MURRAY-DARLING BASIN COMMISSION

Riparian Vegetation of The River Murray

REPORT PREPARED BY MARGULES AND PARTNERS PTY LTD
P. AND J. SMITH ECOLOGICAL CONSULTANTS
DEPARTMENT OF CONSERVATION FORESTS AND LANDS

1990

COVER:
Healthy red gum in the Koondrook State Forest near Barham N.S.W.
Background, black box silhouette.

PHOTO:
D. Eastburn

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RIVER MURRAY RIPARIAN VEGETATION STUDY

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SUMMARY AND CONCLUSIONS

The River Murray Riparian Vegetation Survey was initiated by the Murray-Darling Basin Commission to assess the present status of the vegetation along the Murray, to identify causes of degradation, and to develop solutions for its rehabilitation and long term stability.

The study area was the floodplain of the Murray River and its anabranches, including the Edward-Wakool system, from below Hume Dam to the upper end of Lake Alexandrina.

The components of the study were:

- **Literature Review**
  A comprehensive bibliography was compiled on the floodplain vegetation, its environment and the impact of man's activities. The literature was reviewed and summarised.

- **Floristic Survey**
  A field survey was carried out, visiting 112 sites throughout the study area and collecting vegetation data from 335 plots. Data collected were the species present, their relative abundance, the condition of the eucalypts, the amount of eucalypt regeneration and indices of grazing pressure. Brief studies were made of the effects of river regulation and salinisation at specific sites.

  Thirty-seven plant communities were identified from a numerical analyis of the floristic survey data. The differences reflect environmental changes both along the river and across the floodplain. The most important factors were identified as soil salinity levels and flooding frequency. There are three vegetation zones: the river red gum *Eucalyptus camaldulensis* zone of the inner floodplain (21 communities), the black box *E. largiflorens* zone of the outer floodplain in the semi-arid reaches (12 communities) and the rises within the floodplain but above flood levels (4 communities). Wetland vegetation was not surveyed. At least 767 species of vascular plants occur on the floodplain, of which one third are introduced species.

- **Vegetation Mapping**
  The riparian vegetation of the Murray, Edward, Wakool and Niemur Rivers has been comprehensively mapped and described for both freehold and public land. Areas of severe degradation have also been located and mapped. Nine primary causal factors for this degradation have been identified. All mapping information has been compiled on a geographic information system to facilitate retrieval and updating.

  The mapping has shown that there are 232 100ha of red gum forests and woodlands across the study area, with 85% of these occurring on the River Murray. The box species (yellow, grey and black box) total 173 300ha with 70% occurring on the River Murray. A further 323 000ha of native vegetation was found throughout the study area. An additional 581 000ha was assessed as not containing native vegetation. These areas include: cleared agricultural land, water bodies, sand dunes and other developed areas.

The past 150 years of intensive land use have brought many changes to the vegetation. There has been extensive clearing, especially on the vast floodplains between the Edward and Murray Rivers. This has been conservatively estimated at 335 000ha or some 30% of the study area. Other major factors have been grazing by stock and rabbits, river regulation and soil salinisation. Further changes have resulted from logging, recreational use, introduction of European carp and changes in the fire regime. Not all changes have been detrimental to the native vegetation. Some species and communities have benefitted. However, the riparian vegetation is generally in poor condition.

Approximately 18 000ha of severely degraded vegetation was mapped of which 93% occurs on the River Murray. Red gum woodlands are the most severely affected.

The most widespread form of degradation is weed infestation. The plant communities vary but all have high numbers of introduced weeds: 18-63% of the species in a 400m^2 plot. The dominants in most communities are native species but six communities consist of native tree layers above an understorey completely dominated by weeds. Two other communities are dominated by introduced trees, the willows **Salix babylonica* and **S. Xrubens*. Dense thickets of **S. babylonica* are now the main river-fringing vegetation in the lowermost reaches of the Murray.

Soil salinisation has occurred at many sites from several causes. This has led to death of the original vegetation and gradual change to a low, open, depauperate shrubland dominated by salt-tolerant samphires *(Halosarcia* spp.). These sites are some of the worst examples of environmental degradation along the river. The insidious nature of the problem and the likelihood of much more widespread effects in future make soil salinisation probably the issue of most concern for the long term health of the riparian vegetation.

Other sites of severe degradation are the sandy rises found within the floodplain in some localities. These are highly susceptible to erosion and have suffered from heavy grazing, especially by rabbits, which concentrate at these sites because of the ease of burrowing. Many sandy rises have been denuded of their original vegetation and now support only a sparse herb layer.

Vegetation changes associated with river regulation involve the expansion of some communities and species at the expense of others. Expanding communities are ones associated with infrequent flooding or with semi-permanent wetlands. Declining communities are ones associated with frequent inundation alternating with dry periods. Changes to flood regimes can be expected to bring about long-term changes in the quality of river red gum stands, namely a greater proportion of the lower, more open, slower growing stands associated with infrequent flooding.

There are problems with red gum regeneration. Although good regeneration occurs where timber production is the primary land use, it is poor on land used chiefly for grazing. Of particular concern is the patchy nature of red gum regeneration throughout the South Australian reaches of the river. Regeneration is so sparse in this region that the long-term survival of the stands is threatened.

Black box stands were generally in poor condition, with a high proportion of unhealthy trees, over most of their distribution along the river. Like river red gum, regeneration was sparse in South Australia.

Eighteen species of plants recorded on the Murray floodplain are classified as threatened species at a national level, including two species that now appear to be extinct. A further 50 species are classified as threatened in either Victoria or South Australia.

There is a need for more conservation reserves along the Murray, particularly in New South Wales. But dedication of additional lands as reserves is not enough. Protection and rehabilitation of the native vegetation will require active management on a large scale, both inside and outside reserves.

RECOMMENDATIONS

1. CONTROLS ON CLEARING

The importance of the remaining natural vegetation along the Murray River should be recognised through a special zoning for the entire floodplain and controls on further clearing of floodplain vegetation. In New South Wales and South Australia, existing controls over clearing should be exercised more rigorously in respect of floodplain vegetation. In Victoria, the government should provide additional incentives for landholders to preserve areas of high conservation value, particularly through continued and extended support of the buy-back program.

2. CONSERVATION RESERVES

There are few significant conservation reserves along the river, and none at all in New South Wales below Kosciusko. ***A larger, more representative sample of floodplain vegetation should be reserved. There is a particular need for more national parks. Reservation of additional lands must be accompanied by allocations of additional funds and staff for their management.*** Untended reserves face problems of degradation through uncontrolled recreational use, and the spread of weeds and rabbits. Expanding kangaroo populations may also pose a serious problem, as demonstrated in theHattah-Kulkyne National Park. Active management is essential simply to maintain the reserves. There is also a need to develop and implement rehabilitation programs for floodplain reserves, to restore and preserve something of the original character of the Murray. This would involve reducing populations of introduced plants and animals to minor levels, revegetation of salt-affected or badly eroded sites, and artificial manipulation of flooding patterns in backwaters and wetlands. ***Significant areas of floodplain habitat such as the Chowilla area should be considered for Conservation Reserve status. In New South Wales, leasehold crown land on the floodplain should be retained as crown land, at least until a systematic assessment of reservation needs has been completed.***

The mapping produced by this study could be used as part of this systematic assessment. An assessment of the degree to which the existing reserve systems of the the three States are representative of the floodplain vegetation can be obtained by overlaying the existing reserves onto the vegetation maps. Communities not sampled by the current reserves could be identified. A similar process could then be used to locate candidate areas from existing crown lands to fulfil identified requirements.

3. RIVER CORRIDOR

A river corridor of stable native vegetation should be established along both banks of the River Murray . This corridor should then be managed to maintain the unique character of the river and its associated tourist and recreation values. It would also provide a corridor for native fauna. Maintenance of more stable vegetation would help to protect river water quality from the effects of adjacent land use and development. Clearing should be strictly controlled within this corridor . Development proposals would also need to be planned in such a way as to be compatible with the objectives of management. ***It is recommended that the Commission develop, in conjunction with the relevant local and state government agencies, land use plans to control development and to ensure the protection and adequate regeneration of streamside vegetation on both banks of the river.***

4. COORDINATION OF RESEARCH

This study has identified the major factors influencing the condition of the riparian vegetation. It provides a framework for further research. What is now needed is a more detailed understanding of how these factors operate and how their effects might be controlled. This will require systematic ecological research, focussing on particular aspects and particular sites. ***It is recommended that experimental studies of the identified degrading factors be undertaken. There is wide scope for such, for example, through manipulation of grazing levels, exclosures, watering trials or manipulation of water levels at weirs.*** Such studies should be encouraged and supported, and they should be coordinated at a national level.

Field studies should be undertaken to manipulate watering regimes to determine the response of riparian vegetation both in terms of general 'health' and growth rates. The studies should seek to address specific questions related to sites identified in the conduct of the study.

In addition to providing data on growth rates, the trials would provide data on the use of water management techniques to provide specific sites with an appropriate watering regime. The techniques derived from these trials would provide an alternative to the difficult task of re-creating 'natural' flooding events and should help satisfy the requirements for ecosystems and commercially productive forests.

5. REHABILITATION OF IDENTIFIED SITES

Sites where serious degradation of the vegetation has occurred have been identified and mapped. Many of these sites require further investigation to establish the particular factors causing degradation and the measures needed for local rehabilitation. Rehabilitation programs are already under way or planned for a number of sites, including Disher's Creek, Katarapko and Loveday Evaporation Basins. ***Rehabilitation programs should be planned and executed at other sites. Where possible, local interest groups should be encouraged to participate in rehabilitation works and maintenance. The results should be monitored and, together with the methods used, disseminated to similar groups to aid in planning their rehabilitation efforts.***

6. GRAZING MANAGEMENT

Appropriate management guidelines should be developed for grazing use of different floodplain land units, with particular regard to stocking levels, regeneration, wetland management and control of weeds and pests. Formulation of the guidelines requires a strong research base that is currently lacking. The necessary studies should be undertaken as a matter of priority. The management guidelines should be passed on to graziers via government extension services. In the context of a special floodplain zoning along the

Murray, they should also be backed by regulations to prevent serious overgrazing. Such regulations should be consistent between States.

7. RED GUM REGENERATION IN SOUTH AUSTRALIA

The survey has shown lack of red gum regeneration to be a particular problem in the South Australian reaches of the river. The long-term survival of these stands is threatened and there is an urgent need to promote further regeneration. ***Glasshouse and field investigations should be undertaken to determine the specific requirements for successful red gum regeneration in South Australian reaches of the river, especially in regard to different flooding and grazing regimes.*** Field trials should be initiated of possible methods of encouraging regeneration, for example, by manipulation of water levels at the weirs or by minor earthworks to delay the recession of flood waters. Studies of red gum regeneration in South Australia would also have implications upstream and would complement the major, continuing studies in the Barmah-Millewa forests.

8. RED GUM HEALTH IN RELATION TO FLOODING

Another possible avenue of research that would complement the Barmah-Millewa studies is dendrochronology - the use of tree-growth-ring patterns to examine the relationship between flooding events, river regulation and river red gum growth and health. The work could lead to a more definitive statement of watering requirements. If this approach proves feasible then the relationship could be examined over a much wider span of years than is otherwise possible. Such a study would most usefully be undertaken at sites for which good growth and flooding data are already in existence. ***It is recommended that dendrologic studies be undertaken at appropriate points along the river that enable calibration using existing data.*** The Continuous Forest Inventory (CFI) plots in Millewa, Barmah and Gunbower State Forests have records extending back for several decades and would therefore be a suitable starting point for these investigations.

9. BLACK BOX HEALTH

The high proportion of unhealthy black box trees revealed by the study is cause for concern and warrants further investigation. ***Investigation should be undertaken of the causes of the major dieback epidemic which occurred in the Chowilla region in 1985, causing extensive defoliation and death of black box trees. The regeneration requirements of black box should also be examined.***

10. REVEGETATION OF SALT-AFFECTED SITES

Development of more effective techniques for revegetation of salt-affected areas is required, using plant species and varieties more tolerant of highly saline conditions. Not only would these serve to maintain a more stable vegetative cover, they may also assist in lowering the water table and ameliorating conditions in their immediate vicinity.

Establishment of Arboreta

A planned series of arboreta should be established at sites along the Murray to provide information on suitable species for revegetation. These sites

should sample the full range of known and anticipated problem areas. At each site a wide variety of salt-tolerant trees and shrubs would be grown to assess their performance, including assessments of different varieties and provenances within species. Particular emphasis should be placed on growing a range of provenances of river red gum, derived from different sites along the Murray and from saline sites elsewhere in Australia. Such a program would require periodic monitoring of growth and survival. The range of species could be increased as new material becomes available. The arboreta should also be used to monitor the effectiveness of such plantings in lowering groundwater levels on a localised basis. **The arboreta should be established as soon as possible - the longer they have been established, the more reliable the assessment of performance by individual species.**

Tree-cloning Techniques

A current research program at the Victorian Department of Conservation, Forests and Lands is investigating tree-cloning techniques for propagation of salt-tolerant river red gums from naturally saline areas. The program has considerable potential for revegetation of salt-affected areas. It should be supported and extended.

11. ADVERSE EFFECTS OF SALINITY CONTROL SCHEMES

Salinity control schemes, despite their general benefits, may cause severe local land salinisation. ***It is recommended that local salinisation impacts arising from salinity control schemes should be thoroughly assessed during the planning and design stage and every effort made to limit their impact on floodplain vegetation.*** The effects will be insidious and must be considered in a long time-frame.

12. CONTROL OF WILLOWS

The spread of willows along the river should be halted. Planting of willows (*Salix spp.) on the floodplain, whether as ornamental plantings or for riverbank stabilisation, should be prohibited. Alternative methods of bank stabilisation and revegetation need to be developed, with the aim of establishing a cover of native vegetation, specifically, a river red gum stand.

13. THREATENED SPECIES

Specific studies are needed of the ecology of individual plant species whose populations along the Murray are threatened. The review of threatened species in this report provides a basis for assigning priorities. An important aspect of the studies should be the development of propagation techniques for re-establishment of populations at former localities.

14. VEGETATION MONITORING

Permanent Monitoring Plots

Permanent monitoring plots should be established along the river. They should be visited periodically to monitor change in the floodplain vegetation over time. Some plots should be located to monitor specific effects of salinisation, grazing and river regulation, other plots to monitor general levels of change.

Broad Scale Monitoring

Periodic monitoring of changes in vegetation patterns and condition should be undertaken using Landsat TM digital data. Regular monitoring of clearing activities within the riparian zone could be achieved quickly and reliably at a scale of 1:50 000 using a combination of satellite imagery and aerial photography. The monitoring could commence in 1990 and be repeated at two to five-year intervals. Monitoring would support efforts to control clearing by providing positive evidence of clearing after known dates.

Monitoring of Degraded Sites

Sites identified in the mapping as severely degraded should be monitored to see whether vegetation condition is declining or improving and whether the affected area is increasing or decreasing. Further investigations will no doubt reveal additional sites that should be incorporated in the database and the monitoring program. The computerised geographic information system used for the study is a particular advantage for this type of monitoring and updating.

15. ADDITIONAL SURVEY AND MAPPING

Similar vegetation surveys and mapping should be carried out for the other major rivers of the Murray-Darling Basin. A schedule of priorities should be established to ensure continuity of the work initiated in this study. Clearly the Murrumbidgee, Darling, Goulburn and Ovens Rivers should be given a high priority.

Use of the Mapping Database

It is recommended that additional relevant information be added to the mapping database as it becomes available. The storage of the vegetation mapping in a computerised geographic information system now facilitates regular updating and revision. Additional mapping of vegetation types, particularly in the river red gum forests, is periodically undertaken by state authorities. For example Barmah State Forest has recently been re-mapped at 1:25 000 scale and Gunbower State Forest is in the final stage of a comprehensive re-mapping at 1:25 000. Both maps indicate a range of river red gum classes that clearly show stands which are likely to suffer significantly from long-term flooding restrictions. This is important information that was not available at the time of this study and it should be incorporated in the national database as a matter of priority. In addition this form of mapping should be extended to the New South Wales state forests. An interstate working group should be convened by the MDBC to coordinate this task.

Wetlands

It is recommended that the Wetlands Mapping of Pressey (1986) should be entered into the database.

Land Tenure

It is recommended that land tenure and cadastral boundaries should be added to the database. This is a complex and time consuming task and will require the formation of another study group working with state authorities.

16. COMMUNICATION OF MANAGEMENT INFORMATION

The spread of 'Trees on Farms' programs in recent years provides a network whereby more appropriate management practices can be promoted among landholders. ***It is recommended that the Commission prepare a management guide for landholders specific to the floodplain environment.*** This would cover issues such as how to encourage regeneration, and grazing regimes compatible with regeneration. The guide could be updated as further information becomes available through research. There is a general need for better communication between professional land managers, landholders, research workers and others with an interest in riparian vegetation and the river in general. Information should be disseminated more widely and more quickly. A link could be provided through a regular newsletter. This could be used to share experience and knowledge, to educate people on issues relating to management within the riverine environment, and to identify specific problems when and where they occur.

17. TRIAL PLANTATIONS

Trial plantations aimed at providing data on potential yields from a range of native and exotic species should be implemented. The objective would be to provide indicative data on possible yields from such plantations together with an assessment of the other benefits accruing from their establishment and growth. Other benefits could include reductions in groundwater levels and disposal of municipal and industrial waste water leading to lasting improvements in water quality. Plantations of appropriate salt-tolerant species or provenances may also be a feasible method to rehabilitate salt-affected sites.

STUDY TEAM

MARGULES AND PARTNERS	**Doug Parsonson**	Study team leader, report compilation and editing
	Hugh Dunchue	Co-ordinator aerial photo interpretation for New South Wales and Victoria
P AND J SMITH ECOLOGICAL CONSULTANTS	**Peter Smith** **Judy Smith**	Literature review, floristic study, co-author of report
PRIVATE SUB-CONSULTANTS	**Keith Forrest**	Aerial photo interpretation for the Middle Murray River/Edward River area (New South Wales and Victoria)
	Frank van der Sommen	Aerial photo interpretation for South Australia
DEPARTMENT OF CONSERVATION FORESTS AND LANDS	**Adam Choma**	Principal computer mapper (ARC/INFO) Advisor aerial photo interpretation
	Lucille Turner	Computer mapper (ARC/INFO)
	Peter Woodgate	Overall mapping co-ordinator (aerial photo interpretation and computer) Co-author of report

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- Dr Norm Mackay (Convenor), Murray-Darling Basin Commission
- Dr Jacki Venning, Department of Environment and Planning, SA
- Mrs Jenny Lopez, Department of Resources and Energy, ACT
- Dr Marilyn Fox, National Herbarium, NSW
- Dr Paul Gullan, Department of Conservation Forests and Lands, Vic.
- Mr Bob Pressey, National Parks and Wildlife Service, NSW

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CONTENTS

1. INTRODUCTION

The Murray River and its tributaries form the largest river system in Australia, with a catchment, the Murray-Darling Basin, covering nearly one seventh of the continent. The Murray-Darling Basin provides half of Australia's gross primary production. A predominantly semi-arid region, it is dependent on the meagre water resources of the Murray and its tributaries. The waters of the Murray River are intensively used for agricultural, domestic and industrial supplies. They account for three-quarters of all water used in Australia (Fleming 1982a).

The Murray-Darling Basin Commission (formerly the River Murray Commission) is responsible for the management of Murray River waters. As part of its responsibilities, the Commission is considering environmental problems along the river in relation to use of the waters and the adjacent lands. One important issue is the health of the riparian or floodplain vegetation and the factors likely to influence this.

The floodplain environment is a dynamic place. Natural changes in stream morphology have been reflected in changes to adjacent riparian vegetation. The sometimes complex arrangements of communities across the floodplain are evidence of subtle variations in the microenvironment. Changes in the microenvironment result in changes to the community occupying the site.

The scale and rate of change within the floodplain environment has increased dramatically since European settlement. The vegetation communities which existed at the time of European settlement have since been modified by the activities of the settlers and those who have followed them. Very significant changes to the riparian vegetation have occurred and will continue in the foreseeable future. These changes are largely the result of actions that have already taken place, often acting in concert with other modifying influences that continue to occur.

Effects on communities can be as subtle as a long term drop in the productivity of a red gum community or as obvious as the stands of dead red gums surrounded by the permanent waterbodies created by river regulation. Many but not all changes that have taken place or will take place are negative. For example while river regulation has killed or modified communities in many areas, other communities have established to take advantage of the changed conditions.

In recognition of the amount and rate of changes the River Murray Riparian Vegetation Survey was initiated by the Commission. The study, which involved a literature review, field survey and vegetation mapping was to assess the present distribution and status of the vegetation and causes of degradation. The study was also to develop solutions for its rehabilitation and long-term stability. The study will therefore provide both a baseline record of the existing vegetation communities and their condition and a yardstick against which changes to vegetation distribution and condition can be measured. This overview of the floodplain environment will provide a planning tool that is readily available to land use managers and others. Its use will encourage an holistic approach to vegetation management by Federal and State authorities.

The study, in the form of a published report and a map-based database is designed to be interactive and readily updatable. Users should note that customised maps and associated information can be generated to meet specific requirements. The range of potential mapping products available is set out in Appendix 9. Additional information can and should be incorporated into the database to ensure its currency and to maintain its long-term value.

1.1 STUDY OBJECTIVES

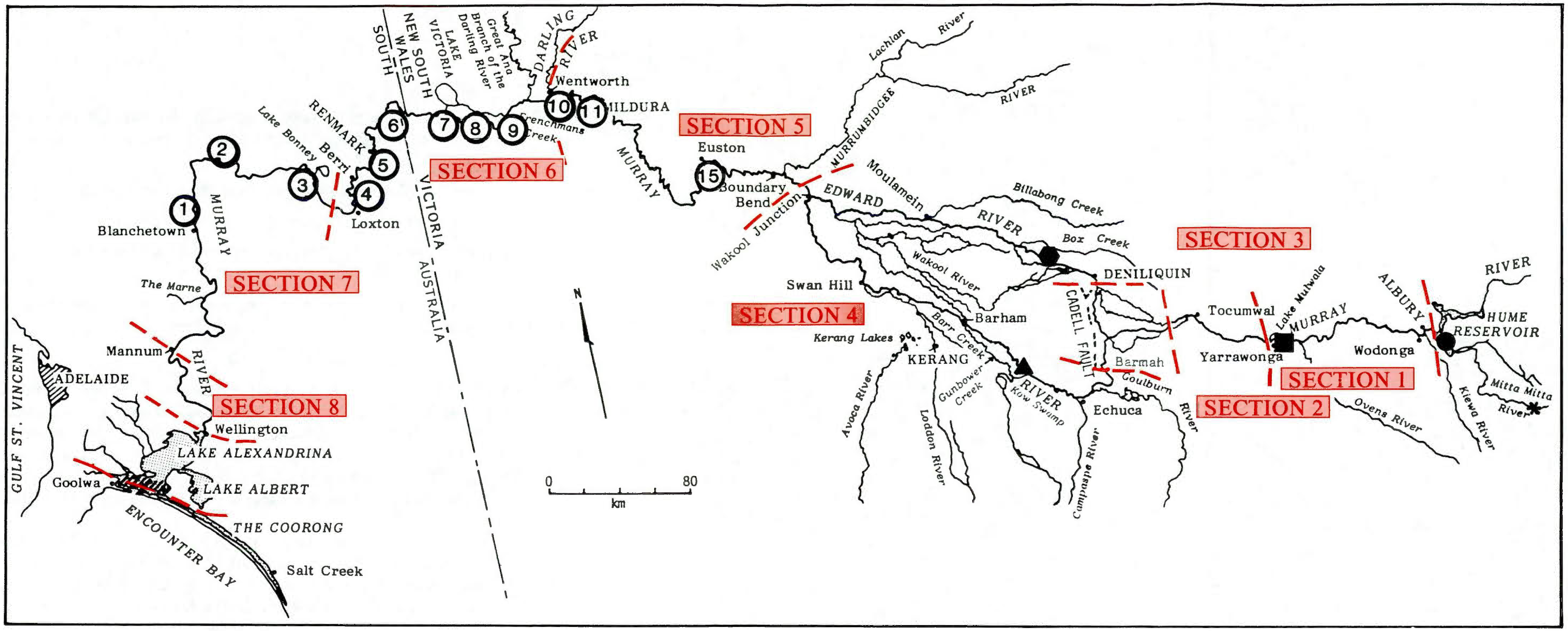
The specific aims of the study were:

- to investigate and describe the present riparian vegetation along the Murray River and assess its condition.
- to identify factors affecting regeneration and degradation of the vegetation.
- to propose recommendations for the rehabilitation of riparian vegetation, and for management and research to ensure the long-term stability of the vegetation.

1.2 DEFINITION OF STUDY AREA

The study area was the floodplain of the Murray River and its anabranches, including the Edward-Wakool system, from below Hume Dam to the upper end of Lake Alexandrina (Figure 1).

The vegetation mapping study area boundary was defined by the outer extent of contiguous riparian vegetation. In the absence of an objective and consistent topographic or flooding frequency boundary, the outer study area boundary was arbitrarily determined by the Study Team as each locality was examined. On average this ensured that about the first two kilometres from the river bank were included.



Lock Number

Stevens Weir

Torrumbarry Weir

Yarrawonga Weir

Hume Dam

Dartmouth Dam

Murray Mouth Barrages

State Border

FIGURE 1
STUDY AREA

2. METHODS

2.1 FLORISTIC SURVEY

2.1.1 LITERATURE REVIEW

Appendix 6 is a comprehensive bibliography on the floodplain vegetation of the Murray River. This covers three aspects and has been subdivided accordingly:

- Vegetation - descriptions, species lists, ecology, rare species.
- Environment - geology, geomorphology, soils, climate.
- Impact of man - Aboriginal impact, land and water use history, environmental changes and their effects.

This literature has been reviewed and is discussed in the relevant chapters of this report.

2.1.2 FIELD SURVEY

A total of 112 sites were visited on the floodplains of the Murray and Edward Rivers and their anabranches between Hume Dam and Lake Alexandrina. The majority (100) were surveyed during a field trip from 8 September to 23 November 1987. The remainder were surveyed between 26 January and 6 February 1988. The sites were selected to provide an even coverage of the entire study area. Their locations are recorded on the mapping database.

At each site, vegetation data were collected from one or more plots, making a total of 335 plots. Plots were selected at each site to sample several different habitats, usually one plot per habitat. Habitats right across the floodplain were sampled, including rises within the floodplain above flood levels, but excluding inundated areas and cleared areas.

At two sites of particular interest, three replicate plots were sampled per habitat. These sites were in salt-affected vegetation at Disher's Creek Evaporation Basin, and in vegetation under different flooding regimes upstream and downstream of Lock 2.

Each plot was 400m^2 in area, either a 20m x 20m square or, in narrow, elongated habitats such as riverbanks, a 40m x 10m rectangle. Vegetation structure was recorded by estimating the average height and cover of each layer of vegetation. All vascular plant species in or overhanging the plot were identified and their abundance recorded on a scale of 1 to 6 (1 - few plants, cover <5%; 2 - many plants, cover <5%; 3 - cover 5-25%; 4 - cover 25-50%; 5 - cover 50-75%; 6 - cover 75-100%).

Tree condition was measured by counting the trees in or overhanging the plot and dividing them into three categories: healthy, unhealthy (40% or more of crown dead) or dead (not including stumps). Additional trees surrounding the plot were included, where necessary, to make a count of at least 10 trees per plot.

Eucalypt regeneration was measured by counting the number of seedlings and saplings within each plot. Coppice regeneration was not included in the counts, nor seedlings under 5cm high, nor saplings with a diameter at breast height of 20cm or more. The height class composition of the regeneration was recorded in detail but the data are presented here in terms of two broad classes, <4m and >4m.

Grazing pressure was measured by counting the number of animal droppings touching a 20m line across the plot. For species producing droppings in clusters, the clusters were counted rather than individual droppings. The chief grazers were rabbits, sheep, cattle and kangaroos. Grazing by pigs, goats and horses may be locally important but, overall, was negligible. General observations indicated that the kangaroos were mainly eastern grey kangaroos *Macropus giganteus* on the Riverine Plain and western grey kangaroos *M. fuliginosus* in the Mallee Zone.

The field data sheets for the plots have been lodged with the Murray-Darling Basin Commission.

2.1.3 ANALYSIS

The 335 plots were classified into plant communities using the species lists and abundance data. Because of the large size of the data set, the classification was carried out in two stages. An initial non-hierarchical classification was performed by the technique of composite clustering (Gauch 1980), using the computer program COMPCLUS (Gauch 1979). This clustered the 335 plots into 78 groups. An hierarchical classification of the 78 groups was carried out by two-way indicator species analysis (Gauch & Whittaker 1981), using the program TWINSPAN (Hill 1979a). Relationships among the 78 COMPCLUS groups were further examined by the ordination technique of detrended correspondence analysis (Hill & Gauch 1980), using the program DECORANA (Hill 1979b).

The COMPCLUS groups within each TWINSPAN grouping were assessed subjectively. They were retained in the final classification if they reflected an obvious vegetation difference, or combined if the difference was considered minor. A few plots appeared to have been misclassified and were reassigned to other groups in the classification. One unusual plot was excluded from the analysis.

Thirty-seven communities were recognised in the final classification. The data collected on vegetation structure, number of species per plot, proportion of weed (introduced) species, tree condition, eucalypt regeneration and grazing pressure have been summarised in terms of these communities.

2.2 STRUCTURAL VEGETATION SURVEY

2.2.1 STRUCTURAL VEGETATION MAPPING

The most efficient method for ensuring complete coverage of the large areas involved in this study was to use existing aerial photography. Structural vegetation mapping from aerial photographs involves the delineation of homogeneous classes of vegetation based on the presence of the visually dominant species or groups of species. Key factors on the photographs for identifying dominant species are stem height, crown shape, size, density and shadow, class texture, colour, tone and geographic location.

Virtually all aerial photographic interpretation was performed on stereo photo pairs. Mapping was undertaken directly onto clear overlays on each photo and then traced onto the base topographic map which had also been prepared at photo scale. Where necessary the aerial photo interpretation was supported by field checking.

The interpretation of aerial photographs required specialised skills. There are ecotones or zones of transition along environmental gradients from one vegetation community to another. Placing boundaries on photographs to define the extent of these communities invariably simplifies the real situation. To a certain extent this has been overcome by in the creation of 'mixed' classes in the mapping including; red gum/box forest and woodland, mixed box woodland and cypress pine/casuarina woodland. A detailed description of each structural vegetation class is given in Chapter 4.2 and Appendix 2 while a summary of each class and its predominant, or common, species is given on each 1:50 000 scale mapsheet produced by the study.

The mapping was continuous for all four rivers and undertaken in a consistent manner irrespective of land tenure. All classes of structural vegetation within the study area were identified and mapped. No areas within the outer boundary were left unclassified, although large areas of riparian vegetation on the extensive floodplain between the Murray and Edward Rivers were not examined in this study.

2.2.2 VEGETATION CONDITION MAPPING

The original project brief requested an assessment of the condition of the vegetation in terms of whether it is regenerating, stable or degrading. Initial investigations showed that it was not possible to map from the aerial photographs the small and scattered patches of regeneration beneath an overstorey canopy. It was also not practical to institute a ground survey that would detect all of the regenerating areas.

What was clearly mappable from the photos were the many patches of degrading crowns and emerging dead stems. Therefore the objective was re-defined to identify areas of unhealthy vegetation that are suffering from severe long-term degrade and decline. Most trees in these areas were observed to have thinning crowns while some were already dead. Field inspection confirmed that these areas supported little or no viable regeneration. Areas suffering from transitory effects such as leaf skeletoniser attack and that were otherwise healthy were not assessed as suffering long term degrade.

Mapping was undertaken by aerial photos, field inspection and consultation with local land managers. This process permitted an identification of the factors contributing to the decline. These factors included prolonged flooding or drought, excessive salting, erosion, fire damage, clearing, or areas affected by recreation pressures. Each site has been individually numbered on the maps and the primary causal factor noted. Detailed descriptions of these 'condition' classes is given in Chapter 5.1.1.

There are some 46 mapsheets in the 1:50 000 scale series of structural vegetation maps covering the entire study area. This series is one of a number that can be produced containing both vegetation type and condition at a range of scales for nominated localities. Appendix 9 provides additional information on the formatting, production and availability of potential map products. Map 1 (fold-out at the back of the report) illustrates a selection of these products.

2.2.3 MAP PREPARATION USING ARC/INFO

A description of ARC/INFO

The software package ARC/INFO is a Geographic Information System marketed by ESRI Australia Pty Ltd under licence to the parent company in the USA. The system is installed and operating at the Kew offices of the Department of Conservation Forests and Lands, Victoria.

This system has the following advantages over conventional map systems:

- maps are stored in digital form permitting ready updating and additions.
- maps can be reconfigured to highlight specific features of interest and produced at any scale using a colour plotter.
- statistical and descriptive information can be linked to any geographical part of a map and recalled upon request. Calculation of area statements and review of point-based sample data are readily achieved.
- the digital data is readily transferred from CCT tape to floppy disk for access by other end users.

An ARC/INFO work-station consists of:

- a keyboard and colour screen for display of maps.
- a digitising table for the tracing of raw map data into the computer.
- a colour plotter for map output.

Method of map preparation

The following tasks were undertaken in the preparation of maps for this survey:

1. Selection of appropriate topographic base and map grid for segmentation into a convenient sized mapsheet.

   Starting with no existing digital map data meant the creation, initially, of a topographic 'skeleton' upon which the vegetation information could be constructed. This topographic information was to be selected from existing maps. Unfortunately no consistent series of 1:50 000 scale maps existed for the length of the river. Pressey's (1986) 1:50 000 scale maps showed only the main river channels and the outline of wetlands. For precise vegetation mapping major creeks, roads and other localities were required.

The NATMAP 1:100 000 scale series provided this additional information for the entire river length so portions of it were entered into ARC/INFO, enlarged to 1:50 000 scale and tested for spatial accuracy against the Pressey series and the Central Mapping Authority, NSW (CMA) maps. Mapping accuracies were shown to be acceptable. Selected topographic and roading information was therefore entered into ARC/INFO for the entire study area and the data segmented according to the standard NATMAP 1:100 000 scale mapsheet series. Later, as the vegetation information was entered into the system, modifications and additions were made to the NATMAP data to reflect more accurate or more relevant data derived from aerial photographs or larger scale local maps.

2. Entry of existing map-based vegetation information.

   Several extensive series of vegetation maps already existed for portions of the study area prior to this study. These maps were reviewed, digitised and then entered into the system.

3. Output of plotted topographic maps.

   In order to transfer the photo-interpreted data from the photographs to the topograhic maps, the topographic maps were enlarged to precisely photo scale. This permitted direct tracing from the photographs thereby eliminating the potentially time consuming task of transferring by an optical map-revision device.

4. Output of draft vegetation maps at 1:50 000 scale for field checking.

   All draft maps were circulated to local land managers for revision and comment.

5. Map revision.

6. Final map plotting and calculation of area statements.

   The 1:50 000 scale colour print maps that will be available as a standard series show:

   - 20 vegetation classes.
   - 9 condition classes with unique numbering of each site for later reference.
   - major rivers and important creeks.
   - permanent and semi-permanent water bodies.
   - all 13 locks (numbers 1-11, 15 and 26) and weirs (Stevens, Torrumbarry, Yarrawonga and Hume).

- several classes of roads, some railways.
- major towns.

However, the range of map products capable of being produced is large and includes:

- colour or black and white prints
- colour or black and white transparencies
- custom made maps up to AO sheet size of any scale and location commensurate with the input scale of the raw data.

A complete list of mapping products produced for this survey is given in Appendix 9.

2.2.4 RELIABILITY GUIDE FOR MAPPING ACCURACY

The base topographic, vegetation and condition data for this study was compiled from a range of sources including:

- NATMAP 1:100 000 scale topographic maps.
- existing vegetation maps prepared between 1953 and 1987 at scales ranging from 1:15 830 to 1 100 000 (refer Appendix 8).
- aerial photography from 1963 to 1985.
- field checking data, published and unpublished data, local consultation and anecdotal evidence.

