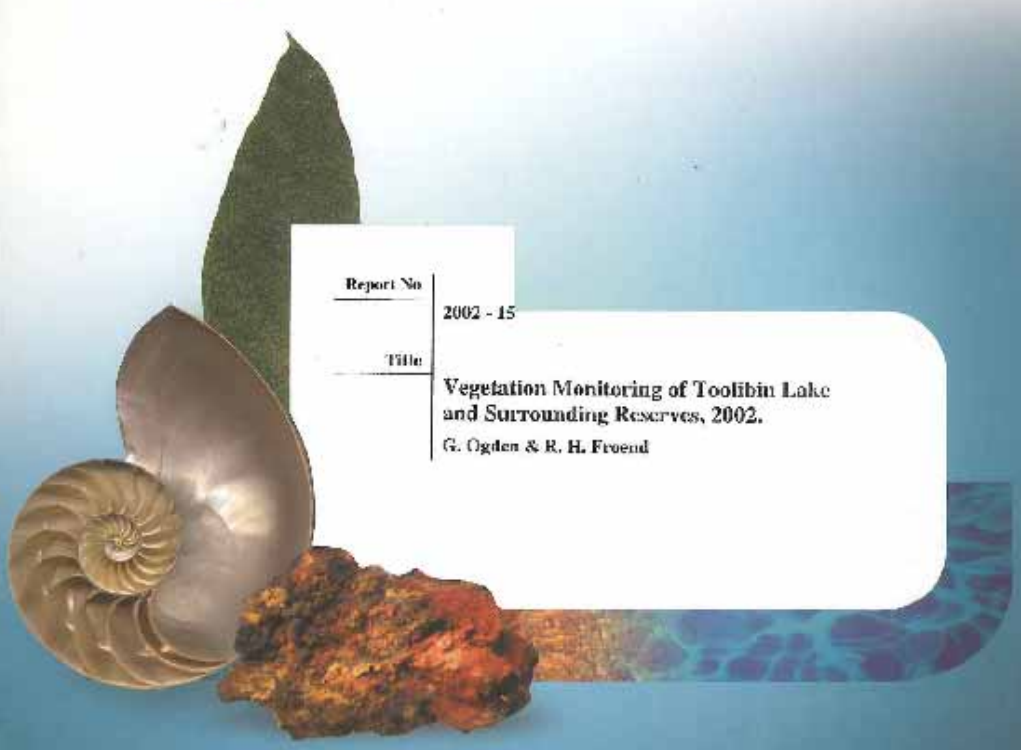
EDITH COWAN UNIVERSITY
PERTH WESTERN AUSTRALIA



Report No
2002 - 15

Title
Vegetation Monitoring of Toolibin Lake and Surrounding Reserves, 2002.

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CENTRE FOR ECOSYSTEM MANAGEMENT

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Summary

The wetland trees of Lake Toolibin and reserves continue to show a decline in vigour. The *Melaleuca strobophylla* population has declined severely. Eighty percent of the *M. strobophylla* trees within the monitoring plots are now dead compared to 40 percent in 1998. This trend is also apparent in the vegetation plots established in 2000 with an increase in dead *M. strobophylla* of more than 25 percent. Very few healthy individuals can be found in the monitoring plots or elsewhere on the lake bed. The *Casuarina obesa* population shows a slight decline with a approximately 3% of the trees moving from the "healthy" to "stressed" vigour class and fewer than 4% of the trees dying within the last 4 years. The understorey plant community on the lake bed and in other seasonally wet areas shows a continuing trend toward salt tolerant species. Germination and establishment of *C. obesa* is continuing on the lake bed around pump 9 with the number of seedlings increasing significantly in the last 4 years.

The terrestrial tree species of the Toolibin reserves have shown little change since 1998. The most notable change has occurred in the *B. prionotes* community in the south-east reserve where the number of dead individuals has increased by more than 40%. Other areas of *B. prionotes* woodland appear in relatively good health.

The recent history of below-average rainfall is likely to have serious consequences with respect to mature tree survival and seedling establishment. Some of these consequences are already evident in the significant decline of mature trees across the lake bed but continued dry conditions are likely to exacerbate salinisation impacts. Recent investigations by ECU at Toolibin Lake have shown that both mature trees and seedlings of *C. obesa* and *M. strobophylla* are very dependent on rainfall to surface soils. Direct rainfall is the primary water source during dry periods (no or low inflow events) and is required to leach salts from the rhizosphere in the absence of shallow saline watertables.
Similarly, the impact of the current drought on terrestrial vegetation is likely to be significant. Some impacts may already be observed in the dramatic decline in the *B. prionotes* woodland as reduced water source availability imposes further stresses on a senescent plant population.

In light of the results presented in this report, the following recommendations are made;

1) **Continue the vegetation monitoring using the Salinity Action Plan protocols at least every 3 years to ensure quantitative data on vegetation response is available. Given the rapid decline in the *M. strobophylla*, yearly monitoring may be advisable.**
2) **Monitor the seedling transects (plots 39-41) every year for seedling number, seedling height and soil salinity (EM38) to build an understanding of the factors influencing recruitment.**
3) **Establish seedling monitoring plots for *M. strobophylla* seedlings on the west side of the lake and for the saplings on the eastern side.**
4) **Develop the strategies required to actively manage recruitment and recovery of *C. obesa* and *M. strobophylla* within the lake and *B. prionotes* in the surrounding reserves.**

5) **Assess and extend the existing trial revegetation programme and include terrestrial vegetation trials.**
6) **It is recommended that management strategies include rabbit and kangaroo control programs to minimise the impact of grazing on natural seedling recruitment and planted seedlings. Herbivore control may be extended (at the operational level) to include fencing of recruitment near pump 9 and culling of kangaroo population.**

1. Introduction

As part of the Toolibin Lake Recovery Plan, The Department of Conservation and Land Management (CALM) oversees and implements the monitoring of lake and reserve vegetation composition and health. The monitoring is an integral part of the Recovery Plan and has been conducted since 1977 when a baseline flora and vegetation survey was conducted for the Northern Arthur River Wetlands Rehabilitation Committee by Mattiske Consulting.

The baseline work involved the establishment of 22 monitoring plots and the mapping of plant communities and their status and condition. Four additional plots were established in 1980 in the reserve to the north of the Lake, to record the impact of burning and clearing activities. Of these 26 plots, eleven are located on the lake bed, with the remainder located in the reserves to the north east of the lake. Reassessment of the plots was conducted in 1980, 1982, 1986 and 1992.

In 1983, additional research plots were established by Dr Ray Froend, Edith Cowan University, to investigate the causes of lake bed tree mortality. Four plots were established in this study, one across the Northern Arthur River channel, two plots on the lake edge with similar elevational gradients and vegetation zonation but differing soil conditions, and a plot located on the lake bed with no elevational gradient.

Five more vegetation plots were added in 1998, 2 in the *Banksia prionotes* woodland in the south east of the reserve and 3 on the lake bed. The lake bed plots were located in the west and south west areas of the lake to improve the coverage in these areas and to replace the plots lost during construction of the separator channel.

The 1998 Vegetation Monitoring of Toolibin Lake and Reserves found a general decline in the health of both the aquatic and terrestrial vegetation in most of the 30 plots sampled. Some recovery of trees was noted in certain areas of the lake, particularly in the vicinity of pump 9 on the western side where significant numbers of seedlings were found. This improvement in both the tree health and soil salinity was likely to be in response to the effectiveness of the groundwater pump. The existing vegetation monitoring plots were not well located to monitor the effectiveness of the network of groundwater abstraction bores so in 2000, five additional plots were established on the lake bed in close vicinity to pumps 1, 2, 12, 13 and 15. Independent monitoring of the seedling recruitment around pump 9 was also undertaken in 2000 and these transects have now been formally marked and added to the Lake Toolibin vegetation monitoring plots. The system of monitoring plots now consists of 18 plots on the lake bed, 2 in the reserve to the east of the lake, 15 in the reserves to the north east and 3 seedling transects on the west side of the lake.

In the 1998 monitoring, all existing plots were upgraded to the standard of the Salinity Action Plan Wetland Vegetation Monitoring program and all new plots have been established using this

methodology. Regular (every three years) monitoring of these plots using the Salinity Action Plan methods was a key recommendation of the 1998 report.

The following was undertaken for the 2002 vegetation monitoring of the Toolibin Lake and reserves:

1. Resurvey and reassess all existing monitoring plots consistent with the methodology used by Froend *et al*. (1998).
2. Permanently mark and survey 3 seedling transects on the western side of the lake near pump number 9 including EM38 measurments.
3. Discuss management options in light of the results of the 2002 vegetation monitoring.

2. Methods

2.1 Overview of the Salinity Action Plan Methodology

The SAP Program methodology used in the 1998 reassessment involved the collection of a significant amount of additional data on biotic and abiotic factors. The methodology used was specifically designed to address change in wetland vegetation floristics, physiognomy, individual plant vigour and population vigour and dynamics in response to long-term changes in hydrology and salinity. An overview of the various components of the SAP methodology follows (how this methodology was applied to the Toolibin plots is discussed later):

1) Transect establishment.

   The location of each transect determined using GPS and marked on maps for future reference. All location markers and tags are metal. Transects made up of contiguous 20 x 20 m quadrats running perpendicular to the shoreline into upland vegetation. Each of the 20 x 20 m quadrats divided into five 4 x 20 m quadrats. Photographs taken each monitoring year from two marked reference points. Site data such as, topographic position, slope, aspect, surface soil characteristics, litter and water depth recorded.

2) Floristic composition.

   Within each 4 x 20 m subplot of each 20 x 20 m quadrat all overstorey species and large understorey species (>1.5 m) identified. All trees tagged and given a unique reference number. Data for each overstorey subplot will be kept distinct to determine gradient transitions. Understorey 4 x 4 m subplots focus on species < 1.5 m. Presence of seedlings of tree and large shrub species recorded in overstorey sub-plots.

3) Density and foliage cover.

   Density of overstorey and understorey species determined for each subplot. Percentage foliage cover for each understorey species determined by direct measurement of (two foliage diameter measurements at right angles) each individual within each 4 x 4 m subplot. The foliage cover of understorey species without distinct projected foliage area, such as sedges and rushes, estimated as a percentage of the subplot area. Percentage canopy cover determined for each 20 x 20 m quadrat.

4) Physiognomy.

   Height ranges for each vegetation strata measured within quadrats and subplots. Profile diagrams depicting vegetation structure constructed for each transect.

5) Tree vigour.

The vigour of each individual tree within overstorey subplots categorised using a subjective 3 factor system based on crown density, presence of dead branches and epicormic growth.

6) Population dynamics.

Size class structure of key tree species determined by measuring height and diameter at breast height (DBH) of each individual in each 20 x 20 m quadrat. Seedling recruitment events recorded in the field when found.

7) Distribution of wetland plant communities, populations.

The different structural units of vegetation at each wetland mapped from aerial photography and ground truthing. At the transect scale, distribution of plant populations or community types is related to hydrology and salinity. The ground level (in relation to the deepest point in the lake) at each end of the 4 x 20 m overstorey subplots is measured using an auto level and staff. These relative levels are converted to mAHD if suitable benchmarks exist. The elevational gradient along each transect can then be compared to wetland water levels (information from other CALM and WRC SAP projects) and the water regime determined for different positions on the transect. Where available, historical wetland water levels will be related to vegetation distribution to identify past impacts and explain current distributions.

8) Physico-chemical parameters.

Transects are located adjacent to piezometers (if present) established as part of the Wetland Monitoring Project. Information on groundwater level and salinity is vital to correct interpretation of vegetation change. Surface soil salinities at each transect measured each monitoring year using an EM 38 and validated with limited soil sampling and direct measurement (EC of 1:5 soil:water extracts).

9) Database

All data collected as part of the wetland vegetation monitoring project are databased using Microsoft Excel and presented to CALM in digital form on an annual basis.

2.2 Plot Establishment and Maintenance

Each plot was subdivided into subplots for measurement of understorey and overstorey vegetation. From the north-west corner of each plot, 4 x 20m subplots were marked out with measuring tapes running in a southerly direction for assessment of the overstorey. Understorey subplots were then established at the northern end of each overstorey subplot to provide a set of contiguous 4 x 4m understorey plots (Fig. 2.1).

