Vegetation Monitoring of Toolibin Lake and Reserves

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SUMMARY

The 1998 reassessment of the Toolibin Lake vegetation monitoring plots revealed two general points:

- There continues to be a decline in the health of vegetation in both aquatic and terrestrial habitats.
- There is also some evidence of recovery where conditions allow.

The vegetation on or near the lake bed and other wetland vegetation in the surrounding reserves, continues to show decline in vigour. The key wetland trees species, overall, show static or declining health. Except for E. rudis which was lost from the lake bed before 1986, the vigour of the major wetland tree species has been declining gradually since monitoring began.

Some areas of the lake bed have shown signs of stability and/or recovery in tree health. On the western side of the lake were tree vigour is typically declining (Plot 3), *Casuarina obesa* are surviving with no further decrease in health. *C. obesa* seedlings were also observed in the area. On the eastern side of the lake, Plot 7 has shown recovery in *C. obesa*.

The spread of halophytic species such as *Halosarcia* and *Atriplex* on the lake bed continues. There were several lake bed plots where the presence of these species was recorded for the first time in 1998. Although in most cases their cover was very sparse, they have spread to new areas on the lake. This is likely to be due to increasing soil salinities and extended periods of poor inundation.

There continues to be decline in the vigour of *E. salmonophloia* to the point where very few live trees remain in the monitoring plots. There has been significant regrowth in the regeneration area to the north of the lake but most of the trees there are *E. wandoo* and not *E. salmonophloia*. The *E. salmonophloia* woodlands with *Melaleuca* understorey and the *E. loxophleba - A. acuminata* woodlands continue to decline but some plots have shown stability or recovery (improved health and/or recruitment) in the understorey (e.g. Plots 26, 24, 19 and 12). The *Banksia prionotes* woodland plots show continued decline, however the additional *B. prionotes* plots added in 1998 (Plots 30 and 31 on the eastern sand dunes) show higher vigour and seedling recruitment.

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

1. **Adopt and implement the recommendations for vegetation management outlined in the Monitoring Design Report (Froend and Storey, 1996). Some of the recommendations below are repeated from this document.**

2. **Monitoring of all plots listed in this report continue every 3 years. Periods between monitoring have been irregular and there should be a commitment to maintaining a regular and thorough monitoring of the plots.**

3. **Monitoring should continue to use the SAP wetland vegetation monitoring methods so that results will be of a high standard and can be compared with wetlands elsewhere in the southwest.**

4. **Monitor and investigate the survival and growth of seedlings on the lake bed and the surrounding reserves. This will need to be conducted on a more frequent basis than every 3 years to permit tracking of seedling fate and identification of critical factors.**

5. **Monitor and assess the recovery of tree populations on the western side of the lake in response to saline groundwater abstraction.**

6. **Develop the strategies required to actively manage recruitment and recovery of vegetation within the lake and surrounding reserves.**

7. **A trial revegetation program is recommended to assess the practicality and success of seedling planting, particularly in areas of the lake bed where vegetative cover is poor.**

8. **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.**

9. **An additional sub-program of vegetation monitoring is required to accurately assess vegetation response to groundwater pumping.**

10. **An outflow modification feasibility study should be undertaken to determine an appropriate structure design, management strategy and assessment of likely impacts.**

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 the total 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. All plots were reassessed in 1988 but have not been monitored since.

The wetland vegetation of Toolibin Lake is also monitored as part of the Salinity Action Plan (SAP) Wetland Monitoring Program. Permanent monitoring plots, separate to the Mattiske plots but incorporating one of the Froend plots, were established in the summer of 1997/98. This monitoring and research program involves the assessment of wetland vegetation at 27 wetlands in the southwest of Western Australia and the vegetation monitoring is coordinated by Dr Neil Gibson, CALM. Monitoring and research is conducted by Dr Ray Froend and Mr Gary Ogden, Edith Cowan University. The methodology developed for the SAP monitoring was seen as being more consistent with the requirements of long-term assessment of vegetation response to environmental changes and therefore its adoption in the Toolibin monitoring program was recommended.

Reassessment of all existing lake and terrestrial vegetation monitoring plots is now required. In addition, the establishment of new plots is required, in vegetation types and locations that are currently under represented.

The requirements for the 1998 monitoring of the Toolibin Lake vegetation were as follows:

1. All Mattiske and Froend plots stipulated in the contract brief will be relocated and permanently marked.

2. Resurveying of the Mattiske and Froend transects will be conducted and will follow the methodology used for the Salinity Action Plan Wetland Vegetation Monitoring Program. This will ensure a continuation of the current data set, while standardising methods with the SAP program. All aspects of the SAP monitoring will

be included, however the extent of aerial photography and GIS analysis may be varied according to CALM requirements.

3. Addition transects will be established in the south east portion of the lake bed.

4. Additional plots in the Banksia woodland communities to the east of Toolibin Lake will be established to improve the representation of this community type in the monitoring program.

5. A reassessment of Froend Plot 1 and 4 will be conducted.

6. Recommendations as to the optimum management of terrestrial and lake vegetation at Toolibin Lake and associated reserves will be provided.

2. METHODS

2.1 Overview of the SAP Wetland Vegetation Monitoring Procedures

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 Methods Employed in the 1998 Assessment of the Toolibin Plots

Plot Design

The plots consist of a single 20 x 20m quadrats which are marked at each corner with a steel fence post. Tape measures and an optical square were used to ensure all plots were square and of equal size.

The plots are further divided into five 4 x 20m subplots for overstorey measurement and 4 x 4m subplots for understorey measurement (Fig. 2.1). The overstorey subplots enable the trees within the whole plot to separated according to distribution along an elevation gradient. The 4 x 20 subplots were oriented so that they were perpendicular to the shoreline if a gradient was present. Most of the Toolibin plots were not situated on elevation gradients. Within each 4 x 20m plot, a 4 x 4m plot is located at either the left or right side for assessment of all understorey plants (Fig 2.1).

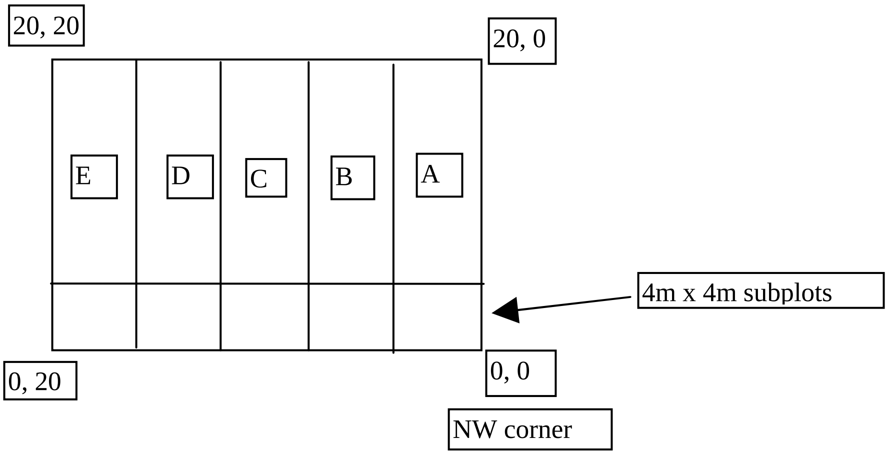


Figure 2.1: Plot layout.

With this design, the overall size and orientation of the plots has not been changed, allowing comparable overstorey data to be collected as well as improved tree location data. The design represents a slight modification of the SAP design but it was done this way so that past records would be compatible.

The 4 x 4m understorey plots were not individually marked as it was felt that this made the plots too visible. The information gathered from the understorey plots is more comprehensive than previous assessments and is the first time all understorey species have been recorded.

An aluminium tag was attached to the NW corner post of each plot indicating the site number. Compass bearings were also taken from this point across and down the transect to enable the transect to be re-estiblished in the event of fence posts being stolen. Location of each plot was quantified by GPS readings from the centre. Note that the readings were obtained with a hand-held GPS with an accuracy of 15-100m.

Vegetation Monitoring

2.3.1 Tree species

All trees were tagged with numbered aluminium tags. Tags were attached at breast height (approx. 1.5m) with a galvanised roofing nail or a large loop of galvanised wire if the stem was too narrow to nail. For each tree within each plot the species, diameter at tag height and crown condition was recorded. Stem diameter was measured directly under the tag if nailed or at breast height if the tag was wired onto the tree unless otherwise noted in the data. 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. In addition to tracking growth and vigour of trees in the future, stem diameters also permit size class analysis of the populations.

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) (Figure 2.2). The higher the overall score the better the condition of the tree. The number, species and height of tall shrubs

(>1.5m) and seedlings of trees were also recorded in the 4 x 20m plots. Seedlings were counted in the 4 x 4m subplots.

So that crown assessment results could be compared to the previous results, crown assessment values less than and equal to 11 were considered stressed, values greater than 11 were considered healthy.

2.3.2 Understorey Species

Within the 4 x 4m sub-plots, all understorey plants were identified and percentage foliage cover determined by direct measurement (two foliage measurements at right angles) for species with a distinct foliage area or percentage estimate for rushes and sedges. Height ranges for each species were also recorded.

Samples of each plant species were collected and returned for identification. Difficult to identify species were confirmed in the Herbarium reference collection. Species which are yet to be accurately identified are noted in the data by a question mark. Voucher specimens can be lodged with the WA Herbarium if requested.

Within each 20 x 20m plot, heights of trees and tall shrubs were measured with a clinometer and tape to enable construction of profile diagrams if required. Percentage canopy cover for each tree species was determined for each 20 x 20m plot by walking a 100 point grid (every 2m across and 2m along the plot). At each point the canopy was examined and any species with foliage projecting across this point was recorded giving a 100 point assessment of the canopy which was directly converted to percentage cover for each species. A clinometer was used to ensure the user was looking directly 90^0 into the canopy.

Physico-chemical Parameters

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 the soil samples.

Elevations

The gradient of each monitoring plot was measured using an auto level and staff, with measurements generally being taken every 4m along the transects except in steep areas where a smaller interval was used.

Mapping of Structural Vegetation Units

A 1:5000 scale colour aerial photograph (Oct 1996) was used to determine the initial boundaries of the mapping units. Ground-truthing was then conducted to verify the boundaries as well as map areas of seedling recruitment. Plot locations were placed on the final vegetation map according to their GPS-determined co-ordinates.

Photographs

A colour photograph of each plot was taken from the NE corner peg facing diagonally to the far metal peg. Digital copies of the photographs have been loaded onto the CD-ROM attached to this document as well as presented as part of each plot description.