A primary objective of this study was to bring together all these data and prepare a consistent and uniform series of maps. This has involved reviewing and revising existing map data, creating new information from aerial photo interpretation and extensive field checking. The size of the study area coupled with the dynamic and ever-changing river processes has almost certainly meant, however, that some areas will have been more thoroughly treated than others. For example, more emphasis was placed on mapping previously unmapped regions, particularly on freehold land, than was given to revising existing vegetation maps. To reflect this approach and to assist the map user in interpreting each map a reliability guide has been included on each of the 1:50 000 scale mapsheets. Each guide is specific to the sheet on which it occurs.

The guide shows the following information in relation to the source data for that mapsheet:

- whether the source data was derived from existing maps or aerial photo interpretation undertaken specifically for this study.
- scale of the source data (maps or photos).
- year of origin of maps or photos.
- component of field checking undertaken for this study.

3. RIVER SECTIONS

The Murray River passes through three major geomorphic zones on its route to the sea (Hills 1974; Wasson 1982). The Headwaters Zone extends from the source of the river near Kosciusko to about Corowa, corresponding to the tablelands and western slopes of the Great Dividing Range. Only the very eastern end of the study area lies within this zone.

The Murray leaves the foothills at Corowa and enters the Riverine Plain, which extends to about Wakool Junction. This vast alluvial plain, formed under a different climate and hydrology from the present, has a characteristic anastomosing drainage and it is here that the Murray receives most of its major Victorian tributaries (Butler *et al.* 1973; Storrier & Kelly 1978).

For the remainder of its course the Murray flows through the Mallee Zone. With its sand dunes and highly saline groundwater, the Mallee Zone is an area formerly inundated by the sea (Bowler & Magee 1978; Storrier & Stannard 1980). Surface runoff after rain is insufficient to form a local stream system. The two major tributaries joining the Murray in the Mallee Zone, the Murrumbidgee and Darling Rivers, both come from better-watered regions.

Further divisions may be made within these three broad zones. In a study of Murray River wetlands, Pressey (1986) divided the floodplain between Hume Dam and Lake Alexandrina into eight sections, based on differences in hydrology and geomorphology but also corresponding to climatic differences (Figure 1). Similar divisions have been made by Currey & Dole (1978) and Cole (1978). Pressey's sections are used again in this report. Their characteristics are outlined below. The geomorphology is described by Thompson (1975), Currey (1976, 1978), Cox & Friedman (1983) and Pressey (1986), and the soils by Taylor & Poole (1931), Smith *et al.* (1943), Rowan & Downes (1963), Potter *et al.* (1973) and Crouch & Junor (1976).

SECTION 1

Floodplain of the Murray River from Hume Dam to Yarrawonga Weir. Located at the junction of the Headwaters Zone and the Riverine Plain. River length is 233km and the floodplain is relatively narrow, varying from 1.5 to 5km in width, with a total area of 292km^2 (statistics from Pressey 1986). The climate is cooler and moister than in the other river sections, corresponding to Nix & Kalma's (1982) climatic subregion B12a. Mean annual rainfall is 500-650mm, distributed fairly evenly through the year.

SECTION 2

Floodplain of the Murray River from Yarrawonga Weir to the downstream end of Ulupna Island, below Tocumwal. Forms part of the Riverine Plain. River length is 124km, floodplain width is generally 2-3km and floodplain area is 164km^2. Forms part of Nix & Kalma's climatic subregion B12b, with a generally warmer, drier climate than Section 1. Mean annual rainfall is 420-500mm.

RIVER SECTION 3

Floodplain of the Murray River from Ulupna Island to Barmah, and floodplain of the Edward River from the offtake to 3km upstream of the Lawson Siphon, near Deniliquin. Also includes the Tuppal-Bullatale anabranch system. Forms part of the Riverine Plain. River lengths are Murray 108km, Edward 51km. Floodplain width varies from about 1km at the upstream end to more than 25km near the Edward offtake. Floodplain area is $1366km^2$. The climate is similar to Section 2, forming part of Nix & Kalma's climatic subregion B12b. Mean annual rainfall is 400-420mm. The broad, triangular floodplain and complex channel system are largely due to the Cadell Fault, which runs roughly from Echuca to Deniliquin (Figure 1). The uplifting of the Cadell Fault some 25_000 years ago blocked the westward passage of the Murray and brought about a division into the Edward flowing north of the fault and the present Murray flowing south (Bowler 1978).

SECTION 4

Floodplain of the Murray River from Barmah to 11km downstream of Wakool Junction, and floodplain of the Edward River below Deniliquin. Includes the extensive network of anabranches enclosed by the Edward and Murray, the largest of which are Wakool River, Niemur River, Colligen Creek, Yarrein Creek and Merran Creek. Forms part of the Riverine Plain. River lengths are Murray 487km, Edward 356km. The floodplain of the Murray varies in width from about 1km near Echuca to about 20km near Cohuna. The floodplain of the Edward is generally less than 1km in width, except in the Werai Forest area, where the combined floodplain of the Edward and two of its anabranches is more than 10km wide. Several anabranches, in particular the Wakool River, have larger floodplains than the Edward. Total floodplain area is $3482km^2$. Section 4 lies within Nix & Kalma's climatic subregion B11a, indicating higher temperatures, greater solar radiation and, in particular, lower rainfall than the B12 classification of Sections 1 to 3. Mean annual rainfall is 300-400mm.

SECTION 5

Floodplain of the Murray River from 11km downstream of Wakool Junction to the Darling Junction. Forms part of the Mallee Zone. River length is 448km. The floodplain is broad, generally 5-12km wide, but narrowing at Mildura and Wentworth to 1-3km, with a total area of $1568km^2$. The climate is similar to Section 4, forming part of Nix & Kalma's climatic subregion B11a. Mean annual rainfall is 250-300mm.

SECTION 6

Floodplain of the Murray River from the Darling Junction to 22km downstream of Loxton. Forms part of the Mallee Zone. River length is 358km, the floodplain is broad, generally 5-10km wide, and the total area is $1515km^2$. The climate is hot and dry, corresponding to Nix & Kalma's climatic subregion B11b. Mean annual rainfall is around 250mm.

SECTION 7

Floodplain of the Murray River from 22km downstream of Loxton to

Mannum. Forms part of the Mallee Zone. River length is 316km. The river flows through a narrow valley, 30-40m deep, and the floodplain is generally less than 2km wide, with a total area of 416km^2. Within Section 7 the Murray passes from Nix & Kalma's climatic subregion B11b to subregion B11c, which is cooler, moister and has a more pronounced rainfall seasonality, higher in winter and lower in summer. Mean annual rainfall is 200-300mm.

SECTION 8

Floodplain of the Murray River from Mannum to 2km downstream of Wellington, at the head of Lake Alexandrina. Forms part of the Mallee Zone. River length is 76km, the floodplain is generally less than 2km wide, with a total area of 105km^2. Forms part of Nix & Kalma's climatic subregion B11c. Mean annual rainfall is 300-350mm.

4. VEGETATION PATTERNS

4.1 FLORISTIC ANALYSIS

4.1.1 VEGETATION ZONES

The vegetation of the Murray River floodplain is dominated by two tree species: river red gum *Eucalyptus camaldulensis* and black box *E. largiflorens*. River red gum grows on the river banks and low-lying areas, while black box grows on the higher, outer parts of the floodplain. There is a natural and well known division into a red gum zone and a black box zone. A third vegetation zone is made up of the occasional rises within the floodplain but above flood levels. These support non-riparian vegetation of types found on similar soils outside the floodplain, namely woodlands of grey box *E. microcarpa*, yellow box *E. melliodora*, and cypress pine *Callitris* spp. A further zone is the vegetation of the wetlands. These were the subject of a previous report (Pressey 1986) and are not considered here.

River red gums line the Murray throughout the study area except for Section 8, where they have been largely replaced by the introduced weeping willow **Salix babylonica*. River red gum is, in fact, the most widely distributed of all eucalypts, growing along inland watercourses right across Australia and in some non-riparian situations in South Australia and Victoria (Boomsma 1950; Beadle 1981; Chippendale & Wolf 1981). In the flood-prone Barmah-Millewa forests of Section 3, the red gums form tall, dense forests, some exceeding 45m in height. They cover almost the entire floodplain, which is some 25km wide. In contrast, in the dry inland, the red gums are restricted to the immediate vicinity of the river and its associated channels and billabongs. They occur here as woodlands rather than forests, often in a strip only one or two trees wide.

The understorey in the red gum zone is predominantly herbaceous. There is a mixture of perennials, annuals and post-flooding ephemerals. Prominent, widespread species include Warrego summer-grass *Paspalidium jubiflorum*, Moira grass *Pseudoraphis spinescens*, common spike-rush *Eleocharis acuta*, spiny sedge *Cyperus gymnocaulos*, common sneezeweed *Centipeda cunninghamii*, cotton fireweed *Senecio quadridentatus* and river bluebell *Wahlenbergia fluminalis*.

Black box is less widespread in Australia than river red gum, being restricted to inland floodplains of the southeast (Beadle 1981; Chippendale & Wolf 1981). It is also less widespread along the Murray, where it occurs in the semi-arid reaches from the upper junction of the Edward River downstream to Mannum. In Section 3, black box occurs only in small stands on the outer margin of the floodplain. In Section 6, the black box zone covers most of the floodplain.

Black box communities generally have a lower, more open tree layer than red gum communities, forming woodlands rather than forests. They also have a shrubbier understorey. The black box zone also includes extensive shrublands, lacking a tree layer but otherwise similar in floristic composition to the adjacent black box woodlands. The principal shrub species are lignum *Muehlenbeckia cunninghamii*, dryland tea-tree *Melaleuca lanceolata* and various chenopods - nitre goosefoot *Chenopodium nitrariaceum*, silver saltbush *Atriplex rhagodioides*, old-man saltbush *A. nummularia*, bladder saltbush *A. vesicaria* and desert glasswort *Pachycornia triandra*.

4.1.2 PLANT COMMUNITIES

Thirty-seven plant communities were distinguished in the COMPCLUS and TWINSPAN analyses. These are described in Appendix 1.1, grouped into the three vegetation zones. No general classification of Murray River riparian vegetation has been attempted previously at this level. However, there have been classification schemes for various parts of the river (National Parks & Wildlife Service 1983; Chesterfield 1984, 1986; Ashwell 1987; Land Conservation Council 1987). In general, these are consistent with the classification presented here.

As a one-off sampling, the survey has not considered the dynamics of understorey composition, especially the effects of ephemerals. These effects are most apparent in the changing nature of the vegetation in temporary wetlands at different stages of the flooding cycle. However, the classification presented here is a broad one and ephemerals are unlikely to have a major influence. This conclusion is borne out by observations during the survey that some red gum plots had been recently flooded while others in similar situations had missed out on flooding, yet still grouped with the flooded plots in the analysis.

Floristic relationships among the communities, as indicated by the TWINSPAN analysis, are shown by a dendrogram (Table 1) and a two-way classification of communities and species (Appendix 1.2). Not surprisingly, the primary TWINSPAN division corresponds to the red gum zone/black box zone division (Table 1). However, the *E. largiflorens-Eleocharis* community groups with the *E. camaldulensis* communities, while the *E. camaldulensis-Muehlenbeckia* community (and the related *Callistemon-Muehlenbeckia* shrubland) group with the *E. largiflorens* communities. The communities of the rises do not separate as a group but split between the two primary groupings. Those of Riverine Plain rises (the *Callitris glaucophylla*, *E. melliodora* and *E. microcarpa* communities) show affinity with weedy red gum communities, because of the many weed species they share. The *Dodonaea-Callitris* community of Mallee Zone rises shows more affinity with black box communities from the same region.

Within the red gum grouping, the major division is between Riverine Plain communities (Sections 1 to 4) and Mallee Zone communities (Sections 5 to 8). The Riverine Plain subgroup divides into the more weedy communities (including the communities of the rises) and the less weedy ones. The latter then divide into the more frequently flooded communities and the less frequently flooded ones. The frequently flooded communities include the tallest red gum forests (the *E. camaldulensis-Eleocharis-Pseudoraphis* community) and also herb communities from sites where flooding is too regular for tree growth. The Mallee Zone subgroup consists of the **Salix babylonica* community and various *E. camaldulensis* communities, the latter dividing into those typical of Section 5 and those typical of South Australia.

Within the black box grouping, the major division is between the communities of the higher, outer parts of the black box zone (characterised by the perennial saltbushes *Atriplex rhagodioides*, *A. nummularia* and *A. vesicaria*, occurring chiefly in Section 6) and those of the lower, inner parts (characterised by lignum *Muehlenbeckia cunninghamii*, but including the uncommon *E largiflorens-Melaleuca* communities, which grow on higher ground). The latter subgroup also includes the *Dodonaea-Callitris* community of the rises, while the former includes the samphire *Halosarcia* spp. community of the most saline sites.

In both black box subgroups, there is a division between the South Australian communities (e.g. the *E. largiflorens -Muehlenbeckia -Atriplex* and *E. largiflorens-Atriplex rhagodioides* communities) and their counterparts across the border (the *E. largiflorens -Muehlenbeckia -Chenopodium* and *E largiflorens -Atriplex nummularia* communities). The reason for this division is unclear. It contrasts with the major division among the red gum communities, which is between the Mallee Zone and the Riverine Plain, where there is a more obvious change in the environment.

An alternative representation of floristic relationships is provided by the results of the DECORANA ordination (Figure 2). The ordination represents community relationships in a two-dimensional space, with similar communities close to each other and dissimilar communities far apart. The four main groups of the TWINSPAN classification can be distinguished in the ordination, arranged along Axis 1 in a sequence: Riverine Plain red gum communities, Mallee Zone red gum communities, inner black box zone communities, outer black box zone communities. Axis 2 serves to separate communities within the main groups.

The axes in Figure 2 have been derived entirely from the floristic data. However, they also reflect environmental gradients. Axis 1, the principal axis, corresponds closely with the distribution of chenopods. There is a highly significant correlation between a community's Axis 1 score and the mean proportion of chenopod species per plot ($r = 0.91$, $v = 35$, $P << 0.001$, arcsine transformation of proportions), accounting for 84% of the variation in Axis 1 scores. Most, perhaps all, chenopods are salt-tolerant (Waisel 1972), suggesting that Axis 1 is primarily a salinity gradient, reflecting the more saline conditions in the Mallee Zone compared with the Riverine Plain, and the increase in salinity across the floodplain (because less frequent flooding means less frequent flushing of accumulated salt). The strength of this relationship between floristics and salinity levels is an important finding. It emphasises the major impact that future salinisation is likely to have on the floodplain flora.

Interpretation of Axis 2 is more complex. It appears to represent a combination of floristic changes associated with changes in flooding frequency, and floristic changes associated with climatic and other changes along the river.

On a local scale, there is typically a marked change in vegetation across the floodplain, and often a mosaic of different communities. For example, Figure 3 shows the vegetation pattern at one site in the Murtho area, north of Renmark, in Section 6, where 12 plots were located. The changes portayed occur over a distance of about 1km, which is by no means the full width of the floodplain. Such complex patterns are a result of the complex land form, soil and hydrological patterns across the floodplain, which have been determined chiefly by fluvial processes, both past and present (van der Sommen 1987).

Especially important is the land form, since minor differences can have a major effect on the frequency and duration of flooding. This is illustrated by vegetation patterns at the water's edge. Typically, there is a series of narrow bands of different plant species at different heights above the water. For example, at a drying billabong on Ulupna Island in Section 2, there was a sequence from the water's edge of *Amphibromus fluitans*, *Agrostis avenacea*, *Eleocharis* spp., *Carex tereticaulis* and **Bromus diandrus*, over a distance of some 10m and a change in elevation of about 1m. Such sequences show how closely linked are local vegetation patterns to flooding patterns.

4.1.3 PLANT SPECIES

At least 767 species of vascular plants occur on the Murray floodplain (Appendix 3). One third of the species (256) are introduced. The dominant plant families, both native and introduced, are the Poaceae (grasses) and Asteraceae (daisies). Other well represented families are the Chenopodiaceae, Fabaceae, Brassicaceae, Cyperaceae, Caryophyllaceae, Juncaceae and Polygonaceae (Table 2). The Myrtaceae, though few in species, are the dominant trees.

The prominence of *E. camaldulensis* throughout the study area gives a misleading impression of uniformity in the vegetation. In fact, most species have a much more restricted distribution, reflecting the changes in climate, land form and soils along the river (Appendix 3). Apart from *E. camaldulensis*, only 17 species were recorded in every river section. This number would undoubtedly increase with further sampling, but even the most widespread species typically show marked changes in abundance along the river. These patterns are reflected in the restricted distribution of most plant communities (Table 1).

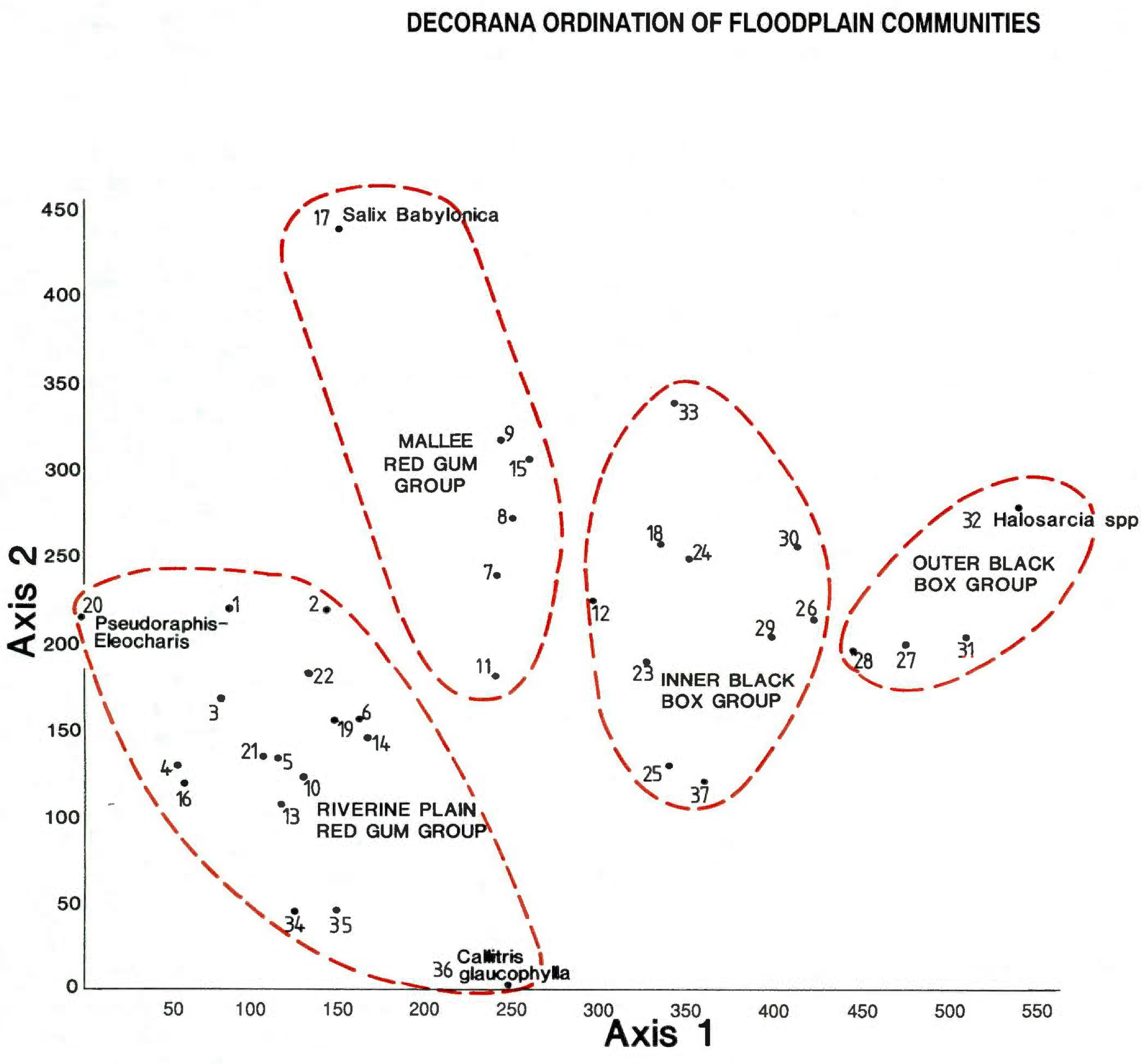
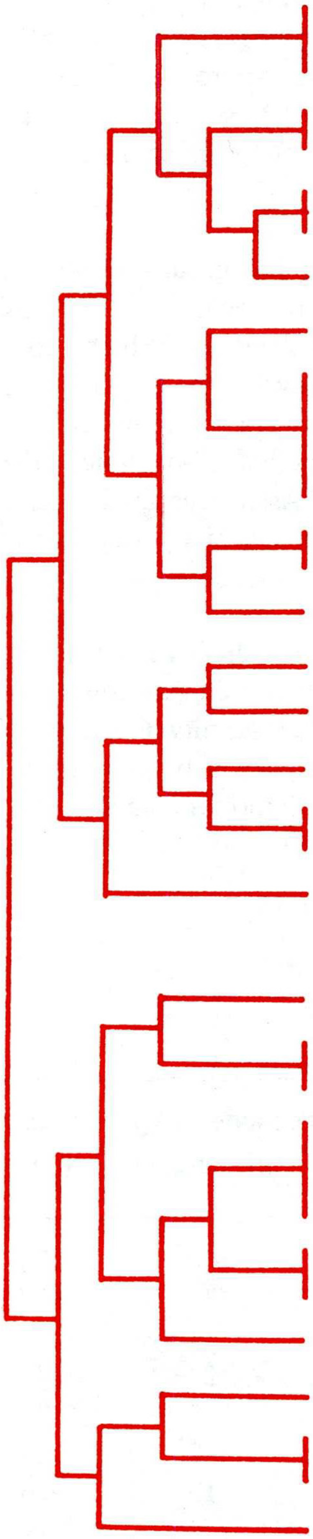


FIGURE 2

TABLE 1. TWINSPAN CLASSIFICATION OF FLOODPLAIN COMMUNITIES



	Sp	Wd	Cd	Sections
36 *Callitris glaucophylla*	27	62	4	3
35 *Eucalyptus melliodora*	32	59	3	1-3
34 *E.microcarpa*	37	58	3	2-3
16 **Salix Xrubens*	32	59	0	1-3
4 *E.c.-Poa-Hemarthria*	33	57	0	1-2
19 *Agrostis-*Cynodon*	25	58	0	2
14 *E.c.-*Bromus-Danthonia*	29	57	2	4
13 *E.c.-*Bromus-*Vulpia*	29	63	0	1-4
3 *E.c.-Poa-Agrostis*	37	47	0	1-4
10 *E.c.-Danthonia*	35	49	1	2-4
6 *E.c.-Paspalidium-Senecio*	31	44	1	2-4
5 *E.c.-Carex*	35	44	1	3-4
2 *E.c.-Eleocharis-Wahlenbergia*	33	31	0	3-4
22 *E.l.-Eleocharis*	29	38	0	4
1 *E.c.-Eleocharis-Pseudoraphis*	14	18	0	1-6
20 *Pseudoraphis-Eleocharis*	10	21	0	3-4
21 *Centipeda-Polygonum*	25	39	0	2-5
11 *E.c.-E.l.*	25	37	5	4-5
7 *E.c.-Paspalidium-*Cynodon*	30	38	5	4-7
8 *E.c.-Cyperus*	24	37	3	6-7
9 *E.c.-Phragmites*	18	41	2	7-8
15 *E.c.-*Cynodon*	35	59	7	7-8
17 **Salix babylonica*	25	50	0	1-8
25 *E.l.-Melaleuca-Allocasuarina*	21	45	14	4
23 *E.l.-Muehlenbeckia-Chenopodium*	26	32	17	4-6
29 *Chenopodium-Muehlenbeckia*	30	24	28	4-6
26 *E.l.-Melaleuca-Atriplex*	26	34	30	6
24 *E.l.-Muehlenbeckia-Atriplex*	22	36	22	6-7
30 *Muehlenbeckia-Halosarcia*	27	38	28	6-7
33 *Sporobolus-Atriplex*	14	48	19	6-7
12 *E.c.-Muehlenbeckia*	27	36	10	5-7
18 *Callistemon-Muehlenbeckia*	31	48	20	7
37 *Dodonaea-Callitris*	24	35	5	5-6
28 *E.l.-Atriplex rhagodioides*	23	24	24	6
27 *E.l.-Atriplex nummularia*	32	32	29	5-6
31 *Atriplex-Pachycornia*	22	27	25	5-6
32 *Halosarcia* spp.	12	38	37	4-8

KEY:

Sp species per plot
Wd % weed species
Cd % chenopod species

E.c. *Eucalyptus camaldulensis*
E.l. *Eucalyptus largiflorens*

The TWINSPAN analysis provides a classification of species as well as plots, shown in Appendix 1.2 for the 176 most frequent species (including several pairs or groups of species not consistently identified in the field and thus combined for analysis). These divide into four major groups: 69 species (39%) closely associated with the red gum communities; 29 species (16%) found in both groups but more common in the red gum group; 22 species (13%) common in both groups; and 56 species (32%) associated with the black box group, although many also occur in red gum communities, especially those of the Mallee Zone.

The Poaceae and Asteraceae are well represented in all four groups. However, other families are associated with either the red gum zone or the black box zone. The Cyperaceae, Fabaceae and Juncaceae occur chiefly in the herbaceous understorey of the red gum zone, as do most representatives of the Polygonaceae except lignum Muehlenbeckia cunninghamii, which is a common shrub of the black box zone. The characteristic family of the black box zone is the Chenopodiaeeae, which is co-dominant there with the Asteraceae and Poaceae. The shrubby nature of the black box understorey is chiefly due to the abundance of chenopods and lignum.

The prominence of the salt-tolerant Chenopodiaceae is indicative of the more saline conditions in the black box zone compared with the red gum zone. The results of the DECORANA ordination suggest that salinity is the most important factor responsible for the floristic difference between the two zones, although flooding frequency may be the more important factor for the tree species themselves.

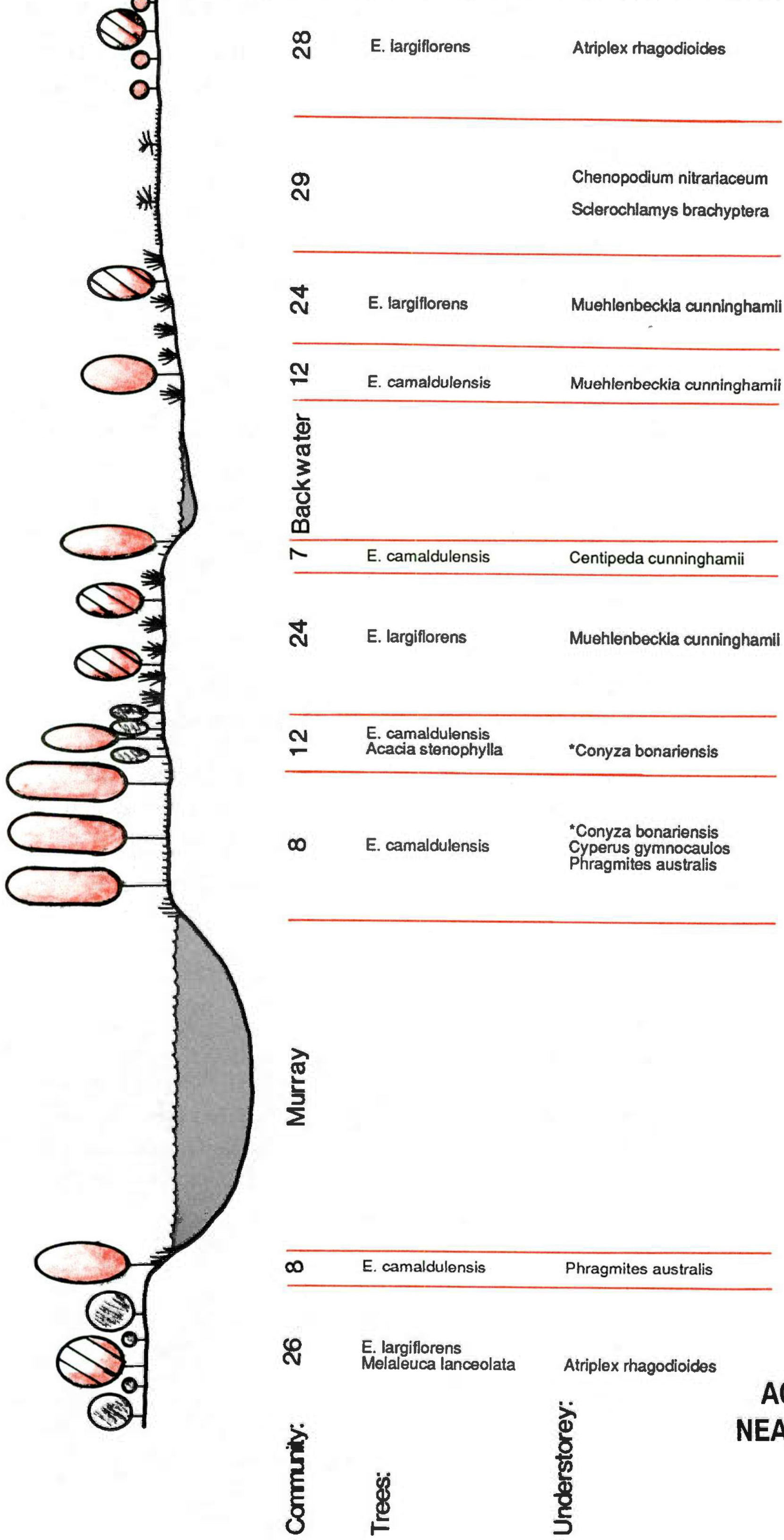
TABLE 2. MAJOR PLANT FAMILIES OF THE FLOODPLAIN FLORA

Family	Number of species recorded (Appendix 3)		
	Native	Introduced	Total
Poaceae (grasses)	60	60	120
Asteraceae (daisies)	81	36	117
Chenopodiaceae (chenopods)	56	4	60
Fabaceae (peas)	18	24	42
Brassicaceae (cress family)	14	15	29
Cyperaceae (sedges)	26	2	28
Caryophyllaceae (chickweed family)	3	13	16
Juncaceae (rushes)	12	2	14
Polygonaceae (dock family)	9	5	14
Other families	232	95	327
Total	**511**	**256**	**767**

4.2 STRUCTURAL VEGETATION CLASSES

4.2.1 CLASS DESCRIPTIONS

Sixteen structural vegetation classes and four non-vegetated classes were identified by the mapping. These classes are listed in Table 3 and described in detail in Appendix 2. This is the first time that a complete vegetation map of the Murray River has been attempted. Previous mapping has been largely confined to the state forests of New South Wales and Victoria (Appendix 8).



VEGETATION CHANGE ACROSS THE FLOODPLAIN NEAR MURTHO IN SECTION 6
FIGURE 3

TABLE 3. STRUCTURAL VEGETATION CLASSES

Associations	Common Species	
Trees		
1. Red Gum Forest	*Eucalyptus camaldulensis* *Eucalyptus blakelyi*	(River Red Gum) (Blakely's Red Gum)
2. Red Gum Woodland	*Eucalyptus camaldulensis* *Eucalyptus blakelyi*	(River Red Gum) (Blakely's Red Gum)
3. Red Gum/Box Forest & Woodland	*Eucalyptus camaldulensis* *Eucalyptus blakelyi* *Eucalyptus microcarpa* *Eucalyptus melliodora* *Eucalyptus largiflorens* *Eucalyptus albens*	(River Red Gum) (Blakely's Red Gum) (Grey Box) (Yellow Box) (Black Box) (White Box)
4. Mixed Box Woodland	*Eucalyptus microcarpa* *Eucalyptus melliodora* *Eucalyptus largiflorens* *Eucalyptus albens*	(Grey Box) (Yellow Box) (Black Box) (White Box)
5. Black Box Woodland	*Eucalyptus largiflorens*	(BLack Box)
6. Black Box (mallee form)	*Eucalyptus largiflorens*	(Black Box)
7. Cypress Pine/ Casuarina Woodland	*Callitris preissii* *Callitris glaucophylla* *Callitris verrucoca* *Allocasuarina cristata* *Allocasuarina luehmannii*	(Murray Cypress Pine) (White Cypress Pine) (Scrub Cypress Pine) (Belah) (Buloke)
8. River Cooba	*Acacia stenophylla*	(River Cooba)
9. Mallee Fringe Woodland	*Allocasuarina cristata* *Heterodendron oleifolium* *Myoporum platycarpum* *Dodonaea* spp. *Eucalyptus* spp.	(Belah) (Cattlebush) (Sugarwood) (Hopbush) (Mallee types and Black Box)
10. Mallee	*Eucalyptus* spp.	(Mallee types)
Shrubs Grasses Herbs		
11. Lignum	*Muehlenbeckia cunninghamii*	(Lignum)
12. Saline Shrubland	*Halosarcia* spp. *Atriplex nummularia* *Atriplex vesicaria* *Chenopodium nitrariaceum* *Sclerostegia tenuis* *Maireana pyramidata*	(Samphire) (Old-man Salt-bush) (Bladder Salt-bush) (Nitre Goosefoot) (Slender Glasswort) (Black Bluebush)
13. Open Areas	(grassland, sedges, salinas)	
Non-Native Vegetation		
14. Exotic Trees & Shrubs	pines, poplars, willows, pepper-trees, amenity plantings	
15. Cultivated pasture & cropping	(irrigated and non-irrigated)	
16. Orchards & vineyards	(irrigated)	

Associations	Common Species
Non-Vegetated Areas	
17. Urban	(includes semi-urban, golf courses, hobby farms)
18. Quarries & sand-pits	
19. Sand Dunes	(includes naturally occurring lunettes)
20. Water bodies	(permanent and semi-permanent)

4.2.2 DISTRIBUTION AND EXTENT

There are 196 900ha of river red gum on the Murray River and further 35 200ha on the anabranches of the Edward, Wakool and Niemur Rivers (Table 4). New South Wales has the largest areas of river red gum forests and woodlands on the Murray River with 48% of the total, followed by Victoria with 44% and South Australia with 8%.

The box species (yellow, grey and black box) occupy 121 600ha of the Murray River study area with a further 51 700ha on the anabranches.

Within the Murray River study area clearings for pastures and orchards, both irrigated and non-irrigated total 322 000ha or 29% of the total Murray area. It would be reasonable to assume that most of this area was originally made up of box, river red gum and open grassland communities, although this is now almost impossible to determine with any confidence.

Loss of riparian vegetation could also be attributable to the urban, quarry and exotics classes which total 13 200ha. Still further losses of the original vegetation would be evident in some sections of the open areas (class 13), saline shrubland (class 12) and water classes (class 20), portions of which have been modified by agricultural and other land management practices. Therefore total losses of native vegetation since European settlement, the majority of which was riparian, conservatively total 335 000ha or some 30% of the total study area for the Murray River.

The middle Murray area, characterised by Geographic Section 3 (Table 5) and representing the Barmah and Millewa State Forests, comprises the largest tracts of river red gum forests and woodland with 61 800ha. Section 4 carries marginally less areas of river red gum with 60 100ha mainly occurring around the Gunbower, Perricoota and Koondrook State Forests. The largest stands of black box woodland are found in the Hattah area of Section 5. Table 1, Appendix 5 provides additional information on the distribution of structural vegetation classes by geographic sections for both the Murray River and the anabranches.

4.3 RELATIONSHIP OF STRUCTURAL CLASSES TO FLORISTIC COMMUNITIES

The floristic survey was based on point samples at selected sites. This survey has not produced a complete picture of floristic diversity across the entire area. Rather, it has provided quantitative, site specific data on the presence and health of vascular plants. A quantitative analysis of these data has sorted these species into natural associations or communities. These communities may or may not be characterised by the largest or dominant species.

On the other hand the structural vegetation mapping has provided a continuous picture of the distribution of the dominant structural vegetation types for the entire study area. However the mapping has only identified vegetation classes according to the physically largest and most dominant species.