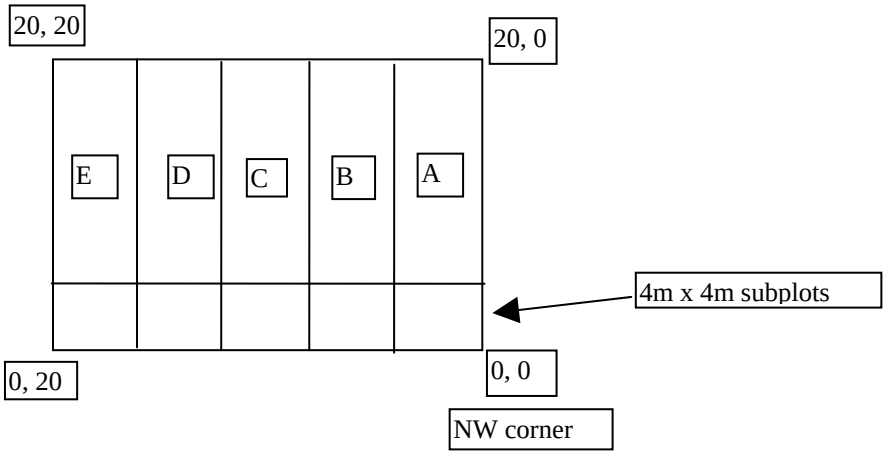

Figure 2.1 Plot Design

Where plot markers were missing, the original location was determined with tapes and an optical square and a new star picket installed. All tree tags were inspected and replaced where necessary. Some trees, which have increased in girth significantly have either begun to enclose the head of the nail or push the tag off the nail. Attempts to remove the nails appeared to do more damage to the tree than simply leaving the nail. Most tags that had worn through from swinging on the nail were found and reattached or replaced with a new tag. The majority of the remaining tags were bent over the nail head to prevent this from occurring in the future.

More regular inspection of the trees within the monitoring plots may be necessary to prevent tags and nails damaging vigorously growing trees.

2.3 Overstorey

For each tree within each 4 x 20m subplot, the tag number, diameter at tag height and crown condition was recorded. Stem diameter was measured directly under the tag if nailed or at breast height if wired onto the tree. In the case of individual trees with multiple stems, all stems were measured at the same height as the position of the tag or at breast height.

Crown assessment was carried out using a subjective three-part scale where a score is recorded for crown density, dead branches and epicormic growth. Using diagrams for comparison, crown density is given a score out of nine, dead branches a score out of nine and epicormic growth a score out of five (Ladd, 1996) (Fig. 2.2). The higher the overall score, the better the condition of the tree. For the purpose of comparison with previous results, crown assessment values less than or equal to 11 were considered stressed and values greater than 11 considered healthy.

In dense stands of trees, stand height was measured with a clinometer and tape measure and presented as a height range for each species present. In open woodlands, height was directly measured for each tree. Number, species and height of seedlings was also measured within the 4 x 20m subplots.

2.4 Understorey

Within the 4 x 4m subplots, all perennial understorey plants were identified and percentage foliage cover determined by direct measurement (two foliage measurements at right angles) or percentage estimate. Height ranges for each species was also recorded.

2.5 Soil Salinity

EM38 measurements, which determines soil conductivity over 1-1.5m depths were taken at three points across each plot, every 4m along the transect. Adequate distance was always allowed when measuring near the fence posts or other metallic objects in the plots. EM38 data was validated against direct conductivity measurement of one soil sample taken at the north west corner of each plot. For plots 39 to 41, vertical and horizontal EM38 measurements were taken down the centre of the 5m wide transects every 5 metres from 0 to 100m. Salinity measurements are interpreted using the Agwest Soil Salinity Classes for Revegetation (Agwest, 2002) which provides a more accurate comparison for EM38 data than the modified Hunt and Gilkes (1992) scale used in the1998 report.

2.6 Reference Photographs

Two reference photographs were taken at each plot. Photograph A is taken from approximately 1m directly behind the north west corner post facing diagonally across the plot and photograph B from the opposite side of the plot diagonally back towards the north west corner. Digital copies of all photographs are included on the CD-ROM attched to this document.

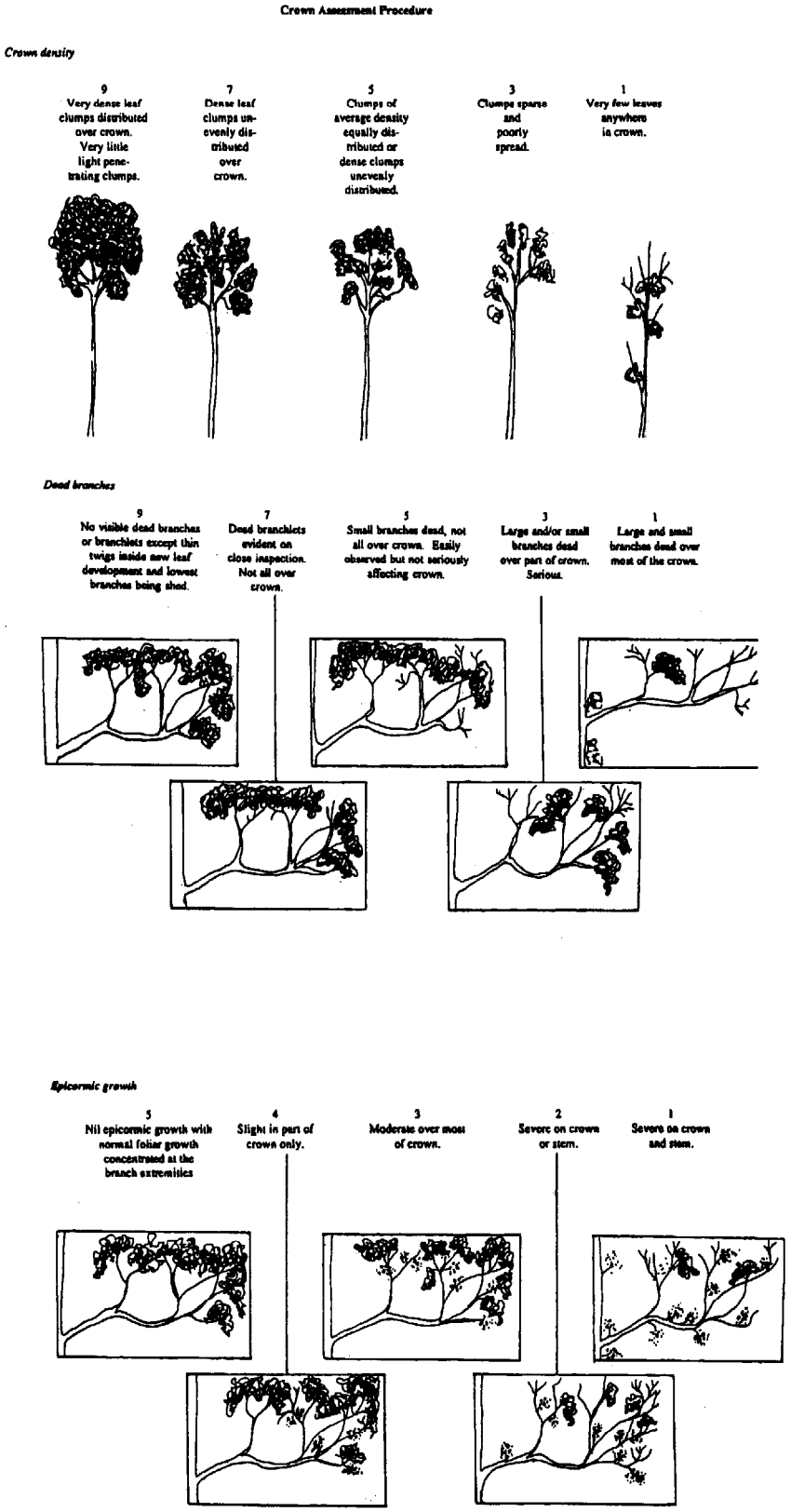

Figure 2.2: Crown Assessment Procedure Diagrams (Ladd, 1996).

3. Results

No results are presented for Plots 1,2 and 14. Plots 1 and 2 were destroyed during the construction of the separator channel. Plot 14, near Dulbinning Lake, could not be located in 1998 or 2002.

Key results for each vegetation plot are presented including vegetation description, tree vigour trends, salinity trends and a reference photograph. Tree vigour categories are Healthy (H), Stressed (S) and Dead (D).

Overstorey data for each plot sampled in 2002 are presented in Appendix 1. This includes species composition, DBH, height and crown health. Appendix 2 is comprised of the vigour vs time tables for the dominant species of each plot. This data set includes information since 1977 (since 1983 for plots 32 and 33; since 1998 for plots 27 to 31 and since 2000 for plots 34 to 38) for all plots monitored. The understorey data are presented in Appendix 3 and include the density, % cover and height of perennial species. Soil salinities, as determined with the EM38, are presented in Appendix 4. Appendix 5 contains seedling number, seedling height and EM38 data for the three transects established in April 2000 to monitor the *C. obesa* recruitment on the west side of the lake around pump 9.

Plot 1 and 2: Destroyed during construction of separator channel.

Plot 3

Location: E 555961; N 6357279

West side of the lake bed. North of pump 9.

Vegetation Description:

Low woodland of *Casuarina obesa*. Understorey of *Halosarcia lepidosperma* and *Maireana brevifolia*

Condition in 2002 and Trend To-date:

Most of the *C. obesa* trees are dead with the majority of the live trees in poor health. Overstorey condition remains unchanged since 1998. Eleven *C. obesa* seedlings were found in this plot, all in good condition. Soil salinities remain moderate to high, favouring the increasing density of samphires in the understorey.

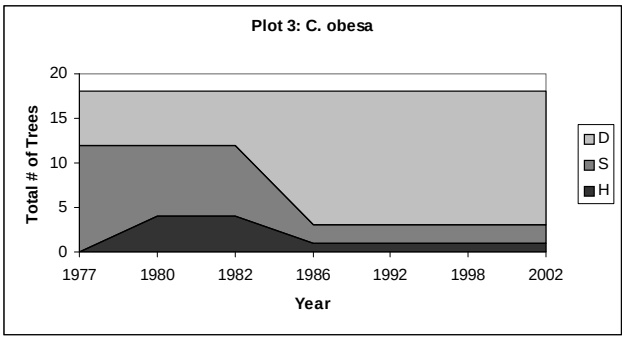

Figure 3.1: Trend in the vigour of the dominant species at Plot 3

Plate 1: Facing diagonally across Plot 3

Plot 4

Location: E 556207; N 6357274

West side of the lake bed. North east of Pump 9.

Vegetation Description:

Woodland of *Casuarina obesa – Melaleuca strobophylla*. Understorey consists of *Halosarcia lepidosperma* and *Atriplex semibaccata*.

Condition in 2002 and Trend To-date:

The decline in overstorey vigour is continuing despite decreasing soil salinity. Maximum values in 1998 exceeded 700 mS/m while the 2002 survey found conductivity below 400 mS/m. All *M. strobophylla* trees are now dead with the more salt tolerant *C. obesa* trees in decline. A significant number of *M. strobophylla* seedlings (15) are present in this plot and in the surrounding area which suggests salinities are within the tolerance range for germination and establishment.

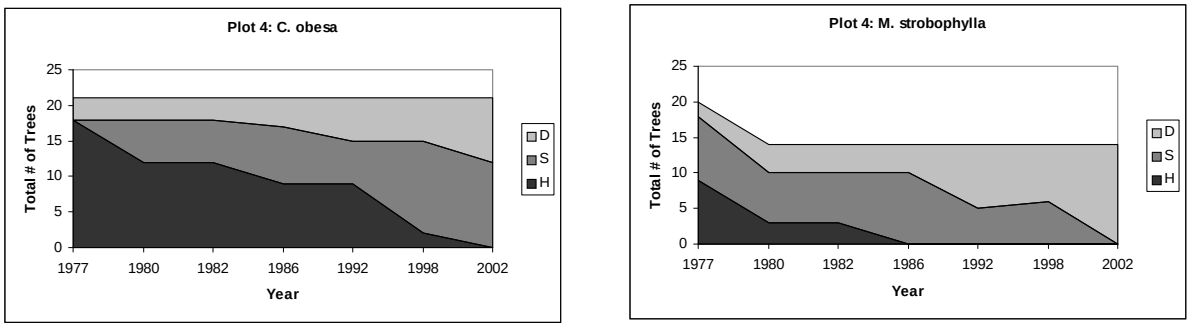

Figure 3.2 : Trend in the vigour of the dominant species at Plot 4

Plate 2 : Facing diagonally across Plot 4

Plot 5

Location: E 556207; N 6357274

West side of the lake bed (Adjacent to Plot 4).

Vegetation Description:

Woodland of *Casuarina obesa – Melaleuca strobophylla*. Dense stand in parts (closed canopy). Large number of younger plants. Understorey of *Atriplex semibaccata* and *Halosarcia sp.*

Condition in 2002 and Trend To-date:

The dense stands of *C. obesa* and *M. strobophylla* sampled in plot 5 have shown a steady decline in canopy condition over the last 10 years. Of the 60 live *M. strobophylla* trees surveyed in 1998, only 20 remain alive with the majority of these trees in poor condition. Similarly to plot 4, the *C. obesa* population remains in better condition however many of these individuals are now showing signs of stress.