3. RESULTS

3.1 Plot Location

Not all existing plots were re-assessed in 1998. Plots 1 and 2 were destroyed during the construction of the separator channel. The authors were unable to locate Plot 14 near Dulbinning Lake. Plots 8, 21 and 22 have no 1998 data as there was no live vegetation. The location of each plot is presented in Fig. 3.1.

Locating existing plots was difficult due to the unavailability of accurate plot location data/maps. When found, the presence of wooden pegs and bricks outlining the plot perimeter, was taken as confirmation of location.

3.2 Plot Vegetation Data

As the objectives of the Toolibin vegetation monitoring are principally concerned with change in the health of the vegetation, the key results presented in this section will be restricted to tree vigour trends and a summary of the vegetation character for each plot. Photographs of each plot are also included in each plot description. Plots of tree vigour trend are presented for each plot. The three vigour categories used are Healthy (H), Stressed (S) and Dead (D).

Overstorey data for each plot sampled in 1998 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) for all plots, including those not monitored in 1998. The understorey data are presented in Appendix 3 and include the density, % cover, height, and canopy diameter of both perennial and annual species. Perennials not in the understorey subplots but obvious in the remainder of the plot, are also listed for reference.

Soil salinities, as determined with the EM38, are presented in Appendix 4. Elevations and location co-ordinates are presented in Appendix 5 and 6 respectively. Elevations can be tied-in with benchmarks to convert to mAHD readings and then be used compare past flood patterns with tree vigour and recruitment, as required.

Figure 3.1

Map of plot locations and vegetation units at Toolibin Lake

Plot 1

Location:

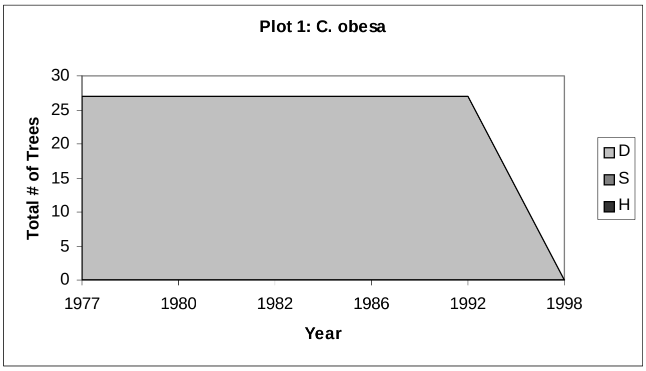
South West corner of lake bed.

Vegetation Description:

Initially a low woodland of *Casuarina obesa, Melaleuca strobophylla*.

Condition in 1998 and Trend To-date:

All trees are dead and have been since records began. Salt crusting on the soil surface was evident in the past. The plot was destroyed during the construction of the separator channel.



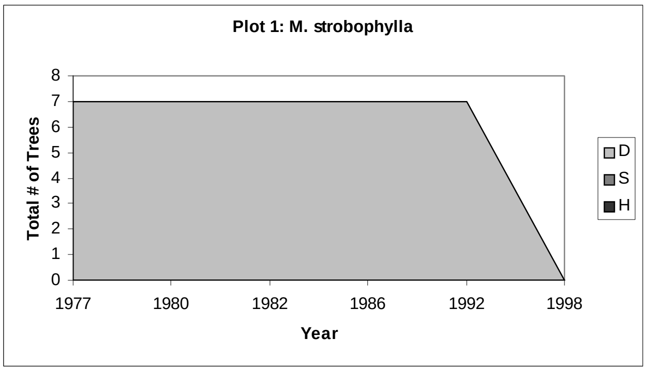


Figure 3.2 : Trend in the vigour of the dominant species at Plot 1

Plate : No photographs possible.

Plot 2

Location:

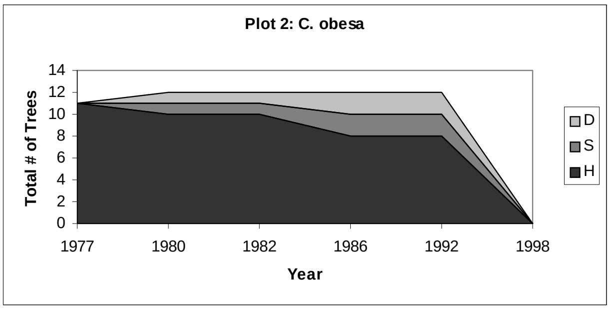
South west corner of the lake bed.

Vegetation Description:

Initially a woodland of *Eucalyptus rudis* near the bank of the lake. Lower storey included *Melaleuca uncinata*, *Casuarina obesa* on lower slopes near lake edge and *Allocasuarina huegeliana* on the upper slopes.

Condition in 1998 and Trend To-date:

The plot was destroyed when the separator channel was constructed. Condition of all tree species declined since 1977, *C. obesa* being the most resilient. Seedlings of *C. obesa* were observed in 1986 all of which died by 1992.



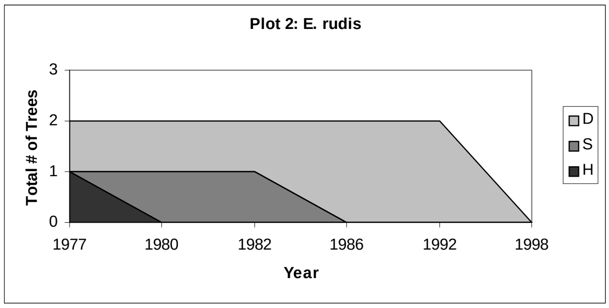


Figure 3.3: Trend in the vigour of the dominant species at Plot 2

Plate : Photograph not possible.

Plot 3

Location: E 555961; N 6357279

West side of the lake bed.

Vegetation Description:

Low woodland of *Casuarina obesa*. Understorey of *Halosarcia lepidosperma* and various annuals.

Condition in 1998 and Trend To-date:

Most of the *C. obesa* trees were dead with the majority of the live trees in poor health. Moderate to high soil salinities recorded and there is evidence of salt crusting on the soil surface. There has been some variability in the vigour of the trees in the past but the trend in recent years is towards complete mortality. The understorey of samphires is evidence of elevated soil salinities for several years.

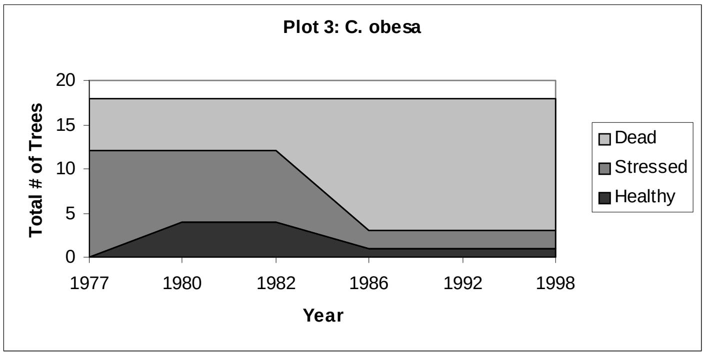


Figure 3.4: Trend in the vigour of the dominant species at Plot 3

Plate 1: Facing diagonally across Plot 3

Plot 4

Location: E 556207; N 6357274

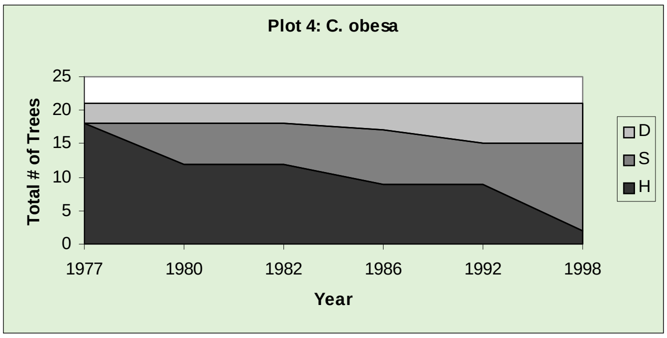
West side of the lake bed.

Vegetation Description:

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

Condition in 1998 and Trend To-date:

There has been a steady, declining trend in the vigour and survival of both overstorey species. Current vigour of the overstorey is poor with *M. strobophylla* showing the most significant decline. The understorey composition indicates elevated soil salinities for some years. This is confirmed by the moderate to high soil salinities recorded by the EM38 measurements.



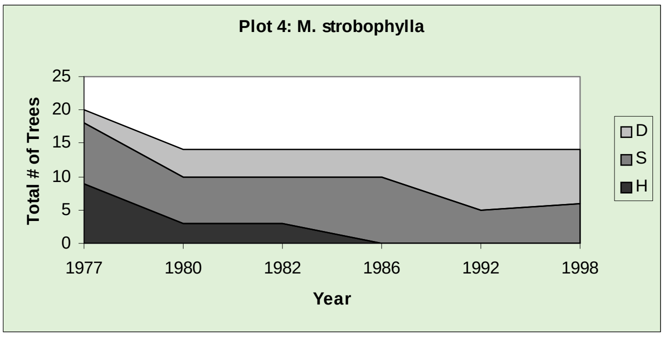


Figure 3.5 : Trend in the vigour of the dominant species at Plot 4

Plate 2 : Facing diagonally across Plot 4

Plot 5

Location: E 556207; N 6357274

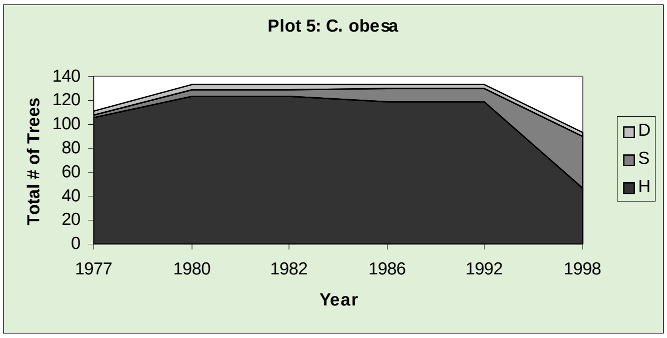
West side of the lake bed (Adjacent to Plot 4).

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 lepidosperma*. Some annuals present.

Condition in 1998 and Trend To-date:

Generally, a stand of consistently higher vigour in both overstorey species. However, a vigour decline has been noted in the 1998 assessment. Soil salinities are moderate to high. This is one of very few plots that cover the dense stands of *C. obesa* and *M. strobophylla* typical of the centre of the lake. Higher vigours are attributable to most of the trees being located on gilgai mounds 20-40 cm above soils of higher salinity. The understorey is sparse and indicative of saline soil. Some annuals present.