TABLE 4. STRUCTURAL VEGETATION CLASS AREAS (HA) FOR THE MURRAY RIVER AND ANABRANCHES (EDWARD, WAKOOL, NIEMUR RIVERS) FOR EACH STATE

STRUCTURAL VEGETATION CLASS		STATE				
		NSW		VIC	SA	TOTAL
1	RG-FOR	119945	(29.9%)	77954	2389	200288
2	RG-WOOD	14916	(50.2%)	4890	12048	31854
3	RG/BOX	20187	(41.8%)	2585	516	23288
4	MIX BOX	49525	(71.3%)	9796	0	59321
5	BB-WOOD	26625	(4.0%)	45653	11562	83840
6	BB MALLEE	13611		6191	10376	30178
7	CASUARINA	794	(2.8%)	3830	17	4641
8	RVR COOBA	136		24	0	160
9	M FNG WOOD	17348	(0.3%)	4730	15181	37259
10	MALLEE	9183	(3.5%)	16705	13723	39611
11	LIGNUM	25483	(49.8%)	3140	8007	36630
12	SAL SHRUB	14858		21069	16142	52069
13	OPEN	103781	(46.8%)	31675	16896	152352
14	EXOTIC	626	(8.5%)	891	862	2379
15	PASTURE	153034	(31.8%)	114208	34942	302184
16	ORCHARD	10304	(0.3%)	22415	35853	68572
17	URBAN	4937	(26.5%)	4447	2232	11616
18	QUARRY	277	(0.4%)	242	0	519
19	SAND DUNE	2306	(0.2%)	585	874	3765
20	WATER	60886	(12.8%)	34630	73726	169242
	Total	648762	(32.0%)	405660	255346	1309768

Note
Anabranch area as percentage of total NSW area (in brackets)

TABLE 5. STRUCTURAL VEGETATION CLASS AREAS (HA) B Y GEOGRAPHIC SECTION FOR THE MURRAY RIVER

STRUCTURAL VEGETATION CLASS	GEOGRAPHIC SECTION								
	1	2	3	4	5	6	7	8	TOTAL
1 RG-FOR	3372	8711	58862	55849	31204	13291	139	0	171428
2 RG-WOOD	2891	1082	2934	4266	1793	6243	5919	347	25475
3 RG/BOX	331	378	548	2647	8302	2587	128	0	14921
4 MIX BOX	816	730	5284	17169	0	0	0	0	23999
5 BB-WOOD	0	0	78	12967	45712	29414	4997	8	93176
6 BB MALLEE	0	0	0	10	14783	13197	2175	13	30178
7 CASUARINA	3	131	290	85	20	350	0	0	879
8 RVR COOBA	0	0	0	0	139	21	0	0	160
9 M FNG WOOD	0	0	0	218	18118	6268	12601	0	37205
10 MALLEE	0	0	0	273	19171	9301	16463	0	45208
11 LIGNUM	0	0	0	441	10576	9418	3462	36	23933
12 SAL SHRUB	3	0	0	0	2434	46731	3101	0	52269
13 OPEN	826	569	6308	13767	42194	34469	5245	314	103692
14 EXOTIC	657	299	26	151	298	35	154	706	2326
15 PASTURE	35224	20678	32047	84014	43810	11686	15294	10801	253554
16 ORCHARD	354	2231	11	2952	26040	15590	13092	8266	68536
17 URBAN	2482	1434	203	2068	1876	869	495	882	10309
18 QUARRY	169	3	10	11	313	12	0	0	518
19 SAND DUNE	0	0	46	0	355	3124	129	107	3761
20 WATER	31256	1991	3617	17493	15160	25827	16094	50038	161476
Total	78384	38237	110264	214381	282298	228433	99488	71518	1123003

While structural vegetation classes are readily identified in the field by most land managers, trained botanists are often required to identify the subtle species groupings that characterise a floristic community. In order to provide a comprehensive picture of the likely species diversity within any class on the vegetation map there is an obvious need to relate the floristic communities to the structural classes. The relationship between the 20 structural vegetation classes and the 37 floristic communities is summarised in Table 6.

Table 6 shows that there is a good correlation between the two classifications but also some anomalies:

- Although *E. camaldulensis* communities may be classified as either red gum forest or red gum woodland on the basis of their typical structure, individual stands vary and may often have been mapped as the alternative.
- The *E. largiflorens-Atriplex nummularia* community typically has a sparse tree layer and was mapped as black box (mallee form), but the same

understorey may occur without a tree layer, when it was mapped as saline shrubland.

- The *Dodonaea viscosa-Callitris preissii* community was mapped as cypress pine/casuarina woodland where the *Callitris* was prominent, but as mallee fringe woodland in more degraded sites, where the *Callitris* had often been eliminated.
- Stands of river cooba *Acacia stenophylla* were mapped as a separate structural class. However, there were marked differences in understorey among the sample plots and they were not recognised as a separate community in the floristic analysis.
- The *Chenopodium nitrariaceum-Muehlenbeckia cunninghamii* community was typically mapped as lignum but includes some open stands dominated by *Chenopodium* and mapped as saline shrubland.
- The vegetation mapping covered many areas along the fringes of the floodplain and outside it. The vegetation of these sites was not sampled in the floristic survey, although plots were sometimes located in similar vegetation on isolated rises within the floodplain. Thus the floristic survey did not cover the mallee structural class and only covered a few examples of the mixed box woodland, cypress pine/casuarina woodland and mallee fringe woodland classes. All of these are non-riparian classes. Furthermore, several riparian classes included some vegetation from outside the floodplain: the *E. blakelyi* stands included in the red gum forest and red gum woodland classes; the *E. blakelyi/E. microcarpa/E. melliodora/E. albens* stands included in the red gum/box forest and woodland class; and the *Maireana pyramidata* shrubland included in the saline shrubland class.
- The floristic survey did not cover cleared lands. Thus, it did not cover the cultivated pasture and cropping class, the orchards and vineyards class, those parts of the open areas class that consist of cleared pastureland, and those parts of the exotic trees and shrubs class that consist of plantations or other plantings.

TABLE 6. RELATIONSHIP BETWEEN THE STRUCTURAL VEGETATION CLASSES AND FLORISTIC COMMUNITIES

Structural Vegetation Class (used in the mapping)		Floristic Communities (derived from the point-based field survey)
1. Red Gum Forest	1	*Eucalyptus camaldulensis - Eleocharis acuta Pseudoraphis spinescens* Open Forest
	2	*E. camaldulensis - E. acuta - Wahlenbergia fluminalis* Open Forest
	3	*E. camaldulensis - Poa labillardieri - Agrostis avenacea* Open Forest
	4	*E. camaldulensis - P. labillardieri - Hemarthria uncinata* Open Forest
	5	*E. camaldulensis - Carex tereticaulis* Open Forest
	6	*E. camaldulensis - Paspalidium jubiflorum - Senecio quadridentatus* Open Forest
	13	*E. camaldulensis - * Bromus diandrus - Vulpia bromoides* Open Forest
	14	*E. camaldulensis - * B. diandrus - Danthonia caespitosa* Open Forest
2. Red Gum Woodland	7	*E. camaldulensis - P. jubiflorum * C. dactylon* Woodland
	8	*E. camaldulensis - Cyperus gymnocaulos* Woodland
	9	*E. camaldulensis - Phragmites australis* Woodland
	10	*E. camaldulensis - D. caespitosa* Woodland
	15	*E. camaldulensis - * C. dactylon* Woodland
3. Red Gum/Box Forest and Woodland	11	*E. camaldulensis - E. largiflorens* Open forest
	= 12	*E. camaldulensis - Muehlenbeckia cunninghamii* Woodland
4. Mixed Box Woodland	34	*E. microcarpa* Open forest
	35	*E. melliodora* Woodland
5. Black Box Woodland	22	*E. largiflorens - E. acuta* Open Forest
	= 23	*E. largiflorens - M. cunninghamii - Chenopodium nitrariaceum* Woodland
	= 24	*E. largiflorens - M. cunninghamii - Atriplex semibaccata* Woodland
	25	*E. largiflorens - Melaleuca lanceolata - Allocasuarina leuhmannii* Woodland
	26	*E. largiflorens - M. lanceolota - A. rhagodioides* Woodland
6. Black Box (mallee form)	= 27	*E. largiflorens - Atriplex nummularia* Open Woodland
	28	*E. largiflorens - A. rhagodioides* Woodland

Structural Vegetation Class (used in the mapping)			**Floristic Communities (derived from the point-based field survey)**
7. Cypress Pine/ Casuarina Woodland		36	*Callitris glaucophylla* Woodland
		37	*Dodonaea*
8. River Cooba	=	12	*E. camaldulensis - M. cunninghamii* Woodland
	=	23	*E. largiflorens - M. cunninghamii - C. nitrariaceum* Woodland
9. Mallee Fringe Woodland		37	*Dodonaea*
10. Mallee			Not sampled - outside floodplain
11. Lignum		18	*Callistemon brachyandrus - M. cunninghamii* Shrubland
	=	29	*C. nitrariaceum - M. cunninghamii* Shrubland
		30	*M. cunninghanii - Halosarcia pergranulata* Shrubland
12. Saline Shrubland	=	27	*E. largiflorens - A. nummularia* Open Woodland
	=	29	*C. nitrariaceum - M. cunninghamii* Shrubland
		31	*A. versicaria - Pachycornia triandra* Shrubland
		32	*H. pergranulata - H. indica - Sclerolaena tricuspis*
13. Open Areas	=	19	Agrotis avenacea - * C. dactylon Grassland
		20	*Pseudoraphis spinescens - E. acuta* Herbland
		21	*Centipeda cunninghamii - Polygonium plebeium* Herbland
		33	*Sporobolus mitchellii - Atriplex leptocarpa* Grassland
14. Exotic Trees and Shrubs		16	* Salix Xrubens Scrub
		17	* S. babylonica Scrub
15. Cultivated Pasture and Cropping			Not sampled - cleared land
16. Orchards and Vineyards			Not sampled - cleared land
17. Urban			Not sampled
18. Quarries and Sandpits			Not sampled
19. Sand Dunes			Not sampled
20. Water Bodies			Not sampled

5. VEGETATION CONDITION

5.1 MAPPING VEGETATION CONDITION

5.1.1 DESCRIPTION OF CONDITION CLASSES

Many factors are contributing to the decline of riparian vegetation at specific sites along the Murray River and its tributaries. On any given site there may be several of these factors in evidence however for the purposes of this study an attempt has been made to identify the primary casual factor and to indicate this on the maps.

Nine of these factors, or condition classes, have been identified and they are described below:

1. Saline Groundwater (S)

Widespread salinisation of groundwater in the root zone is primarily caused by recharge of groundwater tables and exacerbated by local seepage and drainage from nearby irrigation areas. Extreme examples of vegetation decline are evidenced around evaporation basins where tree and woody shrub deaths are common. This problem often occurs in association with high surface levels of water that may also be contributing to a water logging, or drowning, effect.

2. Drowning (W)

Excessive water levels in the root zone, or high surface water levels cause a decline in tree health. Prolonged water logging will cause tree death (refer to Class 3 - Drowned)

3. Drowned (T)

Permanently high surface water levels around locks and lakes have caused the death of all terrestrial vegetation. Evidence of the former presence of forests exists in the form of dead trees, which are sometimes referred to as stags.

4. Water Stress (D)

Prolonged lack of watering on local sites is causing a decline in health of trees and woody shrubs. The density of crowns is reduced as are the height and diameter growth rates. Scattered deaths are occurring. The problem is more likely to occur on levees and other areas raised above the floodplain.

Water stress is also more likely to occur in saline soils as a result of an adverse osmotic gradient away from plant roots.

The problem is both man-made (water stress through river regulation) and natural (drought, through lack of rain).

5. Overgrazing (G)

Excessive grazing by domestic (cattle and sheep), feral (rabbits, pigs and goats) and native (kangaroos) animals causes a general decline in vegetation health through browsing, bark removal, soil compaction and consumption or trampling of regeneration. Areas under pastoral lease are particularly at risk.

Very few areas of decline on the maps were attributed primarily to overgrazing simply because the effects are most evident beneath the overstorey canopy and are therefore only detectable on aerial photographs in extreme instances. The small areas mapped should in no way detract from the widespread severity of the grazing problem (refer to Chapter 6.2.2).

6. Fire (F)

Fire has occasionally been used to stimulate regeneration and reduce slash following prescribed logging operations in river red gum stands. Fire kills the remaining overstorey trees and where regeneration also has been inadequate a declining stand is created.

Fire deaths are also possible following recreational activities or vandalism. Few fires are naturally occurring in the riparian forests of the Murray River.

7. Clearing/Logging (C)

Logging is defined as selective removal of merchantable river red gum stems on public, freehold and leasehold land. Sites in this category have been delineated as a condition class where inadequate regeneration has resulted following logging. On public land poor regeneration may be caused by both overgrazing and lack of watering. On freehold and leasehold land the intention may be to maintain the area for primary production purposes. In this instance they are deemed clearings.

Wholesale clearings are not included in this category but have been mapped as structural vegetation classes 15 and 16.

8. Recreation (R)

Excessive traffic can damage and destroy regeneration and affect the health of overstorey trees. Some river bends and floodplain areas are a maze of tracks and constitute degraded sites.

9. Unexplained (U)

On some sites there are no apparent causes for the decline and death of overstorey stems. These sites should be investigated further.

5.1.2 DISTRIBUTION AND EXTENT OF DEGRADING VEGETATION

A total of 17 999ha of severely degraded vegetation was identified and mapped across the study area (Table 7). Almost 93% of this area, or 16 726ha, occurs along the Murray River (Table 8).

Of the degraded sites along the Murray, 6947ha (42%) is river red gum forest and woodland and 4508ha (27%) is box woodland with most of the remainder comprising lignum and open areas (grasslands and herblands).

Saline groundwater has been identified as the single largest causal factor for degradation making up 53% of the problem areas along the Murray. Drowning or waterlogged areas comprise 19% and long-drowned areas characterised by their bleached, dead stems make up a further 18%. Other significant areas of degradation are attributable to drought, or water stress (6.2%), logging and clearing (1.9%), grazing (1.7%) and unexplained factors (0.6%). The figure for grazing may be considered to be somewhat low, however it must be remembered that only the most severe forms of degradation have been identified by this mapping. The grazing problem is widespread and of concern and is treated in detail in Chapter 6.2.2.

Considering the Murray in total, some 1.4% of the river red gum forest and 17.7% of the river red gum woodland is in severe decline. Black box woodland, with 2.7%, black box (mallee form) with 5.5% and lignum with 4.7% represent the other most degraded communities. An analysis of the distribution of degrade by geographic sections is given in Table 9. This table shows that the largest areas of river red gum forest are being affected in Sections 5 and 6, predominantly in the Mildura and Renmark/Loxton irrigation areas respectively. This latter area in association with the Lake Victoria area accounts for more than 50% of the severely degraded river red gum woodland.

Black box woodland is also suffering most in Section 5 while black box (mallee form) is most degraded in the lower reaches of the Murray, Sections 6 and 7.

TABLE 7. STRUCTURAL VEGETATION CLASS AREAS (HA) BY CONDITION CLASS FOR SEVERELY DEGRADED AREAS ALONG THE MURRAY RIVER AND ANABRANCHES (EDWARD, NIEMUR, WAKOOL RIVERS)

	CONDITION CLASS									
STRUCTURAL VEGETATION CLASS	Salt	Drowning	Drowned	Water Stress	Grazing	Fire	Clearing	Recreation	Unexplained	TOTAL
1 RG-FOR	644	1107	0	632	244	9	1009	0	58	3703
2 RG-WOOD	2578	1274	0	652	0	0	8	0	5	4517
3 RG/BOX	17	105	0	0	0	0	58	0	0	180
4 MIX BOX	0	76	0	57	0	0	0	0	0	133
5 BB-WOOD	2113	227	0	93	0	0	24	35	44	2536
6 BB MALLEE	1425	234	0	0	0	0	0	0	0	1659
7 CASUARINA	34	0	0	0	0	0	0	0	0	34
8 RVR COOBA	0	0	0	0	0	0	0	0	0	0
9 M FNG WOOD	35	17	0	0	0	0	20	0	0	72
10 MALLEE	0	3	0	0	0	0	0	0	0	3
11 LIGNUM	1098	17	0	0	0	0	0	0	0	1115
12 SAL SHRUB	0	0	0	0	0	0	0	0	0	0
13 OPEN	839	194	105	0	33	0	25	0	0	1196
14 EXOTIC	0	0	0	0	0	0	0	0	0	0
15 PASTURE	0	0	0	0	0	0	0	0	0	0
16 ORCHARD	0	0	0	0	0	0	0	0	0	0
17 URBAN	0	0	0	0	0	0	0	0	0	0
18 QUARRY	0	0	0	0	0	0	0	0	0	0
19 SAND DUNE	0	0	0	0	0	0	0	0	0	0
20 WATER	0	0	2851	0	0	0	0	0	0	2851
Total	8783	3254	2956	1434	277	9	1144	35	107	17999

TABLE 8. STRUCTURAL VEGETATION CLASS AREAS (HA) BY CONDITION CLASS FOR SEVERELY DEGRADED AREAS ALONG THE MURRAY RIVER

STRUCTURAL VEGETATION CLASS		CONDITION CLASS									
		Salt	Drowning	Drowned	Water Stress	Grazing	Fire	Clearing	Recreation	Unexplained	TOTAL
1	RG-FOR	644	1060	0	236	244	9	179	0	58	2430
2	RG-WOOD	2578	1274	0	652	0	0	8	0	5	4517
3	RG/BOX	17	105	0	0	0	0	58	0	0	180
4	MIX BOX	0	76	0	57	0	0	0	0	0	133
5	BB-WOOD	2113	227	0	93	0	0	24	35	44	2536
6	BB MALLEE	1425	234	0	0	0	0	0	0	0	1659
7	CASUARINA	34	0	0	0	0	0	0	0	0	34
8	RVR COOBA	0	0	0	0	0	0	0	0	0	0
9	M FNG WOOD	35	17	0	0	0	0	20	0	0	72
10	MALLEE	0	3	0	0	0	0	0	0	0	3
11	LIGNUM	1098	17	0	0	0	0	0	0	0	1115
12	SAL SHRUB	0	0	0	0	0	0	0	0	0	0
13	OPEN	839	194	105	0	33	0	25	0	0	1196
14	EXOTIC	0	0	0	0	0	0	0	0	0	0
15	PASTURE	0	0	0	0	0	0	0	0	0	0
16	ORCHARD	0	0	0	0	0	0	0	0	0	0
17	URBAN	0	0	0	0	0	0	0	0	0	0
18	QUARRY	0	0	0	0	0	0	0	0	0	0
19	SAND DUNE	0	0	0	0	0	0	0	0	0	0
20	WATER	0	0	2851	0	0	0	0	0	0	2851
	Total	8783	3207	2956	1038	277	9	314	35	107	16726

Note
Only the most severely damaged grazing areas have been mapped. However, it should be noted that grazing problems are far more widespread than depicted by this table.

TABLE 9. AREA (HA) OF SEVERELY DEGRADED STRUCTURAL VEGETATION BY GEOGRAPHIC SECTIONS FOR THE MURRAY RIVER

STRUCTURAL VEGETATION CLASS	GEOGRAPHIC SECTION 1	2	3	4	5	6	7	8	TOTAL
1 RG-FOR	55	0	216	197	953	1009	0	0	2430
2 RG-WOOD	19	0	0	28	684	2356	1386	44	4517
3 RG/BOX	0	0	0	58	9	113	0	0	180
4 MIX BOX	0	0	57	76	0	0	0	0	133
5 BB-WOOD	0	0	0	0	1778	501	257	0	2536
6 BB MALLEE	0	0	0	0	46	1199	414	0	1659
7 CASUARINA	0	0	0	0	34	0	0	0	34
8 RVR COOBA	0	0	0	0	0	0	0	0	0
9 M FNG WOOD	0	0	0	0	72	0	0	0	72
10 MALLEE	0	0	0	0	0	3	0	0	3
11 LIGNUM	0	0	0	0	1045	70	0	0	1115
12 SAL SHRUB	0	0	0	0	0	0	0	0	0
13 OPEN	0	0	237	411	499	33	16	0	1196
14 EXOTIC	0	0	0	0	0	0	0	0	0
15 PASTURE	0	0	0	0	0	0	0	0	0
16 ORCHARD	0	0	0	0	0	0	0	0	0
17 URBAN	0	0	0	0	0	0	0	0	0
18 QUARRY	0	0	0	0	0	0	0	0	0
19 SAND DUNE	0	0	0	0	0	0	0	0	0
20 WATER	259	0	23	97	712	1195	565	0	2851
Total	333	0	533	867	5832	6479	2638	44	16726

Comparatively little degrade is occurring in riparian communities between Hume Weir and Yarrawonga Weir (Sections 1 to 3). In Appendix 5, Tables 2 to 9 treat each of the 8 sections in detail while analysis of degrade by states is given in Tables 10 to 12.

5.2 EUCALYPT HEALTH

Eucalypt health was measured by the condition of the trees and the density of regeneration. These data are summarised here by river sections (Table 10) and by communities (Table 11), with further details in Appendix 1.1. They should be treated with some caution, especially for communities represented by only a few plots. They represent a preliminary survey rather than a definitive study. Nevertheless, they provide an overall perspective and quantify some general trends. Further information was obtained from the literature review.

5.2.1 RIVER RED GUM

River red gum trees were generally healthier in Sections 1 and 2 than in the semi-arid regions, while dead trees were most numerous in Sections 7 and 8 (Table 10). Tree death here was mostly attributable to raised water levels. In one plot at McBean's Pound north of Blanchetown (Section 7), a large area of red gums had been inundated and killed after the construction of Lock 1. However, there was prolific regeneration behind (2325 per ha), establishing a new stand at a higher level. The plot was grazed by sheep, cattle and kangaroos but grazing may have been excluded in the past by a fence now in disrepair. This plot was exceptional among those sampled for this survey. In other South Australian plots where there were numbers of inundated trees, the fringing regeneration was poor, as reflected in the low densities overall for Sections 7 and 8.

Thompson (1986) has also commented on the many dead trees along the river in South Australia and the patchy nature of the regeneration. He concluded, as did Venning (1984) and Kiddle (1987), that grazing is severely restricting red gum regeneration in South Australia. This conclusion is based on the observation that where regeneration ocurs it is often in situations where there is some protection from grazing - provided, for example, by islands, reedbeds or dense patches of lignum. Similar observations were made during this survey. A survey in the Clare district of South Australia indicated that reduced grazing pressure by sheep, combined with two wet seasons, were needed for broad acre regeneration of river red gums in a non-riparian situation (Venning & Croft 1983).

In contrast, Dexter (1967, 1970, 1978) found that grazing was not seriously restricting red gum regeneration in Barmah State Forest (Section 3). In fact, cattle grazing appeared to have a beneficial effect by reducing competition from grasses and weeds. This probably reflects the low stocking rate in this area - where timber production is the primary land use - and the less destructive grazing of cattle compared with sheep and rabbits (Department of Crown Lands & Survey 1977; Wilson *et al.* 1984). However, cattle in high numbers have continually chewed off regeneration in Corowa State Forest in

Section 1 (Forestry Commission 1985) and appear to be restricting regeneration in Section 8 (Table 10).

Apart from raised water levels, the most obvious cause of tree death along the Murray is soil salinisation. This was observed at many sites, particularly in Sections 6 and 7, but only one badly salt-affected plot is included in Table 10 - a depression in Maize Island Conservation Park (Section 7) where salt was crusting on the surface but some live red gums remained. In other badly salt-affected plots the red gums had all been killed and the vegetation had changed to shrublands of *Muehlenbeckia-Halosarcia* and *Halosarcia* spp. (see Chapter 6.4).

TABLE 10. EUCALYPT HEALTH BY RIVER SECT

River section	Plots	Trees (%) h	u	d	Regeneration (/ha)	Grazing index r	s	c	k
(a) ***Eucalyptus camaldulensis***									
1	24	85	13	2	452	0.3	+	2.0	0
2	20	83	14	3	185	4.5	0.2	0.6	1.1
3	40	76	17	7	957	1.7	0.03	1.3	1.2
4	62	67	25	8	579	0.8	1.6	0.6	1.1
5	21	72	21	7	480	0.6	1.3	0.2	1.6
6	20	76	18	7	301	0.5	3.8	+	1.7
7	25	65	19	16	130	2.6	0.8	0.4	0.1
8	10	63	12	25	93	0.3	0	6.5	0
(b) ***E. largiflorens***									
4	20	56	35	8	203	2.9	1.6	0.6	1.2
5	12	59	31	10	331	4.7	0.2	0.1	1.8
6	21	62	31	7	39	7.1	2.0	+	1.4
7	10	81	11	8	10	11.2	0.9	0.5	+

h healthy **u** unhealthy (>40% of crown dead) **d** dead **r** rabbit **s** sheep **c** cattle **k** kangaroo

Regeneration counts did not include seedlings under 5cm high or young trees over 20cm stem Diameter at Breast Height (DBH). Grazing indices are mean numbers of droppings clusters along a 20m line. Figures do not include either the *Agrostis-*Cynodon* and *Centipeda- Polygonum* communities, which have dense eucalypt regeneration, nor the *Muehlenbeckia-Halosarcia* and *Halosarcia* spp. communities, which often have an overstorey of salt-killed eucalypts.

TABLE 11. EUCALYPT HEALTH BY COMMUNITIES

Regeneration counts did not include seedlings under 5cm high or young trees over 20cm stem Diameter at Breast Height (DBH). Grazing indices are mean numbers of droppings clusters along a 20m line. Figures do not include either the *Agrostis-*Cynodon* and *Centipeda-Polygonum* communities, which have dense eucalypt regeneration, nor the *Muehlenbeckia-Halosarcia* and *Halosarcia* spp. communities, which often have an overstorey of salt-killed eucalypts.

h healthy **u** unhealthy (>40% of crown dead) **d** dead **r** rabbit **s** sheep **c** cattle **k** kangaroo

Community	Plots	Trees (%)			Rgntn	Grazing index			
		h	u	d	(/ha)	r	s	c	k
(a) *Eucalyptus camaldulensis*									
1 *E.c.-Eleocharis-Pseudoraphis*	26	81	15	4	838	0.2	0.5	0.5	0.2
2 *E.c.-Eleocharis-Wahlenbergia*	4	76	19	5	163	0.8	1.8	1.3	0.8
3 *E.c.-Poa-Agrostis*	30	76	19	5	736	0.4	0.2	0.9	0.6
4 *E.c.-Poa-Hemarthria*	7	84	15	1	50	9.3	0.4	0.6	0.1
5 *E.c.-Carex*	11	81	14	5	950	0.2	+	0.5	1.0
6 *E.c.-Paspalidium-Senecio*	25	71	19	10	863	1.6	0.6	0.4	2.2
7 *E.c.-Paspalidium-*Cynodon*	28	77	17	6	466	1.0	3.4	0.1	1.3
8 *E.c.-Cyperus*	12	70	15	15	3	0.2	2.2	0.2	1.4
9 *E.c.-Phragmites*	5	80	10	10	60	0.4	0	0.4	0
10 *E.c.-Danthonia*	8	72	22	6	28	0.9	+	3.5	2.0
11 *E.c.-E.largiflorens*	13	55	37	8	67	1.2	2.5	0.4	1.5
12 *E.c.-Muehlenbeckia*	13	52	35	14	44	3.5	1.0	0.2	0.5
13 *E.c.-*Bromus-*Vulpia*	21	79	18	3	356	2.5	0.1	2.5	0.7
14 *E.c.-*Bromus-Danthonia*	6	57	29	14	250	0.3	+	0.5	0.2
15 *E.c.-*Cynodon*	12	60	13	27	88	3.5	0	5.4	0
19 *Agrostis-*Cynodon*	3				558	0.3	0	1.0	2.0
21 *Centipeda-Polygonum*	5				4080	5.0	3.4	0.4	0.4
(b) *E. largiflorens*									
11 *E. camaldulensis-E.l.*	13	49	44	7	428	1.2	2.5	0.4	1.5
22 *E.l.-Eleocharis*	3	74	26	0	0	0.7	+	+	0.7
23 *E.l.-Muehlenbeckia-Chenopodium*	19	57	32	11	201	5.2	0.1	0.5	2.2
24 *E.l.-Muehlenbeckia-Atriplex*	13	74	18	8	6	11.5	0.6	0.4	0.7
25 *E.l.-Melaleuca-Allocasuarina*	2	70	30	0	0	1.5	4.5	0.5	1.0
26 *E.l.-Melaleuca-Atriplex*	3	43	57	0	0	6.0	6.0	0	2.3
27 *E.l.-Atriplex nummularia*	4	70	25	5	0	3.0	6.8	+	+
28 *E.l.-A. rhagodioides*	8	53	34	13	103	6.5	1.0	+	0.9
(c) Other Species									
34 *E. microcarpa*	2	75	22	3	625	0	0	0	3.5
35 *E. melliodora*	4	100	0	0	56	15.0	0	2.0	1.5

Another factor affecting red gum condition is the gum leaf skeletoniser *Uraba lugens*, a moth whose larvae feed on eucalypt foliage, particularly river red gums. The larvae seldom kill the trees but cause severe defoliation over large areas (for example, some 40 000ha of red gum forest in the Murray and Goulburn Valleys in 1975) and drastically check growth (Campbell 1962; Harris 1972, 1974, 1986; Harris *et al.* 1977).

Eggs are laid mostly on low foliage, often on regeneration or coppice growth. After the larvae hatch, they gradually move up the trees and consume more and more of the leaves. The main controlling factor is flooding, which increases humidity, allowing two species of *Aspergillus* fungus that kill the larvae to flourish. In addition, some larvae and cocoons may be drowned. Without flooding, most larvae reach maturity and large numbers of eggs are laid, increasing the potential population of the next generation. Major outbreaks occur in roughly ten-year cycles, when the forest is almost completely defoliated. Moth populations then crash because larvae starve and suitable egg-laying sites are not available. The trees recover rapidly.

There was evidence of skeletoniser activity at some sites during the present survey, for example, Nyah State Forest in Section 4. However, this was very minor and likely to be a negligible influence on the tree condition figures.

Red gum regeneration was densest in Section 3, declining downstream to its lowest density in Section 8, lower by an order of magnitude (Table 10). Regeneration was much sparser in South Australia than in the other States, even just within Section 6 (60 regenerants per ha in 13 plots in South Australia compared with 750 per ha in 7 plots in the other States).

One important factor appears to be logging, which promotes regeneration, even without subsequent silvicultural treatment, by opening the canopy (Jacobs 1955; Dexter 1967). Timber production is a very minor land use along the river in South Australia, where only 2% of plots showed evidence of logging, but a major land use in the other States, where 83% of plots had been logged.

There is also a correlation with grazing pressure. The poor regeneration in Section 8 corresponds with high densities of cattle from the adjacent irrigated pastures. Similarly, poor regeneration in Section 2 corresponds with high rabbit numbers, although this may be a feature of the sample sites rather than the section as a whole.

Tree condition and regeneration in individual communities follow the general pattern of decline downstream (Table 11). They also decline across the floodplain, which can be seen by comparing the characteristic communities of the higher, outer parts of the red gum zone (communities 10, 11 and 12) with the major communities of the inner red gum zone (1, 3, 5, 6, 7 and 8). The outer communities are also lower and more open in structure than the inner ones (Appendix 1.1). In Barmah State Forest, Bren & Gibbs (1986) have demonstrated how poorer quality red gum stands (mainly determined by height at maturity) are closely associated with lower flood frequencies.

An exception to these general patterns is the *E. camaldulensis-Poa-Hemarthria* community, whose sparse regeneration corresponds to high rabbit densities and is reflected in the poor regeneration in Section 2 as a whole. This community may be more suitable for rabbits because of its rather sandy soils, which are easier for burrowing in than the heavier soils of most red gum communities.

Prolific regeneration occurs in depressions within the red gum zone. Regeneration was more abundant in the *Centipeda-Polygonum* herbland community, which is characteristic of such sites, than in any other community. The importance of the depressions was also noted in a regeneration survey in South Australia (Kiddle 1987). These sites are subject to frequent flooding - from both river and rain - and fluctuating water levels. Seeds come from surrounding red gums and there is extensive germination after flooding, although most of the seedlings are killed by later flooding. Saplings only become established around the edges of the depressions.

Another site of prolific red gum regeneration was the edges of the extensive Moira grass plains (*Pseudoraphis-Eleocharis* community) in Barmah State Forest. In one plot near Hut Lake this regeneration averaged 11m in height with a density of 7400 regenerants per ha (all ages), representing a young stand of the *E. camaldulensis-Eleocharis-Pseudoraphis* community on what was presumably once *Pseudoraphis* grassland. There was an abrupt boundary between the regeneration and the remaining *Pseudoraphis* grassland, from which red gum trees and regeneration were almost entirely absent. Similar red gum colonisation at Buck's Lake dates from about 1961 (B. Dexter, pers. comm.).

Chesterfield (1986) estimated that this red gum invasion of former *Pseudoraphis* grassland covers about 4% of the total area of Barmah State Forest (including Barmah State Park). It appears to be a consequence of the reduced frequency of minor flooding since river regulation, allowing red gums to become established where flooding was once too frequent and prolonged for them (Dexter *et al.* 1986; Bren 1987a).

The changes to flood regimes in Barmah State Forest, and their effects on red gum growth and regeneration, have been the subject of numerous studies (Dexter 1967, 1970, 1978; Dexter *et al.* 1986; Chesterfield *et al.* 1984; Chesterfield 1986; Bren 1987a-c; Bren & Gibbs 1986, 1987; Bren *et al.* 1987a,b). Major floods have been little affected by river regulation but there is concern that the reduced frequency of minor flooding in winter and spring has meant less vigorous growth and regeneration of red gums over large areas. The forest may now be unable to sustain intensive utilisation for timber production and eventually become dominated by the lower, more open, more slow-growing stands associated with infrequent flooding. On the other hand, as described above, red gums are actively colonising large areas that were once *Pseudoraphis* grassland. Ultimately, these areas may support the tallest, most vigorous stands in the forest.

In addition, river levels at Barmah are now higher in summer and autumn than before regulation, with frequent unseasonal flooding from 'rain rejection' flows - water released for irrigation but not used because of subsequent rainfalls. Some low-lying areas near the river, for example on Top Island, have become more or less constantly inundated. Red gums have been killed at these sites and they now support wetland vegetation, specifically, reedbeds of *Juncus ingens* and *Phragmites australis* (Chesterfield 1986; this survey). The Barmah-Moira forests are particularly prone to unseasonal summer-autumn flooding because of the very limited capacity of the 'Barmah Choke,' the stretch of river through the forests below the Edward River offtake. Downstream, summer-autumn flows usually remain within the river banks (Dexter *et al.* 1986).

River regulation is also implicated, together with grazing as inhibiting red gum regeneration in South Australia. The system of weirs and barrages here has raised the river level and reduced its variability (see Chapter 6.3). From a perspective of regeneration patterns along the length of the river, red gum regeneration in South Australia, although excellent in some sites, is generally poor for such a vigorous coloniser. This conclusion is tempered by the difficulties of comparing regeneration in logged and unlogged forests, which is what is effectively involved in broad comparisons between South Australia and the other States. Nevertheless, it warrants further investigation. While much attention has been devoted to the Barmah-Millewa forests, the problems there are chiefly ones of stand quality. In South Australia, regeneration is so patchy that there are real problems of stand survival.

5.2.2 BLACK BOX

The proportion of unhealthy black box trees was high in Sections 4, 5 and 6, appreciably higher than for red gums in the same sections, and for black box in Section 7 (Table 10). In some plots, mainly in Section 6, there was evidence that poor condition was the result of soil salinisation. This is a major problem. In other plots not included in Tables 10 and 11, salinisation had led to death of all black box trees and a change to *Muehlenbeckia-Halosarcia* or *Halosarcia* spp. shrublands (see Chapter 6.4).

Other factors are also affecting black box condition. John Chappel, the manager of Chowilla Station (Section 6), reported that there had been extensive defoliation of black box in his region in 1985. The trees had since recovered by epicormic growth but many had been killed. The cause of this dieback epidemic remains unknown. It warrants further investigation and may have much wider implications.

Black box regeneration was very poor in Sections 6 and 7, an order of magnitude lower than in Sections 4 and 5 (Table 10). As with river red gum, this downstream decline in regeneration is correlated with logging history. There was evidence of logging in 84% of black box plots in Sections 4 and

5, but only 13% of plots in Sections 6 and 7. There is also a correlation with rabbit numbers, which were generally higher in the black box zone than the red gum zone, and especially so in Sections 6 and 7.

The uneven distribution of rabbits on the floodplain seems to be a result of their requirements for shelter. This is provided either by sandy soils where they can burrow (communities 4, 35, 36 and 37 - see Appendix 1.1) or, on the heavy clay soils of the black box zone, by dense shrub thickets, especially lignum (communities 23, 24, 26, 28, 29 and 30). Eucalypt regeneration was consistently poor in sites with high rabbit densities.