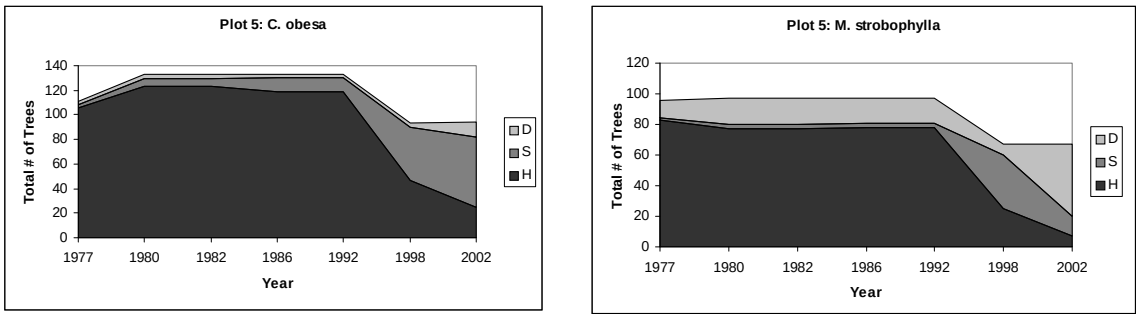

Figure 3.3 : Trend in the vigour of the dominant species at Plot 5

Plate 3 : Facing diagonally across Plot 5

Plot 6

Location: E 557135; N 6357456

Eastern edge of lake bed.

Vegetation Description:

Initially an open woodland of *Eucalyptus rudis*. Understorey of *Halosarcia lepidosperma* and *Atriplex semibaccata*.

Condition in 2002 and Trend To-date:

All trees are dead and have been since 1980. The understorey shows a slight increase in density of *Halosarcia sp.* with *Atriplex semibaccata* occurring throughout much of the plot. Soil salinities are lower than in 1998 but remain moderate to high.

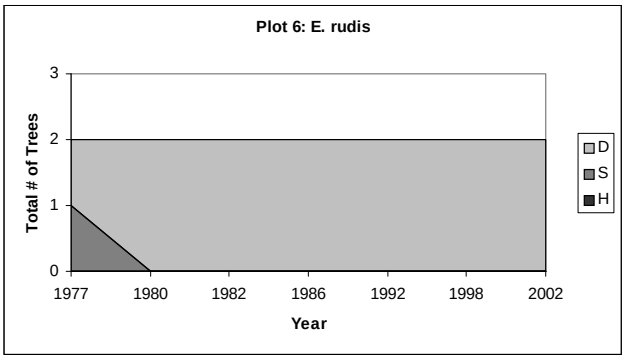

Figure 3.4 : Trend in the vigour of the dominant species at Plot 6

Plate 4 : Facing diagonally across Plot 6

Plot 7

Location: E 557335; N 6357490

Eastern edge of lake bed, to the east of Plot 6.

Vegetation Description:

Open woodland of *Casuarina obesa – Eucalyptus rudis*. Sparse understorey of *Halosarcia lepidosperma*, *Maireana brevifolia* and *Atriplex semibaccata.*

Condition in 2002 and Trend To-date:

All *E. rudis* are dead and have been since 1986. The vigour of *C. obesa* declined significantly in 1986 and 1992 but increased in 1998, indicating a revival of the adults of this species. The condition of these trees has remained essentially unchanged since 1998. The soil salinity is high and understorey composition shows a trend toward increasing density of samphires and *Atriplex sp.* Three *Eucalyptus* seedlings are present however the species of these seedlings is unclear.

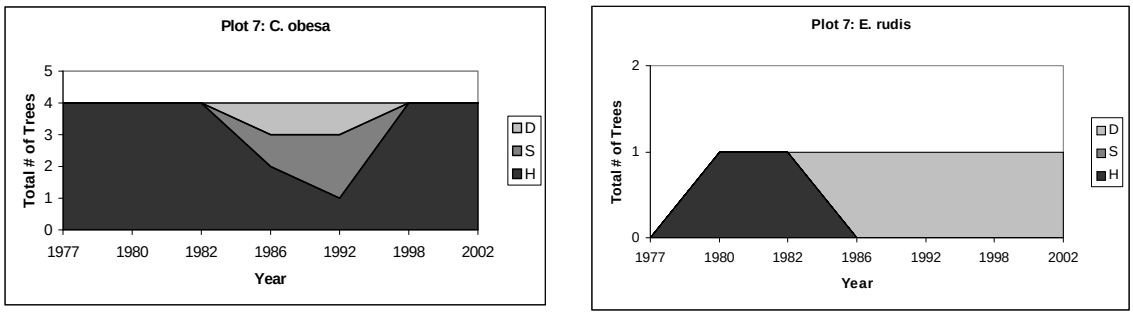

Figure 3.5 : Trend in the vigour of the dominant species at Plot 7

Plate 5 : Facing diagonally across Plot 7

Plot 8

Location: E 557196; N 6357571

Eastern edge of lake bed.

Vegetation Description:

Surrounded by an open woodland of *Casuarina obesa – Melaleuca strobophylla*. The plot itself has never contained any trees and has a sparse understorey of *Halosarcia lepidosperma.*

Condition in 2002 and Trend To-date:

No trees present. Soil salinities are high to very high.

Plate 6 : Facing diagonally across Plot 8

Plot 9

Location: E 557411; N 6357712

Eastern fringe of the lake bed.

Vegetation Description:

Woodland of *Casuarina obesa – Melaleuca strobophylla*. No understorey.

Condition in 2002 and Trend To-date:

The *M. strobophylla* population has been in poor condition since assessment began and all individuals were dead by 1998. The *C. obesa* vigour has declined steadily since 1982 with a significant decrease since 1992. There is no understorey. Soil salinities are high.

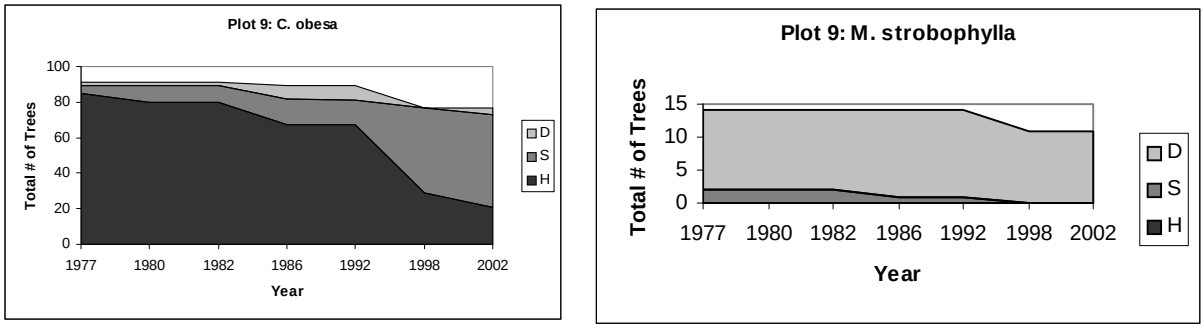

Figure 3.6 : Trend in the vigour of the dominant species at Plot 9

Plate 7 : Facing diagonally across Plot 9

Plot 10

Location: E 556949; N 6357788

Northern end of lake bed.

Vegetation Description:

Open woodland of *Casuarina obesa*, *Melaleuca strobophylla* and *Eucalyptus rudis*. Understorey of *Halosarcia lepidosperma* and *Atriplex semibaccata*.

Condition in 2002 and Trend To-date:

The *C. obesa* trees show a very slight decline in condition since 1998. Of the 2 *M. strobophylla* trees present in the plot, both are now classified as stressed. Soil salinities are high to very high. Both *Halosarcia lepidosperma* and *Atriplex semibaccata* have increased in density.

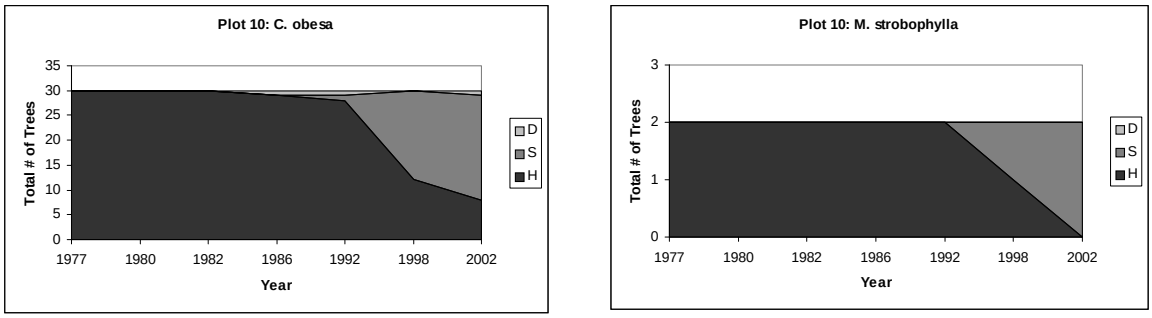

Figure 3.7 : Trend in the vigour of the dominant species at Plot 10

Plate 8 : Facing diagonally across Plot 10

Plot 11

Location: E 556874; N 6358247

Northern lake edge.

Vegetation Description:

Originally a woodland of *Eucalyptus rudis* with substorey of *Melaleuca strobophylla* and *Casuarina obesa*. Now an open woodland of *C. obesa* with a dense understorey of *Halosarcia lepidosperma* and *Halosarcia indica.*

Condition in 2002 and Trend To-date:

The condition of the *C. obesa* trees has remained stable since 1998. Soil salinities are very high and the understorey continues to be dominated by dense *Halosarcia sp.*

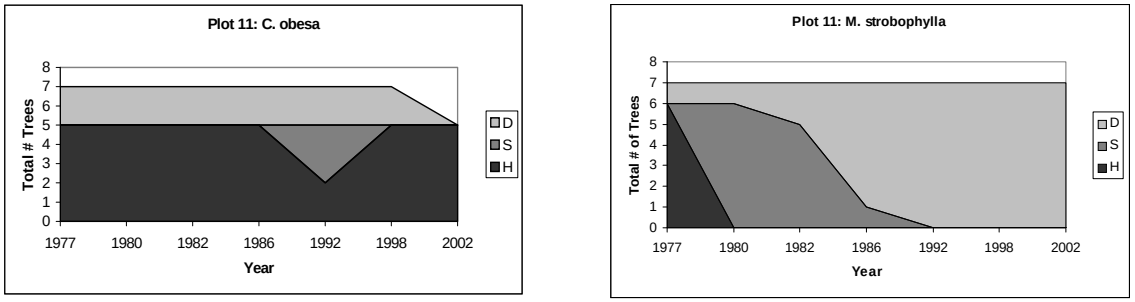

Figure 3.8 : Trend in the vigour of the dominant species at Plot 11

Plate 9 : Facing diagonally across Plot 11

Plot 12

Location: E 556994; N 6358428

On sandy soils to the north of the lake.

Vegetation Description:

Woodland of *Eucalyptus loxophleba* with a substorey of *Acacia acuminata* and *Allocasuarina huegeliana*. Understorey dominated by *Atriplex semibaccata* and *Stipa elegantissima.*

Condition in 2002 and Trend To-date:

There has been minimal change in the vigour of the dominant overstorey species. The increase in the total number of *A. acuminata* is due to successful seedling establishment over the monitoring period. No perennial species are present in the understorey plots however *Atriplex semibaccata* and *Stipa elegantissima* are scattered elsewhere in the 20 x 20m plot. Soil salinity is low.

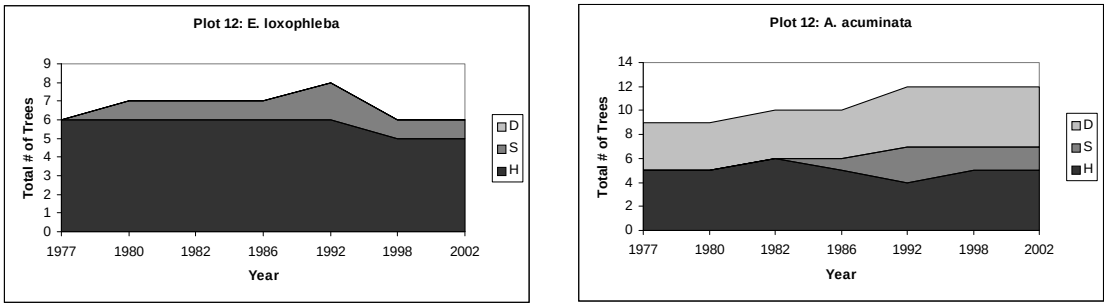

Figure 3.9 : Trend in the vigour of the dominant species at Plot 12

Plate 10 : Facing diagonally across Plot 12

Plot 13

Location: E 557451; N 6358719

North of the lake, roadside.

Vegetation Description:

Low open forest of *Allocasuarina huegeliana – Banksia prionotes*. *Banksia attenuata* also nearby on sandy soils. Diverse understorey dominated by *Jacksonia furcellata*.