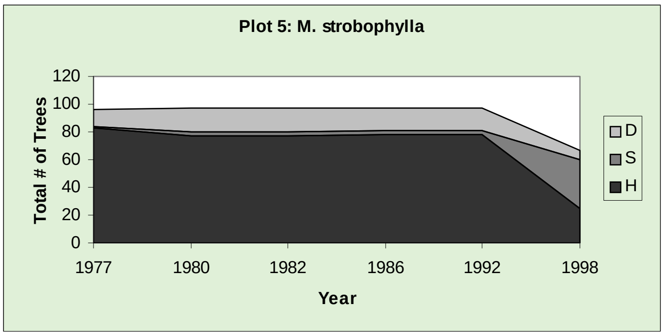


Figure 3.6 : Trend in the vigour of the dominant species at Plot 5

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 vary sparse *Halosarcia indica*. Some annuals present.

Condition in 1998 and Trend To-date:

All trees are dead and have been since 1980. Very open area of the lake bed with no evidence of salt crusting. Soil salinities are moderate to high.

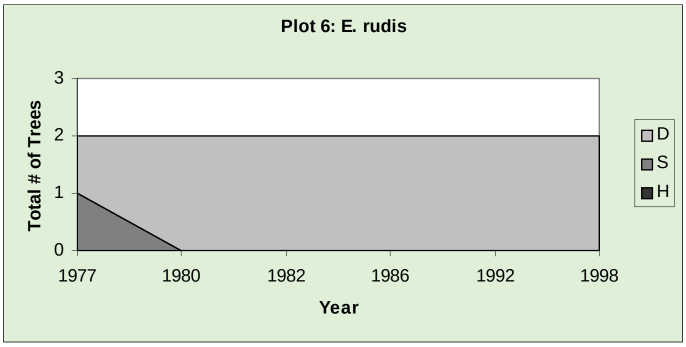


Figure 3.7 : Trend in the vigour of the dominant species at Plot 6

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 indica* and some annuals.

Condition in 1998 and Trend To-date:

All *E. rudis* is dead and has 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. One seedling of *C. obesa* was noted in the plot. The sparse understorey is indicative of saline soil. Soil salinities were moderate.

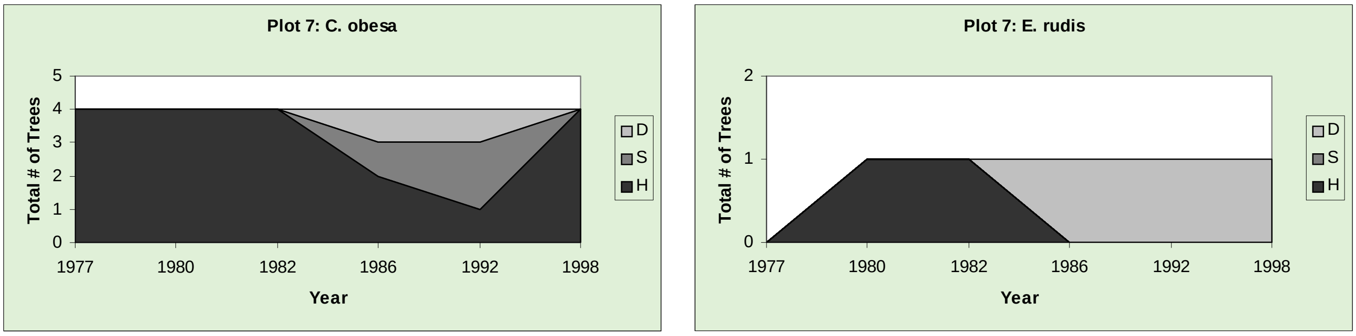


Figure 3.8 : Trend in the vigour of the dominant species at Plot 7

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 but has an understorey of *Wilsonia rotundifolia, Spergularia rubra*.

Condition in 1998 and Trend To-date:

No trees present. Understorey is dominated by annuals. A large number of *C. obesa* seedlings were observed in 1986 but disappeared in 1992. No seedlings were observed in 1998. Soil salinities are moderate.

Plate 6 : Facing diagonally across Plot 8

Plot 9

Location: E 557411; N 6357712

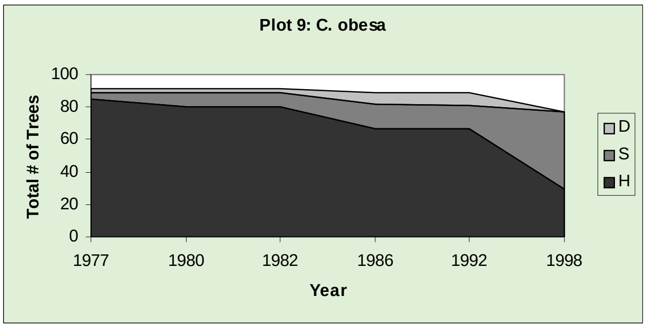
Eastern fringe of the lake bed.

Vegetation Description:

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

Condition in 1998 and Trend To-date:

The *M. strobophylla* population has been in poor condition since assessment began. The *C. obesa* vigour has declined steadily since 1982 with a significant decrease since 1992. There is no understorey. Soil salinities are moderate.



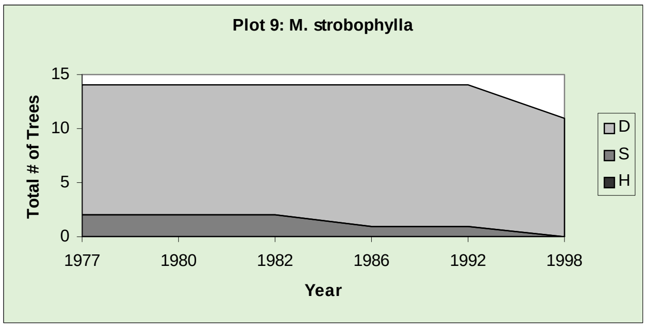


Figure 3.9 : Trend in the vigour of the dominant species at Plot 9

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 1998 and Trend To-date:

A plot of relatively high tree vigour. Little change in vigour has occurred in earlier assessment years. There has been a decline in vigour since 1992. All *E. rudis* have been dead since 1980. *C. obesa* seedlings were observed in 1986 (505 seedlings) but all died by 1992. No seedlings were observed in 1998. Soil salinities are moderate to high.

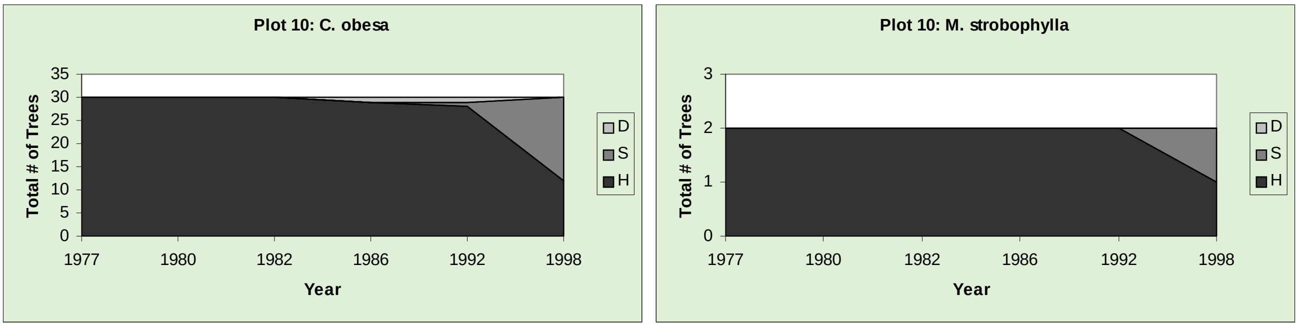


Figure 3.10 : Trend in the vigour of the dominant species at Plot 10

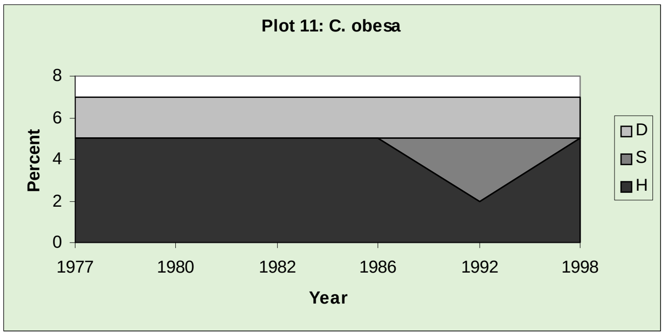
Plate 8 : Facing diagonally across Plot 10

Plot 11

Location: E 556874; N 6358247
Northern lake edge.

Vegetation Description:
Woodland of *Eucalyptus rudis* with substorey of *Melaleuca strobophylla* and *Casuarina obesa*. Sparse understorey of *Halosarcia lepidosperma, Halosarcia indica, Atriplex semibaccata.*

Condition in 1998 and Trend To-date:
The few *C. obesa* have remained relatively healthy whereas the *M. strobophylla* has declined and died. The once dominant *E. rudis* population has been dead since monitoring began. A significant change has occurred in the understorey with *Hakea preissii*, *M. lateriflora* and *M. acuminata* being replaced with *Halosarcia lepidosperma, Halosarcia indica,* and *Atriplex semibaccata.* Loss of the former species was complete by 1992 but advanced decline was noted by 1980. The latter species are typical of saline soils. Soil salinity is moderate.



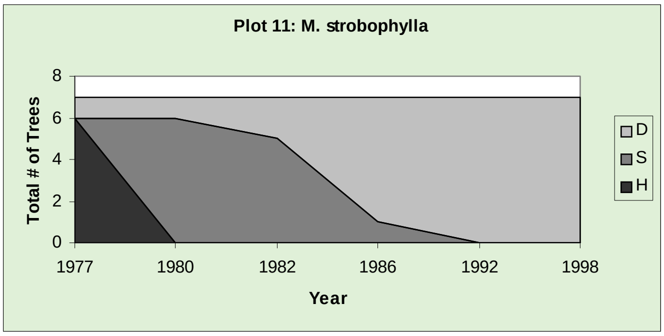


Figure 3.11 : Trend in the vigour of the dominant species at Plot 11

Plate 9 : Facing diagonally across Plot 11

Plot 12

Location: E 556994; N 6358428

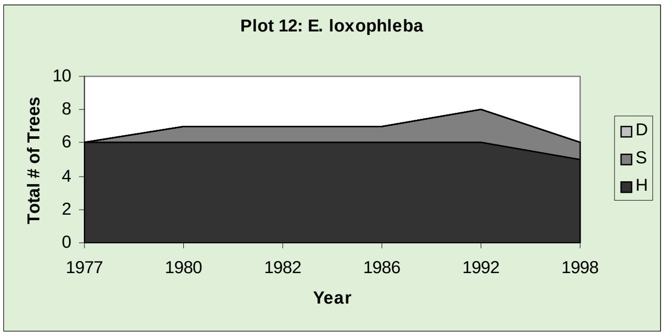
On sandy soils to the north of the lake.