Stock grazing also limits regeneration, particularly sheep grazing. In the Nyah forests of Section 4, Chettle (1959) recorded how exclusion of sheep, but not cattle, led to a marked improvement in eucalypt regeneration, especially of black box, whose leaves may be more palatable to stock than those of river red gum (Jacobs 1955). Other observations of sheep grazing black box and restricting regeneration have been made by Jensen (1983a) and Pressey (1987) in Section 6.

Like river red gum, natural regeneration of black box is largely dependent on flooding (Treloar 1959). It has been widely observed after flooding that seedlings only establish in a narrow belt along the high water line of that particular flood (e.g. Cunningham *et al.* 1981). River regulation has reduced the frequency of minor flooding but has had little effect on major floods (Caldwell Connell Engineers 1981; Bren 1987a). Thus, black box regeneration has probably been less affected than red gum. However, the indications of poor condition and regeneration revealed by this survey are cause for concern.

5.3 WEED INVASION

Invasion of the floodplain by weeds - the term being used here to refer to all introduced species - has been one of the most pervasive effects of European settlement along the Murray. Even in the most remote areas, weeds are now a major component of the vegetation. Thirty-three percent of all plant species on the floodplain are introduced (Table_2), compared with a figure of ten percent for the Australian flora as a whole (Michael 1981).

A wide range of alien species has been introduced, either accidentally or intentionally. Some have become established and spread through the native vegetation with little further assistance from man. Most, though, depend on clearing, grazing or other disturbances to provide the conditions under which they can out-compete the indigenous species. The spread of weeds has been assisted on the floodplain by the natural regime of disturbance associated with the river and flooding, and by dispersal of seeds and other propagules by water. For these reasons, floodplain communities are particularly susceptible to weed invasion (van der Sommen 1986; Fox & Fox 1986).

The proportion of introduced species was high in all floodplain communities, but variable. Community means ranged from 18 to 63% of species per plot (Table 1, Appendix 1.1). The variation followed two general patterns. First, the proportion of weeds was lower in semi-arid regions. The weediest communities (those with 50% or more weed species per plot) were all associated with the higher rainfall, upper or lower reaches of the river.

The second pattern was a lower proportion of weeds in sites subject to regular flooding. Thus, the least weedy communities, the *E. camaldulensis-Eleocharis-Pseudoraphis* and *Pseudoraphis-Eleocharis* communities, were ones characteristic of very frequently flooded sites. These same communities had low species diversity overall (Table 1), possibly reflecting the degree of specialisation required for their difficult environment. This pattern has been noted before by Chesterfield (1986).

Despite high proportions of weeds, most communities are dominated by native species, which is reflected in the community names. In some communities, however, weeds are not only common but dominant. Obvious examples are the stands of willows, **Salix babylonica* and **S. Xrubens*. In other examples the tree layer is native but the understorey is completely dominated by weeds, its original composition unknown.

There are several of these latter communities on the Riverine Plain: the *Callitris glaucophylla*, *E. melliodora* and *E. microcarpa* communities of the rises, and the two *E. camaldulensis*-**Bromus* communities, which are also typically associated with higher ground. Dominant weeds here are the grasses **Bromus diandrus*, **B. hordeaceus*, **Lolium perenneX rigidum*, **Vulpia myuros* and **V. bromoides*, and the clovers **Trifolium campestre* and **T. arvense*. The Lower Murray equivalent is the *E. camaldulensis*-**Cynodon* community. Its dominant weeds are somewhat different: the grasses **Cynodon dactylon*, **Bromus rubens* and **Critesion murinum*, and the medic **Medicago polymorpha*.

Weediness is a conspicuous feature of the Murray floodplain. It is undoubtedly the most widespread form of vegetation deterioration along the river. Weeds are prominent even in the least weedy communities. The weediest communities have been changed beyond recognition.

5.4 THREATENED SPECIES

Rare and threatened Australian plants have been listed by Briggs & Leigh (1989). Eighteen of these species occurred on the Murray floodplain: two are presumed extinct, three endangered, nine vulnerable, three rare and one is of uncertain status. A further 50 species have been classified as endangered or vulnerable in either Victoria (Cheal 1987) or South Australia (Lang & Kraehenbuehl 1987). Two of these are particularly noteworthy: *Casuarina obesa* and *Psoralea tenax*, both of which are highly endangered in south-east Australia. The 68 species are discussed individually in Appendix 4.

Information is generally lacking on the history of each species. Some have undergone dramatic and relatively well documented declines, for example, *Senecio behrianus*, *Swainsona recta* and *Psoralea tenax*. Other species appear to be naturally rare. Others are rare along the Murray because they are at the southern limits of their distribution. These include some, such as *Eragrostis australasica* and *Geijera parviflora*, that are common further north.

The threats to individual species vary but clearing and grazing are probably the most general ones (Leigh *et al.*1984; Parsons & Scarlett 1987). Many of the species on the list are small herbaceous plants known, or likely, to be susceptible to grazing. Examples include the various species of *Brachycome*, *Lepidium*, *Psoralea* and *Swainsona*. Grazing is also considered the most likely cause of extinction of the thorny shrub *Acanthocladium dockeri*, though probably indirectly through vegetation and soil changes in its heavily overgrazed sandhill habitat (Leigh *et al.* 1984; Davies 1987).

Among the species considered threatened in South Australia are several aquatic and semi-aquatic plants which have declined there but remain common upstream. The chief examples are *Damasonium minus*, *Eleocharis pusilla*, *Najus tenuifolia* and *Nymphoides crenata*. A similar pattern is shown by *Pseudoraphis spinescens*. Although recorded in the past as far downstream as Murray Bridge, there have been no records of this otherwise common species below Overland Corner for many years (Lang & Kraehenbuehl 1987). It also seems to have declined in Sections 5 and 6 (Ashwell 1987, comparing his observations with those of Zimmer 1937). It is possible that these species have been adversely affected by the dampening of water level fluctuations by the system of weirs and barrages along the lower river. By contrast, other species characteristic of more stable water levels have increased in abundance in South Australia, especially *Phragmites australis* and *Typha* spp. (see Chapter 6.3).

At a national level, the number of threatened species along the Murray is moderately high for an inland region (Leigh *et al.* 1984; Briggs & Leigh 1989). Higher numbers occur elsewhere, notably in south-west Western Australia, but this reflects a combination of intensive development and a flora that originally contained many species of restricted distribution. The widespread distribution of many Murray species has cushioned them to some extent from a more dramatic decline. Nevertheless, there is a large number of species whose populations, at least along the Murray, are very small and whose survival is threatened there.

6. FACTORS INFLUENCING CONDITION

6.1 CLEARING

Clearing of floodplain vegetation has occurred to varying degrees along the length of the Murray but often to a lesser extent than on the lands beyond the floodplain. This is because the floodplain forests have been widely used for timber production, and the land is unsuitable for many purposes because of the risk of flooding.

Nonetheless, a large proportion of the floodplain has been cleared. Cleared pastureland, agricultural land and urban areas constitute 33% of the mapped area (excluding the water). A further 13%, classified as open areas, is also chiefly cleared pastureland. Furthermore, the mapping does not cover large parts of Section 4, the complex network of anabranches and distributaries between the Murray and Edward Rivers. It is this section, constituting about two-thirds of the entire study area (Chapter 3), which has been the most extensively cleared.

Much of the vast area of Section 4 is covered by the Wakool Irrigation District. The irrigated land is used mainly for pasture but crops are also grown, notably rice. The irrigation development dates from 1935, when Steven's Weir began operation. It was preceded by a century of heavy grazing. The associated clearing and vegetation change have mainly affected the woodlands and shrublands of the black box zone. The extensive red gum forests of this section are a valuable timber resource and have been largely retained as State forests.

Two other river sections have been heavily cleared. In Section 1, from Hume Dam to Yarrawonga, the proportion of floodplain set aside as timber and other reserves is much less than further downstream. With its higher rainfall, the land can carry more stock than in the semi-arid reaches. This section is closely settled and there has been widespread clearing of the narrow floodplain.

There has also been widespread clearing in Section 8, along the lower reaches of the Murray below Mannum. The river here was once flanked almost continuously by wetlands. Since the 1880s most of these have been drained and protected from flooding by building embankments along the river. The reclaimed swamps were used at first for cropping but soon converted to irrigated pasture. The river here is fringed mainly by introduced willows (the **Salix babylonica* community), planted originally to stabilise the embankments and mark the main channel.

6.2 GRAZING

6.2.1 HISTORY

The Murray floodplains are subject to heavy grazing pressure from native animals and, over the past 150 years, from stock and feral animals. The droppings counts and other observations during the survey indicated that the chief native grazers are the eastern grey kangaroo *Macropus giganteus* on the Riverine Plain and the western grey kangaroo *M. fuliginosus* in the Mallee Zone. Cattle and sheep are the chief stock and rabbits the most abundant of the feral animals. There is also grazing by pigs, goats and horses but although this may be locally important, their overall numbers are low.

The initial exploration of the Murray by Charles Sturt and Thomas Mitchell in the 1830s was soon followed by overlanders taking sheep and cattle to the new colony in South Australia. The first herd of cattle was taken to Adelaide in 1838 and the Murray rapidly became a major stock route traversed by enormous numbers of stock. In 1865 the South Australian Surveyor-General estimated that some 350 000 sheep per year were being brought along the river, monopolising the feed (Department of Environment & Planning 1987b).

After the reports of the explorers and overlanders, squatters quickly moved in and took up large runs. Early settlement concentrated along permanent water. By the end of the 1840s, squatters occupied most of the river frontage land along the length of the Murray (Frith & Sawer 1974). Both cattle and sheep were stocked but sheep soon predominated in the semi-arid reaches. Stocking of each station was often highly variable - numbers fluctuated from year to year, and even from month to month, as graziers continually moved their stock about (Land Conservation Council 1983).

Closer settlement in subsequent decades meant greater and more constant grazing pressure. The number of sheep in the Victorian Mallee Area tripled between 1853 and 1871 (Land Conservation Council 1987). The development of a major riverboat trade in the 1850s greatly accelerated settlement along the Murray in comparison with other inland areas. The numbers of stock on the fringing properties were sometimes very large. In 1881 more than 70000 sheep were shorn at Chowilla Woolshed, on the banks of the Murray in Section 6 (Barratt & Choate 1983). Sheep numbers in the western division of New South Wales increased to a peak of 13.7 million in the 1890s before falling rapidly during the severe droughts around the turn of the century. Numbers have remained relatively stable since then at around 7.5 million (Noble & Tongway 1986b).

Grazing of unimproved pasture remains a major land use along the Murray. Sheep grazing predominates in the drier regions and cattle grazing in the wetter regions (Table 10). Stocking rates and patterns depend on management practices on each property. If the property extends well outside the floodplain, the floodplain part may be grazed very heavily for short periods following floods or during droughts. If the property is more or less confined to the floodplain, the sustainable stocking rates are necessarily much lower, but more constant (Department of Environment & Planning 1987b). Little research has been carried out on desirable stocking rates for different land units on the floodplain (Department of Lands 1985).

Of the feral grazers, the rabbit has undoubtedly had the greatest effect on floodplain vegetation. As early as 1862, rabbits were mentioned in the Albury papers (McBarron 1955). By 1879 there were rabbit populations along the length of the Murray and farmers were abandoning properties rendered useless by rabbits in northwest Victoria (Rolls 1969; Myers 1986). About one million rabbits were killed on a single property in the Riverina in 1880 (Buxton 1967).

The period 1880 to 1950 saw recurring rabbit plagues of gigantic proportions. Since 1950, when myxoma virus was released among rabbit populations on the upper Murray, numbers have been held in check by myxomatosis, and the great plagues of the past have not been repeated. However, rabbits are still by far the most abundant feral grazers along the river and their increasing resistance to myxomatosis is a matter of concern.

6.2.2 EFFECTS

All grazing animals are selective. By preferentially grazing some species and avoiding others they can alter the floristic composition of a plant community (Morley 1981; Wilson & Harrington 1984). In general, cattle are less selective grazers than sheep (Wilson 1976; Graetz & Wilson 1980). Sheep cause greater overgrazing damage than cattle, and goats more than sheep. The difference lies in the ability of goats to survive longer than sheep, and sheep longer than cattle, goats eating more browse than sheep, and sheep grazing closer to the ground than cattle (Wilson & Mulham 1980; Graetz & Wilson 1980).

Rabbits are more catholic in their tastes than sheep and are particularly efficient at finding the last vestiges of green feed (Wilson & Harrington 1984). In addition, they often chew the bark of woody species and may ringbark them. Rabbits are sedentary and have greatest impact in the vicinity of their warrens. Studies on the diets of eastern and western grey kangaroos indicate that, like other grazers, they prefer green grasses and forbs. They shift to dry material and to chenopods and other shrubs during drought but less readily than do sheep (Griffiths & Barket 1966; Griffiths *et al.* 1974; Caughley *et al.* 1987). Because of differences in bodyweight, comparative grazing pressures are such that one head of cattle is equivalent to eight sheep, 11 goats, 13 kangaroos or 133 rabbits (Wilson & Harrington 1984).

Some plant species are reduced or eliminated by grazing, while others increase or invade. The invading species are typically introduced weeds and the abundance of these on the Murray floodplain is due in large part to grazing (see Chapter 5.3). It is noteworthy that the more common weeds are typically annuals, for example, most species of **Bromus*, **Critesion*, **Lolium*, **Medicago*, **Trifolium* and **Vulpia*. The replacement of perennials by annuals is a typical change under grazing (Harrington *et al.* 1984) and has been described for river red gum and black box communities in the Riverina by Leigh & Noble (1972).

One well documented change under heavy grazing has been the decline of the large perennial saltbushes *Atriplex vesicaria* and *A. nummularia* (Beadle 1948; Williams 1956; Williams 1979; Wilson 1979). Although still common west of the Darling (Appendix 3), they have been eliminated or greatly reduced over large areas further east where once they were dominant shrubs. Many early pastoralists saw the replacement of the saltbushes by more palatable annual grasses as desirable, and it was quoted as evidence that the stock were 'pushing the desert back' (Jeans 1972). However, loss of the perennial saltbushes meant a much diminished carrying capacity during drought and was soon regretted.

Atriplex vesicaria on the Riverine Plain is often replaced in heavily overgrazed areas by the utterly unpalatable *Nitraria billardierei* (Noble & Whalley 1978a,b). Shrubland dominated by *N. billardierei* covers extensive areas in Section 4 (Smith *et al.* 1943; general observations this survey). This highly derivative community, which occurs on cleared black box woodland as well as former probable *A. vesicaria* shrubland, was not sampled during this survey.

Other native species known to be increasers under heavy grazing include the small annual saltbushes *Atriplex leptocarpa* and *A. lindleyi*, and the spiny subshrubs *Sclerolaena muricatus* and *S. tricuspis* (Cunningham *et al.* 1981). These are now common along the floodplain but were probably much less so in the original vegetation.

Grazing also affects the tree layer through inhibition of regeneration. These effects are discussed for river red gum and black box in Chapter 5.2. At very high densities, stock may cause tree decline through ringbarking. The 277ha of floodplain mapped as severely degraded by grazing refers to this effect.

Overgrazing can lead to serious degradation of soils. The effects have been reported in many studies (reviewed by Noble & Tongway 1986a,b). Trampling loss or changes in vegetation, alters soil properties indirectly. Important consequences of reduced vegetation cover are greater exposure to erosion by water and wind, changes to the soil water regime and loss of nutrients.

A widespread consequence of overgrazing and erosion of sandy soils in western New South Wales has been invasion by inedible native shrubs ('woody weeds'), which then multiply to form dense stands over a much thinned ground layer (Barker & Booth 1980; Booth n.d.). *Dodonaea viscosa* ssp. *angustissima* is one of the main species involved. On the Murray floodplain it is a common shrub on sandy rises in Sections 5 and 6: the *Dodonaea-Callitris* community. The original dominants on these rises appear to have been *Callitris preissii*, *Hakea leucoptera*, *Eremophila longifolia* and *Heterodendrum oleifolium* (Zimmer 1937), all of which are now rare (Ashwell 1987; this survey). The sandy rises are typically overrun by rabbits and badly eroded.

Grazing inevitably leads to vegetation change. Some changes involve only minor differences in the relative abundance of the component species - the plants and animals assume a dynamic balance that can be manipulated by adjusting the grazing pressure. Other changes may become irreversible, with species of the original vegetation disappearing and new species colonising the site. The changes may be so drastic that the mutually supporting relationship between plants and soil is disrupted and the soil degrades.

6.3 RIVER REGULATION

6.3.1 HISTORY

Irrigation of small areas of land by simple stream diversions was occasionally practised along the Murray from the earliest days of settlement (Buxton

1967). Larger scale diversions began in the 1880s (Frith & Sawer 1974). Fluctuating and unpredictable river flows, which could be reduced to a mere trickle, posed problems for large-scale irrigation and also for the flourishing riverboat trade. A campaign began in the 1890s for the construction of dams and weirs on the Murray to ensure an adequate supply of water for both irrigation and navigation. This resulted in the River Murray Waters Agreement of 1915 and the establishment of the River Murray Commission. The Commission's task was to regulate the river so that its water resources could be put to greater use and efficiently shared among the various users.

The 1915 Agreement provided for the construction of 26 weirs with locks to ensure permanent navigation upstream to Echuca. Construction of Lock 1 at Blanchetown in Section 7 began in 1922. The riverboat trade was already dying by this time, overtaken by competition from the railways. Maintaining a supply of water for irrigation became the chief purpose of the weirs. Eventually, Locks 1 to 11 were built between Blanchetown and Mildura but, of the remainder, only Lock 15 was built at Euston and Lock 26 at Torrumbarry. Other weirs, without locks, have been built on the Edward River (Steven's Weir) and upstream on the Murray at Yarrawonga (Figure 1). Following the construction of the weirs in the 1920s and 1930s, five barrages were built in the 1940s between the islands at the Murray mouth, separating Lake Alexandrina and the lower Murray from the influence of tides and seawater.

The weirs and barrages are operated so that water levels above the weir remain at or near a specified 'normal pool level' except during floods (Jacobs 1989). Fluctuations in level increase gradually upstream along the weir pools. All but one of the weir pools are more or less contained within the original banks of the river. The exception is Lake Mulwala, covering an extensive area upstream of Yarrawonga Weir. From the Murray mouth to the top of the Lock 11 pool, some 92km upstream of Mildura, the weir pools are continuous. Above this point the river is free-flowing and water levels fluctuate with variations in flow, except for the weir pools at Euston, Torrumbarry and Yarrawonga on the Murray, and Steven's Weir on the Edward.

Between Hume Dam and Wellington, 52% of the length of the Murray consists of weir pools, and 9% of the length of the Edward (Pressey 1986). In these parts of the river the water level has been raised and its fluctuations reduced, the effects attenuating towards the upper ends of the pools (Jacobs 1989). In effect, the river in South Australia has been converted to a series of stepped lakes. On the adjacent floodplains many previously temporary wetlands below normal pool level have become permanently flooded (Pressey 1986; Thompson 1986).

The other major provision of the River Murray Waters Agreement was the construction of an upper Murray storage, so that river flow could be maintained during drought and irrigation development greatly expanded. Hume Dam was subsequently constructed between 1919 and 1936, and enlarged in 1961 to its present capacity of 3038gl. A second major storage - Dartmouth Dam on the Mitta Mitta River, above Hume Dam - was constructed between 1972 and 1979, providing an additional 4000gl storage capacity. These headwater storages are supplemented by downstream storages of 680gl at Lake Victoria on the Murray, and 1794gl at Menindee Lakes on the Darling. The Lake Victoria storage was completed in 1928, the Menindee Lakes storage in 1968.

Except for the Kiewa and Ovens Rivers, all of the Murray's tributaries below Hume Dam are regulated. Inflows from such important tributaries as the Murrumbidgee and Goulburn Rivers have been greatly diminished through regulation and use of their waters. On the other hand, the Snowy Mountains Scheme, completed in several stages between 1955 and 1974, has diverted water westward across the Great Dividing Range to augment flows in the Murray and Murrumbidgee.

Natural flows in the Murray were highly variable but, over a long period of time, showed a pronounced seasonal pattern (Baker & Wright 1978; Walker 1985). Peak flows in the upper Murray corresponded to higher rainfall in the catchment over winter, continuing through spring as snow melted on the ranges. Summer and autumn were typically periods of low flow. Peak flows in South Australia were usually in spring and early summer, reflecting the travel time of flows along the river.

The Murray River now supplies water to extensive irrigation areas. The total area irrigated, including areas irrigated from the Goulburn River, is around 730 000ha, of which 89% is on the Riverine Plain between Yarrawonga and Swan Hill. The Murray also supplies water for domestic, industrial and stock supplies, including water for Adelaide. Thus, Murray River flows are closely managed to maintain adequate supplies throughout the year. In winter and spring the feeder streams generally carry large flows and there is a surplus over downstream requirements. Much of this surplus is taken into storage. In summer and autumn, when natural flows decline, releases from storage are usually necessary to meet demands, particularly the heavy irrigation demands over summer.

The changes to flow patterns from river regulation have been greatest over the past 30 years, corresponding to the rapid growth of irrigation developments in New South Wales through the 1950s and 1960s (Mackay *et al.* 1988). Figures 4 (a), 4 (b) and 4 (c) show average monthly flows at Albury, Yarrawonga and Euston over this period, compared with simulated natural flows derived from the Monthly Simulation Model of river flow (Close 1986).

The changes vary along the river as water is diverted for irrigation. At Albury there has been a large decrease in average flows between June and November, and a large increase between December and May. At Yarrawonga, below the large irrigation diversions from Lake Mulwala, there is a similar pattern of June-December decrease and January-May increase, but the latter is much less than at Albury. At Euston, below the other major irrigation diversions at Torrumbarry and Steven's Weirs, the pattern has changed to one of decreased flow throughout the year, although July-December remains the period of greatest decrease. Despite the changes, the natural pattern has been retained of average winter-spring flows much greater than average summer-autumn flows.

Seasonal flow patterns further downstream are similar to those at Euston, the subsequent water diversions being much less than those upstream. Diversions in New South Wales and Victoria total some 3400gl per year on average, compared with 500gl in South Australia. The average annual flow to South Australia is about 6660gl. This is an estimated 41-43% lower than under natural conditions (Mackay *et al.* 1988).

The pattern of change is complicated by long-term climatic variability. Mackay *et al.* (1988) have compared average monthly flows to South Australia in 1950-1984 with 1902-1936, before Hume Dam. The values were unexpectedly similar. In part this is due to the substantial irrigation development in Victoria before 1936. Another reason is that rainfall and natural inflows to the system in 1950-1984 were significantly higher than average, possibly due to the 'greenhouse effect' (Pittock 1983; Close 1988) although still within the bounds of chance variability.

Despite increasing regulation, flows remain highly variable between years (Figure 5). Storage is insufficient to prevent major floods and these pass down the river as before. For Barmah State Forest in Section 3, Bren (1987a) has estimated that regulation has increased the frequency of flows in the range 6000-10 000ml per day (due to irrigation releases), decreased the frequency of flows in the range 10 000-60 000ml per day (often taken into storage), but has probably had little effect on flows above 60 000ml per day.

Dexter *et al.*(1986) estimated that an average flow of at least 24 500ml per day for a month is necessary to flood about 80% of Barmah State Forest. Under the present regulated flow conditions a flood of this magnitude is expected in two out of every six years; under natural conditions it would be expected in five out of every six years (Francis 1987). Further analyses by Bren (1987a) indicate that the mean duration of flooding in most parts of the forest has decreased by 1-2 months since regulation.

Furthermore, minor flooding has become frequent in Barmah State Forest in the January to March period, but was almost unknown before regulation (Dexter *et al.*1986; Bren 1987a). This is usually caused by 'rain rejection' flows - water released for irrigation but not used because of subsequent rainfall. Barmah State Forest is specially susceptible to such flooding because of the very low channel capacity there. Summer and autumn flows downstream of Barmah are usually well below bank-full capacity and rain rejection flows seldom cause flooding.

The reduced frequency, extent and duration of winter-spring flooding has been a more general effect. Caldwell Connell Engineers (1981) analysed peak annual water levels at Loxton (Section 6) before and after regulation. They estimated that the larger floods - with a return period of seven years or more - had not been significantly affected. However, the heights of flood

AVERAGE MONTHLY FLOWS MAY 1957-APRIL 1987

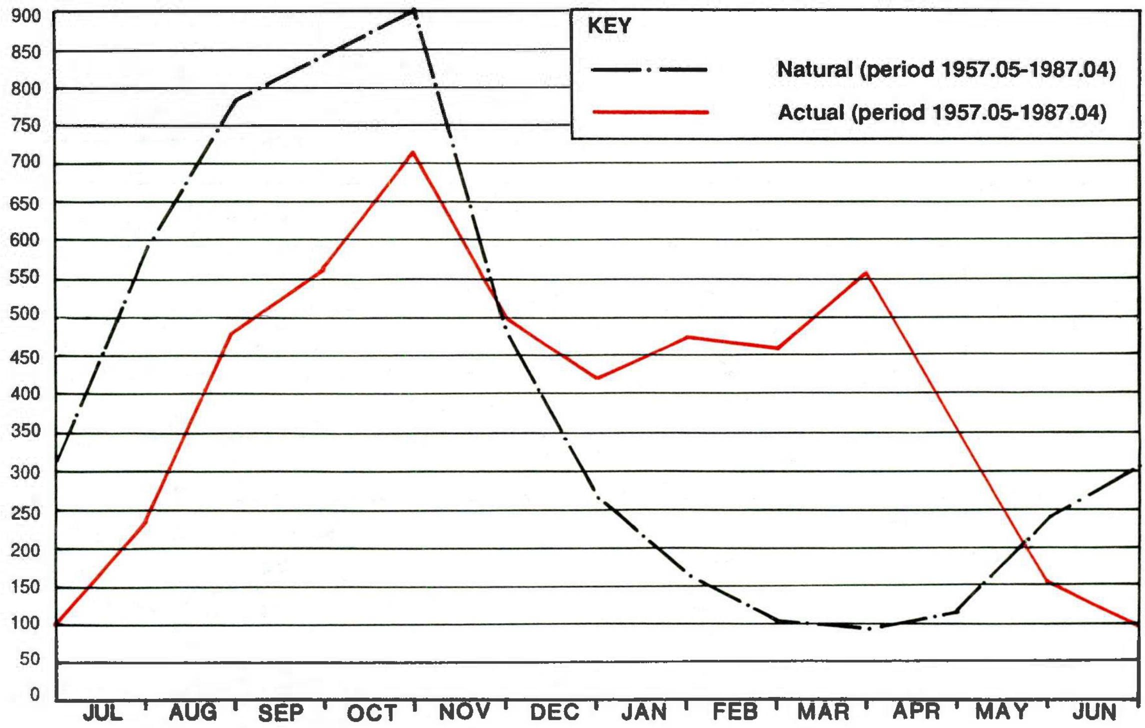


FIGURE 4(a)
ALBURY

AVERAGE MONTHLY FLOWS MAY 1957-APRIL 1987

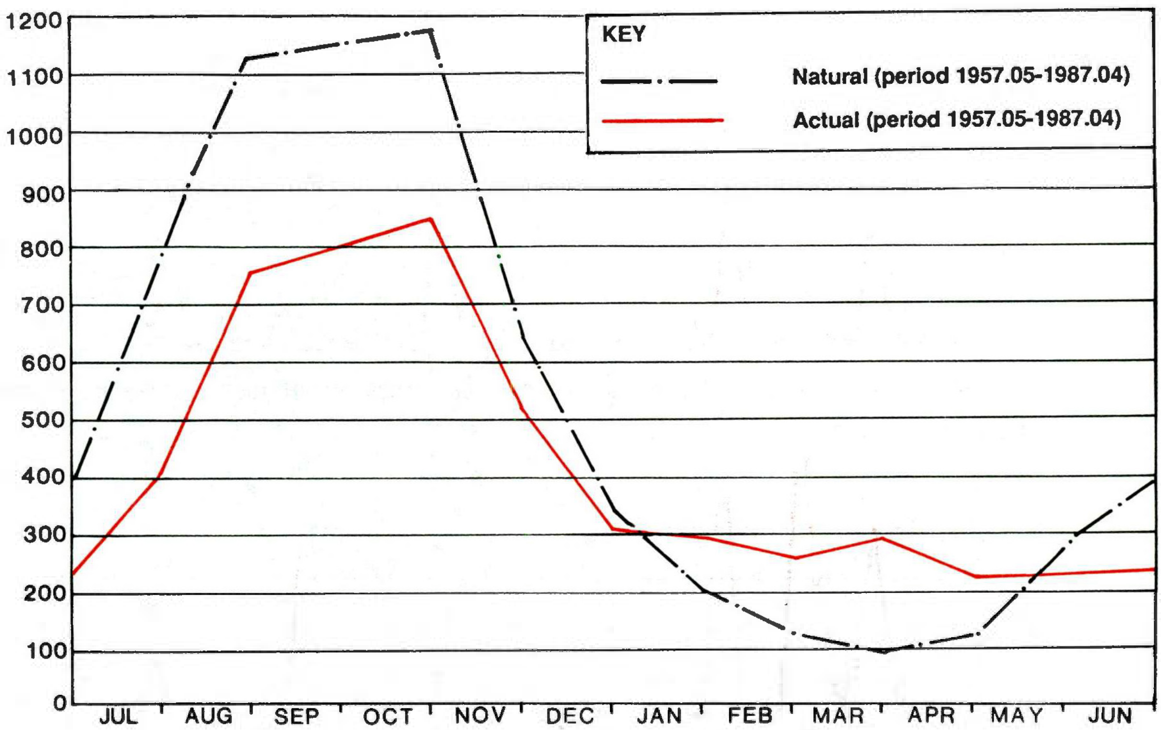


FIGURE 4 (b)
YARRAWONGA

AVERAGE MONTHLY FLOWS MAY 1957-APRIL 1987

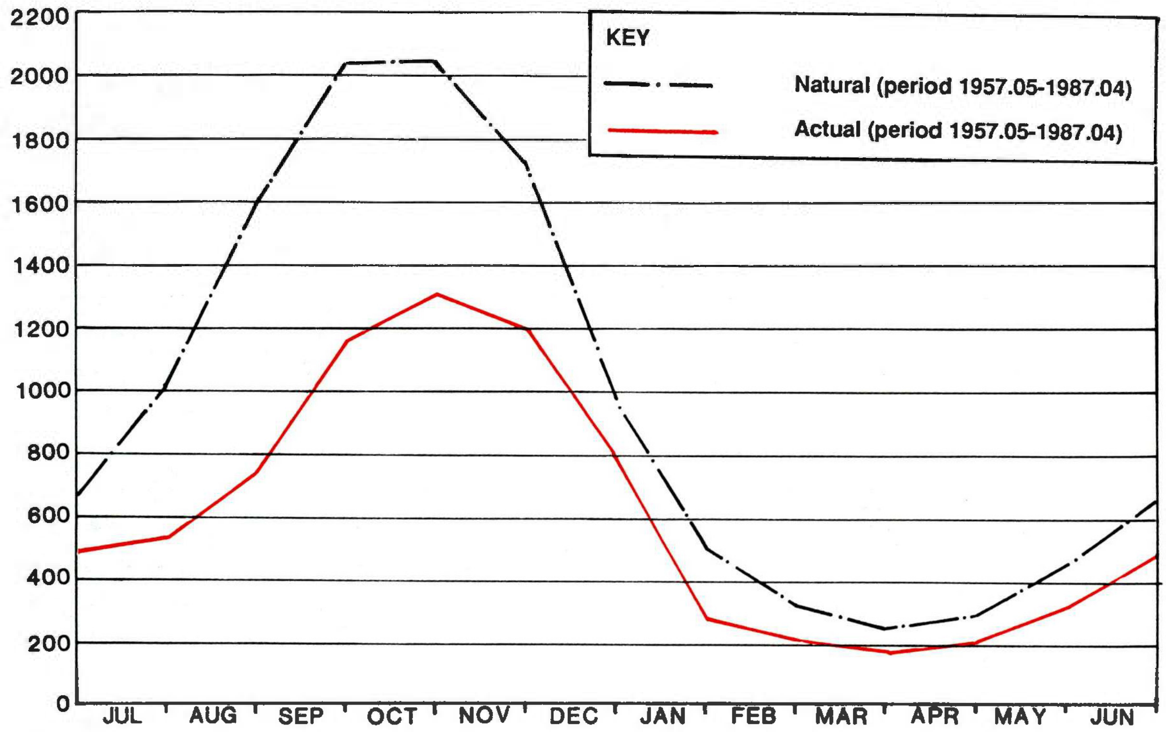


FIGURE 4(c)
EUSTON

MONTHLY FLOWS AT EUSTON MAY 1957-APRIL 1987

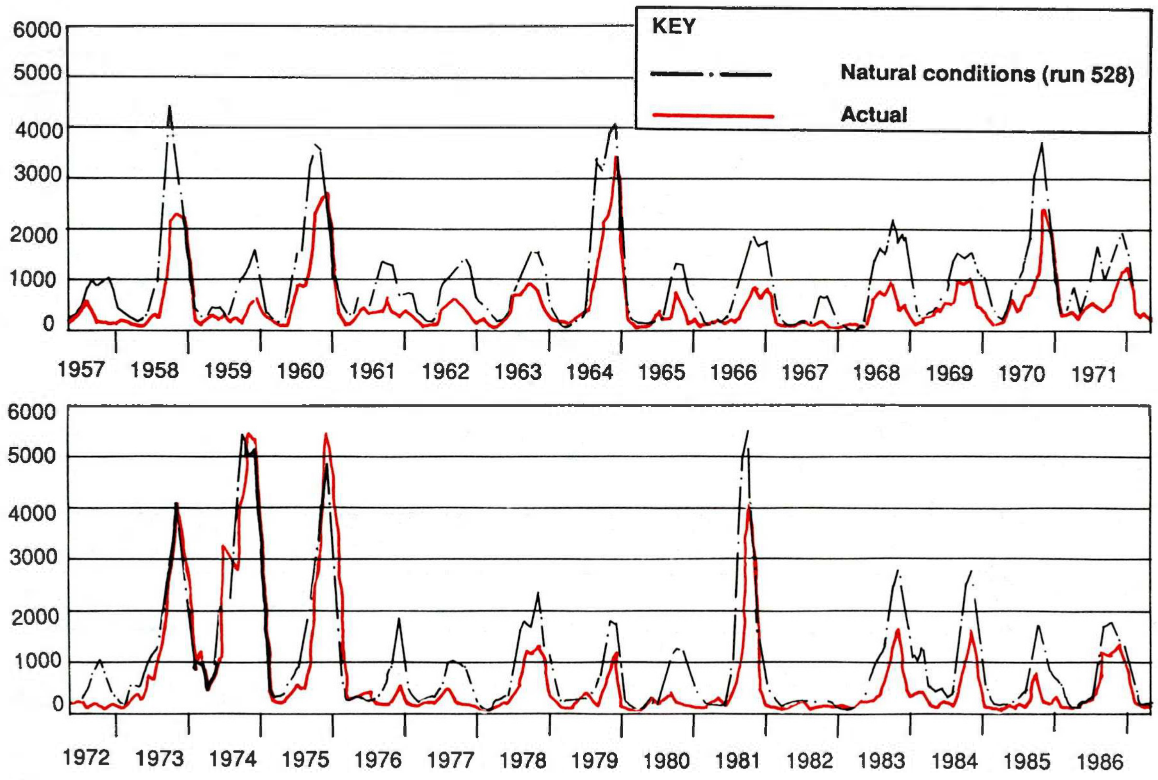


FIGURE 5

events with a more frequent return period had been reduced, which meant they covered a smaller area of floodplain.

Another notable effect of river regulation has been higher flows during droughts. Before the construction of dams and weirs along the Murray, the river would virtually cease flowing during severe drought. This happened, for example, during the drought of 1914/15, when the Murray in South Australia was reduced to a saline trickle. Computer simulations indicate that if the 1914/15 conditions were repeated now, flows to South Australia would be maintained at about 4000ml per day for most months (Collett 1978).

6.3.2 EFFECTS

The effect of weirs on the riparian vegetation was examined briefly at Lock 2 (near Waikerie in Section 7). The riverbank vegetation upstream of the weir, where water levels have been raised and stabilised, was compared with that downstream, where water levels fluctuate more often (Table 12).