Condition in 2002 and Trend To-date:

The condition of the *A. huegeliana* population continues to improve with seedlings and saplings persisting and growing vigorously. Four additional *A. huegeliana* seedlings were observed and the seedlings recorded in 1998 have grown significantly. One *B. prionotes* sapling was discovered which was not present in 1998. The mature *Banksia prionotes* trees remain in good condition. Many of the mature *Jacksonia furcellata* have died but are generally being replaced with seedlings. Soil salinity is low.

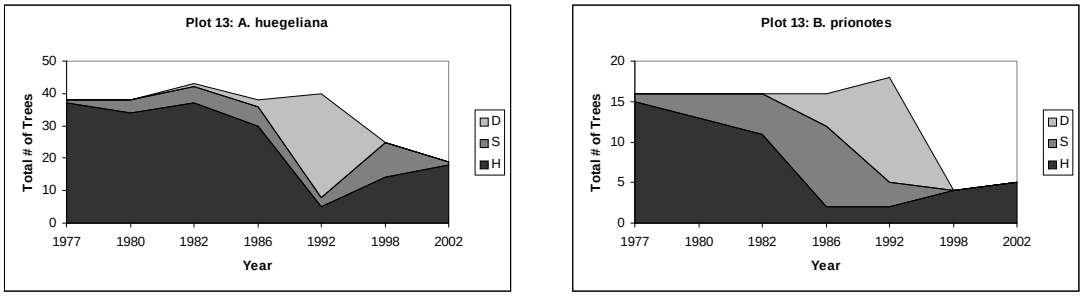

Figure 3.10 : Trend in the vigour of the dominant species at Plot 13

Plate 11 : Facing diagonally across Plot 13

Plot 14: Unable to locate in 1998 and 2002.

Plot 15

Location: E 559612; N 6360638

On northern fenceline of Dulbinning Nature Reserve, south of dam in adjacent property.

Vegetation Description:

Open woodland of *Eucalyptus salmonophloia – Eucalyptus wandoo*. Understorey of *Gahnia ancistrophylla, Lomandra micrantha* and *Daviesia debilior.*

Condition in 2002 and Trend To-date:

Decreasing *E. salmonophloia* vigour over monitoring period however the 3 remaining individuals have remained in good condition since 1998. Larger shrub species noted in previous assessments have not survived, being replaced with more salt-tolerant species. The *Atriplex semibaccata* noted in 1998 is no longer present within the plot. Salinity of the heavy soil is moderate to high.

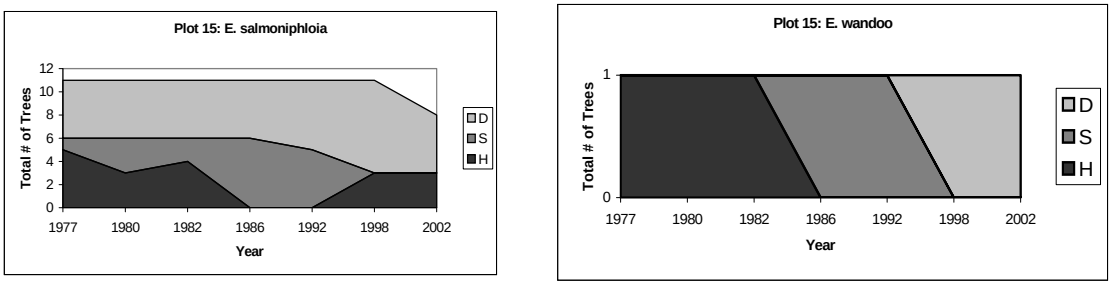

Figure 3.11 : Trend in the vigour of the dominant species at Plot 15

Plate 12 : Facing diagonally across Plot 15

Plot 16

Location: E 559612; N 6360638

On northern fringe of Dulbinning Nature Reserve, south of dam in adjacent property. Just east of Plot 15.

Vegetation Description:

Open woodland of *Eucalyptus salmonophloia*. Understorey dominated by *Gahnia trifida* and *Lomandra micrantha.*

Condition in 2002 and Trend To-date:

E. salmonophloia vigour has been poor during most of the monitoring period. The slight increase in health observed during 1998 has continued for the 2 remaining individuals. Understorey diversity has decreased possibly due to continued poor rainfall. Soil salinities are moderate.

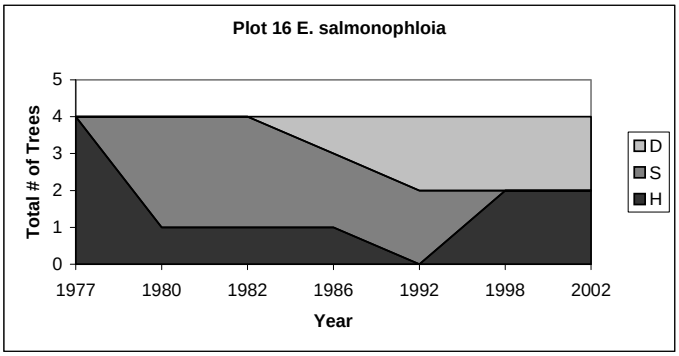

Figure 3.12 : Trend in the vigour of the dominant species at Plot 16

Plate 13 : Facing diagonally across Plot 16

Plot 17

Location: E 560356; N 6360561

Northern fringe of Dulbinning Nature Reserve, just south of fenceline. East of Plots 15 and 16.

Vegetation Description:

Open woodland of *Eucalyptus salmonophloia*. Understorey dominated by *Melaleuca acuminata* and *Gahnia ancistrophylla*.

Condition in 2002 and Trend To-date:

E. salmonophloia condition poor since monitoring began. All trees are now dead. *M. acuminata* vigour remains high. Soil salinities are moderate to high.

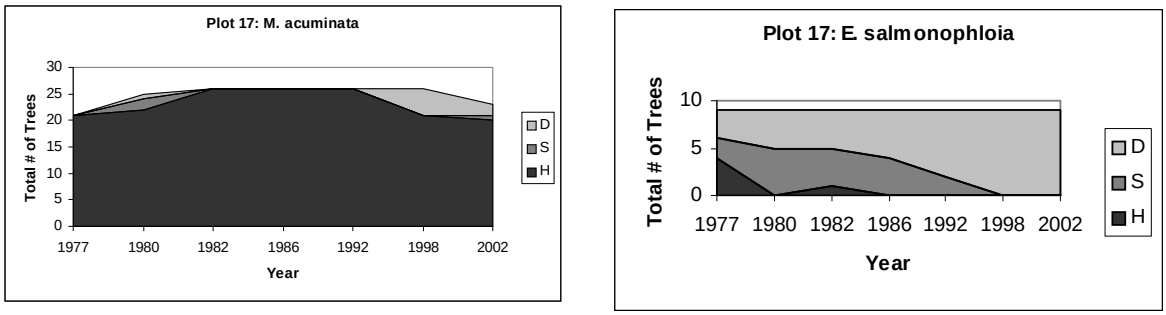

Figure 3.13 : Trend in the vigour of the dominant species at Plot 17

Plate 14 : Facing diagonally across Plot 17

Plot 18

Location: E 560900; N 6360655

Northern fringe of Dulbinning Nature Reserve, to the east of Plot 17.

Vegetation Description:

Initially an open woodland of *Eucalyptus salmonophloia*. Understorey dominated by *Melaleuca acuminata* and grasses.

Condition in 2002 and Trend To-date:

All *E. salmonophloia* have been dead since monitoring began. *E. loxophleba* was also present in small numbers. *M. acuminata* has not been monitored in previous reports however, as this is now the dominant overstorey species, it was surveyed and included in 2002. Presence of *Atriplex semibaccata* indicates increasing soil salinities. Soil salinities are high.

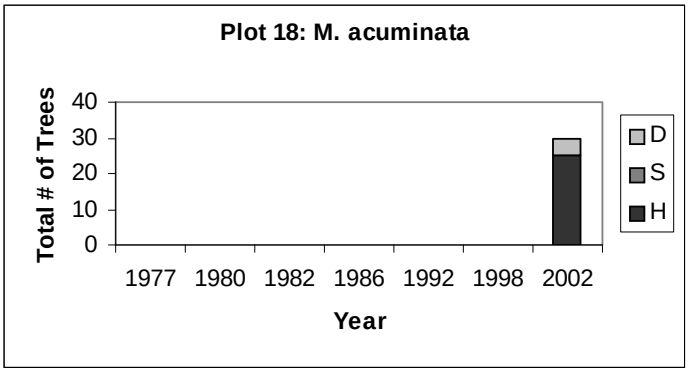

Figure 3.14 : Trend in the vigour of the dominant species at Plot 18

Plate 15 : Facing diagonally across Plot 18

Plot 19

Location: E 561197; N 6360674

Northern fringe of Dulbinning Nature Reserve on western edge of drain.

Vegetation Description:

Closed scrub of *Melaleuca lateriflora*. Very dense stand. Sparse understorey of *Atriplex semibaccata*.

Condition in 2002 and Trend To-date:

Mixture of healthy and dead *M. lateriflora*. Vigour trend is relatively constant over the monitoring period. Understorey unchanged except for the introduction of scattered *Halosarcia lepidosperma* and *Atriplex semibaccata* indicating increasing soil salinities. Soil salinities are very high.

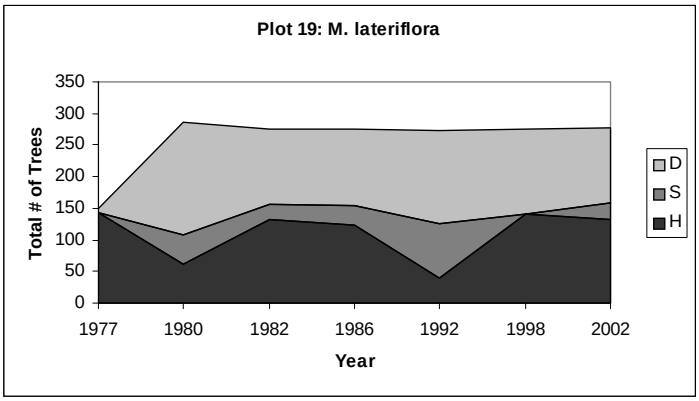

Figure 3.15 : Trend in the vigour of the dominant species at Plot 19

Plate 16 : Facing diagonally across Plot 19

Plot 20

Location: E 558908; N 6360157

In Dulbinning Nature Reserve near Oval Rd, between Chadwicks block and reserve.

Vegetation Description:

Initially an open woodland of *Eucalyptus salmonophloia*. Understorey dominated by *Melaleuca acuminata* and grasses.

Condition in 2002 and Trend To-date:

All of *E. salmonophloia* trees dead since 1998. The one live *E. loxophleba* recorded in 1998 is now dead. Understorey of *M. acuminata* generally healthy with some improvement from 1998. *Gahnia trifida* common in the understorey with *Stipa elegantissima*. The *Atriplex semibaccata* noted in 1998 is no longer present within the plot. Soil salinities are moderate to high.

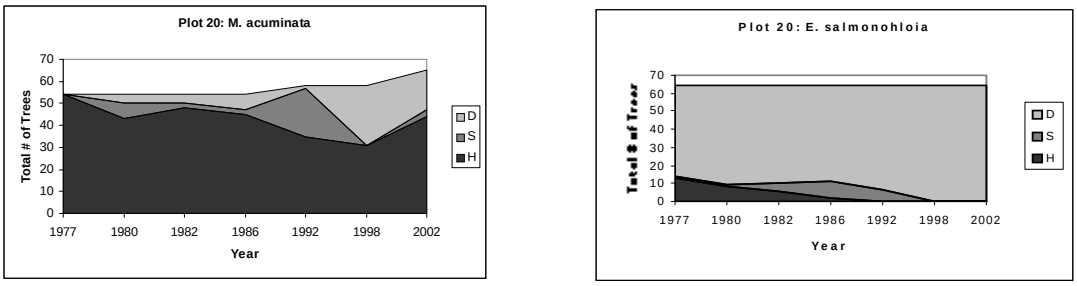

Figure 3.16 : Trend in the vigour of the dominant species at Plot 20

Plate 17 : Facing diagonally across Plot 20

Plot 21

Location: E 560907; N 6359632

Southern fringe of Dulbinning Nature Reserve, just north of dam in adjacent property.

Vegetation Description:

Initially a woodland of *Eucalyptus rudis*, *Casuarina obesa* and *Melaleuca strobophylla*. Understorey of *Melaleuca lateriflora*. Only *Halosarcia indica* remains.

Condition in 2002 and Trend To-date:

All trees are dead and have been since monitoring began. Understorey of samphires has been present since 1977. Soil salinity is extreme.

Plate 18 : Facing diagonally across Plot 21

Plot 22

Location: E 560942; N 6359813

Southern fringe of Dulbinning Nature Reserve, just west of dam in reserve.