Vegetation Description:

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

Condition in 1998 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. One new seedling was observed in 1998. There were numerous annual species and obvious perennial species not included in the subplots are listed in Appendix 3. Soil salinity is low.



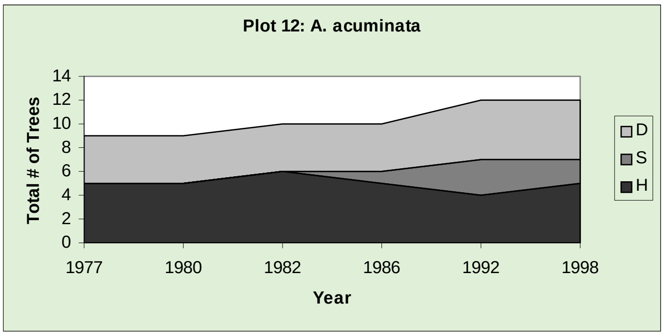


Figure 3.12 : Trend in the vigour of the dominant species at Plot 12

Plate 10 : Facing diagonally across Plot 12

Plot 13

Location: E 557451; N 6358719

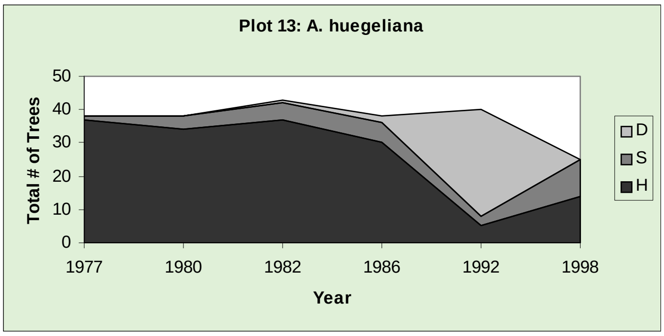
North of the lake, roadside.

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 1998 and Trend To-date:

A. huegeliana has declined in recent years. *B. prionotes* vigour has remained poor since 1982 and there has been a significant increase in the number of dead trees since 1986. The understorey is one of the more diverse of the Toolibin plots (see Appendix 3). Many of the understorey species that were recorded in previous assessments are no longer present however the understorey has remained diverse. Two *A. huegeliana* seedlings and 7 *A. acuminata* seedlings were observed in 1998. Decline of this vegetation is unlikely to be due to salinity. The salinity of the sandy soil is low.



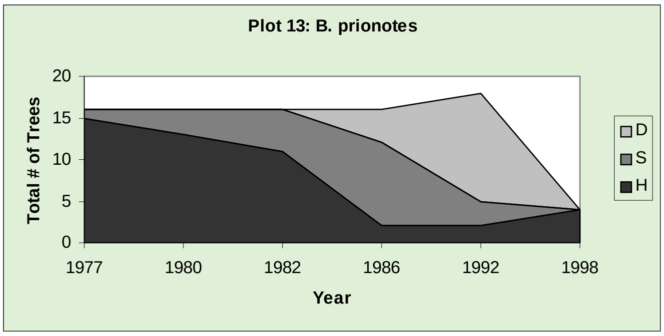


Figure 3.13 : Trend in the vigour of the dominant species at Plot 13

Plate 11 : Facing diagonally across Plot 13

Plot 14

Location:

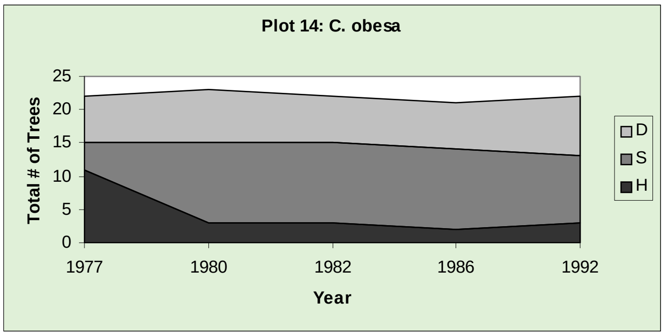
On southern fringes of Dulbinning Lake.

Vegetation Description:

Woodland of *Casuarina obesa – Melaleuca strobophylla*. Understorey very sparse.

Condition in 1998 and Trend To-date:

NOT ACCESSED IN 1998. Extensive searching for the plot was unsuccessful. Gradual decrease in the vigour of *C. obesa* over the monitoring period. *M. strobophylla* remains healthy.



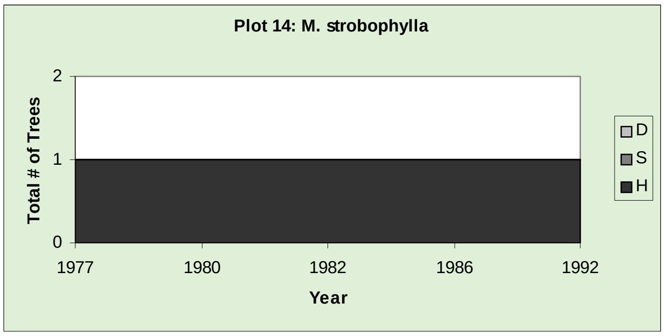


Figure 3.14 : Trend in the vigour of the dominant species at Plot 14

Plot 15

Location: E 559612; N 6360638

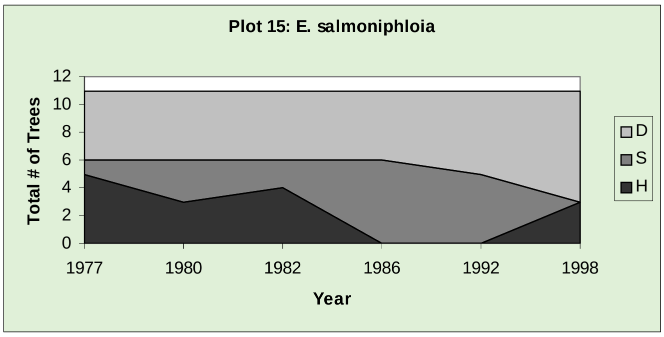
On northern fenceline of Dulbinning Nature Reserve, south of dam in adjacent property.

Vegetation Description:

Open woodland of *Eucalyptus salmonophloia – Eucalyptus wandoo*. Understorey of *Atriplex semibaccata* and others.

Condition in 1998 and Trend To-date:

Decreasing *E. salmonophloia* vigour over monitoring period. The few *E. wandoo* present have died. Larger shrub species noted in previous assessments have not survived, being replaced with more salt-tolerant species. Salinity of the heavy soil is low to moderate.



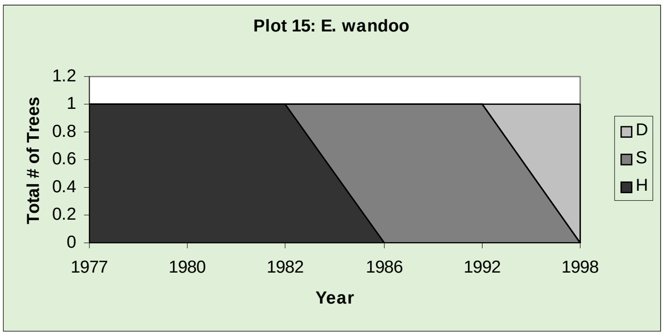


Figure 3.15 : Trend in the vigour of the dominant species at Plot 15

Plate 13 : 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 mixed low shrubs and small herbs.

Condition in 1998 and Trend To-date:

E. salmonophloia vigour has been poor during most of the monitoring period. Slight increase in health during 1998. Understorey is sparse but has experienced little change. Soil salinities are low to moderate.

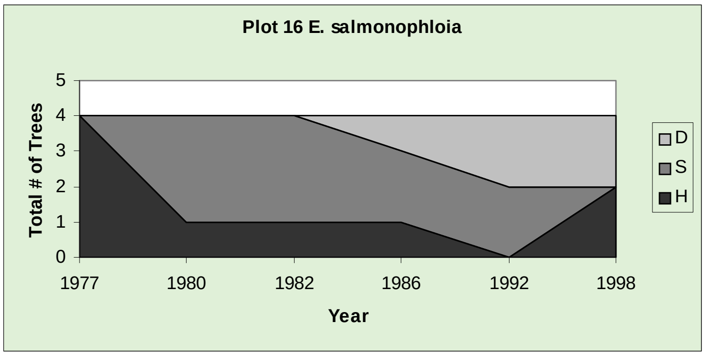


Figure 3.16 : Trend in the vigour of the dominant species at Plot 16

Plate 14 : 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 small herbs.

Condition in 1998 and Trend To-date:

E. salmonophloia condition poor since monitoring began. All trees are now dead. *M. acuminata* (incorrectly identified as *M. viminea* in previous reports) vigour remains high. Soil salinities are moderate.

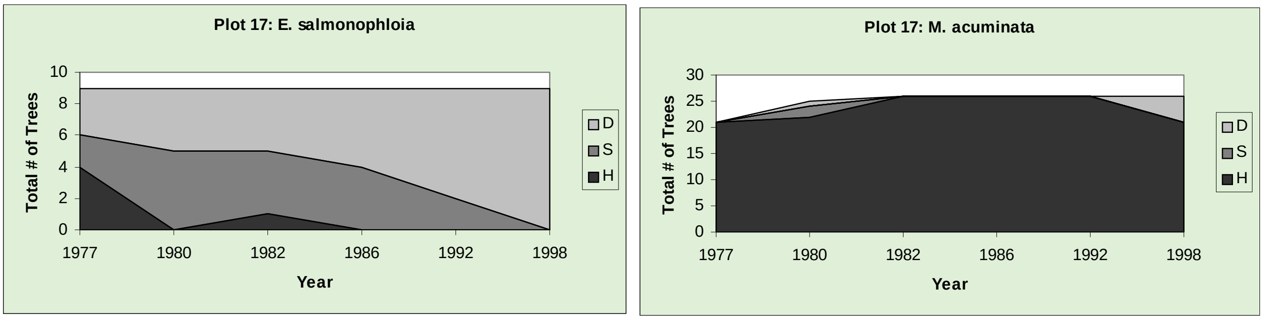


Figure 3.17 : Trend in the vigour of the dominant species at Plot 17

Plate 15 : 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* , grasses and small herbs.