The differences were marked. The river was fringed upstream by reedbeds of *Phragmites australis* and *Typha domingensis* which ended abruptly at the weir. Behind the reedbeds, on top of the levee, some 2m above pool level, the ground layer was dense and tall (averaging 65cm high and 85% cover), and characterised by several large herbaceous daisies - **Aster subulatus*, **Cirsium vulgare*, *Picris squarrosa*, *Sonchus hydrophilus* and **Urospermum picroides*. It is noteworthy that *Sonchus hydrophilus*, although apparently native to Australia, appears to be a polyploid derivative of the introduced **Sonchus asper* (Boulos 1973). *Picris squarrosa* is also closely related to an introduced species, **P. hieracioides*, and may be a recent derivative.

Downstream of the weir, the ground layer was lower and more open, with a greater diversity of species, both native and introduced. It averaged 45cm high and 50% cover from the water's edge to the top of the levee, up to about 4m above the water level (in September 1987). Lignum *Muehlenbeckia cunninghamii* formed a shrub layer along the levee both upstream and downstream of the weir but was denser upstream (average cover 20% versus 10%).

These differences can be interpreted in the light of general plant community patterns. The vegetation fringing the river downstream of the weir corresponds to the *E. camaldulensis-Paspalidium-*Cynodon* community, which is the dominant red gum community of Section 5 and the eastern half of Section 6, but is uncommon further west (Appendix 1.1). The dominant riverside communities in South Australia are the *E. camaldulensis-Cyperus* and *E. camaldulensis-Phragmites* communities, both characterised by a band of *Phragmites australis* along the edge of the water, the latter community being found on less steep banks where the band is wider. The vegetation fringing the river upstream of Lock 2 corresponds to the *E. camaldulensis-Phragmites* community.

This indicates that the *E. camaldulensis-Paspalidium-*Cynodon* community was formerly more widespread in South Australia, and its replacement by the *E. camaldulensis-Cyperus* and *E. camaldulensis-Phragmites* communities is a consequence of the building of the weirs. Other authors have also suggested that the ubiquitous reedbeds are a consequence of the weirs (Pillman 1980; Department of Environment & Planning 1987i). Historical photos provide evidence of dense reedbeds developing along the South Australian reaches of the river this century.

Also associated with more stable water levels are the stands of introduced willows, the **Salix babylonica* community. At a number of weirs these were found to be common above the weir but absent below (e.g. Lock 9 and Steven's Weir). General observations suggest they require not only more stable water levels but also considerable riverbank disturbance, even deliberate planting, to become established. Once established, though, they spread quickly and are difficult to remove. In Section 8, where they were originally planted to mark the main channel and to stabilise the extensive man-made levee system, they are now the main river-fringing vegetation, forming dense thickets up to 40m or more in width. The river character is utterly changed and red gums are almost extinct below Murray Bridge. The willows have so choked the riverbanks that they are a major obstruction of public access to the waterfront (Department of Environment & Planning 1988).

Chesterfield (1986) describes vegetation changes in Barmah State Forest since river regulation. The most obvious have been the spread of *Juncus ingens* reedbeds into former *E. camaldulensis* forest, and the spread of *E. camaldulensis* into *Pseudoraphis spinescens* grassland (see Chapter 5.2). There is also evidence of *Pseudoraphis spinescens* declining in South Australia, together with a number of other aquatic and semi-aquatic species (see Chapter 5.4).

These limited observations accord with predictions from a knowledge of the hydrological changes. In general, vegetation changes associated with river regulation involve the expansion of some communities and species at the expense of others. Expanding communities are ones associated with infrequent flooding or with semi-permanent wetlands. Declining communities are ones associated with frequent inundation alternating with dry periods.

The vegetation mapping identified a total of 17 101ha of severely degraded vegetation on the floodplain, of which 6722ha (39%) were attributed to the effects of river regulation. This comprised 2769ha of dead trees standing in water, 2722 ha of vegetation apparently degrading because of increased flooding, and 1231ha apparently degrading because of reduced flooding.

TABLE 12. RIVERBANK VEGETATION UPSTREAM AND DOWNSTREAM OF LOCK 2

Figures are numbers of plots - three in each category, all within 500m of the Lock, southern bank. Uncommon species (not found in more than one plot in any category) are not included.

Species	Upstream		Downstream	
	Riverside	Levee	Riverside	Levee
MORE FREQUENT UPSTREAM				
**Aster subulatus*	1	3	1	
**Cirsium vulgare*	2	3		
Muehlenbeckia cunninghamii	3	3		3
Phragmites australis	3	3		
Picris squarrosa	1	3	2	
Sonchus hydrophilus	2	3	1	1
Typha domingensis	2			
**Urospermum picroides*	2	3	1	
MORE FREQUENT DOWNSTREAM				
Acacia stenophylla		1	2	2
Atriplex lindleyi				2
**Brassica tournefortii*			2	1
**Bromus rubens*	1	3	3	3
**Critesion murinum*		1	1	3
Eclipta platyglossa			2	1
Einadia nutans	1	3	3	3
Enchylaena tomentosa	1	1	2	3
Euphorbia drummondii			2	1
**E. terracina*		1	1	2
**Hypochoeris glabra*	1	1	3	3
**Lepidium africanum*		1		3
Pseudognaphalium luteo-album			2	1
**Reichardia tingitana*		2	3	3
**Sonchus oleraceus*	1	3	3	3
Sporobolus mitchellii			2	
Stipa scabra group			2	2
Vittadinia cuneata			3	3
V. dissecta				2
Wahlenbergia fluminalis	1	3	3	3
**Xanthium californicum*	1		3	
SIMILAR FREQUENCIES				
**Bromus diandrus*	2	3	2	3
**Conyza bonariensis*		1		2
**Cynodon dactylon*	3	1	3	2
Cyperus gymnocaulos	3	3	3	3
Eucalyptus camaldulensis	3	3	3	3
**Heliotropium curassavicum*	2		1	
Paspalidium jubiflorum	3	3	3	3
NUMBER OF SPECIES PER PLOT				
Mean	16	22	26	27
Range	10-23	20-26	23-31	25-30

6.4 SALINISATION

6.4.1 SOIL SALINITY

Saline soils and groundwater are a natural feature over much of the Murray-Darling Basin (Northcote & Skene 1972; Jacobsen *et al.* 1983). Since European settlement, man's activities have redistributed and exposed this naturally occurring salt and created major environmental problems (Peck *et al.* 1983; Salinity Committee 1984). Soil salinisation has occurred at many sites on the Murray floodplain. There have been a number of causes.

Soil salinisation results when rising water tables bring saline groundwater close to the soil surface, where the salt is concentrated by evaporation. Waterlogging is often an associated problem. This is a general, indeed inevitable, consequence of irrigation, affecting about one third of all irrigated land throughout the world (Reeve & Fireman 1967). It affects about 16% of the irrigated land along the Murray in Victoria and New South Wales, and about 35% in South Australia (Peck *et al.* 1983). These percentages will increase as water tables continue to rise. The higher value in South Australia reflects the highly saline groundwater in the Mallee Zone and the increase in salinity of Murray waters downstream (Gutteridge, Haskins & Davey 1970). Soil salinisation in irrigation areas is most pronounced on the surrounding lands and the unirrigated sections. Continual applications of water limit the effects on the irrigated sections themselves (Water Resources Commission 1985).

Rising water tables may result from dryland farming as well as irrigation (Standing Committee on Soil Conservation 1982; Salinity Committee 1984). The removal of trees and shrubs and their replacement by short-rooted pasture and crops results in reduced utilisation of the soil water. Water tables rise and saline seeps develop, often at a considerable distance from the site of clearing. Saline seeps are wet, salty areas where the saline groundwater reaches the surface. Typically, they occur in depressions, along drainage lines and on hillsides at the break of slope or above outcrops of impermeable strata. The length of time between clearing and the appearance of saline seeps is typically several decades for small, localised aquifers, but may be much longer for regional aquifers. The Mallee Zone, with its high natural salinity and extensive clearing, is specially susceptible to saline seeps, which cover some 9000ha in the Victorian Mallee Zone and are thought to be expanding at an annual rate of about 2% (Land Conservation Council 1987).

The regional water tables are deeper along the Murray than elsewhere in the Mallee Zone and increases due to land clearance have had little effect as yet on the Murray floodplain. However, it is estimated that substantial problems will develop within the next 30 years and continue to escalate for the following century or more (Murray-Darling Basin Ministerial Council 1987b).

Local water tables may rise, and salinity problems develop, where the river level has been raised by weirs and other structures. The construction of the Lake Victoria storage in 1928, converting it from a temporary to a permanent lake, has had a particularly severe effect. Salt-induced death of red gum and black box has occurred over large areas between the lake and the river (Forestry Commission 1982). Substantial tree death has also occurred in the Chowilla anabranch system, due in a large part to higher water tables resulting from the construction of Lock 6.

Evaporation basins have been constructed at a number of locations on the Murray floodplain in South Australia to dispose of saline irrigation drainage. These occupy former lagoons, creeks and anabranches. Embankments and regulators impound the drainage water, which gradually evaporates. The evaporation basins were a relatively convenient method of disposing of saline drainage, but the vegetation in their immediate vicinity has been severely affected by salinisation and prolonged flooding (Caldwell Connell Engineers 1981; Thompson 1986). Their use has declined to some extent with the construction of a drainage disposal system off the floodplain. Rehabilitation programs are proposed for several basins.

Another form of salinisation is saline scalds. These are areas of land where a naturally saline subsoil has been exposed through erosion of the less saline topsoil. Saline scalds occur naturally but the process of erosion is accelerated when clearing of the vegetation, overgrazing or inappropriate cropping practices leave the topsoil unprotected. There has been extensive scalding in the far northwest of Victoria west of Mildura (Salinity Committee 1984). The Ned's Corner Land System adjacent to the floodplain is badly scalded, but not the floodplain itself (Rowan & Downes 1963).

6.4.2 RIVER SALINITY

A natural feature of the Murray and other rivers throughout the world is a distinct downstream rise in river salinity. The median value rises from 55EC below Hume Dam to 778EC at Tailem Bend (Mackay *et al.* 1988). There is a large increase in salinity between Barham and Swan Hill, caused by inflows via Barr Creek from the badly salt-affected irrigation areas near Kerang. Salinity also increases markedly from below Red Cliffs on through South Australia, the increases being caused by inflows of highly saline groundwater. The natural groundwater inflows here have been exacerbated by the effects of irrigation, clearing and the construction of weirs. As the groundwater flow is relatively constant, river salinity in South Australia fluctuates widely with river flow (Gutteridge, Haskins & Davey 1970).

A number of studies have examined the extent to which river salinity in South Australia has increased since European settlement (Gutteridge, Haskins & Davey 1970; Collett 1978; Engineering & Water Supply Department 1983; Cunningham & Morton 1983; Morton & Cunningham 1985). These have consistently found a marked trend of increasing salinity over the past 50 years, although reliable estimates of the magnitude of the increase have not been possible because of the effects of highly variable river flows (Mackay *et al.* 1988). On the other hand, river salinity no longer reaches the very high levels experienced before river regulation during severe droughts. During the 1914/15 drought, river salinity at Morgan rose to 10 000EC but the maximum salinity there since regulation has been about 1500EC (Collett 1978).

6.4.3 EFFECTS

The effects of salinisation were examined briefly at Disher's Creek Evaporation Basin in Section 6, where there are extensive areas of dead red gums and black box. The vegetation under dead red gum stands on the western edge of the basin, along Disher's Creek itself, was compared with live stands flanking the Murray River on the southwestern border of the basin and separated from it only by a narrow levee. They were also compared with live stands along Katarapko Creek, a similar anabranch to Disher's Creek about 20km to the southwest (Table 13).

The three situations support three different plant communities. The former red gum woodland along Disher's Creek has been replaced by a very different community, *Muehlenbeckia-Halosarcia* shrubland, characterised by salt-tolerant species such as *Disphyma crassifolium*, *Halosarcia indica*, **Heliotropium curassavicum* and *Suaeda australis.* The vegetation along Katarapko Creek, presumably similar to the original vegetation along Disher's Creek, corresponds to the *E. camaldulensis-Paspalidium-*Cynodon* community. The vegetation along the Murray beside the evaporation basin corresponds to the *E. camaldulensis-Cyperus* community, which is the typical riverside community in this area. This persists, at least in the sample plots, in a narrow strip between the river and the extensive area of dead trees behind. Apparently, the leaching effect of frequent flooding has preserved this strip from salinisation.

Also compared was the vegetation under dead black box stands west of Disher's Creek Evaporation Basin (within 1km) with live stands in the same area (apparently associated with slightly higher ground) and with live stands in similar floodplain situations in the Chowilla/Calperum area, 20-30km to the northeast (Table 14).

The plots from all three situations were classified in the TWINSPAN analysis (Chapter 2.1.3) as the *E. largiflorens-Atriplex rhagodioides* community. Apart from the presence or absence of live black box, the differences were minor (Table 14). Salinisation, presumably the reason for tree death, had not yet affected the understorey to an appreciable degree.

The *Muehlenbeckia-Halosarcia* community was encountered at other sites beneath dead, apparently salt-killed, red gums, but also seems to occur naturally in low-lying parts of the black box zone. As salinity levels increase beyond the tolerance of the *Muehlenbeckia*, the community is replaced by the *Halosarcia* spp. community.

The *Halosarcia* spp. community also probably occurs naturally on the Murray floodplain. The two dominants, the samphires *H. pergranulata* and *H. indica*, are widespread native species which grow in highly saline habitats, both coastal and inland (Wilson 1980). However, the majority of samphire stands on the floodplain appear to be the result of recent salinisation. The five plots sampled (Sections 6 and 7) all had dead trees or stumps, either red gum or black box, and two plots also had dead lignum shrubs.

The general pattern of change under increasing salinity would seem to be death of the trees, gradual colonisation by salt-tolerant species, change to a *Muehlenbeckia-Halosarcia* shrubland, gradual loss of the more sensitive species, change to a lower, more open, more depauperate *Halosarcia* shrubland and, finally, complete loss of vegetation. In the early stages of the process, species diversity is maintained, although there are changes in composition. In fact, there is some indication that species diversity may increase after the initial loss of trees (Table 14). The *Muehlenbeckia-Halosarcia* community also is relatively rich in species, but the number of species falls rapidly as salinisation continues. The *Halosarcia* community is very impoverished (Table 1). Its replacement of former red gum and black box woodlands is one of the worst examples of environmental degradation along the river.

Of the total 17 101ha of severely degraded vegetation identified in the mapping, 9010ha (53%) were attributed to salinisation. The insidious nature of the problem and the likelihood of much more widespread effects in future make soil salinisation probably the issue of most concern for the long-term health of the riparian vegetation.

The effects of increased river salinity on the vegetation are unknown but certainly far less severe than the effects of soil salinisation. River salinity in South Australia has been high enough at times to cause considerable production losses among crop plants (Gutteridge, Haskins & Davey 1970). However, the native floodplain plants are likely to be less susceptible, especially in view of the very high salinity levels experienced periodically in the past. Of more concern are measures taken to reduce river salinity, for example, isolating or reducing saline flows from particular creeks or anabranches. Such actions have the potential to cause severe local soil salinisation.

Salinisation is an environmental and economic disaster of much greater dimensions in the Murray-Darling Basin than the immediate Murray floodplain. As recognised in the draft Salinity and Drainage Strategy (Murray-Darling Basin Ministerial Council 1988) and the Natural Resources Management Strategy currently being developed, it is a problem that must be tackled at a Basin-wide level.

6.5 LOGGING

There has been a long history of logging along the Murray. From the earliest times of settlement the tough, durable timber of the river red gums was much sought after for fencing and general construction. Cypress-pine *Callitris* spp. timber was also highly prized, being light and easy to work but durable and resistant to termite attack.

With the development of the riverboat trade in the 1850s came a heavy demand for fuel. The early steamers, with relatively small boilers, burned about a tonne of wood in eight hours. Later boats used up to a tonne an hour and enormous quantities of wood were needed to keep the trade operating. Full-time gangs maintained the supply at strategic points along the river (Mudie 1961).

TABLE 13. SALT-AFFECTED RED GUM PLOTS AT DISHER'S CREEK

The vegetation of dead red gum stands along the edge of Disher's Creek Evaporation Basin is compared with live stands along the adjacent Murray and along Katarapko Creek. Figures are numbers of plots, three in each category. Each plot was 40m x 10m along the edge of the water. species not found in more than one plot in any category are not included.

Species	River Murray (live)	Disher's Creek (dead)	Katarapko Creek (live)
MORE FREQUENT IN DEAD STANDS			
Atriplex leptocarpa		2	
A. lindleyi		3	
A. rhagodioides		3	
Cotula australis		2	
Crassula colorata		2	
**Critesion murinum*		3	
Disphyma crassifolium		2	
Einadia nutans		3	1
Halosarcia indica		3	
**Heliotropium curassavicum*		3	
**Lepidium africanum*		2	
**Schismus barbatus*		3	
Sclerolaena tricuspis		2	
**Spergularia diandra*		3	
Suaeda australis		2	
MORE FREQUENT IN LIVE STANDS			
**Aster subulatus*	3		2
Brachycome basaltica	3		
Centipeda cunninghamii	3		
Cyperus gymnocaulos	3	1	3
Eclipta platyglossa	3		3
Eucalyptus camaldulensis	3		3
Euphorbia drummondii	2		3
**Lactuca serriola*	3	1	3
Paspalidium jubiflorum	3	1	3
**Paspalum distichum*	3		
Phragmites australis	3		2
Picris squarrosa			3
Pseudognaphalium luteo-album			3
Senecio lautus	2	1	3
Sporobolus mitchellii	3	1	3
Vittadinia cuneata			3
Wahlenbergia fluminalis	2		3
**Xanthium californicum*	3		1
SIMILAR FREQUENCIES			
Agrostis avenacea	2	1	
Atriplex semibaccata/suberecta	1	3	2
**Bromus rubens*		2	3
**Cynodon dactylon*	2	1	2
Enchylaena tomentosa		2	1
**Hypochoeris glabra*		2	3
Morgania floribunda		2	3
Muehlenbeckia cunninghamii	3	2	2
**Reichardia tingitana*	3	3	3
Sonchus hydrophilus	1	2	2
**S. oleraceus*	3	3	3
**Vulpia myuros*		1	2
NUMBER OF SPECIES PER PLOT			
Mean	23	32	31
Range	19-25	24-36	27-35

TABLE 14. SALT-AFFECTED BLACK BOX PLOTS AT DISHER'S CREEK

The vegetation of dead black box stands west of Disher's Creek Evaporation Basin is compared with live stands in the same area and in the Chowilla/Calperum area. Figures are numbers of plots, three in each category. Species not found in more than one plot in any category are not included.

Species	Disher's Creek (live)	Disher's Creek (dead)	Chowilla/ Calperum (live)
MORE FREQUENT IN DEAD STANDS			
Dissocarpus biflorus		3	
**Lactuca serriola*	1	3	1
**Medicago polymorpha*		2	
Minuria cunninghamii		3	
**Sisymbrium erysimoides*		2	
Wahlenbergia tumidifructa		3	1
Zygophyllum billardieri		2	
MORE FREQUENT IN LIVE STANDS			
Atriplex lindleyi			3
Calandrinia eremaea	2	1	3
Enchylaena tomentosa	3		1
Eucalyptus largiflorens	3		3
Sclerolaena diacantha			3
Senecio lautus	3	1	
Teucrium racemosum	2		
SIMILAR FREQUENCIES			
Actinobole uliginosum	2	2	2
Atriplex rhagodioides	3	3	3
Brachycome ciliaris	2	1	
B. lineariloba	2	3	2
**Bromus rubens*	2	3	1
Bulbine semibarbata	2	3	2
Calandrinia volubilis	1	2	1
Calotis hispidula	3	3	3
Crassula colorata	2	3	3
**Critesion murinum*	2	3	
Danthonia caespitosa	1	3	3
Daucus glochidiatus	2	2	1
Disphyma crassifolium	3	3	2
Einadia nutans	3	3	3
**Hypochoeris glabra*	2	2	1
Isoetopsis graminifolia		2	1
**Lamarckia aurea*	1	2	
Maireana pyramidata	2	1	
**Medicago minima*	2	3	
Omphalolappula concava	1	2	
Pogonolepis muelleriana	2	3	1
**Reichardia tingitana*	2	3	1
**Rostraria pumila*	2	3	
**Schismus barbatus*	2	1	2
Sclerolaena tricuspis	1	2	1
Senecio glossanthus	2	3	2
**Sonchus oleraceus*	3	3	2
Stipa scabra group	3	3	2
**Vulpia myuros*	2	3	2
Wahlenbergia gracilenta		3	2
NUMBER OF SPECIES PER PLOT			
Mean	28	34	25
Range	23-35	28-41	19-31

The demand for timber increased rapidly during the 1860s. From then until the end of the century was a period of great expansion of the railways. River red gum provided excellent timber for sleepers and the demand was heavy. The railways also provided a link with Melbourne from the 1860s and a large market for timber, particularly during the construction boom of the 1880s (Jeans 1972).

By the 1880s the Barmah and Gunbower forests (Sections 3 and 4) had been heavily cut within several miles of the river and large trees were becoming difficult to procure (Royal Commission 1899). Extensive areas of even-aged trees in Section 3 and elsewhere appear to be the result of regeneration in cutover areas in the 1870s, when there was a sequence of major floods and rabbits were still in low numbers (Jacobs 1955).

The demand for timber and fuel declined in the 1890s as the financial depression brought building to a halt, and the riverboat trade faltered in competition with the railways (Jeans 1972). At the same time all three States were moving towards more controlled and conservative harvesting of their forests. Timber production remains a major land use in red gum forests along the Murray in New South Wales and Victoria (Forestry Commission 1982, 1985; Land Conservation Council 1983, 1987), but only a minor one in South Australia (Lewis 1975).

Current logging practices involve selective logging and clearing of small patches, rather than large-scale clearfelling. Seedling establishment is best on open, bare, disturbed or burnt sites (Dexter 1967). These conditions are promoted during logging by such means as felling trees in groups, burning the logging slash, ripping the soil, and felling or ringbarking large trees of no commercial value which may inhibit regeneration. The general direction of change has been from open stands of veteran trees to dense stands of younger trees and saplings (Jacobs 1955; Chesterfield *et al.* 1984; Forestry Commission 1985). Virtually nothing is known of the effects on the understorey vegetation.

6.6 RECREATION PRESSURE

The Murray River is a popular setting for various forms of recreation. Many areas of natural vegetation are subject to heavy visitation. The effects on the vegetation can be severe but are typically very localised, occurring around sites used regularly for camping, picnicking, boat-launching or other activities. Such sites are concentrated along the immediate riverfront, particularly near towns or access roads. Other sites have been degraded through proliferation of vehicle tracks and heavy use by off-road vehicles.

The condition mapping has identified a total of 35ha of floodplain vegetation severely degraded by recreational use. However, this by no means represents the full extent of over-use. In most cases the degradation involves only the understorey or is too localised to be detected on air photos.

6.7 CARP

Since the early 1960s the introduced carp *Cyprinus carpio* has undergone a dramatic population explosion and is now widespread and abundant in the waterways of southeastern Australia, including the Murray River (Shearer & Mulley 1978). Among many concerns about the adverse effects of carp is their effect on aquatic and flooded vegetation. Carp may have an effect by eating the plants, by uprooting them while foraging in the bottom sediments, or by disturbing the sediments and increasing turbidity (Smith & Pribble 1979).

Field studies in Victoria have found no evidence of carp affecting turbidity, even at high densities (Hume *et al.* 1983; Fletcher *et al.* 1985). These studies also indicated that carp rarely eat plants. However, there was some evidence that shallow-rooted and soft-leaved aquatic vegetation, especially *Potamogeton* spp., have been reduced by feeding and spawning activities at some sites. More robust plants and those that form dense masses appear to be little affected.

These findings are supported by studies in the Northern Hemisphere, where *Potamogeton* spp. have also been identified as particularly susceptible but, again, many authors have concluded that the general effects of carp on vegetation have been overstated (Smith & Pribble 1979). Other changes to the floodplain environment have had a far more crucial and permanent effect than carp (Fletch *et al.* 1985).

6.8 FIRE

Fire is a major environmental factor in Australia and the changes to fire regimes from the activities of both Aboriginals and Europeans have had a substantial effect on native vegetation (Gill *et al.* 1981). However, fire is a rare event in river red gum and black box communities and, unlike other eucalypt communities, does not appear to be an essential part of the forest life-cycle, its place being taken by flooding (Cheal *et al.* 1979; Cheal 1981; Forestry Commission 1985). River red gum in more susceptible to fire damage than most other eucalypts, including black box, and trees may be killed by fires of only moderate intensity (Gloury 1978).

Aboriginal populations in the Murray Valley were relatively dense (Mulvaney 1969) and there was regular light burning of the floodplain forests, perhaps as often as every five years (Curr 1883; Nicholson 1981). European settlement resulted in a reduced frequency of burning but the subsequent build-up of fuels exacerbated by accumulation of logging debris, although countered by heavy grazing by stock and rabbits, may have led to a greater likelihood of more intense fires. In the New South Wales State Forests of Sections 3 and 4 there is evidence of major fires in the first quarter of this century but with improved management of the forests over the past 40 years the fire protection record has been good (Forestry Commission 1985).

7.0 MANAGEMENT ISSUES

It was stated in the introduction to this study that the scale and rate of change within the floodplain environment have increased dramatically since European settlement. It is clear from the information provided in other chapters that the rate and scale of change will continue. Evidence available indicates that for the worst affected sections of the river these environmental changes may eliminate existing remnant areas of riparian vegetation. The long term future of the vegetation in other areas is by no means assured. Existing land uses and the management practices applied combine to preclude adequate regeneration of the native vegetation. This is further exacerbated by the widespread invasion of weeds. This discussion will concentrate on the problems facing riparian vegetation, and the management options available to deal with them.

Issues associated with the management of riparian vegetation along the Murray River system are unique in Australia. Nowhere else are natural resource managers confronted with the prospect of dealing with the commonwealth, three state governments, numerous shires, statutory authorities and other bodies, all of whom have responsibilities, either directly or indirectly, of significance to riparian vegetation management. In addition, the riparian vegetation is vulnerable to impacts resulting from activities that may take place many hundreds of kilometres away in other parts of the catchment as well as being affected by more localised influences.

In many respects the riparian vegetation is the most vulnerable vegetation type in the entire catchment. It is highly dependent on river flooding and groundwater seepage for its water and is therefore affected by river regulation; it is at the lowest point in the landscape and is therefore at greater risk from salinisation, particularly areas affected by irrigation and salt mitigation schemes. Clearing has removed a significant area of the native vegetation within the study area and other factors such as grazing, de-snagging of the river and uncontrolled timber getting all have adverse impacts on the riparian vegetation.

Because of the uniqueness of the problems, a unique approach to management is required. An holistic or total catchment management approach represents the only long term solution to the management needs of the riparian vegetation. However, localised problems can be addressed at a local level with significant benefits to be gained.

The remaining part of this chapter has been divided into four separate sections:

- planning needs
- vegetation monitoring
- factors affecting the vegetation
- rehabilitation works

7.1 PLANNING FRAMEWORK

Consideration of planning issues has been deliberately placed first in this chapter. This reflects the importance good planning will play in improving the management of the river system.

The recent name change from the River Murray Commission to the Murray-Darling Basin Commission (MDBC), which now has a brief to consider the entire catchment, is a move in the right direction. This wider view is required to ensure that the full implications of decisions affecting the river and adjacent lands are planned in the context of the entire system. This is not to say that nothing can or should be done prior to preparation of plans reflecting this wider context, rather it is important that actions aimed at addressing localised problems should not be seen as a substitute for the planned approach that will be needed to tackle the fundamental problems facing natural resource managers working in the Murray-Darling Basin.

Management of a resource as complex and extensive as the river and floodplain environment requires careful planning. Planning provides the framework within which decisions can be made. This is particularly important in view of the involvement of all three levels of government, government bodies, other organisations and private interests in management of the river and adjacent lands.

Planning will have to take place within the existing legislative and administrative framework which identifies commonwealth, state and local government responsibilities.

Planning takes place at various levels with higher level plans setting policies and objectives and lower level plans setting out strategies to achieve these policies and objectives. Still lower levels set out prescriptions and action plans designed to achieve particular results.

7.1.1 POLICY AND OBJECTIVES

Higher level planning is most appropriately carried out by those bodies charged with responsibilities covering the whole catchment. The Ministerial Council and the MDBC are in the best position to coordinate planning at this level. The MDBC has considerable experience in planning related to water quantity and quality issues. This expertise is now required to provide the basic planning framework needed to properly manage the riparian vegetation.

The Salinity and Drainage Strategy (MDBMC 1987) which forms a part of the Natural Resource Management Strategy (NRMS) is evidence of the recognition that the whole basin must be considered in the context of strategic planning within the basin.

The NRMS aims to:

- prevent further degradation
- restore degraded resources
- ensure use of resources within their capability
- minimise adverse effects of resource use
- ensure self-maintaining populations of native species

- ensure appropriate planning and management
- preserve cultural heritage

The NRMS sets out both the objectives for natural resource management and broad strategies to achieve them. Planning of relevance to the river will take place within this wider context.

There is a strong case for recognising the unique characteristics of the river and its associated floodplain. Planning and land management issues of relevance to the river cross existing planning boundaries. This is exacerbated by the linear nature of the floodplain. Decisions made at one point along the river may impact on other parts of the river. This commonality of interest should be recognised in the form of a defined corridor. This is in line with the NRMS which recognises a discrete riverine zone. A planning corridor would take into account the floodplain's unique characteristics. It would provide direction and a degree of uniformity in the planning and land management decision-making processes taking place along the river.

Appropriate planning and land management principles and guidelines should be developed for application within the corridor and modified as required to reflect regional differences. The principles and guidelines would provide the necessary background and wider perspective to assist existing planning authorities in making important decisions affecting the river and its environment.

Of relevance to this study the guidelines should have a component aimed at improving the standards of management and rehabilitation of native vegetation. These would be of value to both public and private land managers. Adoption of this concept would aid the MDBC in discharging its wider responsibilities concerning the river and catchment management. The MDBC could make significant contributions through provision of assistance to coordinate the processes of consultation needed to involve the many government authorities, bodies, groups and private interests that are concerned with planning and land use management within the corridor.

As part of this consultation process, the MDBC is in the best position to provide assistance in drafting a planning framework and guidelines to be used for initiating discussion. This role would be in accordance with the objectives of the NRMS. It would provide a strong base from which to fully develop the other objectives of the strategy.

7.1.2 MIDDLE ORDER OR REGIONAL PLANNING

Middle-order planning is handled by local government and State government bodies at a regional level. Incorporation of the corridor planning at this level would require adoption of the principles and guidelines established for the river corridor but would reflect regional issues and planning needs.

The following issues would need to be included:

- landscape
- recreation

- public access
- wildlife movement
- endangered species habitat
- wetland management
- clearing policies
- waste water disposal
- timbergetting
- grazing
- tourist facility development

Adoption of this concept would extend planning out from the urban areas into other parts of the corridor. If applied consistently it will be of major benefit to the long-term prospects for the floodplain environment. Planning and associated guidelines will require decisions covering land use and management practices on public as well as private land. In this regard State government bodies have the necessary powers to determine appropriate land uses on public land. In contrast only limited controls over management practices on private property are available under the existing legislation prevailing in the three States affected.

CROWN LANDS

The middle order planning must include, as a priority, an inventory of all crown land within the floodplain. An assessment of the conservation status of riparian communities can be obtained by overlaying an inventory marked with current land uses onto the maps produced by this study. This exercise would provide a sound starting point for selecting conservation reserves sampling the full diversity of riparian communities. Those communities not well represented in existing reserves would be readily identified. Other areas of crown land that do support these communities would also be identified as part of this analysis. Other potential public land uses should be assessed at this time with a view to meeting the growing demands for recreation, tourism and timber production.

No areas of crown land should be converted to freehold tenure before this process is completed. In view of the impacts that have occurred to date and the threats facing riparian vegetation, State authorities should review the need to convert riparian lands to freehold status at any time in the future. Buy-back programs should be extended to include areas of high conservation significance.

FREEHOLD LANDS

Extensive clearing has taken place within the floodplain. Data presented in Chapter 6.1 indicates that at least one third of the total area of vegetation within the Murray study area has been cleared. The figures for individual sections of the Murray are even more alarming with up to 96% of the original vegetation having been cleared or substantially modified in some South Australian sections.

Clearing is continuing, particularly in the upper and middle reaches of the river. Clearing therefore represents a significant threat, but one that can be controlled using appropriate measures. Existing controls over clearing were reviewed in the Murray-Darling Environmental Resources Study (MDBMC 1987).

There are controls in place in South Australia. The Native Vegetation Management Act (1985) prohibits clearing of native vegetation without consent. There is provision under the legislation for landholders to sign a 'Heritage Agreement' that becomes binding on the land title. The agreement sets out appropriate management for the native vegetation. In return the State provides financial assistance for fencing and other capital expenditure directed towards management of the native vegetation.

The mechanism to control clearing exists in New South Wales through Section 21 of the Soil Conservation Act 1938 (NSW). This allows certain areas defined on a map, to be declared 'environmentally sensitive lands'. Where such a declaration is in force permission is required from the local Catchment Areas Protection Board before any clearing or forest harvesting can take place.

The Soil Conservation Service has discretion in how it applies powers conferred under the Act. It has elected to attempt to control these activities through education rather than outright prohibition. Landholders are being encouraged to adopt a more responsible attitude to the continued management of riparian vegetation on their lands. The mapped database prepared as part of this study will provide a good basis for the map component of a declaration of 'environmentally sensitive lands' that should apply to the red gum and black box communities. The areas of riparian vegetation between the main streams in the Murray-Edward systems that lie outside the study area should be mapped and included as part of the 'environmentally sensitive lands' classification.

In contrast to the other States, Victoria has little direct legislative control over clearing on freehold land, relying more on incentive schemes and education programs to encourage responsible land management. The Flora and Fauna Guarantee (1988) has provision under its ''critical habitat'' and ''interim conservation order'' sections to review and suspend clearing under certain circumstances, particularly where an area contains rare or endangered species. In 1986 the Victorian Conservation Trust introduced a Conservation Covenant Program which offers landowners a means of arranging permanent protection for the natural values of their land through the addition of a covenant to their land title.

More wide-ranging controls are needed to back up efforts to educate landholders as to the value of remnant native vegetation in general and riparian vegetation in particular. In this regard the NSW approach may provide some guidance.

Significant 'off-site' impacts are known to result from clearing activities in critical parts of the catchment. Land clearing on re-charge sites hundreds of kilometres from the floodplain inevitably contributes to the rise of saline groundwater that is moving towards the riverine system. Therefore additional measures to restrict clearing and influence farm management practices should be considered as part of the planning processes covering the entire catchment.

Fundamental resource information is therefore required across the whole basin to aid this planning process. By concentrating on the riparian strip to the exclusion of the lands beyond, the wider implications of broadscale land management practices employed in those areas can be missed.

A basin-wide study of the extent of clearing should be undertaken to help quantify the magnitude of this problem. This study could extend work recently undertaken in Victoria which mapped the extent of forest clearing and regeneration since 1972. The study was undertaken using Landsat MSS satellite imagery from 1972 and 1987 and was compiled on the geographic information system ARC/INFO. This work could be easily extended to include the whole basin.

7.1.3 LOCAL LEVEL

The third tier of planning involves all parties with direct responsibilities to initiate or undertake works in the field.

In the context of this study planning on individual properties will be an important part of this process. Individual landholders are in a position to significantly improve the future prospects for riparian vegetation on their properties. They can do this if they are motivated and are provided with good advice and/or assistance in the implementation of appropriate management techniques.

Preparation of a farm plan incorporating a native vegetation management plan should be an objective for each freehold property within the floodplain corridor. In some circumstances it would be appropriate for landholders to receive assistance towards the cost of preparing a native vegetation management plan for their property. Priority in offers of assistance should apply to properties affected by salinisation or to those carrying areas of vegetation of high conservation significance. These properties should be identified as part of regional-level planning.

Plans at this level could cover other such widely varying activities as implementation of a public awareness campaign or coordination of volunteer groups to plant trees on weekends.

7.1.4 COMMUNICATION

Given the large number of groups involved, communication is one of the most important aspects of the planning process. Establishment of good communication between all parties involved in river and catchment management is essential in order to ensure: firstly, that all parties are involved, particularly in the initial planning process; secondly, that the planning framework is communicated to all parties; and thirdly, that there are mechanisms for feedback allowing for plans to be revised in the light of experience.