Vegetation Description:

Initially a woodland of *Eucalyptus rudis*, *Casuarina obesa* and *Melaleuca strobophylla*. Understorey of *Melaleuca lateriflora*. Only *Halosarcia indica* and *H. lepidosperma* remain.

Condition in 2002 and Trend To-date:

All trees are dead and have been since monitoring began. Understorey of samphires has been present since 1977. Soil salinity is extreme.

Plate 19 : Facing diagonally across Plot 22

Plot 23

Location: E 558766; N 6359385

On the Dulbinning Nature Reserve to the west of Oval Rd.

Vegetation Description:

Open woodland of *Eucalyptus salmonophloia, E. loxophleba*. Understorey of dense *Melaleuca acuminata* and *M. lateriflora*.

Condition in 2002 and Trend To-date:

The plot occurs within the bulldozed and burnt area of Dulbinning Nature Reserve. Monitoring began in 1980, after the disturbance. Most trees are *E. loxophleba*. Vigour of the trees has been declining since 1986 and this trend has continued over the last 4 years. The understorey is relatively unchanged. Soil salinities are moderate to high.

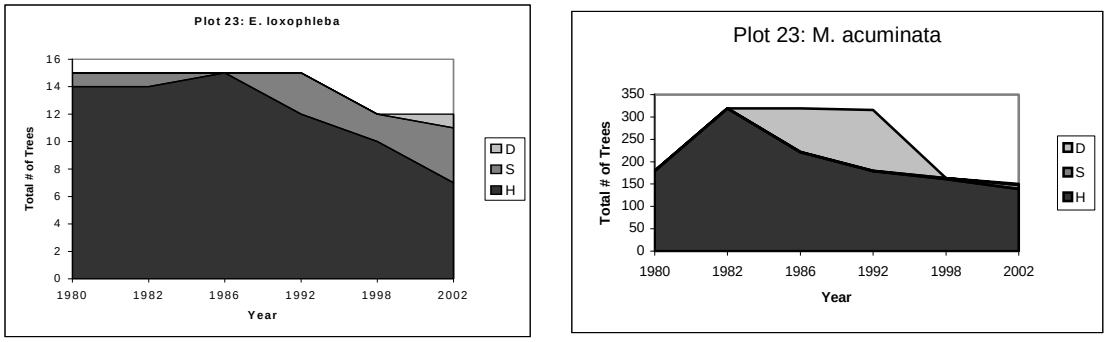

Figure 3.16 : Trend in the vigour of the dominant species at Plot 23

Plate 20 : Facing diagonally across Plot 23

Plot 24

Location: E 558729; N 6359250

Approximately 100m west of Oval Rd. In the regeneration area to the south of Plot 23.

Vegetation Description:

Initially open woodland of *Eucalyptus salmonophloia*. Now an open woodland of *E. loxophleba* and *E. wandoo*. Dense understorey of *Melaleuca acuminata* and *M. lateriflora*.

Condition in 2002 and Trend To-date:

The plot occurs within the bulldozed and burnt area of Dulbinning Nature Reserve. Monitoring began in 1980, after the disturbance. Very sparse trees are *E. loxophleba* and *E. wandoo*. Vigour is reasonably high. The understorey dominates the plot and shows a similar proportion of individuals in each vigour class. Soil salinities are moderate.

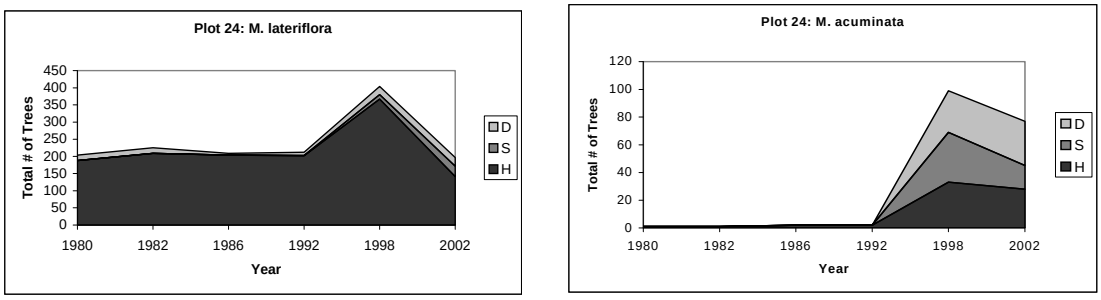

Figure 3.17 : Trend in the vigour of the dominant species at Plot 24

Plate 21 : Facing diagonally across Plot 24

Plot 25

Location: E 558693; N 6359709

On the Dulbinning Nature Reserve to the west of Oval Rd. Plot is approximately 150m south of northern boundary and 100m west of Oval Rd.

Vegetation Description:

Open woodland of *Eucalyptus wandoo* (as identified as *E. salmonophloia* in reports prior to 1998). Understorey of dense *Melaleuca acuminata*, grasses and small herbs.

Condition in 2002 and Trend To-date:

Tree vigour varies over time with health decreasing significantly up to 1998 and declining further in the last 4 years. Four of the 6 *E. wandoo* seedlings noted in 1998 continue to persist. Understorey is relatively unchanged however a small proportion of *M. acuminata* are showing signs of stress. Soil salinities are moderate.

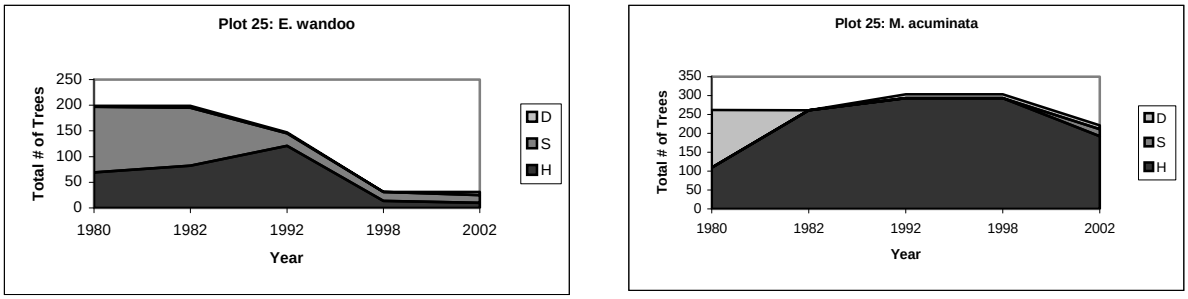

Figure 3.18 : Trend in the vigour of the dominant species at Plot 25

Plate 22 : Facing diagonally across Plot 25

Plot 26

Location: E 558808; N 6358512

To the west of Oval Rd. Located in the regeneration area to the south of Plots 23-25.

Vegetation Description:

Initially *Eucalyptus loxophleba* with *Acacia acuminata* and *Casuarina obesa* (identified as *Allocasuarina huegeliana* in previous reports) substorey. Now only *Acacia acuminata* and *Casuarina obesa* remain. No perennial understorey.

Condition in 2002 and Trend To-date:

Condition is unchanged with numbers of *A. acuminata* gradually increasing. Soil salinities are low.

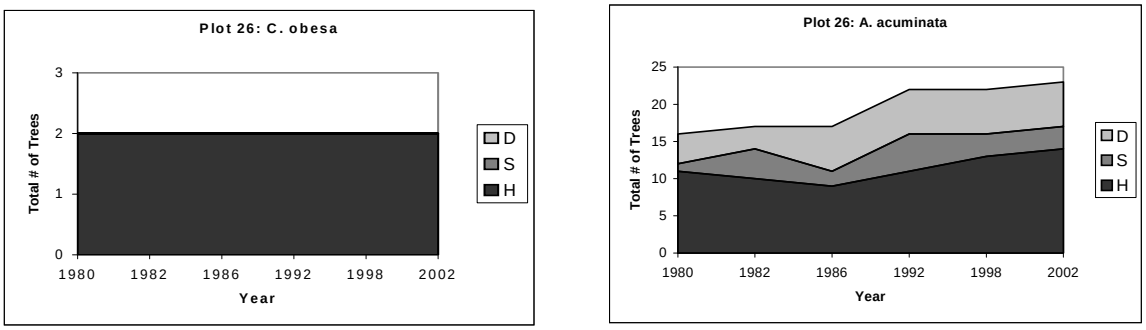

Figure 3.19 : Trend in the vigour of the dominant species at Plot 26

Plate 23 : Facing diagonally across Plot 26

Plot 27

Location: E 555910; N 6357140

Western edge of lake bed, just south of Plot 3. Plot established in 1998.

Vegetation Description:

Open woodland of *Casuarina obesa*.

Condition in 2002 and Trend To-date:

All but one of the trees are healthy. *C. obesa* seedling numbers have increased from 117 in 1998 to 891 in 2002. Seedlings show signs of being grazed however virtually all appear to be in good health. The samphires present in the understorey in 1998 are gone from the plot. Soil salinities are low (mean 120 mS/m) and contrast with the higher salinity of the surrounding plots (plot 3 = 175 and plot 5 = 356 mS/m)

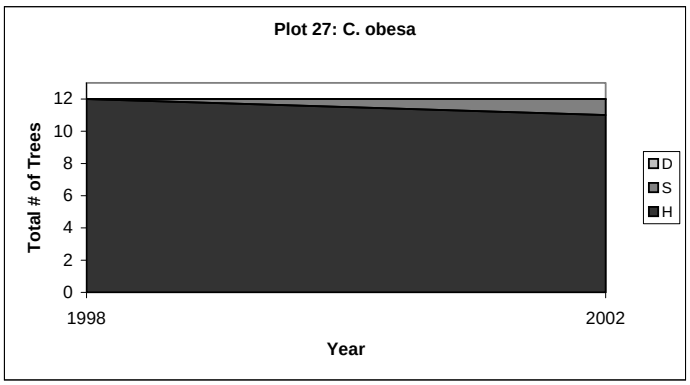

Figure 3.20 : Trend in the vigour of the dominant species at Plot 27

Plate 24 : Facing diagonally across Plot 27

Plot 28

Location: E 556007; N 63565110

Southern portion of lake bed, near abstraction bore 7. Plot established in 1998.

Vegetation Description:

Woodland of *Casuarina obesa*. Some *Melaleuca strobophylla*. Very sparse understorey of *Halosarcia lepidosperma* and *Maireana brevifolia*

Condition in 2002 and Trend To-date:

Nine of the *C. obesa* trees have died since 1998. Of the remaining trees, approximately half are stressed and half healthy. The one *M. strobophylla* tree has moved from the healthy to stressed vigour class. The plot contains one *M. strobophylla* seedling and 6 eucalypt seedlings, possibly *E. loxophleba.* Soil salinities are high and the density of *Halosarcia sp.* are increasing.

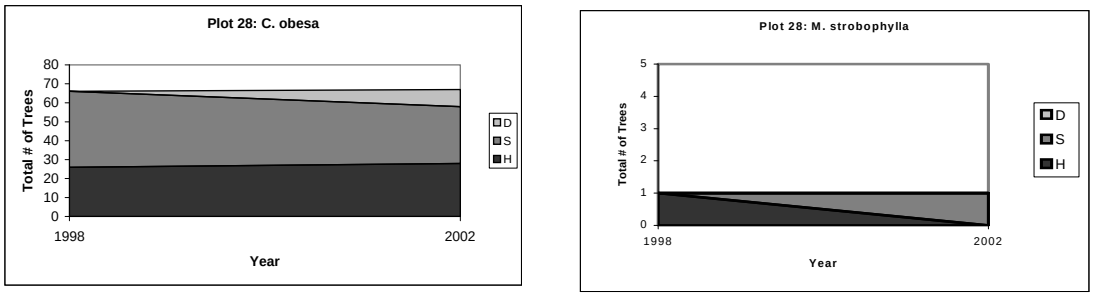

Figure 3.22 : Trend in the vigour of the dominant species at Plot 28

Plate 25 : Facing diagonally across Plot 28

Plot 29

Location: E 556383; N 6356462

Southern portion of lake bed, 300m east of Plot 28. Plot established in 1998.

Vegetation Description:

Open woodland of *Casuarina obesa*. Very sparse understorey of *Halosarcia lepidosperma*.

Condition in 2002 and Trend To-date:

Over 60% of the *C. obesa* appeared stressed in 1998. All these trees have now moved into the stressed vigour class. Soil salinities are very high.