Condition in 1998 and Trend To-date:

All trees have been dead since monitoring began. *E. loxophleba* was also present in small numbers. *M. acuminata* numbers have increased over monitoring period. Presence of *Atriplex semibaccata* indicates increasing soil salinities. Soil salinities are moderate.

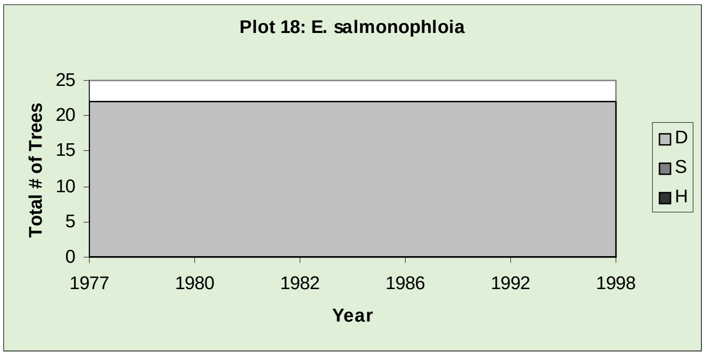


Figure 3.18 : Trend in the vigour of the dominant species at Plot 18

Plate 16 : 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 grasses and small herbs.

Condition in 1998 and Trend To-date:

Mixture of healthy and dead *M. lateriflora*. Vigour trend is relatively constant. Understorey unchanged except for the introduction of *Halosarcia lepidosperma*, indicating increasing soil salinities. Soil salinities are moderate.

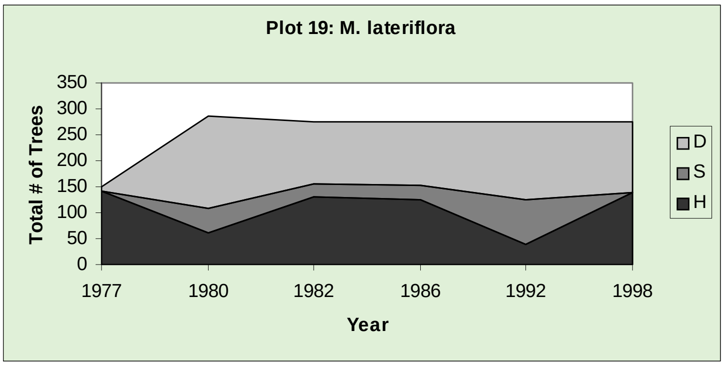


Figure 3.19 : Trend in the vigour of the dominant species at Plot 19

Plate 17 : Facing diagonally across Plot 19

Plot 20

Location: E 558908; N 6360157

In Dulbinning Nature Reserve near track running north between Stanley's property and reserve.

Vegetation Description:

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

Condition in 1998 and Trend To-date:

Majority of *E. salmonophloia* trees dead with the vigour of live trees gradually decreasing. All trees are now dead, except for one live *E. loxophleba*. Understorey *M. acuminata* generally healthy but vigour has decreased significantly since 1986. *Gahnia trifida* also common in the understorey. Sparse *Atriplex semibaccata* indicative of increasing soil salinities. Soil salinities are low – moderate.

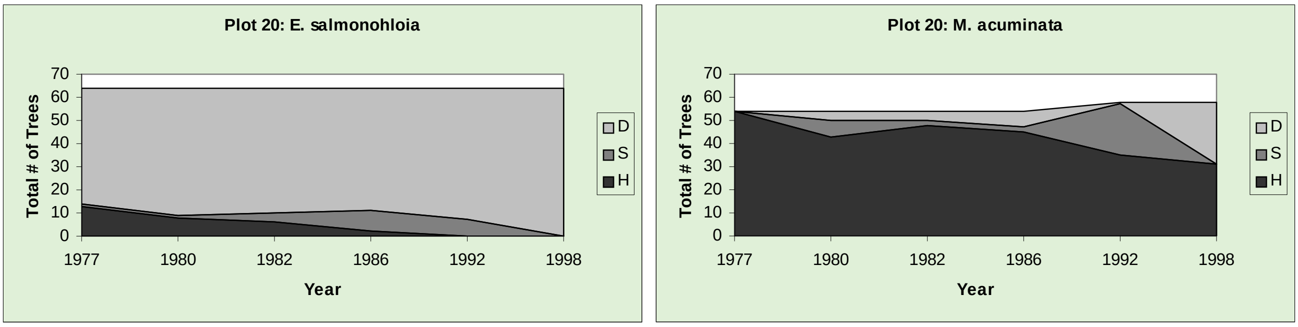


Figure 3.20 : Trend in the vigour of the dominant species at Plot 20

Plate 18 : 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 1998 and Trend To-date:

All trees are dead and have been since monitoring began. Understorey of samphires has been present since 1977. Plot is usually inundated in spring and was so in 1998. Soil salinities not recorded as plot was inundated.

Plate 19 : 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 1998 and Trend To-date:

All trees are dead and have been since monitoring began. Understorey of samphires has been present since 1977. Plot is usually inundated in spring and was so in 1998. Soil salinities not recorded as plot was inundated.

Plate 20 : Facing diagonally across Plot 22

Plot 23

Location: E 558766; N 6359385

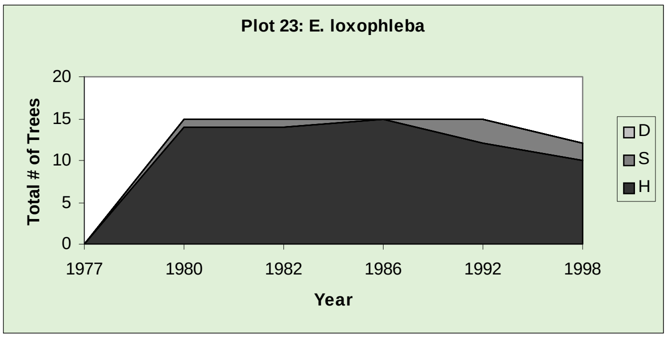
On the Dulbinning Nature Reserve to the west of the road running north.

Vegetation Description:

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

Condition in 1998 and Trend To-date:

The plot occurs within the bulldozed and burnt area of “Stanley’s Property”. Monitoring began in 1980, after the disturbance. Most trees are *E. loxophleba* and *E. wandoo* with some *E. salmonophloia*. Vigour is high with a gradual decline since 1986. The understorey is relatively unchanged but there has been an increase in the number of dead *M. acuminata*. Soil salinities are low to moderate.



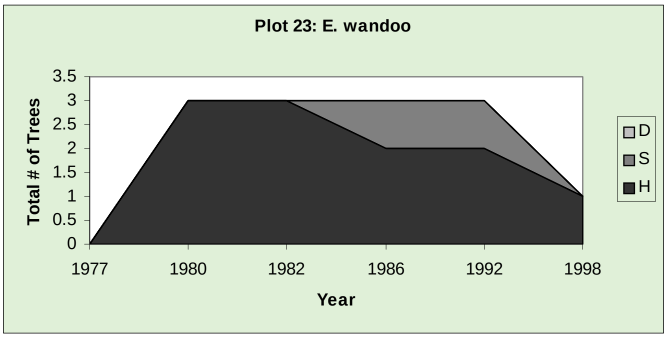


Figure 3.21 : Trend in the vigour of the dominant species at Plot 23

Plate 21 : Facing diagonally across Plot 23

Plot 24

Location: E 558729; N 6359250

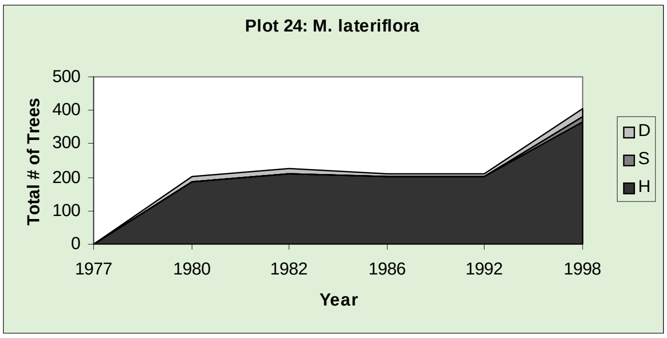
Approximately 100m west of road running north through Dulbinning Nature Reserve. In the regeneration area to the south of Plot 23.

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 1998 and Trend To-date:

The plot occurs within the bulldozed and burnt area of “Stanley’s Property”. Monitoring began in 1980, after the disturbance. Very sparse trees are *E. loxophleba* and *E. wandoo*. Vigour is high. The understorey dominates the plot and shows incresing health in recent years. Soil salinities are low to moderate.



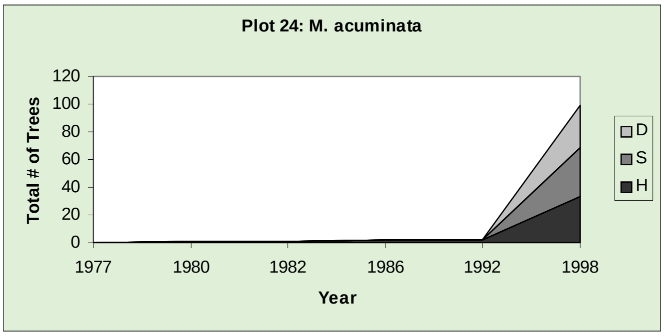


Figure 3.22 : Trend in the vigour of the dominant species at Plot 24

Plate 22 : Facing diagonally across Plot 24

Plot 25

Location: E 558693; N 6359709

On the Dulbinning Nature Reserve to the west of the road running north. Plot is approximately 150m south of northern boundary and 100m west of road.

Vegetation Description:

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

Condition in 1998 and Trend To-date:

E. wandoo identified as *E. sp* or *E. salmonophloia* in previous reports and not monitored in 1986. *E. sp* vigour data used to complete *E. wandoo* graph. Tree vigour varies over time with health decreasing significantly in 1998. A large number of Eucalypt and *Melaleuca* seedlings were noted in 1992 and six *E. wandoo* seedlings were observed in 1998. Understorey is relatively unchanged. Soil salinities are low- moderate.