7.2 VEGETATION MONITORING

Techniques to reliably assess vegetation condition are required. These techniques allow the health of vegetation to be assessed and they provide the means to monitor changes in condition over time. Monitoring of changes will identify new problem areas as they occur and, in the longer term, will provide feedback on the effectiveness of rehabilitation programs. In practice, assessing condition has not been easy. Environmental gradients and seasonal influences can affect apparent condition.

Taking a broad overview, the 'apparent condition' of riparian vegetation generally declines as one moves downstream. This is simply a reflection of the increasing harshness of the environment, rainfall decreases, temperature increases and a general increase in the amount of salt in the environment.

This environmental gradient is clearly evidenced by looking at vegetation communities growing in locations away from the influence of the river. The hills and plains around Albury support forests and woodlands. In the harsher environment of western New South Wales and Victoria the non-riparian vegetation declines in stature to mallee and shrubland. It is also worth noting that in the arid and semi-arid zones typically the vigour of the vegetation deteriorates as one moves across the floodplain away from the influence of the river.

It is important to acknowledge the existence of this environmental gradient in any assessment of vegetation condition. There is no value in drawing conclusions based on a comparison of the relative condition of widely separated communities. In general upstream communities will appear to be more healthy than an equivalent community further down the river. The study has taken this into account through adoption of a system of 'zones' along the river within which valid comparisons of relative condition can be made.

It is also necessary to discount other transient effects when assessing condition. The riparian vegetation varies in its appearance in response to good and bad seasons. Good seasons following widespread flooding are accompanied by a flush in growth. In contrast, during poor seasons, the riparian vegetation can itself look very poor. Red gums shed leaves from their crown as a mechanism to reduce water uptake. Trees in this condition give the impression of being in serious decline when in fact the trees recover with the onset of better conditions. Periodic infestations of leaf miners can also give the impression of a widespread and serious decline in vegetation condition, again this is a short-term effect with no known long-term implications for affected trees.

For this reason long-term studies to monitor changes in condition over time are important. They would provide the necessary hard evidence to reinforce anecdotal evidence concerning changes to vegetation condition.

Changes, both positive and negative are likely to be subtle, at least in the early stages. Therefore assessments should have an appropriate level of resolution to ensure that these changes are detected. This is best achieved by a system of permanent vegetation assessment plots that would be located at representative points along the river.

Sampling and subsequent analysis provides information on the extent of weed invasion at the sample locations. In general the presence of large numbers of weeds is an indication of a community that is under stress. This method provides an 'early warning' of future problems but does not define the cause of the stress which would have to be based on other assessments.

An assessment of the presence or absence of significant numbers of dead trees is a quicker but less reliable method that will indicate gross changes over large areas. This assessment allows vegetation to be broadly classified into 'regenerating' and 'degenerating' categories with a third category of 'stable' which indicates a community that is neither regenerating nor degenerating. This classification system's main virtue lies in its speed and in the fact that it is unaffected by seasonal influences. The major problems associated with its use are that it does not define causes for the observed condition, and that it is a very coarse classification that does not detect subtle changes.

The present study used the latter technique to map condition. This is adequate for the purpose of obtaining an overview and for identifying the most badly affected sites. This needs to be augmented by the permanent plot system mentioned earlier.

7.3 FACTORS AFFECTING THE VEGETATION

Patterns in riparian vegetation are defined by the range of environmental conditions which exist along and across the floodplain. If conditions change to the extent that they fall outside the natural environmental tolerances of the species occupying the site then it is likely that these species will decline and will be replaced by species better suited to the changed conditions. As described elsewhere in this chapter, the process of decline and death of affected vegetation can be dramatic or subtle. Dramatic decline and widespread death of the tree component such as that experienced in badly salt-affected areas provide a graphic indication of the future prospects for a substantial area of riparian land. More subtle changes can weaken the vegetation predisposing it to attack from other pests and diseases.

As discussed elsewhere in other parts of the study, major threats to **existing patterns** of riparian vegetation include: regional salinisation caused by rising saline groundwater, and river regulation. These factors can be described as 'external' influences. This reflects the fact that they result from activities or processes that originate in areas remote from the affected vegetation.

Taken in isolation, increasing salinity or the continuing changes caused by river regulation alone may not kill directly, however the synergistic effect of prolonged waterlogging coupled with increased salinity has been responsible for killing substantial areas of vegetation. In other circumstances these factors weaken trees. The ultimate cause of death may be from another agent which is able to attack trees weakened by these environmental changes. For example, substantial areas of box woodland west of Wentworth in western NSW were killed in 1984. Locals attributed their death to a severe attack of leaf miners. However it is likely that the trees were weakened by an increase in soil salinity which appears to be widespread in the region. The leaf miner attack, which is a periodically occurring natural phenomenon, may have merely hastened what was an inevitable death by adding to the stress already experienced by the trees. Similar but less dramatic examples of the same process may have occurred where salt-stressed trees succumb to the additional stress caused by mistletoe infestations.

7.3.1 SALINISATION

The background papers to the Salinity and Drainage Strategy (MDBC 1987) provide evidence of the many areas where groundwaters are both rising and becoming increasingly saline as a result of changes in the catchment characteristics caused by clearing for agriculture, irrigation and river regulation. Plants vary in their tolerance of salt. For example, some provenances of red gum can tolerate groundwater salinity levels up to around 20 000ppm. Some provenances of black box can survive in levels up to 35 000ppm. There are also variations in tolerances within species with some provenances able to withstand higher levels than others. As the level of salt in the environment increases less tolerant species die out and are replaced by those with a higher tolerance. The detailed botanical study indicated that salt tolerance is the most important determining factor in riparian vegetation patterns and vigour.

There is a need to establish arboreta covering the full range of sites likely to be affected to a significant degree by increasing salinisation. The arboreta would include those species and provenances noted for salt tolerance. In particular red gum provenances from along the Murray and from saline sites elsewhere should be trialled. Arboreta should be established so the full environmental gradient is sampled. This includes the upstream-downstream gradient and the outer to inner floodplain gradient.

In the longer term arboreta will provide future land use managers with reliable information on species performance. It is often the case that good early performers can fail at a later date. This factor is important if the objective is to establish self-maintaining native vegetation communities in the long term.

7.3.2 WATERING REGIMES

Water, or more particularly the frequency, timing and duration of flooding and the quantity of water from other sources are important influences on riparian vegetation communities and their health. The type of community at a particular site, its health and vigour are all influenced by a combination of the above factors.

Water becomes available to riparian vegetation from rain, floods, groundwater seepage and confined aquifers. Chapter 6 discusses the distribution of water across the floodplain, the changes to these processes caused by river regulation and the impacts arising from those changes.

There is an increasing body of evidence, largely anecdotal, that indicates a reduction in the productivity of forests affected by river regulation. A reduction in productivity, if it continues in the long term could see a change to a more depauperate community as the current dominant tree strata is replaced over time.

There is an urgent need to identify and quantify the effect that changes to watering regimes have had on riparian communities, particularly the tree component. Two types of studies are needed. The first type would trial differing watering regimes. These trials would also aim at developing the techniques needed to efficiently distribute water to target areas of vegetation.

The second type of study would seek to provide a longer baseline of information concerning growth response to flooding. This may be possible through the use of dendrochronologic or tree-growth-ring studies. If properly calibrated they offer the prospect of being able to extend our understanding of the flooding history back perhaps hundreds of years. This would provide a sounder base from which to develop watering strategies aimed at achieving particular productivity levels.

7.3.3 LOCALISED FACTORS

Other more 'localised' factors also influence the riparian vegetation. They combine with the broader external factors to define the type and condition of vegetation communities found at any particular point along the floodplain. In some circumstances these localised factors can be the most important influences.

Localised factors include: clearing, grazing, cultivation, fire regime (human-induced and natural), de-snagging, forestry activities, rabbits, weeds, erosion, minor flow control structures, exotic plantings and recreational use. These factors impact physically on existing plants. This is in contrast to the 'external' factors which tend to alter the environmental conditions prevailing at the site and hence its capacity to support pre-existing community types.

It is important to try to identify differing communities' tolerance limits with respect to these factors. In particular, development of appropriate grazing regimes will be a matter of some urgency. This should be a priority in view of the widespread impacts domestic and feral animals are having on the riparian vegetation.

Questions that should be addressed include: what animals can be tolerated for what periods, under what conditions? The results should be compiled and presented as guidelines for landholders.

Control of weeds is another factor of importance, particularly in the context of managing conservation reserves. Appropriate strategies to manage and control weeds will be required as part of the active management needed for reserves in the floodplain. Control of rabbits and other feral animals is another aspect of active management that will be essential for conservation reserves. Effective control will be required if vegetation communities resembling those occurring in pre-European times are to be re-established.

7.3.4 EXOTICS

Exotic plantings, mainly of willows (**Salix* spp.) have been followed by re-invasion and subsequent dominance of substantial areas of river bank. This is a significant factor in South Australia.

There are no adequate data on the performance of native floodplain species that could replace the willows as part of a program to re-establish native vegetation to affected areas. This data can only be obtained from field trials at selected sites using a range of potentially suitable species.

Alternative methods of bank stabilisation and revegetation need to be developed. These would have the objective of re-establishing stable, self-maintaining stands of red gum in place of the willows.

Other woody species that could be planted in conjunction with river red gum are *Acacia dealbata* on the Riverine Plain and *Acacia stenophylla* in the Mallee Zone. Initial stabilisation could be achieved through planting of native grasses and sedges. Species likely to be suitable for this purpose are *Carex tereticaulis*, *Cyperus exaltatus*, *C. gymnocaulos*, *Eleocharis acuta*, *Hemarthria uncinata*, *Paspalidium jubiflorum*, *Phragmites australis*, *Poa labillardieri*, *Pseudoraphis spinescens* and *Sporobolus mitchellii*. The river sections to which each species is best suited are indicated in Appendix 3.

7.4 REHABILITATION WORKS

When considering rehabilitation programs, it is important to distinguish between the two classes of factors described above. The type of response will vary depending whether the program in question is addressing an external factor and therefore regional problem or a localised factor.

7.4.1 EXTERNAL FACTORS

Rehabilitation of salinised land will require a national effort. The problem areas mapped within the study area represent a small proportion of the salt-affected areas within the basin or indeed the nation. The fundamental problems of rising saline groundwater can only be addressed and handled on a regional level. Strategies to slow, stop and ultimately reverse the rise or to intercept and dispose of saline groundwater are the only broadscale, long-term solutions.

In the interim it is possible to rehabilitate areas on a site-by-site basis to achieve specified objectives. Candidate sites would include: important landscape features, conservation areas, recreation areas or areas important for soil conservation.

Management strategies to redress the effects of salinisation on riparian vegetation have to include site amelioration works before a revegetation program will be successful. The scope of amelioration works required will depend on the extent to which environmental conditions have been altered and the type of restoration required. The scope of the works needed can be reduced through the use of salt-tolerant provenances of desired species or through acceptance of a modified community of other, hardier species.

This type of project could be of considerable value for research and or demonstration purposes in the context of a wider program at some time in the future. However, these site specific rehabilitation works should be viewed as addressing only the symptoms - they do not solve the underlying cause(s) of the problem.

The arboreta program discussed in Chapter 7.3 will be important to aid selection of suitable species for future works. The arboreta could be used in part to rehabilitate sites if required.

7.4.2 LOCALISED FACTORS

In contrast to the above, efforts to redress the effects of localised factors can often be effective for individual sites or smaller regions. These efforts include regeneration/ revegetation schemes which can involve something as simple as a change in grazing regime to facilitate regeneration through to more intensive tree planting works. The results from such localised efforts can provide long-term solutions to these problems.

Disused salt evaporation basins are included under localised factors reflecting the localised nature of the degradation. Salt evaporation basins offer the opportunity to rehabilitate obviously degraded sites with a high probability of success. The techniques applicable under these circumstances differ from those that are appropriate in areas of rising groundwater.

7.4.3 ALLOCATION OF RESOURCES

The broad extent of 'degenerating' vegetation within the study area has been identified by this study. It provides an order of magnitude indication of the scope of works required to rehabilitate the riparian vegetation. Additional areas that are known to be vulnerable to salinisation that do not as yet show obvious symptoms of stress should also be included in this scope of works in degraded vegetation as predicted impacts from rising salt levels are manifested.

The resources needed to achieve this restoration will have to be met by the community rather than individual landholders or even individual States. The community will have to decide what value it wishes to place on the riparian vegetation and therefore how much it is willing to spend on restoration and future management of this resource. These fundamental decisions and the attendant commitment of resources must be made as soon as possible. This process of decision making will define the directions and scope for future planning of riparian vegetation management.

APPENDIX 1. FLORISTIC COMMUNITIES

1.1 COMMUNITY DESCRIPTIONS

Grazing indices in the descriptions are the mean numbers of droppings clusters along a 20m line. The term 'weed' refers to all introduced species.

RED GUM ZONE

1. *Eucalyptus camaldulensis-Eleocharis acuta-Pseudoraphis spinescens* Open-forest

Layer	Height (m)	Cover (%)	Major species
Tree	24	30	*Eucalyptus camaldulensis*
Tall herb	0.8	15/0	*Cyperus exaltatus* or absent
Low herb	0.3	55	*Eleocharis acuta, Centipeda cunninghamii, Pseudoraphis spinescens, Alternanthera denticulata, Paspalidium jubiflorum, Rumex brownii, Agrostis avenacea, Myriophyllum crispatum*

Number of plots: 26
Mean number of species per plot: 14.4 (range 7-31)
Mean number of weed species: 2.6 (18% of total)
Mean number of chenopod species: 0
Eucalypt condition: 81% healthy, 15% unhealthy, 4% dead (n=361)
Eucalypt regeneration: 838 per ha (195 <4m, 643 >4m)
Grazing indices: rabbit 0.2, sheep 0.5, cattle 0.5, kangaroo 0.2

Distribution
Sections 1 (1 plot), 3 (9 plots), 4 (11 plots), 5 (3 plots) and 6 (2 plots), in frequently flooded sites. Covers extensive low-lying areas away from the river in Sections 3 and 4; elsewhere restricted to small patches on low ground bordering the river and backwaters.

Notes
These forests are the tallest of all red gum communities. In Section 3 their average height at maturity exceeds 30m, with some stands exceeding 45m (Forestry Commission 1985; Chesterfield 1986). The relatively low average height on the sample plots is largely due to logging.

2. *Eucalyptus camaldulensis-Eleocharis acuta-Wahlenbergia fluminalis* Open-forest

Layer	Height (m)	Cover (%)	Major species
Tree	21	40	*Eucalyptus camaldulensis*
Herb	0.3	70	*Eleocharis acuta, Agrostis avenacea, Ranunculus inundatus, Juncus amabilis, Wahlenbergia fluminalis, Centipeda cunninghamii, Rumex brownii, Myriophyllum crispatum*

Number of plots: 4
Mean number of species per plot: 33 (range 26-47)
Mean number of weed species: 10.3 (31% of total)
Mean number of chenopod species: 0
Eucalypt condition: 76% healthy, 19% unhealthy, 5% dead (n=42)
Eucalypt regeneration: 163 per ha (56 <4m, 107 >4m)
Grazing indices: rabbit 0.8, sheep 1.8, cattle 1.3, kangaroo 0.8

Distribution
Sections 3 (1 plot) and 4 (3 plots). Similar to the more common *E. camaldulensis-Eleocharis acuta-Pseudoraphis spinescens* community, often occurring on slightly higher ground adjacent to that community.

3. *Eucalyptus camaldulensis-Poa labillardieri-Agrostis avenacea* Open-forest

Layer	Height (m)	Cover (%)	Major species
Tree	23	45	*Eucalyptus camaldulensis*
Shrub	5	15/0	*Acacia dealbata*, but mostly absent
Tall herb	1	30	*Poa labillardieri, Carex tereticaulis, Juncus amabilis*
Low herb	0.3	45	*Agrostis avenacea, *Cynodon dactylon, *Lolium perenneXrigidum, *Cirsium vulgare, Centipeda cunninghamii, *Hypochoeris radicata, Eleocharis acuta, Wahlenbergia fluminalis*

Number of plots:30
Mean number of species per plot: 37.1 (range 21-57)
Mean number of weed species: 17.4 (47% of total)
Mean number of chenopod species: 0
Eucalypt condition: 76% healthy, 19% unhealthy, 5% dead (n=328)
Eucalypt regeneration: 736 per ha (510 <4m, 226 >4m)
Grazing indices: rabbit 0.4, sheep 0.2, cattle 0.9, kangaroo 0.6

Distribution
Sections 1 (11 plots), 2 (5 plots), 3 (10 plots) and 4 (4 plots), adjacent to the river and its associated anabranches and wetlands.

4. *Eucalyptus camaldulensis-Poa labillardieri-Hemarthria uncinata* Open-forest

Layer	Height (m)	Cover (%)	Major species
Tree	24	30	*Eucalyptus camaldulensis*
Shrub	7	5/0	*Acacia dealbata* or absent
Tall herb	0.9	20	*Poa labillardieri, Carex tereticaulis, Juncus amabilis*
Low herb	0.2	60	*Hemarthria uncinata, Persicaria prostrata, *Lolium perenneXrigidum, *Hypochoeris radicata, *Cirsium vulgare, *Vulpia bromoides, *Cynodon dactylon, *Paspalum dilatatum*

Number of plots: 7
Mean number of species per plot: 33.3 (range 22-43)
Mean number of weed species: 18.9 (57% of total)
Mean number of chenopod species: 0
Eucalypt condition: 84% healthy, 15% unhealthy, 1% dead (n=99)
Eucalypt regeneration: 50 per ha (11 <4m, 39 >4m)
Grazing indices: rabbit 9.3, sheep 0.4, cattle 0.6, kangaroo 0.1

Distribution
Sections 1 (2 plots) and 2 (5 plots), in similar situations to the previous community but often on sandier soils.

Notes
Apparently represents a weedy form of the more common *E. camaldulensis-Poa labillardieri-Agrostis avenacea* community. Note the high rabbit density and poor eucalypt regeneration compared with that community. Rabbits were particularly common in several plots in Boomanoomana State Forest (Section 2), where the soils were rather sandy and easier to burrow in.

5. *Eucalyptus camaldulensis-Carex tereticaulis* Open-forest

Layer	Height (m)	Cover (%)	Major species
Tree	23	40	*Eucalyptus camaldulensis*
Tall herb	1	45	*Carex tereticaulis, Poa labillardieri*
Low herb	0.2	35	*Wahlenbergia fluminalis, *Hypochoeris glabra, *Lactuca serriola, *Sonchus oleraceus, *Lolium perenneXrigidum, *Bromus hordeaceus, *Vulpia bromoides, *Bromus diandrus*

Number of plots: 11
Mean number of species per plot: 35.3 (range 21-50)
Mean number of weed species: 15.7 (44% of total)
Mean number of chenopod species: 0.3 (1% of total)
Eucalypt condition: 81% healthy, 14% unhealthy, 5% dead (n=136)
Eucalypt regeneration: 950 per ha (655 <4m, 295 >4m)
Grazing indices: rabbit 0.2, sheep +, cattle 0.5, kangaroo 1

Distribution

Sections 3 (7 plots) and 4 (4 plots in eastern half). This community and the following are the dominant red gum communities along this part of the river.

Notes

Chesterfield (1986) has suggested that logging and grazing may have led to an expansion of the *E. camaldulensis-Carex tereticaulis* community at the expense of the *E. camaldulensis-Paspalidium jubiflorum-Senecio quadridentatus* community. His reasoning is that *Carex tereticaulis* tends to be associated with denser tree stockings than *Paspalidium jubiflorum* and that *Carex tereticaulis* is unpalatable to stock, whereas *Paspalidium jubiforum* is palatable.

6. *Eucalyptus camaldulensis-Paspalidium jubiflorum-Senecio quadridentatus* Open-forest

Layer	Height (m)	Cover (%)	Major species
Tree	20	35	*Eucalyptus camaldulensis*
Herb	0.4	55	*Paspalidium jubiflorum, Wahlenbergia fluminalis, *Hypochoeris glabra, Agrostis avenacea, *Lolium perenneXrigidum, Senecio quadridentatus, *Sonchus oleraceus, Centipeda cunninghamii*

Number of plots: 25
Mean number of species per plot: 31.3 (range 20-50)
Mean number of weed species: 13.8 (44% of total)
Mean number of chenopod species: 0.3 (1% of total)
Eucalypt condition: 71% healthy, 19% unhealthy, 10% dead (n=302)
Eucalypt regeneration: 863 per ha (454 <4m, 409 >4m)
Grazing indices: rabbit 1.6, sheep 0.6, cattle 0.4, kangaroo 2.2

Distribution

Sections 2 (2 plots), 3 (5 plots) and 4 (18 plots). The dominant red gum community of Section 4; co-dominant with the *E. camaldulensis-Carex tereticaulis* community in Section 3; replaced by the *E. camaldulensis-Poa labillardieri-Agrostis avenacea* community further east.

7. *Eucalyptus camaldulensis-Paspalidium jubiflorum-*Cynodon dactylon* Woodland

Layer	Height (m)	Cover (%)	Major species
Tree	21	25	*Eucalyptus camaldulensis*
Tall shrub	6	5/0	*Acacia stenophylla,* but mostly absent
Low shrub	1.6	5/0	*Muehlenbeckia cunninghamii,* but mostly absent
Tall herb	1	15/0	*Phragmites australis* or *Cyperus exaltatus* along water's edge, but mostly absent.
Low herb	0.4	60	*Paspalidium jubiflorum, *Cynodon dactylon, Wahlenbergia fluminalis, *Hypochoeris glabra, *Sonchus oleraceus, Centipeda cunninghamii, Eclipta platyglossa, Cyperus gymnocaulos*

Number of plots: 28
Mean number of species per plot: 29.6 (range 16-48)
Mean number of weed species: 11.1 (38% of total)
Mean number of chenopod species: 1.4 (5% of total)
Eucalypt condition: 77% healthy, 17% unhealthy, 6% dead (n=285)
Eucalypt regeneration: 466 per ha (325 <4m, 141 >4m)
Grazing indices: rabbit 1.0, sheep 3.4, cattle 0.1, kangaroo 1.3

Distribution

Sections 4 (5 plots), 5 (7 plots), 6 (11 plots) and 7 (5 plots). Restricted to the immediate vicinity of the river and its associated anabranches and wetlands. The dominant red gum community of Section 5 and the eastern half of Section 6. Replaced to the east by the *E. camaldulensis-Paspalidium jubiflorum-Senecio quadridentatus* community, and to the west by the *E. camaldulensis-Cyperus gymnocaulos* community.

8. *Eucalyptus camaldulensis-Cyperus gymnocaulos* Woodland

Layer	Height (m)	Cover (%)	Major species
Tree	20	25	*Eucalyptus camaldulensis*
Shrub	1.8	5	*Muehlenbeckia cunninghamii*
Tall herb	1.7	15	*Phragmites australis* along water's edge
Low herb	0.4	55	*Cyperus gymnocaulos, Sporobolus mitchellii, Eclipta platyglossa, Wahlenbergia fluminalis, *Cynodon dactylon, *Sonchus oleraceus, Paspalidium jubiflorum, Sonchus hydrophilus*

Number of plots: 12
Mean number of species per plot: 24.3 (range 19-32)
Mean number of weed species: 9 (37% of total)
Mean number of chenopod species: 0.8 (3% of total)
Eucalypt condition: 70% healthy, 15% unhealthy, 15% dead (n=129)
Eucalypt regeneration: 273 per ha (79 <4m, 194 >4m)
Grazing indices: rabbit 0.2, sheep 2.2, cattle 0.2, kangaroo 1.4

Distribution

Sections 6 (5 plots, all in South Australia) and 7 (7 plots). Restricted to the immediate vicinity of the river and its associated anabranches and wetlands.

9. *Eucalyptus camaldulensis-Phragmites australis* Woodland

Layer	Height (m)	Cover (%)	Major species
Tree	16	20	*Eucalyptus camaldulensis*
Shrub	2.5	5	*Muehlenbeckia cunninghamii*
Tall herb	1.7	55	*Phragmites australis, Typha domingensis, Schoenoplectus validus*
Low herb	0.4	35	**Cynodon dactylon, Asperula gemella, Cyperus gymnocaulos, Paspalidium jubiflorum, Sonchus hydrophilus, *Cirsium vulgare, *Bromus diandrus, Picris squarrosa*

Number of plots: 5
Mean number of species per plot: 18.4 (range 10-31)
Mean number of weed species: 7.6 (41% of total)
Mean number of chenopod species: 0.4 (2% of total)
Eucalypt condition: 80% healthy, 10% unhealthy, 10% dead (n=50)
Eucalypt regeneration: 60 per ha (40 <4m, 20 >4m)
Grazing indices: rabbit 0.4, cattle 0.4

Distribution
Sections 7 (4 plots) and 8 (1 plot). Fringes the river on gently sloping banks, the outer parts of the reedbeds standing in water. On more steeply sloping banks, with only a narrow strip of *Phragmites*, the vegetation type is the *E. camaldulensis-Cyperus gymnocaulos* community.

10. *Eucalyptus camaldulensis-Danthonia caespitosa* Woodland

Layer	Height (m)	Cover (%)	Major species
Tree	18	25	*Eucalyptus camaldulensis*
Tall herb	0.7	5	*Juncus flavidus, Carex tereticaulis, Poa labillardieri*
Low herb	0.3	65	*Danthonia caespitosa, Wahlenbergia fluminalis, *Lolium perenneXrigidum, *Vulpia myuros, Danthonia duttoniana, *Hypochoeris glabra, Agrostis avenacea, *Bromus hordeaceus*

Number of plots: 8
Mean number of species per plot: 35.4 (range 26-50)
Mean number of weed species: 17.3 (49% of total)
Mean number of chenopod species: 0.5 (1% of total)
Eucalypt condition: 72% healthy, 22% unhealthy, 6% dead (n=123)
Eucalypt regeneration: 28 per ha (22 <4m, 6 >4m)
Grazing indices: rabbit 0.9, sheep +, cattle 3.5, kangaroo 2

Distribution
Sections 2 (3 plots), 3 (3 plots) and 4 (2 plots). High ground, typically on the outer parts of the red gum zone.

11. *Eucalyptus camaldulensis-E. largiflorens* Open-forest

Layer	Height (m)	Cover (%)	Major species
Tree	18	35	*Eucalyptus camaldulensis, E. largiflorens*
Shrub	1.9	15/0	*Muehlenbeckia cunninghamii* or *Exocarpos strictus* or *Acacia* spp. or absent
Tall herb	0.8	15/0	*Cyperus exaltatus* at water's edge, but mostly absent
Herb	0.1	25	**Hypochoeris glabra, *Sonchus oleraceus, *Vulpia myuros, *Lolium perenneXrigidum, Wahlenbergia fluminalis, *Cynodon dactylon, Paspalidium jubiflorum, Oxalis perennans*

Number of plots: 13
Mean number of species per plot: 24.7 (range 12-41)
Mean number of weed species: 9.2 (37% of total)
Mean number of chenopod species: 1.3 (5% of total)
Eucalypt condition:
E. camaldulensis 55% healthy, 37% unhealthy, 8% dead (n=122)
E. largiflorens 49% healthy, 44% unhealthy, 7% dead (n=95)
Eucalypt regeneration:
E. camaldulensis 67 per ha (46 <4m, 21 >4m)
E. largiflorens 428 per ha (178 <4m, 250 >4m)
Grazing indices: rabbit 1.2, sheep 2.5, cattle 0.4, kangaroo 1.5

Distribution
Sections 4 (8 plots) and 5 (5 plots). On high ground, typically at the junction of the red gum and black box zones. However, *E. largiflorens* is not always present and the community includes vegetation on steep, high riverbanks.

Notes
A rather heterogeneous grouping, including one plot where the vegetation appeared to be changing from a red gum to a black box community, and another plot where the reverse was occurring. The latter was a riverside plot upstream of Torrumbarry Weir and originally would have been located away from the water's edge. The reason for the vegetation change at the other plot was not clear.

12. *Eucalyptus camaldulensis-Muehlenbeckia cunninghamii* Woodland

Layer	Height (m)	Cover (%)	Major species
Tree	18	25	*Eucalyptus camaldulensis*, some *E. largiflorens*
Tall shrub	7	5	*Acacia stenophylla*, sometimes forming dense stands
Low shrub	1.6	10	*Muehlenbeckia cunninghamii*
Herb	0.4	60	*Paspalidium jubiflorum, *Bromus rubens, *Hypochoeris glabra, Cyperus gymnocaulos, Wahlenbergia fluminalis, Einadia nutans, *Sonchus oleraceus, *Cynodon dactylon*

Number of plots: 13
Mean number of species per plot: 27.2 (range 14-33)
Mean number of weed species: 9.7 (36% of total)
Mean number of chenopod species: 2.7 (10% of total)
Eucalypt condition: 52% healthy, 35% unhealthy, 14% dead (n=133)
Eucalypt regeneration: 44 per ha (23 <4m, 21 >4m)
Grazing indices: rabbit 3.5, sheep 1, cattle 0.2, kangaroo 0.5

Distribution
Sections 5 (4 plots), 6 (3 plots) and 7 (6 plots). High ground at the junction of the red gum and black box zones, particularly on the top of high levees.

13. *Eucalyptus camaldulensis-*Bromus diandrus-*Vulpia bromoides* Open-forest

Layer	Height (m)	Cover (%)	Major species
Tree	22	35	*Eucalyptus camaldulensis*
Shrub		15/0	*Acacia dealbata* (6m) or **Salix* spp. (6m) or *Exocarpos strictus* (2.5m), but mostly absent
Tall herb	0.8	15/0	*Carex tereticaulis, Juncus flavidus, J.amabilis,* or absent
Low herb	0.3	70	**Bromus diandrus, *Bromus hordeaceus, *Lolium perenneXrigidum, *Vulpia bromoides, *Hypochoeris radicata, *Critesion murinum, *Cynodon dactylon, *Cirsium vulgare*

Number of plots: 21
Mean number of species per plot: 29.1 (range 13-49)
Mean number of weed species: 18.4 (63% of total)
Mean number of chenopod species: 0
Eucalypt condition: 79% healthy, 18% unhealthy, 3% dead (n=267)
Eucalypt regeneration: 356 per ha (227 <4m, 129 >4m)
Grazing indices: rabbit 2.5, sheep 0.1, cattle 2.5, kangaroo 0.7

Distribution
Sections 1 (10 plots), 2 (5 plots), 3 (5 plots) and 4 (one plot - Gunbower Island). Highly disturbed sites, where the original understorey has been largely replaced by weeds. Occurs in various situations but typically on higher ground than adjacent, less weedy red gum communities.

14. *Eucalyptus camaldulensis-*Bromus diandrus-Danthonia caespitosa* Open-forest

Layer	Height (m)	Cover (%)	Major species
Tree	21	30	*Eucalyptus camaldulensis*
Shrub		30/0	*Acacia dealbata* (6m) or **Salix babylonica* (5m) or *Chenopodium nitrariaceum* (1.5m) or absent
Herb	0.3	55	**Bromus diandrus, Danthonia caespitosa, *Bromus hordeaceus, *Lolium perenneXrigidum, *Avena barbata, *Critesion murinum, *Vulpia myuros, *Cirsium vulgare*

Number of plots: 6
Mean number of species per plot: 28.8 (range 14-38)
Mean number of weed species: 16.5 (57% of total)
Mean number of chenopod species: 0.7 (2% of total)
Eucalypt condition: 57% healthy, 29% unhealthy, 14% dead (n=90)
Eucalypt regeneration: 250 per ha (46 <4m, 204 >4m)
Grazing indices: rabbit 0.3, sheep +, cattle 0.5, kangaroo 0.2

Distribution
Section 4. A mixed group of highly disturbed sites. Four plots were on the sides of high levees; the other two were in dry floodways.

Notes
The *Acacia* and **Salix* layers occurred in levee plots, the *Chenopodium* layer in a floodway plot. The dead trees were mainly in the other floodway plot, which appeared to be salt-affected, the understorey being dominated by the salt-tolerant **Critesion marinum.*

*Eucalyptus camaldulensis-*Cynodon dactylon* Woodland

Layer	Height (m)	Cover (%)	Major species
Tree	18	20	*Eucalyptus camaldulensis*
Tall shrub	8	10/0	**Salix babylonica* along water's edge, but mostly absent
Low shrub	1.8	15	*Muehlenbeckia cunninghamii, Enchylaena tomentosa*
Tall herb	1.5	5/0	*Schoenoplectus validus* along water's edge, but mostly absent
Low herb	0.2	65	**Cynodon dactylon, *Bromus rubens, Cyperus gymnocaulos, *Medicago polymorpha, *Critesion murinum, Sonchus hydrophilus, *Cirsium vulgare, *Rumex crispus*

Number of plots: 12
Mean number of species per plot: 34.5 (range 21-51)
Mean number of weed species: 20.3 (59% of total)
Mean number of chenopod species: 2.4 (7% of total)
Eucalypt condition: 60% healthy, 13% unhealthy, 27% dead (n=120)
Eucalypt regeneration: 88 per ha (8 <4m, 80 >4m)
Grazing indices: rabbit 3.5, cattle 5.4

Distribution
Sections 7 (3 plots) and 8 (9 plots). Highly disturbed sites where the original understorey has been largely replaced by weeds. The dominant red gum community in Section 8. The Lower Murray equivalent of the weedy *E. camaldulensis-*Bromus diandrus* communities of the Upper Murray.

Notes
The high numbers of dead trees seemed to be the result of raised water levels and, in one plot, salinisation.

16. **Salix Xrubens* Scrub

Layer	Height (m)	Cover (%)	Major species
Tree	16	15/0	*Eucalyptus camaldulensis* or absent
Shrub	7	65	**Salix Xrubens*
Tall herb	1	15	*Poa labillardieri, Phragmites australis*
Low herb	0.3	15	**Hypochoeris radicata, *Vulpia bromoides, *Conyza bonariensis, Agrostis avenacea, *Bromus catharticus, Juncus flavidus, *Cirsium vulgare, *Trifolium campestre*

Number of plots: 2
Mean number of species per plot: 31.5 (range 17-46)
Mean number of weed species: 18.5 (59% of total)
Mean number of chenopod species: 0
Eucalypt condition: 64% healthy, 36% unhealthy (n=11)
Eucalypt regeneration: 525 per ha (275 <4m, 250 >4m)
Grazing indices: cattle 1, kangaroo +

Distribution
Sections 1 and 3. **Salix Xrubens* occurs in small patches fringing the river, growing further down the riverbank than *Eucalyptus camaldulensis.* The outer parts of the scrubs were standing in water at the time of the survey.

Notes
Although there was dense eucalypt regeneration in one plot, much of it was unhealthy, being shaded by the **Salix.*

17. **Salix babylonica* Scrub

Layer	Height (m)	Cover (%)	Major species
Shrub	9	60	**Salix babylonica*
Herb	0.6	25	*Juncus aridicola, *Aster subulatus, Hydrocotyle verticillata, *Picris echioides, Triglochin procerum, *Cirsium vulgare, Agrostis avenacea, Azolla filiculoides, Phragmites australis*

Number of plots: 6
Mean number of species per plot: 25.2 (range 17-33)
Mean number of weed species: 12.5 (50% of total)
Mean number of chenopod species: 0
Grazing indices: cattle +, kangaroo +

Distribution
Occurs sporadically along the length of the river but most extensive in Section 8, where five of the six plots were located (the other was in Section 6). **Salix babylonica* occurs here in a 20-40m wide strip between the man-made levees and the river. It is the most common form of fringing vegetation along this part of the river and is virtually continuous below Murray Bridge. **Salix babylonica* grows further down the riverbank than *E. camaldulensis* and the scrubs sampled were all standing in water.

18. *Callistemon brachyandrus-Muehlenbeckia cunninghamii* Shrubland

Layer	Height (m)	Cover (%)	Major species
Tall shrub	4	20	*Callistemon brachyandrus, Muehlenbeckia cunninghamii*
Low shrub	0.6	5	*Enchylaena tomentosa, Maireana brevifolia*
Herb	0.2	55	**Bromus rubens, Cyperus gymnocaulos, *Hypochoeris glabra, *Avena barbata, *Brassica tournefortii, Calotis cuneifolia, *Euphorbia terracina, Einadia nutans*

Number of plots: 2
Mean number of species per plot: 30.5 (range 30-31)
Mean number of weed species: 14.5 (48% of total)
Mean number of chenopod species: 6 (20% of total)
Grazing indices: rabbit 1

Distribution
Only encountered at Morgan Conservation Park in Section 7, on a very sandy levee.