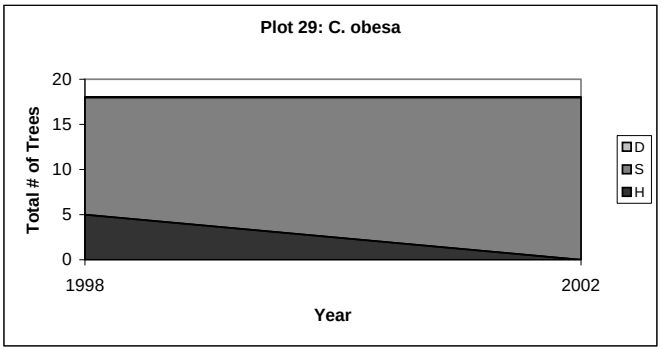

Figure 3.23 : Trend in the vigour of the dominant species at Plot 29

Plate 26 : Facing diagonally across Plot 29

Plot 30

Location: E 557264; N 6356313

On the deep sand dunes near the eastern fringe of the lake. Plot established in 1998.

Vegetation Description:

Woodland of *Banksia prionotes*. Understorey of grasses and small herbs.

Condition in 2002 and Trend To-date:

Of the 36 *B. prionotes* surveyed in 1998, only 2 are alive in 2002. Three seedlings were observed. Understorey sparse with no large perennials. Soil salinity is very low.

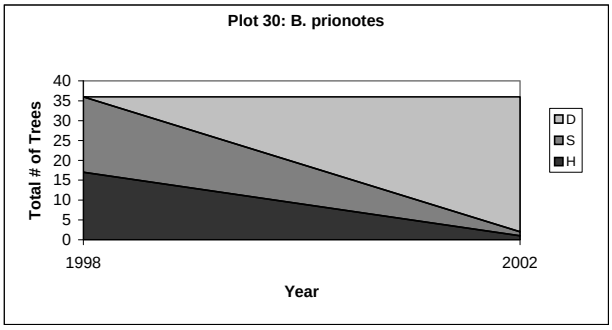

Figure 3.24 : Trend in the vigour of the dominant species at Plot 30

Plate 27 : Facing diagonally across Plot 30

Plot 31

Location: E 557396; N 6356672

On the deep sand dunes near the eastern fringe of the lake. New plot established in 1998.

Vegetation Description:

Woodland of *Banksia prionotes – Allocasuarina huegeliana*. Understorey of grasses and small herbs.

Condition in 2002 and Trend To-date:

A general decline in the *B. prionotes* population is apparent however this is not as severe as in plot 30. All *A. huegeliana* trees healthy with one seedling showing considerable growth since 1998. Understorey is dominated by *Jacksonia furcellata* with sparse grasses and small herbs. Soil salinities are very low.

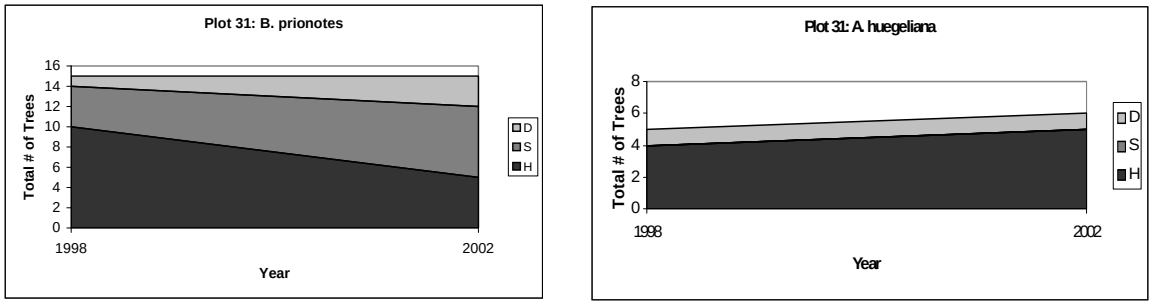

Figure 3.25 : Trend in the vigour of the dominant species at Plot 31

Plate 28 : Facing diagonally across Plot 31

Plot 32

Location: E 557190; N 6358893

Across the Northern Arthur River, 50m south of road. Plot runs across the river and extends approximately 30m east and 30m west from the river channel. Plot originally established in 1983.

Vegetation Description:

Woodland of *Eucalyptus loxophleba*, *Casuarina obesa* and *Melaleuca strobophylla*. Understorey of *Halosarcia indica* and *H. lepidosperma*.

Condition in 2002 and Trend To-date:

C. obesa trees are relatively stable showing only a slight decrease in crown condition. The few *M. strobophylla* trees in the transect were declining in 1998 and have continued this trend to 2002. Soil salinities range from low at higher ground to high near or in the channel.

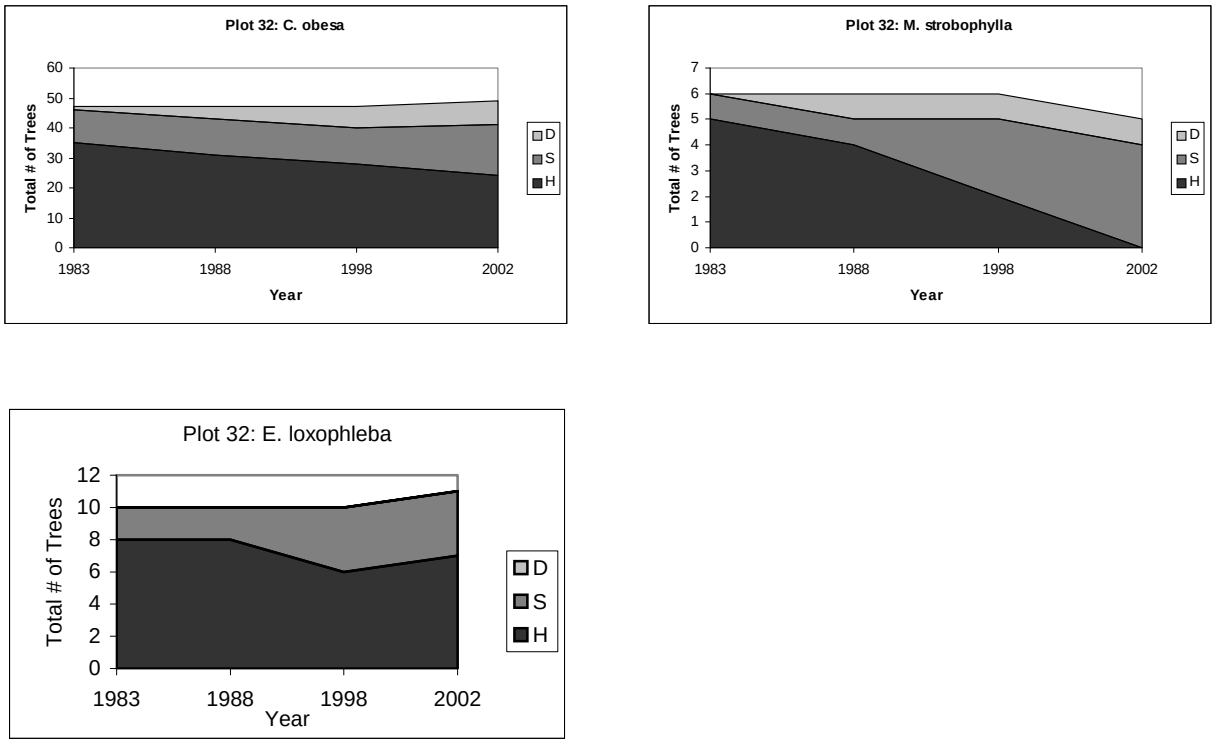

Figure 3.26 : Trend in the vigour of the dominant species at Plot 32

Plate 29 : Facing diagonally across Plot 32

Plot 33

Location: E 555940; N 6357263

South west corner of the lake bed. Plot originally established in 1983

Vegetation Description:

Woodland of *Casuarina obesa*. Understorey of very sparse *Halosarcia lepidosperma* and small herbs.

Condition in 2002 and Trend To-date:

Majority (90%) of the trees were either stressed or dead in 1998. No significant change is apparent in 2002. Salt tolerant understorey species appear to be colonising the area. Soil salinities are moderate to high.

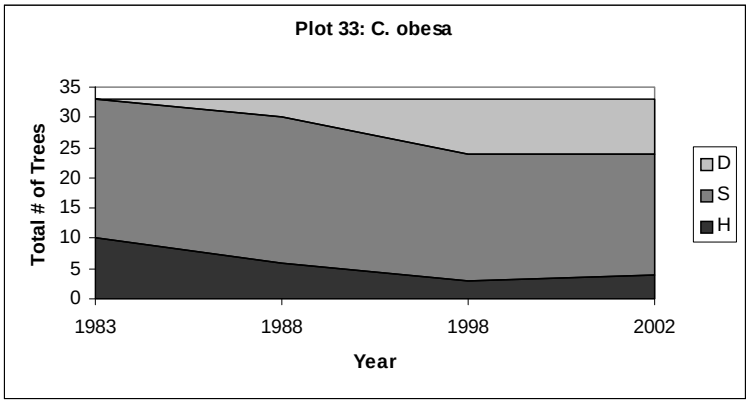

Figure 3.27 : Trend in the vigour of the dominant species at Plot 33

Plate 30 : Facing diagonally across Plot 33

Plot 34

Location: 556892 E, 6358156 N

Approx. 25m east of Pump 1. Plot established in 2000.

Vegetation Description:

Dense *C. obesa* and *M. strobophylla* stand on undulating gilgai mounds. Scattered *Halosarcia sp.* understorey.

Condition in 2002 and Trend To-date:

Very dense stands of trees on raised gilgai mounds with highly suppressed smaller stems. The dominant trees are generally stressed with most *M. strobophylla* now dead or highly stressed. Of the 13 *M. strobophylla* trees alive in 2000, only 2 remain. Soil salinity is moderately high with *Halosarcia lepidosperma* in depressions.

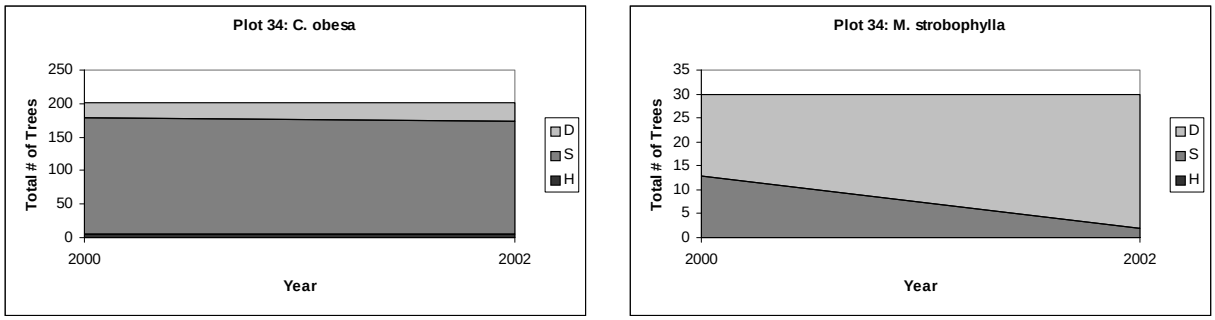

Figure 3.28 : Trend in the vigour of the dominant species at Plot 34.

Plate 31 : Facing diagonally across Plot 34

Plot 35

Location: 556737 E, 6356542 N

Approx. 50m south west of Pump 13. Plot established in 2000.

Vegetation Description:

Open woodland of *C. obesa*. Generally large trees occurring on flat ground. Occasional *Carpobrotus sp.*, otherwise no understorey present.

Condition in 2002 and Trend To-date:

This plot samples the southern end of the lake, characterised by an open woodland of large *C. obesa* stems. No significant change in the tree vigour is apparent. Soil salinities are high to very high.

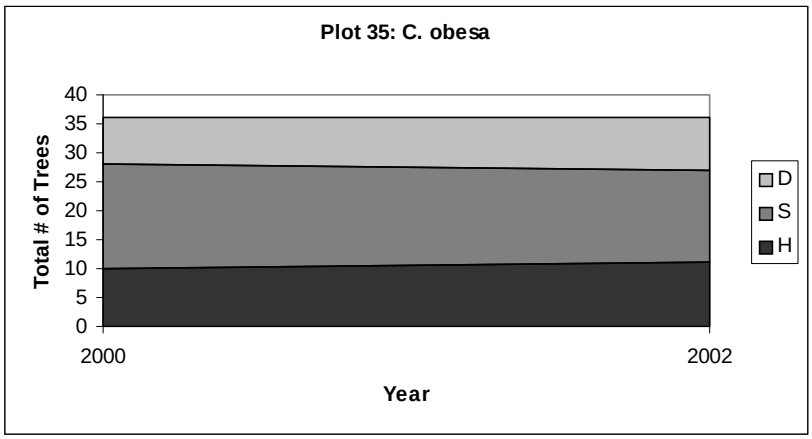

Figure 3.29 : Trend in the vigour of the dominant species at Plot 35.

Plate 32 : Facing diagonally across Plot 35

Plot 36

Location: 557253 E, 6356983 N

Approx. 80m west of Pump 15. Plot established in 2000.