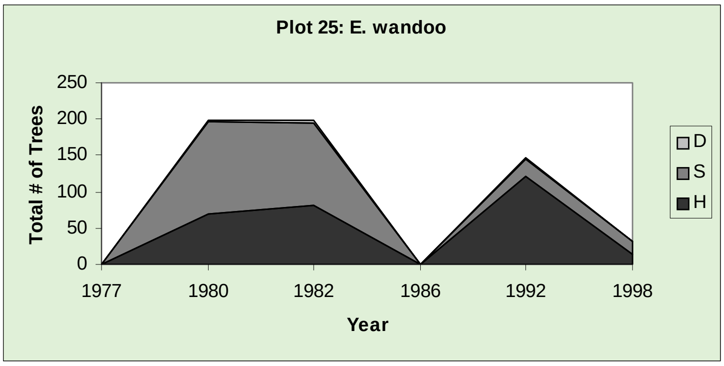


Figure 3.23 : Trend in the vigour of the dominant species at Plot 25

Plate 23 : Facing diagonally across Plot 25

Plot 26

Location: E 558808; N 6358512

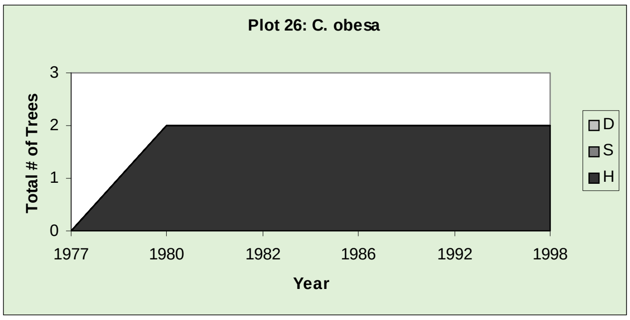
To the west of the road running north through the Dulbinning Nature Reserve. Located in the regeneration area to the south of Plots 23-25.

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. Understorey dominated by grasses and small herbs.

Condition in 1998 and Trend To-date:

Condition is relatively unchanged with numbers of *A. acuminata* gradually increasing. Large numbers of seedlings appeared after the disturbance but few survived. Soil salinities are very low.



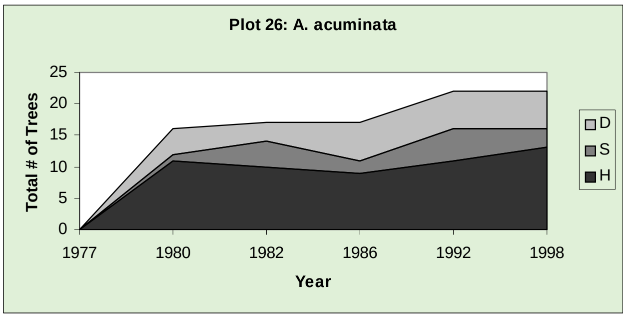


Figure 3.24 : Trend in the vigour of the dominant species at Plot 26

Plate 24 : Facing diagonally across Plot 26

Plot 27

Location: E 555910; N 6357140

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

Vegetation Description:

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

Condition in 1998 and Trend To-date:

All trees are healthy. A significant number (117) of *C. obesa* seedlings observed in 1998. Understorey species indicative of saline soil. Soil salinities low to moderate and contrast with the higher salinities typical of the lake bed.

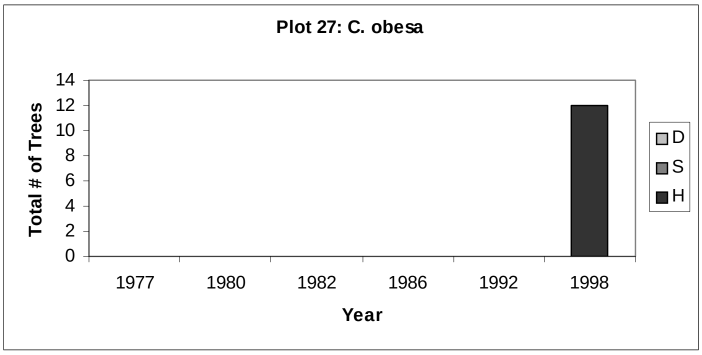


Figure 3.25 : Vigour of the dominant species at Plot 27

Plate 25 : Facing diagonally across Plot 27

Plot 28

Location: E 556007; N 63565110

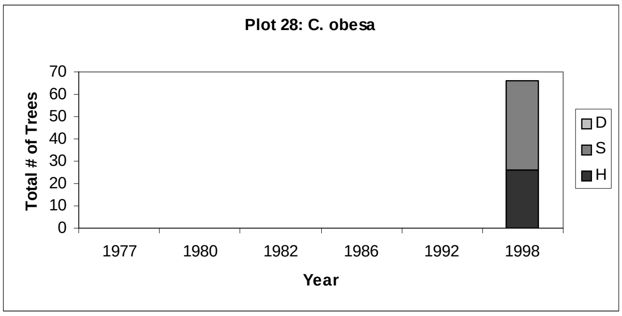
Southern portion of lake bed, near abstraction bore. New plot established in 1998.

Vegetation Description:

Woodland of *Casuarina obesa*. Some *Melaleuca strobophylla*. Very sparse understorey of *Halosarcia lepidosperma* and *Atriplex semibaccata* and small herbs.

Condition in 1998 and Trend To-date:

Almost 60% of the *C. obesa* appeared stressed but there were no dead trees. No seedlings present. Soil salinities were moderate to high.



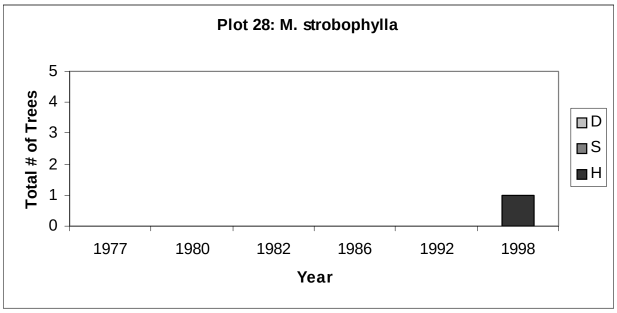


Figure 3.26 : Vigour of the dominant species at Plot 28

Plate 26 : Facing diagonally across Plot 28

Plot 29

Location: E 556383; N 6356462

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

Vegetation Description:

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

Condition in 1998 and Trend To-date:

Over 60% of the *C. obesa* appeared stressed. No seedlings were present. Soil salinities were moderate to high.

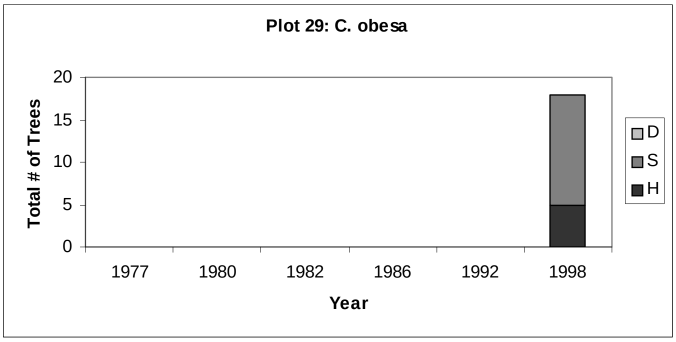


Figure 3.27 : Vigour of the dominant species at Plot 29

Plate 27 : Facing diagonally across Plot 29

Plot 30

Location: E 557264; N 6356313

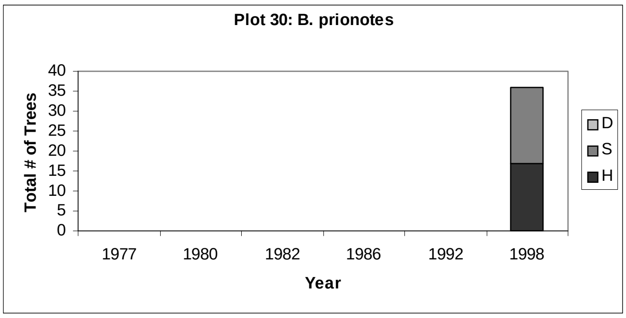
On the deep sand dunes near the eastern fringe of the lake. New plot established in 1998.

Vegetation Description:

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

Condition in 1998 and Trend To-date:

Half of the *B. prionotes* appeared stressed. Eight seedlings were observed. Understorey sparse with no large perennials.



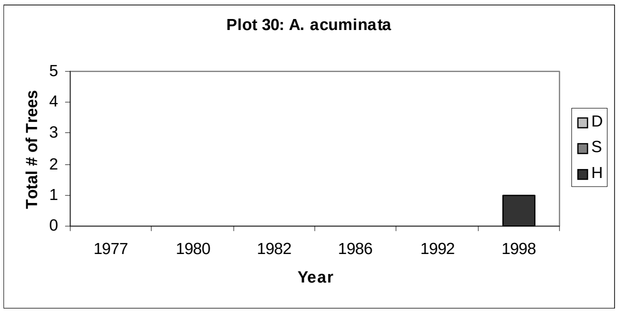


Figure 3.28 : Vigour of the dominant species at Plot 30

Plate 28 : Facing diagonally across Plot 30

Plot 31

Location: E 557396; N 6356672

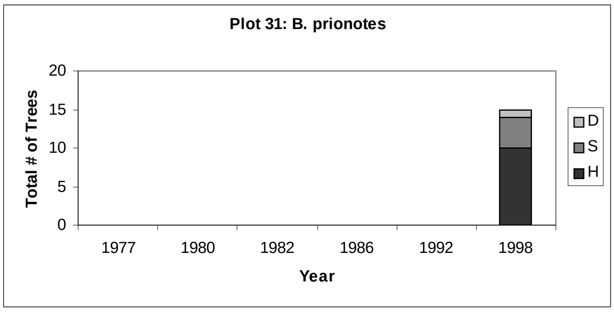
On the deep sand dunes near the eastern fringe of the lake. New plot established in 1998.

Vegetation Description:

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

Condition in 1998 and Trend To-date:

Majority of *B. prionotes* healthy with 30% stressed. All *A. huegeliana* trees healthy except 1 death. Understorey is dominated by sparse grasses and small herbs however, some larger perennials such as *Hibbertia argentea* and *Conospermum distidium* were present. Soil salinities were very low.