19. *Agrostis avenacea-*Cynodon dactylon* Grassland

Layer	Height (m)	Cover (%)	Major species
Sapling	3	5	*Eucalyptus camaldulensis*
Herb	0.1	60	*Agrostis avenacea, *Cynodon dactylon, Crassula sieberiana, *Lolium perenneXrigidum, Persicaria prostrata, *Hypochoeris radicata, Centipeda cunninghamii, Eragrostis elongata*

Number of plots: 3
Mean number of species per plot: 25.3 (range 19-32)
Mean number of weed species: 14.7 (58% of total)
Mean number of chenopod species: 0
Eucalypt regeneration: 558 per ha (408 <4m, 150 >4m)
Grazing indices: rabbit 0.3, cattle 1, kangaroo 2

Distribution
Section 2. Recent sand deposits, usually point bars.

Notes
Represents the early stages of colonisation of the broad point bar deposits (beaches) of Section 2, eventually developing into *E. camaldulensis* open-forest.

20. *Pseudoraphis spinescens-Eleocharis acuta* Herbland

Layer	Height (m)	Cover (%)	Major species
Herb	0.2	85	*Pseudoraphis spinescens, Eleocharis acuta, Centipeda cunninghamii, Agrostis avenacea, Persicaria hydropiper, P. prostrata, Alternanthera denticulata, *Ludwigia peploides*

Number of plots: 4
Mean number of species per plot: 9.5 (range 3-18)
Mean number of weed species: 2 (21% of total)
Mean number of chenopod species: 0
Grazing indices: cattle 1.3

Distribution
All plots were in Section 3 but also occurs in Section 4. Flat, low-lying areas where flooding is too frequent and prolonged to allow growth of *E. camaldulensis.*

Notes
Varies from *Pseudoraphis spinescens* grassland to *Eleocharis acuta* sedgeland.

21. *Centipeda cunninghamii - Polygonum plebeium* Herbland

Layer	Height (m)	Cover (%)	Major species
Sapling	10	5	*Eucalyptus camaldulensis*
Herb	0.2	65	*Centipeda cunninghamii, Polygonum plebeium, Persicaria prostrata, Pseudognaphalium luteo-album, Centipeda minima, Agrostis avenacea, Alternanthera denticulata, Rumex crystallinus*

Number of plots: 5
Mean number of species per plot: 25 (range 14-35)
Mean number of weed species: 9.8 (39% of total)
Mean number of chenopod species: 0
Eucalypt regeneration: 4080 per ha (4070 <4m, 10 >4m)
Grazing indices: rabbit 5, sheep 3.4, cattle 0.4, kangaroo 0.4

Distribution
Sections 2 (1 plot), 4 (2 plots) and 5 (2 plots). Depressions and gently sloping edges of billabongs - sites which are subject to frequent flooding.

Notes
In addition to the eucalypt seedlings included in the counts, there were thousands of seedlings under 5cm high. Germination is prolific after flooding but most of the seedlings are killed by later flooding. Saplings become established only on the outer edges and on rises.

BLACK BOX ZONE

22. *Eucalyptus largiflorens-Eleocharis acuta* Open-forest

Layer	Height (m)	Cover (%)	Major species
Tree	13	35	*Eucalyptus largiflorens*
Herb	0.4	65	*Eleocharis acuta, Agrostis avenacea, Eleocharis pusilla, Juncus flavidus, *Lolium rigidum, Centipeda cunninghamii, *Sonchus oleraceus, Damasonium minus*

Number of plots: 3
Mean number of species per plot: 28.7 (range 23-38)
Mean number of weed species: 11 (38% of total)
Mean number of chenopod species: 0
Eucalypt condition: 74% healthy, 26% unhealthy (n=31)
Eucalypt regeneration: none in plots
Grazing indices: rabbit 0.7, sheep +, cattle +, kangaroo 0.7

Distribution
Section 4, in sites that are often flooded.

Notes
In some sites, at least, this community appears to be the result of a recent increase in flooding frequency, which has brought about a change in the understorey but not yet the tree layer. In time, *E. largiflorens* may be replaced by *E. camaldulensis* at these sites.

23. *Eucalyptus largiflorens-Muehlenbeckia cunninghamii-Chenopodium nitrariaceum* Woodland

Layer	Height (m)	Cover (%)	Major species
Tree	12	30	*Eucalyptus largiflorens,* occasional *E. camaldulensis*
Tall shrub	6	15/0	*Acacia stenophylla,* sometimes forming dense stands but mostly absent
Mid shrub	1.3	25/0	*Muehlenbeckia cunninghamii, Chenopodium nitrariaceum,* sometimes absent
Low shrub	0.4	10/0	*Enchylaena tomentosa, Sclerolaena muricata, S. tricuspis,* or absent
Herb	0.1	25	**Hypochoeris glabra, *Critesion murinum, Einadia nutans, *Vulpia myuros, Danthonia caespitosa, Cotula australis, *Sonchus oleraceus, Solanum esuriale*

Number of plots: 19
Mean number of species per plot: 26.2 (range 6-43)
Mean number of weed species: 8.4 (32% of total)
Mean number of chenopod species: 4.4 (17% of total)
Eucalypt condition: 57% healthy, 32% unhealthy, 11% dead (n=228)
Eucalypt regeneration: 201 per ha (95 <4m, 106 >4m)
Grazing indices: rabbit 5.2, sheep 0.1, cattle 0.5, kangaroo 2.2

Distribution

Sections 4 (7 plots), 5 (10 plots) and 6 (2 plots east of the border). Lower, inner parts of the black box zone. Grey clay soils.

24. *Eucalyptus largiflorens-Muehlenbeckia cunninghami-Atriplex semibaccata* Woodland

Layer	Height (m)	Cover (%)	Major species
Tree	12	20	*Eucalyptus largiflorens,* occasional *E. camaldulensis*
Tall shrub	8	5/0	*Acacia stenophylla,* but mostly absent
Mid shrub	1.5	15	*Muehlenbeckia cunninghamii*
Low shrub	0.4	10	*Enchylaena tomentosa*
Herb	0.2	35	*Einadia nutans, Paspalidium jubiflorum, Atriplex semibaccata, *Sonchus oleraceus, *Critesion murinum, Senecio lautus, Sporobolus mitchellii, *Hypochoeris glabra*

Number of plots: 13
Mean number of species per plot: 21.6 (range 14-27)
Mean number of weed species: 7.8 (36% of total)
Mean number of chenopod species: 4.8 (22% of total)
Eucalypt condition: 74% healthy, 18% unhealthy, 8% dead (n=130)
Eucalypt regeneration: 6 per ha (4 <4m, 2 >4m)
Grazing indices: rabbit 11.5, sheep 0.6, cattle 0.4, kangaroo 0.7

Distribution

Sections 6 (5 plots, all in South Australia) and 7 (8 plots). Lower, inner parts of the black box zone. The South Australian equivalent of the *E. largiflorens-Muehlenbeckia cunninghamii-Chenopodium nitrariaceum* community.

25. *Eucalyptus largiflorens-Melaleuca lanceolata-Allocasuarina luehmannii* Woodland

Layer	Height (m)	Cover (%)	Major species
Tree	13	15	*Eucalyptus largiflorens*
Tall shrub	7	5	*Melaleuca lanceolata, Allocasuarina luehmannii, Hakea tephrosperma*
Low shrub	0.4	30	*Sclerolaena muricatus*
Herb	0.2	70	**Critesion murinum, *Vulpia myuros, *Schismus barbatus, Stipa nodosa, Danthonia caespitosa, Atriplex leptocarpa, Einadia nutans, *Sisymbrium erysimoides*

Number of plots: 2
Mean number of species per plot: 21 (range 20-22)
Mean number of weed species: 9.5 (45% of total)
Mean number of chenopod species: 3 (14% of total)
Eucalypt condition: 70% healthy, 30% unhealthy (n=20)
Eucalypt regeneration: none in plots
Grazing indices: rabbit 1.5, sheep 4.5, cattle 0.5, kangaroo 1

Distribution
Section 4. Reddish loam soils on high ground.

Notes
This community was once widespread in Section 4 (Smith *et al.* 1943) but has been extensively cleared.

26. *Eucalyptus largiflorens-Melaleuca lanceolata-Atriplex rhagodioides* Woodland

Layer	Height (m)	Cover (%)	Major species
Tree	9	10	*Eucalyptus largiflorens*
Tall shrub	7	50	*Melaleuca lanceolata*
Mid shrub	1.5	5	*Atriplex rhagodioides*
Low shrub	0.4	20	*Enchylaena tomentosa, Maireana brevifolia*
Herb	0.1	20	*Atriplex lindleyi, *Sonchus oleraceus, *Critesion murinum, Disphyma crassifolium, Einadia nutans, *Vulpia myuros, Crassula sieberiana, *Reichardia tingitana*

Number of plots: 3
Mean number of species per plot: 25.7 (range 24-28)
Mean number of weed species: 8.7 (34% of total)
Mean number of chenopod species: 7.7 (30% of total)
Eucalypt condition: 43% healthy, 57% unhealthy (n=30)
Eucalypt regeneration: none in plots
Grazing indices: rabbit 6, sheep 6, kangaroo 2.3

Distribution
Section 6 (all plots in South Australia). High ground, typically on reddish, rather sandy soils.

27. *Eucalyptus largiflorens-Atriplex nummularia* Open-woodland

Layer	Height (m)	Cover (%)	Major species
Tree	7	5/0	*Eucalyptus largiflorens* or absent
Shrub	1	15	*Atriplex nummularia, Rhagodia spinescens, Enchylaena tomentosa, Maireana pyramidata*
Herb	0.1	55	**Schismus barbatus, *Vulpia myuros, Atriplex lindleyi, *Medicago polymorpha, Brachycome lineariloba, *Critesion murinum, *Bromus rubens, Plantago drummondii*

Number of plots: 4
Mean number of species per plot: 32 (range 29-34)
Mean number of weed species: 10.3 (32% of total)
Mean number of chenopod species: 9.3 (29% of total)
Eucalypt condition: 70% healthy, 25% unhealthy, 5% dead (n=20)
Eucalypt regeneration: none in plots
Grazing indices: rabbit 3, sheep 6.8, cattle +, kangaroo +

Distribution
Sections 5 (one plot) and 6 (3 plots, all east of the border). Higher, outer parts of the floodplain.

28. *Eucalyptus largiflorens-Atriplex rhagodioides* Woodland

Layer	Height (m)	Cover (%)	Major species
Tree	8	15	*Eucalyptus largiflorens*
Shrub	1	30	*Atriplex rhagodioides, Enchylaena tomentosa,* some *Atriplex nummularia*
Herb	0.1	15	*Crassula colorata, Einadia nutans, Disphyma crassifolium, *Sonchus oleraceus, Actinobole uliginosum, Calotis hispidula, *Vulpia myuros, *Schismus barbatus*

Number of plots: 8 (plus 3 badly salt-affected plots not used for description or statistics)
Mean number of species per plot: 22.9 (range 7-36)
Mean number of weed species: 5.5 (24% of total)
Mean number of chenopod species: 5.5 (24% of total)
Eucalypt condition: 53% healthy, 34% unhealthy, 13% dead (n=85)
Eucalypt regeneration: 103 per ha (72 <4m, 31 >4m)
Grazing indices: rabbit 6.5, sheep 1, cattle +, kangaroo 0.9

Distribution
Section 6 (all plots in South Australia). Higher, outer parts of the floodplain. The South Australian equivalent of the *E. largiflorens-Atriplex nummularia* community.

29. *Chenopodium nitrariaceum-Muehlenbeckia cunninghamii* Shrubland

Layer	Height (m)	Cover (%)	Major species
Tall shrub	1.5	15	*Chenopodium nitrariaceum, Muehlenbeckia cunninghamii*
Low shrub	0.3	10	*Sclerolaena tricuspis*
Herb	0.1	40	*Sclerochlamys brachyptera, *Vulpia myuros, Brachycome lineariloba, Atriplex lindleyi, Calocephalus sonderi, *Bromus rubens, Atriplex leptocarpa, Einadia nutans*

Number of plots: 6
Mean number of species per plot: 30 (range 18-44)
Mean number of weed species: 7.3 (24% of total)
Mean number of chenopod species: 8.5 (28% of total)
Grazing indices: rabbit 20.2, sheep 4.2, cattle 0.2, kangaroo 1.8

Distribution
Sections 4 (not sampled), 5 (4 plots) and 6 (2 plots). Lower, inner parts of the black box zone, typically in association with the *E. largiflorens-Muehlenbeckia cunninghamii-Chenopodium nitrariaceum* community.

Notes
The dominant shrubs may be either *Chenopodium nitrariaceum* or *Muehlenbeckia cunninghamii* or a mixture of the two.

30. *Muehlenbeckia cunninghamii-Halosarcia pergranulata* Shrubland

Layer	Height (m)	Cover (%)	Major species
Tall shrub	1.6	20	*Muehlenbeckia cunninghamii,* some *Atriplex rhagodioides*
Low shrub	0.3	15	*Halosarcia pergranulata, H. indica, Sclerolaena tricuspis, Enchylaena tomentosa*
Herb	0.2	25	*Atriplex lindleyi, A. leptocarpa, Sporobolus mitchellii, Atriplex semibaccata, *Schismus barbatus, Einadia nutans, *Critesion murinum, *Spergularia rubra*

Number of plots: 6
Mean number of species per plot: 26.5 (range 9-36)
Mean number of weed species: 10.2 (38% of total)
Mean number of chenopod species: 7.3 (28% of total)
Grazing indices: rabbit 9.7, sheep 0.3, cattle +, kangaroo 0.3

Distribution
Sections 6 (4 plots, all in South Australia) and 7 (2 plots). The South Australian equivalent of the *Chenopodium nitrariaceum-Muehlenbeckia cunninghamii* community.

Notes
Although this appears to be a natural community of low-lying parts of the black box zone, some plots contained dead red gums and seemed to be the result of recent salinisation. These plots tended to have less *Muehlenbeckia* and more *Halosarcia.*

31. *Atriplex vesicaria-Pachycornia triandra* Shrubland

Layer	Height (m)	Cover (%)	Major species
Shrub	0.4	20	*Atriplex vesicaria, Pachycornia triandra, Sclerolaena tricuspis*
Herb	0.1	35	**Vulpia myuros, Disphyma crassifolium, Brachycome lineariloba, Bromus arenarius, Pogonolepis muelleriana, Actinobole uliginosum, Sclerochlamys brachyptera, Crassula colorata*

Number of plots: 5
Mean number of species per plot: 21.6 (range 17-26)
Mean number of weed species: 5.8 (27% of total)
Mean number of chenopod species: 5.4 (25% of total)
Grazing indices: rabbit 3.6, sheep 3.6, cattle +, kangaroo 1.2

Distribution

Sections 5 (one plot, far west) and 6 (4 plots). Higher, outer parts of the floodplain, typically in association with the *E. largiflorens-Atriplex nummularia* or *E. largiflorens-A. rhagodioides* communities. *Atriplex vesicaria* shrubland was once common also in Section 4 but overgrazing has led to its replacement by *Nitraria billardierei* shrubland (Smith *et al.* 1943; Beadle 1948). The latter, highly derivative community was not sampled during this survey.

Notes

Varies from pure *Atriplex vesicaria* to pure *Pachycornia triandra*, although usually a mixture. *Pachycornia*, an unpalatable samphire, is presumably favoured by higher salinity levels and heavy grazing.

32. *Halosarcia pergranulata-H. indica* Shrubland

Layer	Height (m)	Cover (%)	Major species
Shrub	0.2	35	*Halosarcia pergranulata, H. indica, Sclerolaena tricuspis*
Herb	0.1	10	*Disphyma crassifolium, Atriplex lindleyi, Senecio glossanthus, *Critesion murinum, *Parapholis incurva, *Cressa cretica, *Bromus rubens*

Number of plots: 5
Mean number of species per plot: 12 (range 4-29)
Mean number of weed species: 4.6 (38% of total)
Mean number of chenopod species: 4.4 (37% of total)
Grazing indices: rabbit 1.2, sheep +, cattle +

Distribution

Sections 4 to 8 but only sampled in Sections 6(2 plots) and 7 (3 plots). Highly saline areas, often with salt crusting on the surface. Occurs in both black box and red gum zones, typically in depressions or on the edges of wetlands.

Notes

All plots were formerly eucalypt communities, as indicated by dead trees and stumps. Although this community probably occurs naturally on the floodplain, the majority of occurrences are the result of salinity increases since settlement.

33. *Sporobolus mitchellii-Atriplex leptocarpa* Grassland

Layer	Height (m)	Cover (%)	Major species
Shrub	1	1	*Muehlenbeckia cunninghamii*
Tall herb	0.4	5	**Dittrichia graveolens, Cyperus gymnocaulos, *Lactuca saligna, *Cirsium vulgare, Sonchus hydrophilus, *Aster subulatus*
Herb	0.1	45	*Sporobolus mitchellii, Atriplex leptocarpa, *Spergularia rubra, Agrostis avenacea, *Sonchus oleraceus, Gnaphalium sphaericum, *Asphodelus fistulosus*

Number of plots: 2
Mean number of species per plot: 13.5 (range 11-16)
Mean number of weed species: 6.5 (48% of total)
Mean number of chenopod species: 2.5 (19% of total)
Grazing indices: sheep 31, cattle +, kangaroo +

Distribution:
Sections 6 (National Parks & Wildlife Service 1983; Ashwell 1987) and 7 (plots). *Sporobolus mitchellii* grasslands occur naturally in the black box zone but may also result from clearing or overgrazing.

RISES

34. *Eucalyptus microcarpa* Open-forest

Layer	Height (m)	Cover (%)	Major species
Tree	17	55	*Eucalyptus microcarpa*
Shrub	1.5	20/0	*Acacia acinacea* or absent
Herb	0.2	75	**Lolium perenneXrigidum, Carex inversa, *Trifolium campestre, *Bromus diandrus, *B. madritensis, *Trifolium striatum, Juncus flavidus, Einadia nutans*

Number of plots: 2
Mean number of species per plot: 37 (range 36-38)
Mean number of weed species: 21.5 (58% of total)
Mean number of chenopod species: 1 (3% of total)
Eucalypt condition: 75% healthy, 22% unhealthy, 3% dead (n=32)
Eucalypt regeneration: 625 per ha (225 <4m, 400 >4m)
Grazing indices: kangaroo 3.5

Distribution
Sections 2 (plots) and 3 (Chesterfield 1986). Rises within the floodplain but apparently above flood levels.

Notes
Historical evidence suggests this community once supported a much more diverse shrub layer, but *Acacia acinacea* is the only shrub species that remains common (Chesterfield 1986).

35. *Eucalyptus melliodora* Woodland

Layer	Height (m)	Cover (%)	Major species
Tree	18	30	*Eucalyptus melliodora,* occasional *E. camaldulensis* and *Allocasuarina luehmannii*
Herb	0.2	85	**Bromus diandrus, *B. hordeaceus, *Vulpia bromoides, *V._myuros, *Trifolium arvense, *T. campestre, Stipa nodosa, *Lolium perenneXrigidum*

Number of plots: 4
Mean number of species per plot: 32 (range 24-44)
Mean number of weed species: 18.8 (59% of total)
Mean number of chenopod species: 0.8 (3% of total)
Eucalypt condition: 100% healthy (n=40)
Eucalypt regeneration: 56 per ha (31 <4m, 25 > 4m)
Grazing indices: rabbit 15, cattle 2, kangaroo 1.5

Distribution
Sections 1 (1 plot) and 3 (3 plots). Rises within the floodplain but apparently above flood levels. Sandier soils than the *E. microcarpa* community.

36. *Callitris glaucophylla* Woodland

Layer	Height (m)	Cover (%)	Major species
Tree	13	20	*Callitris glaucophylla*
Shrub	1.3	30/0	*Calytrix tetragona* or absent
Herb	0.2	60	**Vulpia myuros, *Bromus rubens, *B. diandrus, *Pentaschistis airoides, *Echium plantagineum, *Trifolium arvense,*Schismus barbatus, *Hypochoeris glabra*

Number of plots: 3
Mean number of species per plot: 27.3 (range 18-33)
Mean number of weed species: 17 (62% of total)
Mean number of chenopod species: 1 (4% of total)
Callitris condition: 87% healthy, 3% unhealthy, 10% dead (n=30)
Callitris regeneration: 58 per ha (all <4m)
Grazing indices: rabbit 25, cattle 3, kangaroo 2.7

Distribution
Section 3. Rises within the floodplain but apparently above flood levels. Soils very sandy.

Notes
Callitris preissii may also occur in this community but was not encountered at the few sites sampled by us. The plots were all on relatively well vegetated sandridges. Many other sandridges now have only a thin herb layer and few, if any, trees. They are often badly eroded.

37. *Dodonaea viscosa-Callitris preissii* Shrubland

Layer	Height (m)	Cover (%)	Major species
Tree	8	10/0	*Callitris preissii,* but mostly absent
Shrub	2	20	*Dodonaea viscosa*
Herb	0.1	30	**Vulpia myuros, *Bromus rubens, *Hypochoeris glabra, *Pentaschistis airoides, Actinobole uliginosum, Danthonia caespitosa, Myriocephalus stuartii, *Schismus barbatus*

Number of plots: 3
Mean number of species per plot: 23.7 (range 16-28)
Mean number of weed species: 8.3 (35% of total)
Mean number of chenopod species: 1.3 (5% of total)
Grazing indices: rabbit 15, kangaroo 7.3

Distribution

Sections 5 (plots) and 6 (Ashwell 1987). Sandy rises within the floodplain but apparently above flood levels.

Notes

Callitris glaucophylla, Casuarina cristata and *Heterodendrum oleifolium* occur in some sites. The original dominants were probably *Callitris preissii, Hakea leucoptera, Eremophila longifolia* and *Heterodendrum oleifolium* (Zimmer 1937) but the most common shrub encountered nowadays is *Dodonaea viscosa* ssp. *angustissima*, a native 'woody weed.' Many dunes are badly eroded and often the only vegetation is a sparse herb layer. The heavy kangaroo grazing was a particular feature of two plots in Murray-Kulkyne State Park.

1.2 TWO-WAY CLASSIFICATION OF COMMUNITIES AND COMMON SPECIES

* introduced   O occasional   F frequent   A abundant

major division   minor division

Red Gum Zone

1. *E.c.-Eleocharis-Pseudoraphis*
2. *E.c.-Eleocharis-Wahlenbergia*
3. *E.c.-Poa-Agrostis*
4. *E.c.-Poa-Hemarthria*
5. *E.c.-Carex*
6. *E.c.-Paspalidium-Senecio*
7. *E.c.-Paspalidium-*Cynodon*
8. *E.c.-Cyperus*
9. *E.c.-Phragmites*
10. *E.c.-Danthonia*
11. *E.c.-E.largiflorens*
12. *E.c.-Muehlenbeckia*
13. *E.c.-*Bromus-*Vulpia*
14. *E.c.-*Bromus-Danthonia*
15. *E.c.-*Cynodon*
16. **Salix Xrubens*
17. **Salix babylonica*
18. *Callistemon-Muehlenbeckia*
19. *Agrostis-*Cynodon*
20. *Pseudoraphis-Eleocharis*
21. *Centipeda-Polygonum*

Black Box Zone

22. *E.l.-Eleocharis*
23. *E.l.-Muehlenbeckia-Chenopodium*
24. *E.l.-Muehlenbeckia-Atriplex*
25. *E.l.-Melaleuca-Allocasuarina*
26. *E.l.-Melaleuca-Atriplex*
27. *E.l.-Atriplex nummularia*
28. *E.l.-Atriplex rhagodioides*
29. *Chenopodium-Muehlenbeckia*
30. *Muehlenbeckia-Halosarcia*
31. *Atriplex-Pachycornia*
32. *Halosarcia* spp.
33. *Sporobolus-Atriplex*

Rises

34. *E. microcarpa*
35. *E. melliodora*
36. *Callitris glaucophylla*
37. *Dodonaea-Callitris*

SPECIES	COMMUNITY 36	35	34	16	4	#	14	13	3	10	6	5	2	22	1	20	21	#	7	8	9	#	#	25	29	23	33	30	24	26	18	12	37	28	31	27	#
Carex gaudichaudiana	-	-	-	O	-	-	-	O	O	-	-	-	-	-	F	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
C. tereticaulis	-	O	O	-	F	-	O	F	F	F	O	A	O	O	O	O	-	O	O	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
**Cyperus eragrostis*	-	-	-	O	F	O	-	F	F	O	O	O	-	-	O	-	O	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dichondra repens	-	-	-	-	O	-	-	O	F	O	O	O	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Juncus amabilis	-	-	-	-	F	O	-	F	F	-	O	O	F	-	O	-	-	O	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Persicaria prostrata	-	-	-	-	A	F	O	F	F	-	F	-	-	-	F	F	A	O	F	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
**Trifolium subterraneum*	-	-	-	O	F	-	-	F	F	O	O	O	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Eleocharis pusilla	-	-	O	-	O	-	-	O	F	F	F	F	F	F	-	-	-	O	-	-	-	-	-	-	-	O	-	-	-	-	-	-	-	-	-	-	-
Juncus flavidus	-	O	F	O	O	-	F	F	O	F	F	O	O	F	O	-	O	O	O	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
**Leontodon taraxacoides*	O	O	O	-	O	O	O	O	O	O	O	O	-	O	O	-	-	O	O	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
**Lolium rigidum*	-	O	-	-	O	-	-	O	O	O	O	O	-	F	-	-	-	-	-	-	-	-	-	O	-	-	-	-	-	-	-	-	-	-	-	-	-
**Lythrum hyssopifolium*	-	-	-	-	O	-	-	O	F	O	O	O	O	O	-	O	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Acacia dealbata	-	-	O	-	F	-	O	O	O	-	O	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
**Bromus catharticus*	-	-	O	-	O	-	O	O	O	-	O	-	-	-	O	-	-	-	-	-	-	O	O	-	-	-	-	-	-	-	-	-	-	-	-	-	-
**Bromus hordeaceus*	F	A	F	O	F	-	A	A	F	F	F	F	O	O	-	-	-	O	-	-	-	-	-	O	-	-	-	-	-	-	-	-	-	-	-	-	-
Callitris glaucophylla	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
**Carduus tenuiflorus*	F	F	F	-	F	-	-	O	O	-	O	O	O	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Carex inversa	-	-	F	O	F	-	O	F	F	F	F	O	O	F	-	-	-	O	O	-	-	-	-	-	-	O	-	-	-	-	-	-	-	-	-	-	-
**Chondrilla juncea*	F	F	F	-	O	O	-	O	O	O	O	-	-	-	-	-	O	O	O	-	-	-	-	-	-	O	-	-	-	-	-	-	-	-	-	-	-
**Critesion hystrix*	-	-	-	-	O	-	-	F	O	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Danthonia duttoniana	-	O	O	-	-	-	F	O	F	F	F	O	-	-	O	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Elymus scabrus	O	O	O	-	O	-	O	O	O	O	-	O	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Eucalyptus melliodora	-	A	-	-	-	-	-	O	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
E. microcarpa	-	-	A	-	-	-	O	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hemarthria uncinata	-	-	-	-	A	-	-	O	F	-	O	O	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
**Hypochoeris radicata*	-	O	-	F	A	F	O	A	F	F	O	F	-	-	O	-	O	-	O	-	-	O	-	-	-	-	-	-	-	O	-	-	-	-	-	-	-
**Paspalum dilatatum*	-	O	-	-	F	-	O	F	F	O	O	O	-	-	-	-	-	-	-	-	-	F	O	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Poa labillardieri	-	O	-	F	A	O	O	O	A	F	O	F	-	-	-	-	-	-	O	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

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SPECIES	COMMUNITY																																				
	36	35	34	16	4	#	14	13	3	10	6	5	2	22	1	20	21	#	7	8	9	#	#	25	29	23	33	30	24	26	18	12	37	28	31	27	#
*Salix Xrubens	-	-	-	A	-	-	-	O	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
*Trifolium angustifolium	O	O	F	O	O	-	O	F	F	O	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
*T. arvense	F	F	O	-	-	O	O	O	O	O	O	O	-	-	-	-	O	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
*T. campestre	O	F	F	O	F	F	O	F	F	F	O	F	-	-	-	-	-	-	O	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
*T. cernuum	O	O	O	-	O	O	-	O	O	O	O	O	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
*T. dubium	-	-	O	-	O	-	-	F	F	O	-	O	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
*T. glomeratum	F	F	F	O	F	O	F	F	F	F	F	F	-	O	-	-	O	O	O	-	-	F	-	-	-	O	-	-	-	-	-	-	-	-	-	-	-
*T. striatum	O	F	F	O	O	O	O	F	O	-	-	O	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
*T. tomentosum	O	F	F	-	O	-	O	O	-	-	O	O	O	-	-	-	O	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
*Vulpia bromoides	O	A	F	F	F	F	-	A	F	O	O	F	-	-	-	-	-	O	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
*Bromus madritensis	-	-	F	-	O	-	-	O	O	O	O	-	-	-	-	-	-	-	-	-	-	-	-	O	-	-	-	-	-	-	-	-	-	-	-	-	-
*Echium plantagineum	F	F	F	-	O	F	-	F	O	-	F	O	-	-	-	-	F	O	O	-	-	-	-	-	-	-	-	-	O	-	-	-	-	-	-	O	-
*Lolium perenneXrigidum	-	F	A	F	A	F	F	A	A	A	F	F	F	-	O	-	O	F	O	-	-	O	O	O	O	O	-	-	-	-	-	-	-	-	-	-	-
Rumex brownii	-	F	F	O	F	F	O	F	F	F	F	F	F	F	F	O	F	O	F	O	O	-	-	-	-	O	-	-	-	-	F	F	-	-	-	-	-
Alternanthera denticulata	-	-	-	-	O	F	-	O	F	O	F	O	-	O	A	F	F	O	F	-	-	-	O	-	-	O	-	-	-	-	-	-	-	-	-	-	-
Eragrostis elongata	-	O	-	-	-	F	O	-	O	-	O	-	-	-	-	-	-	-	O	-	-	-	-	-	-	-	-	-	-	-	-	O	-	-	-	-	-
*Phalaris spp.	-	-	-	-	F	-	F	O	O	F	F	O	-	O	O	-	O	O	O	-	-	-	-	-	-	O	-	-	-	-	-	-	-	-	-	-	-
Senecio quadridentatus	F	-	O	O	-	-	O	O	F	O	A	F	O	O	O	-	O	O	O	-	-	-	-	-	-	O	-	-	-	-	-	O	-	-	-	-	-
Centipeda minima	-	-	-	-	-	-	-	-	-	-	-	O	-	-	O	-	F	-	O	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
*Paspalum distichum	-	-	-	-	O	O	O	O	F	O	O	-	-	-	F	O	O	O	O	F	F	-	O	-	-	-	-	-	-	-	-	O	-	-	-	-	-
Pseudoraphis spinescens	-	-	-	-	-	O	-	-	F	-	O	O	-	-	A	A	O	O	O	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Triglochin procerum	-	-	-	-	-	-	-	O	O	O	O	-	O	O	F	-	-	-	-	-	-	O	F	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hydrocotyle sibthorpioides	-	-	-	O	O	-	-	O	F	-	O	O	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ranunculus inundatus	-	-	-	-	-	-	-	O	O	-	O	F	A	-	F	O	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Rumex crystallinus	-	-	-	-	O	-	-	O	-	-	-	-	-	O	-	O	F	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

	COMMUNITY																																				
SPECIES	36	35	34	16	4	#	14	13	3	10	6	5	2	22	1	20	21	#	7	8	9	#	#	25	29	23	33	30	24	26	18	12	37	28	31	27	#
Eleocharis acuta	-	-	-	-	-	-	-	O	F	O	F	F	A	A	A	A	O	-	F	-	-	O	-	-	-	O	-	-	-	-	-	-	-	-	-	-	-
Myriophyllum crispatum	-	-	-	-	-	-	O	-	O	O	O	F	F	-	F	O	O	O	O	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Persicaria hydropiper	-	-	-	-	-	-	-	O	O	-	-	-	-	-	O	A	O	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Rorippa eustylis & laciniata	-	-	-	-	-	-	-	-	O	O	O	F	F	-	O	O	O	-	O	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Stellaria sp. `C'	-	-	-	-	-	-	-	-	O	-	-	-	F	O	F	O	O	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
**Solanum nigrum*	-	-	-	-	O	-	O	O	O	-	O	O	-	-	O	-	O	O	O	O	-	O	-	-	-	-	-	-	O	-	-	O	-	-	-	-	-
Cyperus exaltatus	-	-	-	-	-	-	-	-	O	O	O	O	-	-	F	-	O	O	O	O	O	-	O	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Polygonum plebeium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	A	-	-	O	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Azolla filiculoides	-	-	-	-	-	-	O	O	-	-	-	-	O	O	O	-	-	-	O	-	O	O	F	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Crassula helmsii	-	-	-	-	-	-	-	-	-	-	-	-	-	-	O	-	-	-	-	-	-	O	F	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Gnaphalium involucratum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	O	F	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hydrocotyle verticillata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	F	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Juncus aridicola	-	-	-	-	-	-	-	-	-	-	-	-	-	-	O	-	O	-	O	O	O	F	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-
**Salix babylonica*	-	-	-	-	-	-	O	O	-	-	-	-	-	-	-	-	-	O	-	-	-	O	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Schoenoplectus validus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	O	F	O	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
**Rumex crispus*	-	-	-	O	F	-	-	O	O	-	-	-	-	-	-	-	-	-	O	-	O	F	O	-	-	-	-	-	-	-	-	-	-	-	-	-	-
**Anagallis arvensis*	-	-	-	-	-	-	O	O	O	-	O	O	-	O	O	-	-	O	O	-	-	O	-	-	O	O	-	-	-	-	-	-	-	-	-	-	-
Centipeda cunninghamii	-	-	-	-	O	F	O	O	F	O	F	F	F	F	A	A	A	O	F	F	-	-	O	-	O	O	-	-	-	-	-	-	-	-	-	-	-
Pratia concolor	-	-	-	-	-	-	-	O	O	O	O	F	O	-	-	-	-	O	O	O	-	O	F	-	-	O	-	-	-	-	-	O	-	-	-	-	-
**Aster subulatus*	-	-	-	O	O	O	-	-	F	O	O	F	O	O	O	O	O	O	F	F	F	F	A	-	-	-	F	O	-	-	-	O	-	-	-	-	-
Gnaphalium sphaericum	O	-	-	-	-	F	-	-	O	F	O	O	O	F	O	-	-	O	O	-	-	O	-	-	O	O	F	-	-	-	-	-	-	-	-	-	-