Vegetation Description:

Woodland of *C. obesa* and *M. strobophylla*. Density of stems ranges from high on the raised gilgai mounds to low in and around depressions. Understorey consists of occasional *Halosarcia lepidosperma*

Condition in 2002 and Trend To-date:

The trees in this plot have declined in the 2 years since the plot was established. Twelve *C. obesa* and 5 *M. strobophylla* trees have died and soil salinities remain extremely high.

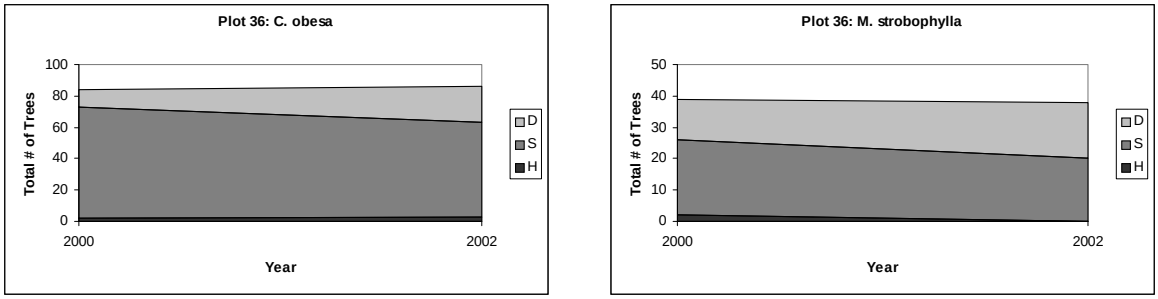

Figure 3.30 : Trend in the vigour of the dominant species at Plot 36

Plate 33 : Facing diagonally across Plot 36.

Plot 37

Location: 556702 E, 6357021 N

Approx. 50m south of Pump 12. Plot established in 2000.

Vegetation Description:

Plot samples one stand of *C. obesa* in an open woodland of *C. obesa*. The majority of trees to the south of Pump 12 are restricted to areas of higher elevation (ie. on gilgai mounds) with scattered *Halosarcia sp.* in the understorey.

Condition in 2002 and Trend To-date:

Many stressed and highly stressed trees present. Relatively few dead stems apparent despite very high soil salinities.

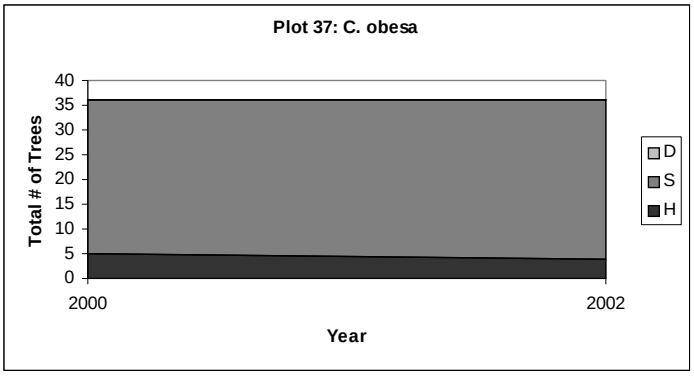

Figure 3.31 : Trend in the vigour of the dominant species at Plot 37

Plate 34 : Facing diagonally across Plot 37.

Plot 38

Location: 556681 E, 6357863 N

Approx. 50m west of Pump 2. Plot established in 2000.

Vegetation Description:

Open woodland of *C. obesa* with low open shrubland of *Halosarcia lepidosperma.*

Condition in 2002 and Trend To-date:

The majority of larger stems in fair to good condition with evidence of stress generally restricted to smaller stems. Slight decline in vigour since 2000. No dead stems are present and soil salinity is moderate.

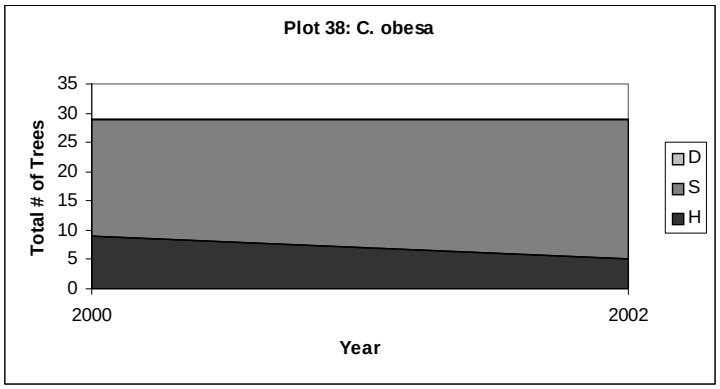

Figure 3.33 : Trend in the vigour of the dominant species at Plot 38.

Plate 35 : Facing diagonally across Plot 38.

Plot 39: Seedling Transect

Location:

Runs east-west, 60m north of pump 9. Plot established in 2000.

Description:

Transect runs at the northern end of the seedling recruitment area and samples a relatively low density of *C. obesa* seedlings in a generally open area. Seedling numbers have doubled in the last two years. Salinity is moderate.

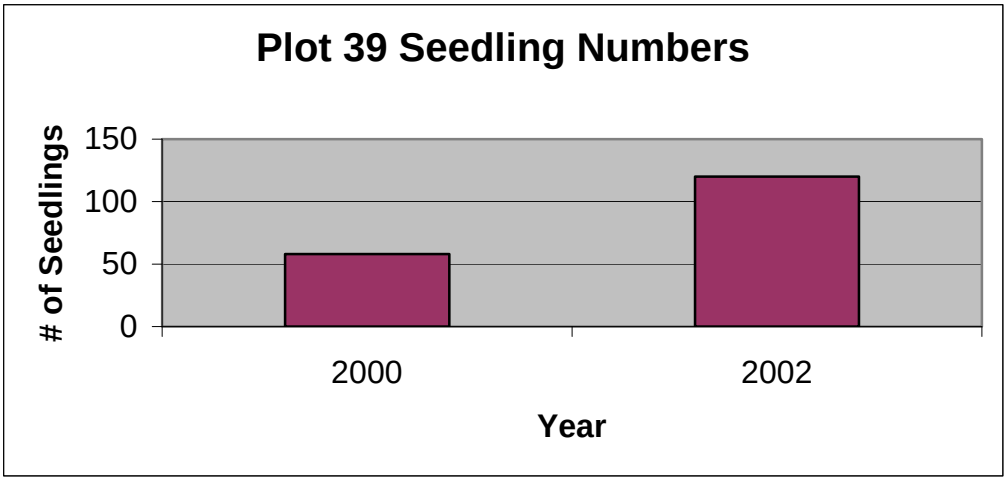

Figure 3.34: Seedling numbers at plot 39.

Plate 36: Seedling plot 39, facing east

Plot 40: Seedling Transect

Location:

Runs east-west, 20m north of pump 9. Plot established in 2000.

Description:

This transect passes through the stand of *C. obesa* trees just north of pump 9 and into the open area east of the pump. *C. obesa* seedling densities are low under the trees becoming higher in the open areas to the east and west. Salinity is low. Seedling numbers have increased from 517 to 927.

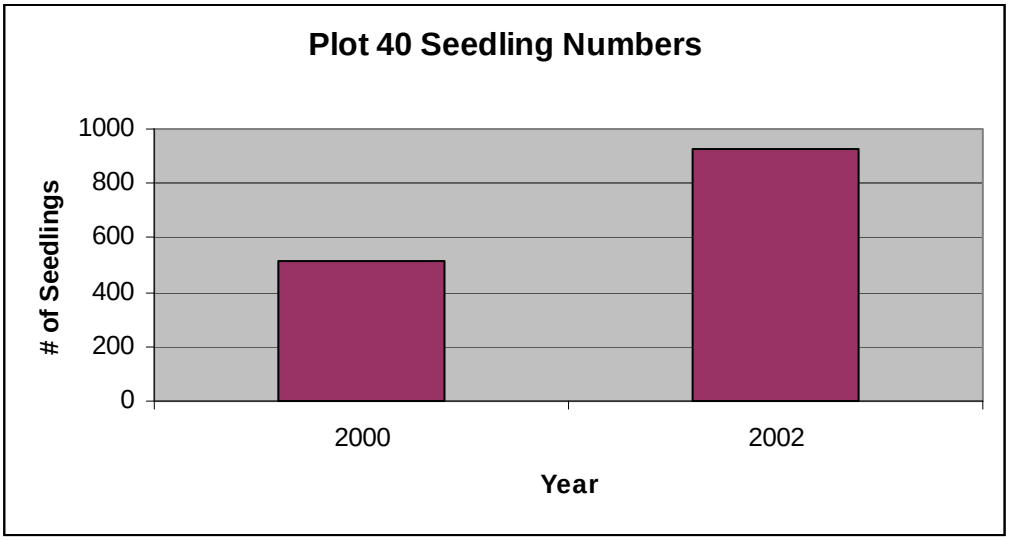

Figure 3.35: Seedling numbers at plot 40.

Plate 37: Seedling plot 40, facing east

Plot 41: Seedling Transect

Location:

Runs east-west, 20m south of pump 9. Plot established in 2000.

Description:

Very high densities of *C. obesa* seedlings with variable heights occur throughout much of this transect. Soil salinity varies from low to moderate at the eastern margin. Seedling numbers have increased from 1469 in 2000 to 2912 in 2002.

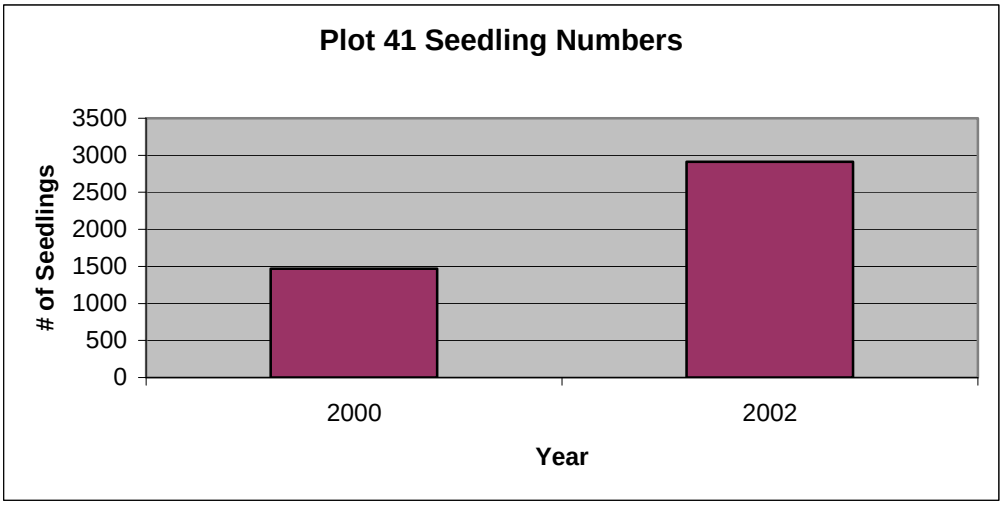

Figure 3.36: Seedling numbers at plot 41.

Plate 38: Seedling plot 41, facing east

4. Discussion

4.1 Wetland Vegetation

The wetland trees of Lake Toolibin and reserves continue to show a decline in vigour. The *Casuarina obesa* population shows a slight decline with a approximately 3% of the trees moving from the "healthy" to "stressed" vigour class and fewer than 4% of the trees dying within the last 4 years. The *Melaleuca strobophylla* population has declined severely. Eighty percent of the *M. strobophylla* trees within the monitoring plots are now dead compared to 40 percent in 1998. This trend is also apparent in the vegetation plots established in 2000 with an increase in dead *M. strobophylla* of more than 25 percent (Fig. 4.1). Very few healthy individuals can be found in the monitoring plots or elsewhere on the lake bed.