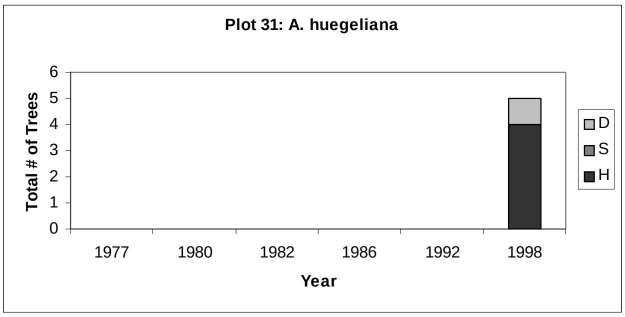


Figure 3.29 : Vigour of the dominant species at Plot 31

Plate 29 : Facing diagonally across Plot 31

Plot 32

Location: E 557190; N 6358893

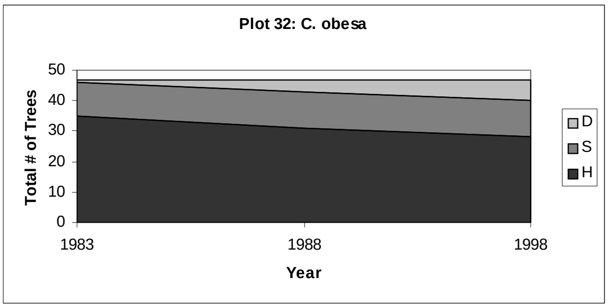
Across the Northern Arthur River just 50m south of road. Plot originally established in 1983.

Vegetation Description:

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

Condition in 1998 and Trend To-date:

Varied vigour in all overstorey species. Up to 50% of the individuals of each species were either stressed or dead. Understorey shrubs indicative of increasing soil salinity. Spare grasses and small herbs also present. Soil salinities ranged from low at higher ground to high near or in the channel.



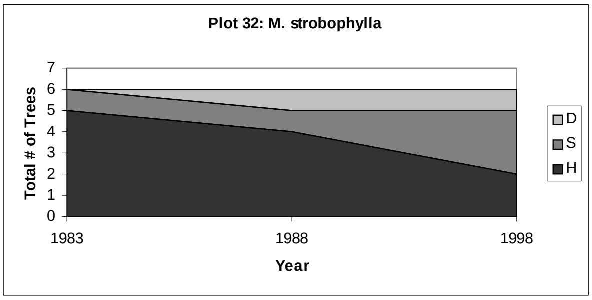


Plate 30 : Facing diagonally across Plot 32

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 1998 and Trend To-date:

Majority (90%) of the trees were either stressed or dead. Salt tolerant understorey species appear to be colonising the area. Soil salinities are moderate to high.

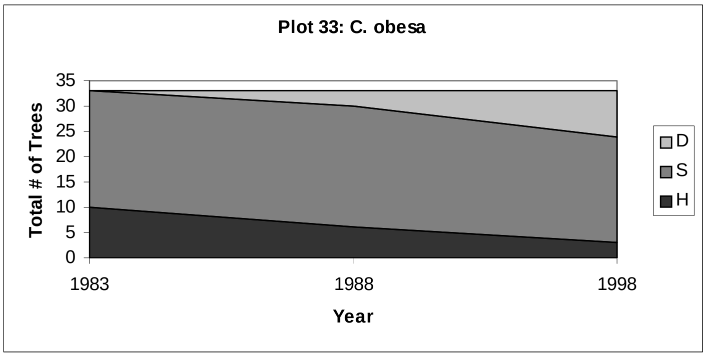


Plate 31 : Facing diagonally across Plot 33

3.3 Seedling Recruitment

During the 1998 reassessment of the Toolibin plots, a significant amount of *Casuarina obesa* seedling recruitment was observed in the western portion of the lake bed. Seedlings were concentrated around Plots 3 and 27 and appear to have germinated during autumn/winter 1998. There was some evidence of grazing however the majority of seedlings appeared healthy.

The site conditions were open soil (no evidence of salt crusting), sparse live parent trees (female) nearby, moderate to significant amounts of dead tree debris on the ground. The lake did not fill with water in winter/spring 1998 however there was sufficient water to saturate sediments and form small ponds in shallow depressions. It is important that the fate of these seedlings is monitored so that more information on the process of successful recruitment is gained.

In 1986, mass seedling recruitment of *C. obesa* was observed on the lake bed. Seedlings were recorded by subdividing the relevant plots into subplots and total numbers and heights noted. Seedlings were found mostly in areas associated with the gilgai mounds. Most of the seedlings were less than 20cm high, some were stunted and many, particularly when at high density, showed signs of grazing. The seedlings were relocated by CALM staff in December of the following year and their survival assessed (Table 3.1). The intervening period was dry and the seedlings were stunted and heavily grazed. All plots showed a decrease in the number of live seedlings except Plot 2 which had a 36.4% increase in seedling numbers probably due to protection from grazing due to fallen debris.

In 1992 the seedling subplots were re-established by Mattiske and again checked for seedling progress, however all had died. Although many seedlings of *C. obesa* were observed on the lake bed in 1986, no seedlings were evident in the 1992 monitoring. The latter death of these seedlings coincided with the extensive crusting of dead algae on the lake bed (Mattiske, 1993). Other possible causes of seedling death suggested by Mattiske are grazing by rabbits and kangaroos. The implications from these observations are that grazing has stunted seedling growth and that seedlings have been submerged by eutrophic water. Seedling mortality has probably been due to the combined effects of depletion of oxygen and direct smothering. The distribution of plots where seedlings were observed is spread across the lake from the western side (plots 2 and 4) to the eastern side (plots 6, 7, 8, 10). However, the greatest density of seedlings appears to have occurred on the eastern plots where soil salinities may be lower.

Table 3.1: Number of *Casuarina obesa* seedlings in Mattiske plots on the bed of Toolibin Lake

Plot No.	Number of Seedlings in Nov. 1986*	Number of Seedlings in Dec. 1987*	% change	Notes on Likely Cause of Death
2	66	90	+36.4	Rabbit grazing
4	162	-	-	Grazing, inundation, dead algae
6	33	26	-21.2	Grazing, inundation, dead algae
7	630	450	-28.6	Grazing, inundation, dead algae
8	3411	2424	-28.9	Grazing and dead algae
10	505	293	-42.0	Grazing, inundation, dead algae

* Number of seedlings in 20x20m plot, all seedlings were dead/missing by 1992

It is evident from the stochastic nature of *Casuarina obesa* seedling recruitment on the floor of Toolibin Lake, that the potential for recruitment is not realised until specific conditions are met. There continues to be speculation as to the requirements for seedling recruitment at Toolibin Lake. Ogden's (1997) work on the recruitment requirements of *C. obesa* at Toolibin Lake is the only information to-date on this matter and sheds some light on the process of and the potential for successful recruitment. The importance of inflow/significant flood events in promoting/limiting recruitment is paramount. Episodes of flooding are important for creating the conditions necessary for successful seedling recruitment. Moist, exposed bed sediments after water levels have receded, are required for successful recruitment. Significant viable seed set is obviously required before recruitment, therefore optimum conditions for flowering and seed set are needed 2-3 years prior to when optimum conditions for seed germination and seedling survival occur.

There are also spatial constraints for seedling establishment. If bare, moist sediment banks are limited in area and distribution, this will limit the potential sites of seedling establishment. Swales on the lake bed have higher salinities (in some areas of the lake) than the tops of gilgai mounds, and seed germination does not occur under these conditions. Lower sediment salinities in the future will increase the potential area of seedling establishment on the lake bed. The tops of mounds also afford a submergence refuge to the seedlings; those fortunate enough to germinate on mounds may not be submerged (and potentially killed) by inflow events during the first 2-3 years of establishment.

There are, of course, temporal constraints for seedling establishment. A viable seed source needs to be available before flood conditions are optimal for seed germination and establishment. Windows of opportunity for successful seedling establishment therefore, may occur infrequently. The frequency of successful seedling recruitment may be increased by decreasing sediment salinities and preventing high water levels within 2-3 years after mass recruitment. The probability that these goals can be achieved will be improved if we have control of the outflow events.

4. DISCUSSION AND RECOMMENDATIONS

The 1998 reassessment of the Toolibin Lake vegetation monitoring plots revealed two general points:

- There continues to be a decline in the health of vegetation in both aquatic and terrestrial habitats.
- There is also some evidence of recovery where conditions allow.

The vegetation on or near the lake bed and other wetland vegetation in the surrounding reserves, continues to show decline in vigour. The key wetland trees species, overall, show static or declining health. Figure 4.1 shows the trend in vigour of all the individuals of the major trees species that are sampled on the lake bed and other wetland areas.

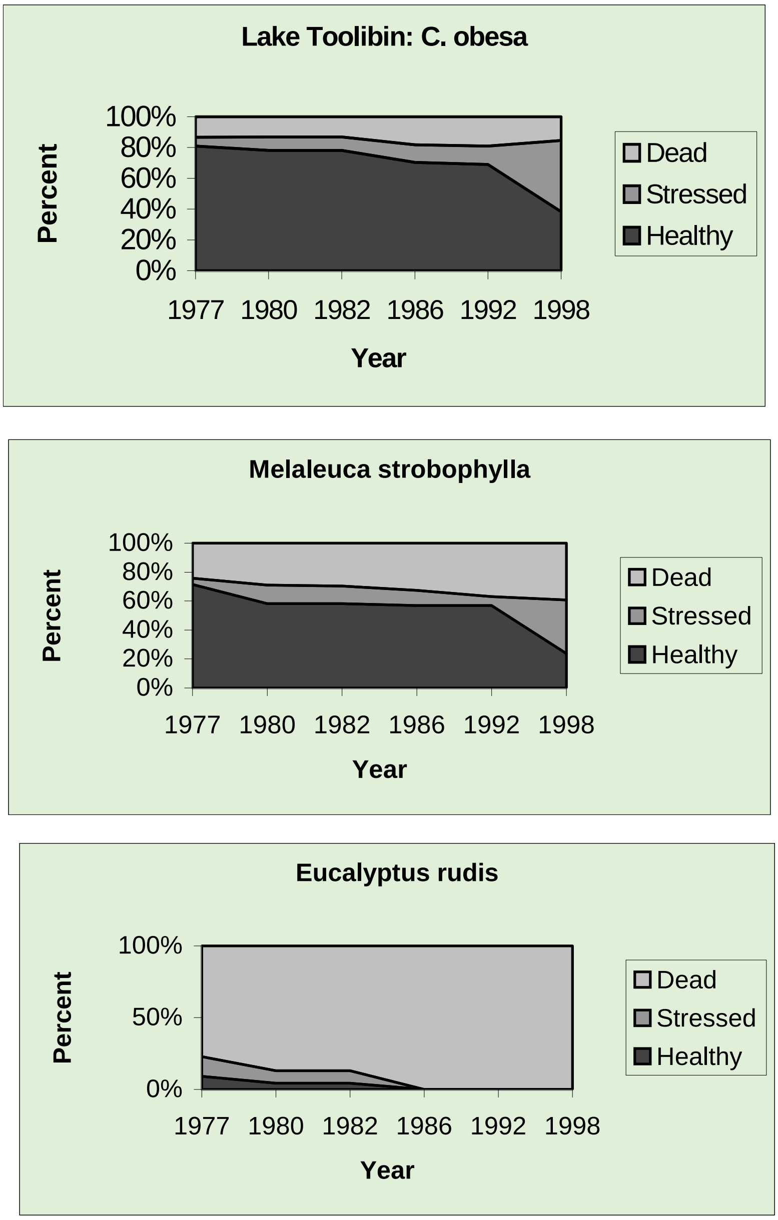


Figure 4.1: Trend in vigour of all individuals of each major wetland trees species at Toolibin Lake.

Except for E. rudis which was lost from the lake bed before 1986, the vigour of the major wetland tree species has been declining gradually since monitoring began. Although there are significant differences in the vigour of trees between individual sites, the overall trend is one of decreasing tree health.

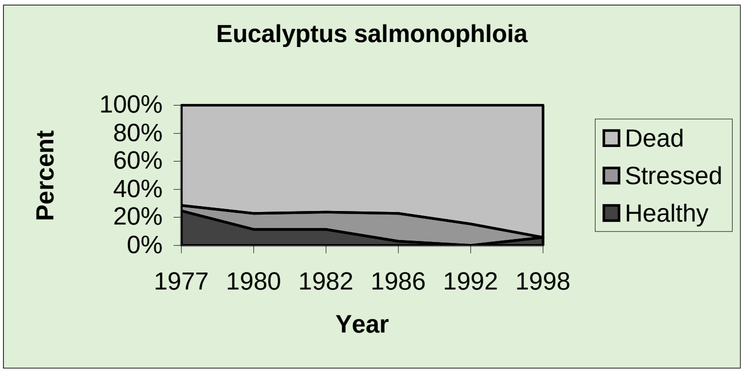
Figure 4.1 shows a sharp decline in tree vigour in 1998. The background to this result needs to be considered before it is interpreted as a significant decline. Some of this change in vigour must be attributable to the change in methodology in assessing tree health. Previous assessments used a simple three class system (healthy, stressed, dead) whereas the 1998 assessment used the 3 part scale (crown density, dead branches and epicormic growth) adopted in the Salinity Action Plan wetland vegetation monitoring program. The 3 part scale gives a numerical score out of 23 and provides justification for the score. For the sake of comparison, the 3 part scores were divided into the three classes used in previous assessments (see methods). Given the finer scale of the 3 part method, some trees that would have been considered as healthy using the previous technique are now scored as stressed. Despite this, the authors believe that the 1998 scores are a true reflection of the current health of the Toolibin trees and that overall vigour of each species has declined further.

Some areas of the lake bed have shown signs of stability and/or recovery in tree health. On the western side of the lake were tree vigour is typically declining (Plot 3) *C. obesa* are surviving with no further decrease in health. *C. obesa* seedlings were also observed in the area. It is possible that the drawdown of the saline groundwater via abstraction is having a positive affect on the vegetation, particularly during dry periods. Further monitoring and study is required to determine if this is the case. On the eastern side of the lake, Plot 7 has shown recovery in *C. obesa*. This site, however, is the only place were *C. obesa* trees showed significant evidence of improved health. Overall, the vegetation in the open, low-lying portions of the lake bed have continued to decline or show no signs of recovery. Lake bed vegetation on the gilgai mounds continues to have higher vigour and although there are a limited number and poor distribution of long-term plots covering this vegetation, it appears this dense vegetation has not declined.

The spread of halophytic species such as *Halosarcia* and *Atriplex* on the lake bed continues. There were several lake bed plots where the presence of these species was recorded for the first time in 1998. Although in most cases their cover was very sparse, they have spread to new areas on the lake. This is likely to be due to increasing soil salinities and extended periods of poor inundation.

The overall trend in vigour of the key terrestrial tree species is shown in Figure 4.2. There continues to be decline in the vigour of *E. salmonophloia* to the point where very few live trees remain in the monitoring plots. There has been significant regrowth in the regeneration area to the north of the lake but most of the trees there are *E. wandoo* and not *E. salmonophloia*. The *E. salmonophloia* woodlands with *Melaleuca* understorey and the *E. loxophleba - A. acuminata* woodlands continue to decline but some plots have shown stability or recovery (improved health and/or recruitment) in the understorey (e.g. Plots 26, 24, 19 and 12).

The *Banksia prionotes* woodland plots show continued decline, however the additional *B. prionotes* plots added in 1998 (Plots 30 and 31 on the eastern sand dunes) show higher vigour and seedling recruitment. This accounts for the 1998 increase in overall vigour of *B. prionotes* in Fig. 4.2. The older monitoring plot was burnt and has shown signs of very slow recovery, hence the poor vigour rating in recent years. This suggests caution is required when planning for controlled burning to enhance recruitment.



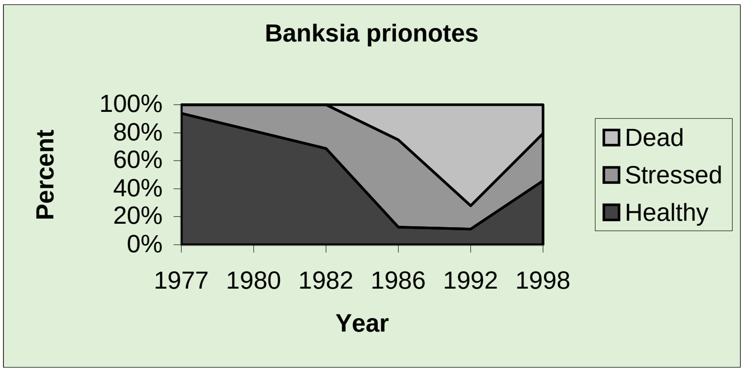


Figure 4.2: Trend in vigour of all individuals of each major terrestrial trees species at Toolibin Lake.

Banksia prionotes does not have a high degree of serotiny and the cone follicles open within a year or two of flowering, dropping the seed to the ground (Cowling and Lamont, 1985, 1987; Enright and Lamont, 1989). The cone follicles on virtually all of the mature trees in the *Banksia* woodland near the eastern fringe of Toolibin Lake, appear to be open. Many trees have been observed to flower. Young (<5 year) saplings of *Banksia prionotes* as well as seedlings (<1 year old) were scattered throughout the woodland, although low in numbers. These observations suggest a degree of successful recruitment in the absence of fire. Key parameters influencing the survival of these inter-fire recruitments would be predation and moisture availability. *Banksia prionotes* is fire-sensitive (adults/saplings killed by fire, no resprouting), and given that the canopy seed store is low, a fire in this community is likely to result in very poor recruitment to replace the loss of saplings and adults. An autumn fire in 1987 burnt an area of similar vegetation along Harrismith Road and resulted in the death of many adult *Banksia prionotes* and very poor seedling recruitment. The timing of a fire is also critical as the highest rate of seedling establishment occurs when seed is released during late summer/autumn and followed soon by late autumn/winter rains (Cowling and Lamont, 1985). A spring burn is likely to result in no successful seedling establishment at all.

It is not known when the last fire occurred in the eastern fringe *Banksia prionotes* woodland of the Toolibin Reserve. Casson (1988) noted no fires in the area since at least 1923. If this is correct, the population has relied on inter-fire establishment for over 73 years.

A detailed assessment of the age distribution of the *Banksia prionotes* population, reproductive potential, stress in adults/seedlings, response to fire and predation of seedlings, needs to be performed. This will involve the establishment of monitoring plots (completed in this assessment), exclosure plots and trial burns. Other species associated with *Banksia prionotes*, such as *Allocasuarina huegeliana*, *Banksia attenuata* and *Acacia acuminata* could also be assessed using similar methodology.

An important requirement of the vegetation monitoring program is to assess the impact of groundwater abstraction from below the lake bed. The current distribution of monitoring plots does not include sufficient plots on the western side of the lake bed where the groundwater abstraction is taking place. Also, the design of the plots and methodology would need to be modified to take into account accurate assessment of improved growth, soil conditions and seedling recruitment and survival. It is recommended that an additional sub-program of vegetation monitoring be conducted to accurately assess vegetation response to the groundwater pumping. This would include fencing areas of seedling recruitment, additional vegetation monitoring plots, analysis of soil salinity profiles and groundwater depth and limited analysis of indicators of plant osmotic stress such as xylem pressure potential and ^{13}C water use efficiency indices.

Previous work on vegetation and lake salinity summarised in Froend and Storey (1996), suggests that the total salt load of the lake basin needs to be reduced via increased frequency of outflow events. Modification of the outflow channel to allow control of lake outflow during periods of lower water levels, could achieve this. Consideration would have to be given to the associated impacts of outflow modification such as sufficient surface water for the water bird breeding period. However, it is recommended that a feasibility study be undertaken to determine an appropriate structure design, management strategy and assessment of likely impacts.

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

11. **Adopt and implement the recommendations for vegetation management outlined in the Monitoring Design Report (Froend and Storey, 1996). Some of the recommendations below are repeated from this document.**

12. **Monitoring of all plots listed in this report continue every 3 years. Periods between monitoring have been irregular and there should be a commitment to maintaining a regular and thorough monitoring of the plots.**

13. **Monitoring should continue to use the SAP wetland vegetation monitoring methods so that results will be of a high standard and can be compared with wetlands elsewhere in the southwest.**

14. **Monitor and investigate the survival and growth of seedlings on the lake bed and the surrounding reserves. This will need to be conducted on a more frequent basis than every 3 years to permit tracking of seedling fate and identification of critical factors.**

15. **Monitor and assess the recovery of tree populations on the western side of the lake in response to saline groundwater abstraction.**

16. **Develop the strategies required to actively manage recruitment and recovery of vegetation within the lake and surrounding reserves.**

17. **A trial revegetation program is recommended to assess the practicality and success of seedling planting, particularly in areas of the lake bed where vegetative cover is poor.**

18. **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.**

19. **An additional sub-program of vegetation monitoring is required to accurately assess vegetation response to groundwater pumping.**

20. **An outflow modification feasibility study should be undertaken to determine an appropriate structure design, management strategy and assessment of likely impacts.**

5. ACKNOWLEDGEMENTS

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7. APPENDICES