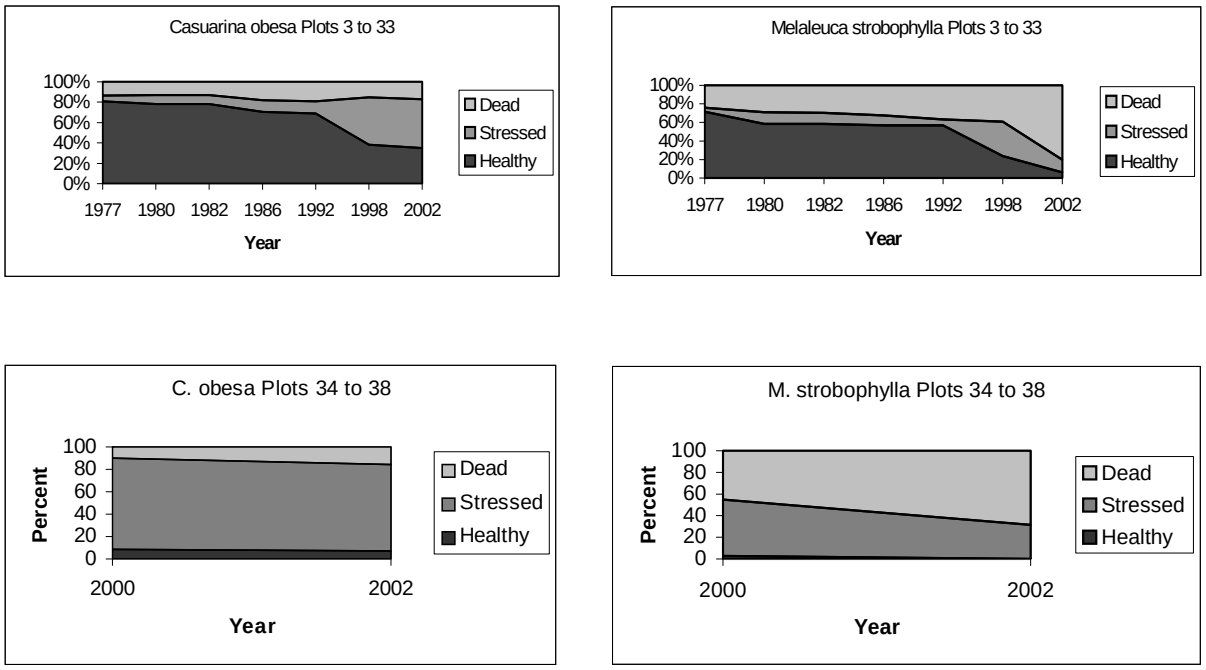

Figure 4.1: Trend in vigour for all *C. obesa* and *M. strobophylla* trees within the Lake Toolibin monitoring plots.

The understorey plant community on the lake bed and in other seasonally wet areas shows a continuing trend toward salt tolerant species of *Halosarcia* and *Enchylaena*. With no inflow and below average rainfall in the period between monitoring, the density of these species has increased in most plots.

The recent history of below-average rainfall is also likely to have serious consequences with respect to mature wetland tree survival and seedling establishment. Some of these consequences are already

evident in the significant decline of mature trees across the lake bed but continued dry conditions are likely to exacerbate salinisation impacts. Recent investigations by ECU at Toolibin Lake have shown that both mature trees and seedlings of *C. obesa* and *M. strobophylla* are very dependent on rainfall to surface soils. Direct rainfall is the primary water source during dry periods (no or low inflow events) and is required to leach salts from the rhizosphere in the absence of shallow saline watertables.

4.2 Terrestrial Vegetation.

The terrestrial tree species of the Toolibin reserves have shown little change since 1998. A slight decline in vigour is apparent for *E. loxophleba* and *E. wandoo* however the remaining *E. salmonophloia* and *Allocasuarina huegeliana* are in good health. The most significant change has occurred in the *B. prionotes* population in the south eastern fringe of the reserve (Fig. 4.2).

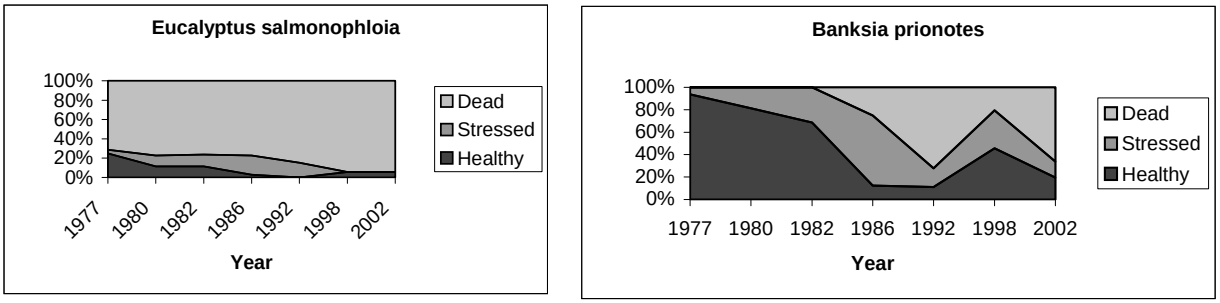

Figure 4.2: Trend in vigour for all *E. salmonophloia* and *B. prionotes* trees within the Lake Toolibin monitoring plots.

Two plots were established in this area in 1998 to improve the representation of the *B. prionotes* community. In the 4 years since the plots were surveyed the number of dead trees has risen from 20 percent to more than 60 percent. One plot (plot 30) has lost virtually all mature trees in the period between 1998 and 2002. Testing has failed to identify the presence of *Phytophthora sp.* (J. Wyland, pers. com.). The population dynamics of the *B. prionotes* should be examined as the recruitment requirements of the species is likely to be associated with more frequent disturbance (fire) intervals than what the woodlands currently experience. Longevity of the species is shorter than other large Banksias and is a function of cumulative pressures, the key elements of which are altered water availability, increased herbivory and increased pathogen attack (P. Groom, pers com).

As for the wetland vegetation, the impact of the current drought on terrestrial vegetation is likely to be significant. Some impacts may already be observed in the dramatic decline in the *B. prionotes* woodland as reduced water source availability imposes further stresses on a senescent plant population.

4.3 Recruitment

A significant germination and seedling establishment event was noted in 1998 in the area on the west side of the lake around pump 9. A plot was established in this area (plot 27) to monitor the condition of the trees and encompassed 119 *C. obesa* seedlings. The number of seedlings in this plot has increased to 891 since 1998 showing that seed germination and seedling establishment is continuing.

The area of seedling establishment extends from approximately 100m south to 80m north of pump 9 and from the separator wall to 100m to the east. In April 2000, three 100 x 5m belt transects were established through this area and seedling numbers, height and soil salinity recorded in each 5m section. In April 2000, 2044 seedlings were counted varying in height from 0.1 to 1.0m. The variability in heights suggested germination was continuing after the initial recruitment in 1998. Seedling numbers in these transects has increased to 3960 in 2002 showing viable seed is continuing to be dispersed and conditions are favourable for germination and establishment. The lower soil salinity around pump 9 should favour seedling establishment however there is considerable variability within the area. High seedling densities are found in areas with conductivities in excess of 220mS/m.

The response of the trees in this area to low soil salinity and lower ground water has been an increase in vigour and very heavy seed set on the female trees. Monthly estimates of seed cone densities on female trees at 5 locations around the lake from 1999 to 2001 have shown negligible seed set other than around pump 9. Seed traps placed at these locations and monitored over the same period caught 52 *C. obesa* seed, 50 of which were found in the trap near pump 9 (G. Ogden, unpublished data).

Peak dispersal of *C. obesa* occurs in summer/autumn when the seed cones dry (Ogden, 1997). Once dispersed, the seed appears to remain viable for up to 1 year if moisture levels remain low. Given sufficient moisture, the seed germinates rapidly but will die if not in contact with a consistent source of moisture (G. Ogden, unpublished data). This suggests that in the absence of surface water, dispersed seed germinates in winter/autumn when soil moisture is consistently high. Survival and establishment of the young seedling may then depend on sufficient soil moisture over the summer months. Figure 4.3 shows that significant summer rainfall has occurred at Lake Toolibin in 3 of the last 5 years. The abundant source of propagules, appropriate rainfall patterns (and no flooding) combined with decreasing soil salinities are likely to be responsible for this major recruitment event. This localised response to lowered groundwater and subsequent reduction in soil salinity is an encouraging sign for the longer term persistence of the *C. obesa* population as the broader network of groundwater pumps take effect.

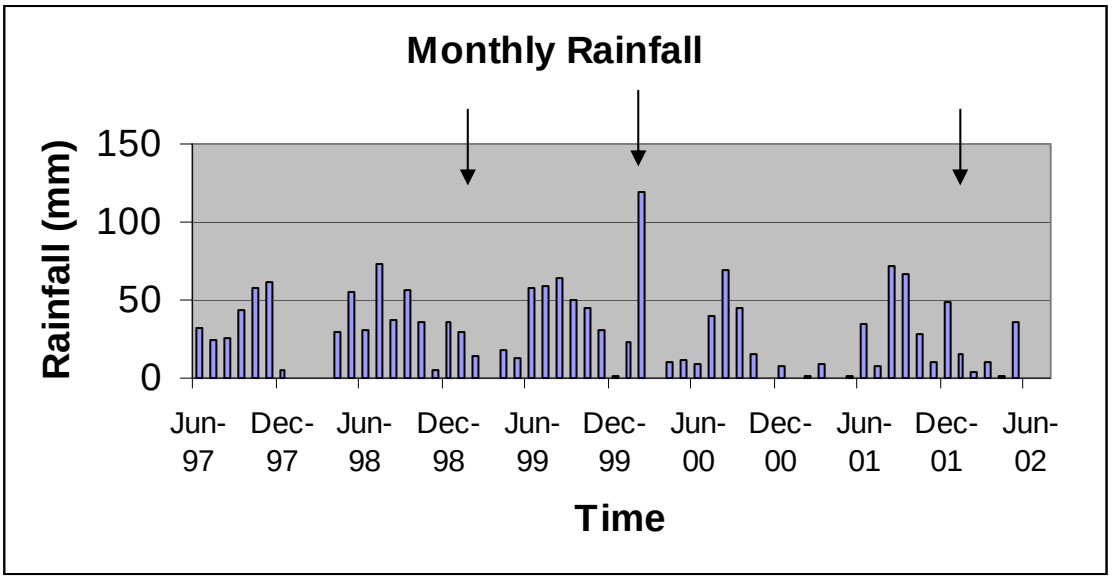

Figure 4.3: Monthly rainfall at Toolibin Lake from June 1997 to June 2002 (arrows indicate summer rainfall events).

Approximately 15 *M. strobophylla* seedlings were found in plot 4 in 2002. This area of the lake (north-east of pump 4) supports more than 80 seedlings however informal counts done in May 2000 recorded more than 500 seedlings (G. Ogden, unpublished data). This decline mirrors the condition of the mature trees which may be suffering the effects of continued low rainfall and high soil salinity.

Poor survival of seedlings and a serious decline in the health of the mature *M. strobophylla* population poses a threat to the long term survival of this species at Lake Toolibin. Seeds appear to survive for up to 2 years if kept dry, however germination is induced under moist conditions. A low level of seed dispersal occurs throughout the year with a distinct peak over the summer months. Most seed is retained in the canopy, only dispersing when the branch (or whole tree) dies and dries out (G. Ogden, unpublished data). Given these regeneration characteristics, the species is unlikely to form a persistent soil seed bank and a poor fruit density can be observed on the majority of trees on the lake. If the decline in this species continues, sources of viable seed may be exhausted before conditions at the lake improve. Significant stands of saplings occur on the eastern side of the lake and scattered seedlings can be observed in the north-west area near pump 1. Soil salinity concentrations clearly do not preclude seedling survival however given the poor seed set and ongoing drought, opportunities for successful recruitment are declining. Bringing these areas of saplings and seedlings into the monitoring program may provide valuable information.

In light of the results presented in this report, the following recommendations are made;

1. **Continue the vegetation monitoring using the Salinity Action Plan protocols at least every 3 years to ensure quantitative data on vegetation response is available. Given the rapid decline in the *M. strobophylla*, yearly monitoring may be advisable.**

2. **Monitor the seedling transects (plots 39-41) every year for seedling number, seedling height and soil salinity (EM38) to build an understanding of the factors influencing recruitment.**
3. **Establish seedling monitoring plots for *M. strobophylla* seedlings on the west side of the lake and for the saplings on the eastern side.**
4. **Develop the strategies required to actively manage recruitment and recovery of *C. obesa* and *M. strobophylla* within the lake and *B. prionotes* in the surrounding reserves.**
5. **Assess and extend the existing trial revegetation programme and include terrestrial vegetation trials.**
6. **It is recommended that management strategies include rabbit and kangaroo control programs to minimise the impact of grazing on natural seedling recruitment and planted seedlings. Herbivore control may be extended (at the operational level) to include fencing of recruitment near pump 9 and culling of kangaroo population.**

5. References

Agwest (2002). *Salinity Measures Units and Classes*. Retrieved December 2002, from http://www.agric.wa.gov.au/environment/land/salinity/measurement/salinity_levels_for_revegetation.htm

Froend, R.H., Pettit, N. E. & Ogden, G. (1998). *Vegetation Monitoring of Toolibin Lake and Reserves: November 1998*. Unpublished report prepared for the Department of Conservation and Land Management.

Hunt, N. & Gilkes, B. (1992). *Farm Monitoring Handbook*. University of Western Australia, Perth, Western Australia.

Ladd, P.G. (1996). *Ecology/Ecological Principles – Unit Manual*. Murdoch University, Perth, Western Australia.

Mattiske, E. M. (1993) Monitoring of Flora and Vegetation, Toolibin Lake. Unpublished Report prepared for the Dept. Conservation and Land Management.

Ogden, G. N. (1997) Recruitment Requirements of *Casuarina obesa* at Toolibin Lake, Western Australia. BSc Hons Thesis, Edith Cowan University, Perth, Western Australia.

6. Appendices