	COMMUNITY																																				
SPECIES	36	35	34	16	4	#	14	13	3	10	6	5	2	22	1	20	21	#	7	8	9	#	#	25	29	23	33	30	24	26	18	12	37	28	31	27	#
**Cirsium vulgare*	O	F	F	F	F	O	F	F	F	F	F	F	F	O	O	-	O	F	F	F	F	F	F	-	-	O	F	-	O	-	-	O	-	-	-	-	-
**Cynodon dactylon*	-	-	-	O	F	A	F	F	A	O	F	O	O	-	O	-	F	F	A	F	A	A	O	-	-	O	-	O	O	-	F	F	-	-	-	-	-
Eucalyptus camaldulensis	-	O	-	F	A	F	A	A	A	A	A	A	A	-	A	-	F	A	A	A	A	A	O	-	-	O	-	-	O	-	O	A	-	-	-	-	-
**Picris echioides*	-	-	-	O	-	-	O	O	O	-	O	-	F	F	-	-	-	O	O	-	-	F	F	-	-	O	-	-	O	-	-	-	-	-	-	-	-
**Bromus diandrus*	A	A	A	O	O	-	A	A	F	O	F	F	O	-	-	-	O	O	O	O	F	F	O	O	-	-	-	-	O	-	O	F	O	-	-	-	-
Eclipta platyglossa	-	-	-	-	-	O	O	O	F	O	F	F	-	-	O	-	O	F	F	F	O	O	O	-	-	O	-	-	O	-	-	O	-	-	-	-	-
Phragmites australis	-	-	-	F	-	-	O	O	O	-	O	-	-	-	O	-	-	O	O	A	A	O	F	-	-	-	-	-	-	-	-	O	-	-	-	-	O
Typha spp.	-	-	-	-	-	-	-	-	O	O	-	-	-	-	-	-	-	-	O	O	F	-	-	-	-	-	-	O	-	-	-	-	-	-	-	-	-
Epaltes australis	-	-	-	-	-	-	-	-	-	-	O	-	-	-	O	-	O	O	F	F	-	-	O	-	-	-	-	-	O	-	-	-	-	-	-	-	-
Pseudognaphalium luteo-album	-	-	-	-	O	O	F	-	F	O	F	O	O	-	O	-	F	O	F	F	-	F	O	-	O	O	-	-	O	-	-	O	O	O	-	-	-
Agrostis avenacea	-	-	-	F	F	A	F	F	A	F	F	F	A	A	F	F	F	F	F	F	O	F	F	-	F	O	F	O	O	O	-	O	-	O	O	O	-
**Avena barbata*	-	O	-	O	-	-	F	F	O	O	F	O	-	-	-	-	-	-	O	O	O	F	-	O	-	-	-	-	O	-	F	O	-	-	-	-	-
**Conyza bonariensis*	-	-	-	F	F	O	O	O	F	O	O	O	O	-	O	-	O	O	F	F	-	O	O	-	-	O	-	F	O	-	-	F	-	-	-	-	-
Euphorbia drummondii	-	O	-	-	-	-	O	O	O	F	F	O	F	-	O	-	O	F	F	F	-	-	-	-	-	F	-	O	O	-	-	O	-	-	-	-	-
**Lactuca serriola*	O	O	O	O	O	-	F	O	F	F	F	F	O	F	O	-	O	F	F	F	O	-	O	-	O	O	-	O	O	-	F	O	-	F	-	O	-
Paspalidium jubiflorum	-	-	-	-	F	O	F	O	F	O	A	F	O	-	F	-	O	F	A	F	F	O	O	O	-	O	-	O	A	-	-	A	-	-	-	-	-
Wahlenbergia fluminalis	-	-	O	O	O	O	O	F	F	A	A	A	F	-	O	-	O	F	A	F	O	O	O	-	O	O	O	-	O	-	O	F	-	-	-	-	-
**Marrubium vulgare*	-	O	-	-	-	-	O	O	-	-	O	-	-	-	-	-	-	O	O	O	-	O	-	O	-	O	-	-	-	-	O	-	-	-	-	-	-
Amyema miquelii	-	-	-	-	O	-	-	O	O	O	O	O	O	-	O	-	-	-	O	-	-	-	-	-	-	F	-	-	O	O	-	O	O	-	-	-	-
Brachycome basaltica	-	-	O	-	-	-	-	-	O	O	O	F	-	O	O	-	-	O	O	O	-	-	-	-	O	O	-	-	O	-	-	O	-	-	-	-	-
Marsilea drummondii	-	-	-	-	O	-	-	-	O	O	O	F	O	F	-	-	-	O	O	-	-	-	-	O	O	O	-	-	O	-	-	O	-	-	-	-	-

RMCTAB.XLS

	COMMUNITY																																				
SPECIES	36	35	34	16	4	#	14	13	3	10	6	5	2	22	1	20	21	#	7	8	9	#	#	25	29	23	33	30	24	26	18	12	37	28	31	27	#
Oxalis perennans	F	F	F	O	F	-	O	F	F	F	F	F	O	-	O	-	-	F	O	-	-	-	-	F	F	F	-	-	-	-	-	-	-	O	-	-	-
**Sonchus asper*	-	O	F	-	F	F	F	F	F	O	F	F	F	F	-	-	F	F	O	-	-	-	-	-	O	O	-	-	-	-	-	O	-	-	-	O	-
**Pentaschistis airoides*	F	F	-	-	-	O	-	O	O	-	O	-	-	-	-	-	-	-	O	-	-	-	-	-	-	O	-	-	-	-	-	-	F	-	-	O	-
Morgania floribunda	-	-	-	-	-	-	-	-	-	-	-	-	-	-	O	-	-	O	F	F	-	O	-	-	-	O	-	F	-	-	-	O	-	-	-	-	-
**Taraxacum spp.*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	O	-	-	F	F	-	-	-	-	-	-	-	-	O	-	-	-	-	-
**Xanthium californicum*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	F	-	O	F	O	-	-	-	-	-	O	-	-	O	-	-	-	-	-
Cyperus gymnocaulos	-	-	-	-	-	-	O	-	-	-	O	-	-	-	O	-	-	-	F	A	A	A	O	-	-	-	F	O	O	-	A	F	-	-	-	-	-
Picris squarrosa	-	-	-	-	-	-	-	-	-	-	O	O	-	-	-	-	-	-	F	F	F	F	O	-	-	-	-	O	O	-	F	F	-	-	-	-	-
Sonchus hydrophilus	-	-	-	-	-	-	O	-	O	-	-	O	O	-	-	-	O	-	F	F	F	F	F	-	-	-	F	F	O	-	-	F	-	-	-	-	-
Asperula gemella	-	-	-	-	-	-	-	-	-	-	O	-	-	-	-	-	-	-	O	O	F	F	F	-	-	O	-	-	-	-	-	O	-	-	-	-	-
**Urospermum picroides*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	O	O	O	O	F	-	-	-	O	-	O	O	-	-	O	O	-	-	-	-
Vittadinia cuneata	-	-	-	-	-	-	O	-	-	O	O	-	-	-	-	-	-	O	O	F	O	O	-	-	-	O	-	-	O	-	F	F	-	O	-	-	-
**Euphorbia terracina*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	O	O	O	F	O	-	-	-	-	-	O	-	F	O	-	-	-	-	-
Haloragis aspera	-	-	-	-	-	-	O	O	-	O	O	-	-	-	-	-	-	F	O	O	-	-	O	-	-	O	-	-	O	-	-	O	-	-	-	-	-
**Phyla nodiflora*	-	-	-	-	-	-	F	-	O	-	O	O	O	-	O	-	-	-	O	O	-	O	-	-	-	O	-	-	O	-	-	F	O	-	-	-	-
Senecio runcinifolius	-	-	-	-	-	-	-	-	O	-	O	O	O	-	-	-	O	O	F	O	-	O	-	-	O	O	-	O	O	-	-	O	-	-	-	-	-
**Sonchus oleraceus*	-	F	F	O	O	F	F	F	F	F	F	F	F	F	O	-	O	A	F	F	O	F	F	-	F	F	F	F	F	A	F	F	-	F	O	F	O
Cotula australis	-	-	-	O	O	-	-	-	O	O	O	-	O	O	-	-	O	O	O	-	-	F	-	-	O	F	-	F	O	O	-	O	-	-	-	O	-
**Hypochoeris glabra*	F	O	F	-	-	O	F	O	O	F	A	A	F	O	-	-	F	A	F	F	O	O	-	-	F	A	-	F	F	O	A	A	A	F	-	F	-

	COMMUNITY																																				
SPECIES	36	35	34	16	4	#	14	13	3	10	6	5	2	22	1	20	21	#	7	8	9	#	#	25	29	23	33	30	24	26	18	12	37	28	31	27	#
Bromus rubens	A	F	-	-	-	-	F	O	O	O	O	-	O	-	-	-	F	A	F	F	O	O	-	-	F	A	-	F	F	O	A	A	A	F	-	F	-
Critesion murinum	O	O	F	O	O	-	F	F	O	F	F	O	O	-	-	-	O	O	O	O	O	F	O	A	F	A	O	F	F	A	O	F	-	F	F	F	F
Medicago polymorpha	-	O	-	-	-	-	F	O	O	O	O	O	O	-	-	-	F	O	O	O	-	F	O	F	F	O	O	O	O	-	O	-	-	O	O	F	O
Stipa scabra group	F	F	O	-	-	-	O	O	-	O	O	-	-	-	-	-	-	O	O	-	-	O	-	F	-	O	-	O	O	O	F	F	F	F	O	F	-
Danthonia caespitosa	F	F	F	-	O	-	A	F	O	A	F	O	-	-	-	-	-	F	O	-	-	O	-	F	F	F	-	O	-	-	-	O	F	F	F	O	-
Vulpia myuros	A	F	F	O	O	F	F	F	O	F	F	O	O	-	-	-	F	A	F	-	-	O	-	A	A	F	-	O	O	F	-	O	A	F	A	A	O
Atriplex lindleyi	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	O	-	-	O	-	-	F	O	-	A	F	A	-	O	-	O	F	A	A
Brachycome lineariloba	-	-	-	-	-	-	-	-	-	O	-	-	-	-	-	-	-	O	O	-	-	O	-	-	A	O	-	-	O	F	-	O	-	F	A	F	O
Calotis hispidula	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	O	O	-	-	-	-	-	O	O	-	O	-	-	-	O	-	F	O	O	-
Plantago annuals	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	O	O	-	O	-	-	-	F	O	-	-	O	-	-	O	-	O	F	F	-
Spergularia rubra	-	-	-	-	-	-	-	-	-	F	O	-	-	-	-	-	-	-	O	O	-	O	-	-	O	F	F	F	O	-	-	O	-	-	O	O	O
Wahlenbergia tumidifructa	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	O	-	-	-	-	-	O	O	-	-	O	O	-	-	O	F	O	-	-
Actinobole uliginosum	F	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	O	-	-	-	-	F	F	F	-	-
Atriplex nummularia	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	O	-	-	-	O	-	-	-	O	-	A	-
A. rhagodioides	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	O	-	F	O	F	O	O	-	A	O	O	-
A. vesicaria	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	O	A	O	-
Bromus arenarius	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	O	-	-	-	-	-	-	-	-	-	F	O	O
Bulbine semibarbata	-	-	-	-	-	-	-	-	-	-	O	-	-	-	-	-	-	-	O	-	-	-	-	-	O	O	-	-	O	-	-	O	-	F	-	O	-
Calandrinia eremaea	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	O	-	-	O	O	-	O	O	F	O	O	O
Crassula colorata	O	-	-	-	-	-	-	-	-	-	-	-	O	-	-	-	O	-	O	-	-	-	-	-	O	O	-	O	O	O	-	-	O	A	F	F	-
**Cressa cretica*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	F	-	-	-	O	-	-	-	-	-	-	-	F
Disphyma crassifolium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	O	-	-	-	-	-	F	O	-	F	O	F	-	-	-	A	A	F	A
Halosarçia indica	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	O	-	-	-	-	-	F	-	-	-	-	-	O	-	-	F
H. pergranulata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	O	-	-	-	-	O	-	-	F	O	O	-	-	-	-	-	-	A
**Mesembryanthemum nodiflorum*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	O	-	-	O	O	-	-	-	-	O	O	-	O

Cont.

	COMMUNITY																																				
SPECIES	**36**	**35**	**34**	**16**	**4**	**#**	**14**	**13**	**3**	**10**	**6**	**5**	**2**	**22**	**1**	**20**	**21**	**#**	**7**	**8**	**9**	**#**	**#**	**25**	**29**	**23**	**33**	**30**	**24**	**26**	**18**	**12**	**37**	**28**	**31**	**27**	**#**
Pachycornia triandra	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	O	A	O	O
Pogonolepis muelleriana	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	F	-	-	-	-	O	-	O	-	F	F	O	-
Sclerochlamys brachyptera	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	O	O	-	-	-	-	-	A	O	-	O	O	O	-	-	-	O	F	F	-
Sclerolaena tricuspis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	A	F	-	F	O	O	-	-	-	F	F	O	F
Senecio glossanthus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	O	-	-	-	-	-	F	O	-	O	F	-	-	O	-	F	F	F	F
Tetragonia tetragonioides	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	O	O	-	-	O	O	-	-	-	O	O	F	O
Wahlenbergia gracilenta	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	O	O	-	-	-	-	-	-	O	F	O	O	-
Allocasuarina luehmannii	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	A	-	-	-	-	-	-	-	-	-	-	-	-	-
Chenopodium nitrariaceum	-	-	-	-	-	-	O	-	-	-	-	-	-	-	-	-	-	O	O	-	-	-	-	-	A	A	-	-	O	-	-	O	-	-	-	O	-
Sclerolaena muricata	-	-	-	-	-	-	O	-	-	-	-	-	-	-	-	-	-	O	O	-	-	-	-	A	-	F	-	O	O	-	-	-	-	-	O	-	-
Melaleuca lanceolata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	A	-	-	-	-	-	A	-	-	-	-	-	-	-
**Brassica tournefortii*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	O	-	-	O	-	-	-	O	-	O	O	O	F	O	O	O	-	-	O
Callistemon brachyandrus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	O	-	-	-	-	-	-	-	-	-	A	-	-	-	-	-	-
Dodonaea viscosa	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	O	-	-	-	-	-	-	-	-	O	-	-	-	A	-	-	-	-
**Silene spp.*	-	-	-	-	-	-	-	-	-	-	-	-	O	-	-	-	-	-	-	-	O	O	-	-	O	O	-	-	O	O	O	O	O	O	-	O	O
Atriplex leptocarpa	-	-	-	-	-	-	-	-	-	-	O	-	-	-	-	-	-	O	O	O	-	O	-	F	F	F	A	A	F	F	-	O	-	-	-	-	-
Maireana brevifolia	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	O	-	-	-	-	-	-	-	O	O	O	F	F	-	-	-	-	-	-
Teucrium racemosum	-	-	-	-	-	-	-	-	-	-	O	-	-	-	-	-	-	O	O	O	-	O	-	-	O	O	-	-	O	-	O	O	O	O	-	-	-
Daucus glochidiatus	-	-	O	-	-	-	-	-	-	-	O	O	-	-	-	-	-	O	O	-	-	-	-	-	O	O	-	O	-	-	-	O	-	F	-	O	-
Rhagodia spinescens	-	-	-	-	-	-	O	-	-	-	O	-	-	-	-	-	-	O	O	-	-	-	-	-	O	O	-	-	-	-	-	O	O	O	O	F	O
**Schismus barbatus*	F	-	-	O	-	-	O	-	O	-	O	O	-	-	-	-	-	O	O	-	-	-	-	F	-	O	-	F	O	F	-	-	F	F	O	A	O
**Sisymbrium erysimoides*	-	-	-	-	-	-	-	O	-	O	O	-	-	-	-	-	O	O	O	-	O	O	-	F	O	O	-	-	O	O	-	-	-	O	-	O	O

	COMMUNITY																																			
SPECIES	36	35	34	16	4	#	14	13	3	10	6	5	2	22	1	20	21	#	7	8	9	#	#	25	29	23	33	30	24	26	18	12	37	28	31	27	#
Crassula sieberiana	-	-	-	-	-	F	-	-	-	O	O	-	-	-	-	-	O	O	O	-	O	O	-	-	-	O	-	O	F	F	O	O	F	-	-	-	O
Einadia nutans	F	F	F	-	-	-	O	-	-	F	O	O	-	-	-	-	-	F	O	O	-	F	-	F	F	A	-	F	A	F	F	F	O	A	-	O	O
Eucalyptus largiflorens	-	-	-	-	-	-	O	-	-	-	O	O	-	A	O	-	-	F	O	-	-	-	O	A	-	A	-	-	A	A	-	O	O	A	-	A	-
**Lepidium africanum*	-	-	-	-	-	-	O	O	-	O	-	O	O	-	-	-	O	-	O	O	-	F	O	O	O	O	O	F	O	O	O	O	-	-	O	-	O
**Medicago minima*	-	O	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	O	O	-	-	O	O	-	-	O	-	O	O	O	O	O	O	F	-	-	-
**Lamarckia aurea*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	O	O	-	-	-	O	O	O	-	O	O	-	-	-	-	O	O	O	-
Muehlenbeckia cunninghamii	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	F	O	F	F	F	-	-	A	A	O	A	A	-	A	A	-	-	-	-	-
Senecio lautus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	O	F	O	O	-	-	O	O	-	F	F	O	O	F	-	F	-	-	O
Calocephalus sonderi	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	O	O	-	-	-	-	-	F	O	-	-	O	-	-	-	-	-	O	-	-
Vittadinia dissecta	-	-	-	-	-	-	-	-	-	-	-	-	O	-	-	-	-	F	O	O	-	-	-	-	-	O	-	-	-	-	-	F	F	O	-	-	-
Acacia stenophylla	-	-	-	-	-	-	-	-	-	-	O	-	-	-	O	-	-	-	O	O	-	-	O	-	-	O	-	-	O	-	-	F	-	-	-	-	-
Sporobolus mitchellii	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	O	A	-	O	O	-	O	O	A	A	F	-	-	O	-	-	-	-	-
Atriplex semibaccata & suberecta	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	O	O	O	-	F	-	-	O	O	-	F	F	O	O	O	-	-	-	-	-
Enchylaena tomentosa	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	O	O	F	O	F	-	-	F	F	-	F	F	A	A	F	F	F	-	F	O
**Reichardia tingitana*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	O	-	F	F	O	F	O	-	-	O	O	F	F	F	F	F	-	F	O	F	O

APPENDIX 2. DESCRIPTIONS OF STRUCTURAL VEGETATION CLASSES

TREES

1. Red Gum Forest
2. Red Gum Woodland
3. Red Gum/Box Forest & Woodland
4. Mixed Box Woodland
5. Black Box Woodland
6. Black Box (mallee form)
7. Cypress Pine/ Casuarina Woodland
8. River Cooba
9. Mallee Fringe Woodland
10. Mallee

SHRUBS GRASSES HERBS

11. Lignum
12. Saline Shrubland
13. Open Areas

NON-NATIVE VEGETATION

14. Exotic Trees and Shrubs
15. Cultivated pasture and cropping
16. Orchards and vineyards

NON-VEGETATED AREAS

17. Urban
18. Quarries and sand-pits
19. Sand Dunes
20. Water bodies

TREES

1. Red Gum Forest

Height : 15-45 m
Density: >20%

Dominant Structural Species:	Sections:
Eucalyptus camaldulensis (River Red Gum)	1-8
Eucalyptus blakelyi (Forest Red Gum)	1-2

This class comprises the tallest and densest forests along the river. It occupies the low lying and most frequently flooded sites. In Sections 6, 7 and 8 it generally occurs downstream of the meander. It is often the first affected by subsequent locking and water-logging. *E. blakelyi* normally occurs on slightly higher ground adjacent to *E. camaldulensis.*

2. Red Gum Woodland

Height : 10-25m
Density : <25%

Dominant Structural Species:	Sections:
Eucalyptus camaldulensis (River Red Gum)	1-8
Eucalyptus blakelyi (Forest Red Gum)	1-2

Characterised by lower canopy density than Red Gum Forest. The lower density has resulted from its location on slightly higher, less well watered sites, or from thinning through logging or clearing.

In Sections 6, 7 and 8 the larger understorey species comprise *Acacia stenophylla* (River Cooba) and *Muehlenbeckia cunninghamii* (Lignum) sometimes indicating an ecotone to

Eucalyptus largiflorens (Black Box). In these Sections the class is normally located on the upper part of the levee grading back to the centre of the meander.

3. Red Gum/Box Forest and Woodland

Height : 12-20m
Density : <35%
Dominant Structural Species:

	Sections:
Eucalyptus camaldulensis (River Red Gum)	1-7
Eucalyptus blakelyi (Forest Red Gum)	1-2
Eucalyptus microcarpa (Grey Box)	1-4
Eucalyptus melliodora (Yellow Box)	1-4
Eucalyptus largiflorens (Black Box)	3-7
Eucalyptus albens (White Box)	1

Occurs as a transitional or ecotonal class between pure Red Gum stands and pure Box stands. The thorough mix of Red Gum and Box species on the one site has precluded the mapping of homogeneous individual classes.

E.microcarpa and *E. melliodora* occur on similar sites. These sites are characterised by sandier soils on rises within the floodplain usually above frequent flooding levels. These two species may occur together on the same site as *E. camaldulensis* in Sections 1 to 3. *E. largiflorens* may occur as an additional species in Section 4 or may occur in the absence of *E. melliodora.*

E. albens occurs occasionally around Albury on higher ground fringing *E. camaldulensis* or *E. blakelyi.*

4. Mixed Box Woodland

Height : 12-18m
Density : 1-50%
Dominant Structural Species:

	Sections:
Eucalyptus microcarpa (Grey Box)	1-4
Eucalyptus melliodora (Yellow Box)	1-4
Eucalyptus largiflorens (Black Box)	3-5
Eucalyptus albens (White Box)	1
Eucalyptus polyanthemos (Red Box)	1

The two dominant Box groups along the river are *E. microcarpa/E. melliodora* and *E. largiflorens*. Floristically and ecologically *E. microcarpa* and *E. melliodora* occupy similar niches while *E. largiflorens* is quite distinct. All three species can occur in large, pure stands or in mixtures. Structurally it was very difficult to separate the three species using aerial photo interpretation despite the desirability of doing so, hence the creation of the mixed class.

However, generalisations can be made regarding species separation: *E. microcarpa* and *E. melliodora* are confined to Sections 1-4, apart from a few individual stems that may be found scattered in bends throughout Section 4 as far downstream as Buchanan's Bend. There is some evidence to suggest that these specimens may be more closely related to *Eucalyptus moluccana* (also known as Grey Box), a species otherwise confined to the coastal areas of New South Wales and southern Queensland. *E. microcarpa* and *E. melliodora* occur in large stands on the upstream end of Gunbower Island and throughout the higher parts of the Millewa forests. They are little known downstream of Gunbower Island on the Murray River or downstream of the junction of Wakool River and Edward River. *E. melliodora* mainly occurs west of the Cadell Fault on the higher, sandier rises fringing the floodplain. Along the Edward, Wakool and Neimur Rivers the two species rarely occur in pure stands and generally occur in the bends as scattered trees with *E. camaldulensis* (Class 3).

E. largiflorens predominantly occurs west of the Cadell fault. It occupies the upper flood plain typically on the edge of the *E. camaldulensis* stands on sites that rarely flood. It can occur in extensive mixtures with *E. microcarpa* throughout parts of Gunbower, Pericoota and Koondrook forests

E. albens and *E. polyanthemos* can occur as scattered individuals on higher ground in Section 1 fringing *E. microcarpa* and *E. melliodora* stands.

5. Black Box Woodland

Height : 10-14m
Density : 10-30%

Dominant Structural Species:	Sections:
Eucalyptus largiflorens (Black Box)	3-8

The most upstream occurrence of *E. largiflorens* is found on the southern fringe of Barmah forest where several small stands occur. However it is to the west of the Cadell fault that *E. largiflorens* becomes a common and widespread structural vegetation class.

It generally occurs on slightly higher sites than *E. camaldulensis* and is rarely subject to flooding. *Muehlenbeckia cunninghamii* (Lignum) is a common understorey associate.

6. Black Box (mallee form)

Height : < 8m
Density : 5-30%

Dominant Structural Species:	Sections:
Eucalyptus largiflorens (Black Box)	5-8

A low branching form of *E. largiflorens* generally occurring on the drier sites of the undissected floodplain. The multi-stemmed mallee form is due to the combination of the coppicing effect caused by cutting, and dry soils caused by low flooding frequency.

7. Cypress Pine/Casuarina Woodland

Height : 10-15m
Density : 1-20%

Dominant Structural Species:	Sections:
Callitris preissii (Murray Cypress Pine)	4-7
Callitris glaucophylla (White Cypress Pine)	2-6
Callitris verrucosa (Scrubs Cypress Pine)	4-7
Casuarina cristata (Belah)	4-7
Allocasuarina luehmannii (Buloke)	4-6

Most frequently found in Sections 5 and 6 on well drained, sandy or sandy/clay rises above flood levels, sometimes inside the flood plain. It is not a riparian class. Fires, cutting and grazing have frequently reduced these stands to depauperate remnants.

8. River Cooba

Height : 10-15m
Density : 1-20%

Dominant Structural Species:	Sections:
Acacia stenophylla (River Cooba)	4-7

Infrequently occurs in pure stands, however is more likely to be found as an understorey component to *E. camaldulensis* or *E. largiflorens* in Sections 5 to 7.

9. Mallee Fringe Woodland

Height : 10-15m
Density : -1-20%

Dominant Structural Species:	Sections:
Eucalyptus oleosa (Oil Mallee)	4-7
Eucalyptus socialis (Grey Mallee)	4-7
Eucalyptus gracilis (White Mallee)	4-7
Eucalyptus dumosa (Dumosa Mallee)	4-7
Eucalyptus incrassata (Yellow Mallee)	4-7
Eucalyptus foecunda (Narrow leaved Red Mallee)	5-7
Casuarina cristata (Belah)	5-7
Heterodendron oleifolium (Cattlebush)	5-7
Myoporum platycarpum (Sugarwood)	5-7
Dodonaea viscosa (Akeake)	5-7
Geijera parviflora (Wilga)	5
Callitris verrucosa (Scrub Cypress Pine)	5
Callitris preissii (White Cypress Pine)	4-7

This class represents a transition from the sandy rises inside the floodplain that once carried *Callistris* sp. and *Casuarina* sp. to the Mallee eucalypt classes on the high sandy terraces outside the floodplain.

The class reflects a range of man-induced disturbance from clearing and grazing to partial cultivating and, like class 7 (Cypress Pine/Casuarina Woodland), is a most depauperate class. This is not a riparian class as it is never flooded.

10. Mallee

Height : < 10m
Density : -10-30%

Dominant Structural Species:	Sections:
Eucalyptus oleosa (Oil Mallee)	4-7
Eucalyptus socialis (Grey Mallee)	4-7
Eucalyptus gracilis (White Mallee)	4-7
Eucalyptus dumosa (Dumosa Mallee)	4-7
Eucalyptus incrassata (Yellow Mallee)	4-7
Eucalyptus foecunda (Narrow leaved Red Mallee)	5-7

While this is not a riparian class it was mapped to clearly indicate the outer edge of the floodplain.

SHRUBS, GRASSES AND HERBS

11. Lignum

Height : < 10m
Density : -10-30%

Dominant Structural Species:	Sections:
Muehlenbeckia cunninghamii (Lignum)	4-8

Tends to occur in depressions, swamps and an areas occassionally flooded. Can form quite extensive pure classes or in association with *Acacia stenophylla*. Is sometimes an understorey associate of *E. largiflorens*.

12. Saline Shrubland

Height : < 10m
Density : -10-30%

Dominant Structural Species:	(Group)	Sections:
Halosarcia Spp. (Samphires)	(1) 5-6	
Pachycornia triandra	(1)	5-6
Atriplex nummularia (Old-man Saltbush)	(2)	5-6
Atriplex vesicaria (Bladder Saltbush)	(2)	4-6
Chenopodium nitrariaceum (Nitre Goosefoot)	(2)	5-7
Enchylaena tomentosa (Ruby Saltbush)	(2)	5-7
Sclerostegia tenuis (Slender Glasswort)	(2)	5-6
Maireana pyramidata (Black Bluebush)	(3)	5-6

This class represents a range of saline sites, from naturally occurring alkaline soils to sites becoming increasingly saline through rising water-tables and irrigation drainage.

In general the species represent decreasingly saline sites from Groups 1 to 3 above. Saline depressions are characterised by Group 1 while trees and depressions are represented by Groups 2 and 3.

13. Open Areas

Height : < 0.2m
Density : variable

Dominant Structural Species:	Sections:
Pseudoraphis spinescens (Moira Grass)	2-7
Paspalum distichum (River Couch)	4-6
Sporobolus mitchellii (Short Rat-tail Grass)	4-6
Disphyma crassifolium (Pig-face)	5-7

This is a broad category that loosely brings together all areas that are devoid of trees and woody shrubs and that are largely uncultivated. They include naturally tree-less areas and areas that have long been cleared and abandoned. The class occurs in all eight Sections of the study.

In South Australia these areas have been further sub-divided to form separate flood-plain, depression and levee classes representing local geomorphology. These ''land-units'' have not been shown as separate classes on the maps but are present in the data-base for use by land managers.

NON-NATIVE VEGETATION

14. Exotic Trees and Shrubs

Height : 5-25m
Density : -10-30%

Dominant Structural Species:	Sections:
Salix babylonica (Weeping Willow)	1-8
Salix Xrubens (Willow)	1-3
Populus sp. (Poplars)	1-3
Pinus sp. (Pines)	1-3
Schinus areira(Pepper Trees)	1-3
Various amenity plantings	1-8

This diverse class comprises exotic trees and shrubs that are growing wild (*Salix* sp. and *Schinus areira*) or have resulted from planting programs (*Populus* sp., *Pinus* sp., and amenity plantings).

The Willows are scattered along the length of the Murray River becoming more prominent down-stream. In Sections 6-8 Willows were initially planted to encourage bank stabilisation following the construction of locks.

The Poplar and Pine plantations were established by private companies and state government departments for commercial wood production. The amenity plantings occur along roads and around towns.

15. Cultivated Pasture and Cropping (irrigated and non-irrigated)

This class includes irrigated and non-irrigated areas both within and adjacent to the floodplain. Around Deniliquin irrigation is important for rice growing while from Remark downstream irrigation is episodic. Irrigation is commonly performed by broad area flooding.

16. Orchards and Vineyards (irrigated)

This class is common in Sections 4 to 7. The most common form of irrigation is by low-throw sprinklers. The older and more wasteful techniques of overhead sprinklers and broad area flooding are slowly being phased out.

Classes 15 and 16 are subject to change as land use practice varies. For this reason less emphasis has been placed on the identification of these sites than was given to the classes representing native vegetation.

NON-VEGETATED AREAS

17. Urban

This class is characterised by the dominance of buildings although it also includes semi-urban areas of gardens, golf courses and hobby farms.

18. Quarries and Sand-pits

A small class found mainly in Sections 1-4.

19. Sand Dunes

This class characterises an absence of vegetation on sandy sites. This may be a natural occurrence such as point bars along the river and lunettes fringing dry lakes, or it may result from sheet erosion or dune blowouts.

20. Water Bodies

Includes all rivers, some streams, permanent and semi-permanent water bodies.

APPENDIX 3. SPECIES LIST

Nomenclature chiefly follows Jessop & Toelken (1986). Species not found in South Australia and *Callitris* and *Critesion*/*Hordeum* follow Forbes & Ross (1988); *Polygonum* s.l. follows Wilson (1988).

* introduced O occasional F frequent A abundant

(+) additional records from Muir (1972), National Parks & Wildlife Service (1983), Chesterfield *et al.* (1984), Ashwell (1987), D Parkes (pers. comm.) and Appendix 4.

Species	Vegetation zone			River section							
	RedGm	BlkBx	Rises	1	2	3	4	5	6	7	8
FERNS											
Adiantaceae											
Cheilanthes austrotenuifolia (+)				-	-	O	-	-	-	-	-
Azollaceae											
Azolla filiculoides	F	O	-	O	O	O	O	-	O	O	F
A. pinnata	O	-	-	-	O	-	-	-	-	-	-
Dennstaedtiaceae											
Histiopteris incisa (+)				-	-	O	-	-	-	-	-
Pteridium esculentum	-	-	O	-	O	O	-	-	-	-	-
Marsileaceae											
Marsilea drummondii	O	O	-	-	O	O	O	O	O	O	-
M. hirsuta (+)	-	O	-	-	-	-	-	O	-	-	-
M. sp. aff. *angustifolia*	O	O	-	-	-	O	O	-	-	-	-
Ophioglossaceae											
Ophioglossum lusitanicum (+)				-	-	O	-	-	-	-	-
GYMNOSPERMS											
Cupressaceae											
Callitris glaucophylla	-	-	F	-	-	F	-	-	O	-	-
C. preissii	-	-	O	-	-	-	-	O	-	-	-
DICOTYLEDONS											
Aizoaceae											
Carpobrotus modestus	-	O	-	-	-	-	-	-	O	-	-
Disphyma crassifolium	O	A	-	-	-	-	-	O	A	O	-
**Glinus lotoides*	O	-	-	-	O	-	O	O	O	-	-
**G. oppositifolius* (+)				-	-	O	-	-	-	-	-
**Mesembryanthemum crystallinum*	O	O	-	-	-	-	-	-	O	-	-
**M. nodiflorum*	-	F	-	-	-	-	-	-	F	-	-
**Psilocaulon tenue* (+)											
Tetragonia eremaea (+)	-	-	O	-	-	-	-	-	O	-	-
T. tetragonioides	-	F	-	-	-	-	-	O	F	O	-
Amaranthaceae											
Alternanthera denticulata	F	O	-	F	F	F	F	F	O	-	-
A. nodiflora	O	-	-	-	-	-	-	O	O	O	-
**A. pungens*	O	O	O	-	O	O	-	O	-	-	-
**Amaranthus albus* (+)				-	-	O	-	-	-	-	-
A. macrocarpus (+)				-	-	-	-	-	O	-	-
Ptilotus atriplicifolius (+)											
P. exaltatus (+)				-	-	O	-	-	O	-	-
P. nobilis (+)				-	-	-	-	O	O	-	-
P. spathulatus (+)				-		O	-	-	-	-	-
Anacardiaceae											
**Schinus areira*	O	-	-	-	O	O	-	-	-	O	O
	RedGm	**BlkBx**	**Rises**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**

Species	Vegetation zone			River section							
	RedGm	BlkBx	Rises	1	2	3	4	5	6	7	8
Apiaceae											
*_Ammi majus_	O	-	-	-	-	-	-	-	-	-	O
*_Berula erecta_	O	-	-	-	-	-	-	-	-	-	O
Centella cordifolia (+)				-	-	O	-	-	-	-	-
Daucus glochidiatus	O	O	O	-	O	O	O	O	O	O	-
Eryngium ovinum (+)				-	O	O	-	-	-	-	-
E. plantagineum (+)				-	-	-	-	O	-	-	-
*_Foeniculum vulgare_	O	-	-	-	-	-	-	-	-	-	O
Hydrocotyle laxiflora	-	-	O	O	-	-	-	-	-	-	-
H. sibthorpioides s.l.	F	-	-	-	F	F	O	-	-	-	-
H. verticillata	F	-	-	-	-	-	-	-	-	-	F
Lilaeopsis polyantha	O	-	-	-	-	-	-	-	-	-	O
Apocynaceae											
*_Vinca major_ (+)				-	-	O	-	-	-	-	-
Asteraceae											
Actinobole uliginosum	-	F	F	-	-	O	-	O	F	-	-
Angianthus tomentosus (+)	-	-	O	-	-	-	-	-	O	-	-
*_Arctotheca calendula_	O	O	O	O	O	O	O	O	O	O	O
*_Artemisia arborescens_	-	O	-	-	-	-	O	-	-	-	-
*_Aster subulatus_	A	O	-	F	F	F	F	F	F	A	A
Brachycome basaltica	F	O	O	-	O	O	F	F	F	O	-
B. ciliaris	O	O	-	-	-	O	-	O	O	O	-
B. decipiens (+)				-	O	-	-	-	-	-	-
B. goniocarpa (+)	-	O	-	-	-	-	-	O	-	-	-
B. gracilis (+)	-	O	-	-	-	-	-	O	-	-	-
B. graminea (+)				-	-	O	-	-	-	-	-
B. lineariloba	O	A	-	-	-	-	O	A	A	O	-
B. muelleroides (+)				-	O	O	-	-	-	-	-
B. readeri (+)	O	O	-	-	O	O	-	-	-	-	-
Calocephalus citreus (+)				-	-	O	-	-	-	-	-
C. sonderi	O	F	-	-	-	-	O	F	O	-	-
Calotis cuneifolia	O	O	-	-	-	O	-	O	O	O	-
C. erinacea (+)	-	-	O	-	-	-	-	O	-	-	-
C. hispidula	O	F	-	-	O	O	-	O	F	O	-
C. scabiosifolia	O	O	-	-	-	-	O	-	-	-	-
C. scapigera	O	O	-	O	O	O	O	O	O	O	-
*_Carduus tenuiflorus_	F	-	F	F	F	F	F	-	-	-	-
*_Carthamus lanatus_	O	-	-	-	O	O	-	O	-	O	O
Cassinia arcuata	O	-	-	-	-	O	-	-	-	-	-
*_Centaurea melitensis_	O	O	O	-	-	O	O	O	-	-	-
Centipeda cunninghamii	A	O	-	A	A	A	A	A	A	O	-
C. minima	O	-	-	-	O	O	O	O	O	-	-
C. thespidioides (+)	O	-	-	-	-	-	-	O	O	-	-
*_Chondrilla juncea_	F	O	F	F	F	O	O	O	-	-	-
*_Cichorium intibus_	O	-	-	O	-	O	-	-	-	-	-
*_Cirsium vulgare_	A	O	F	A	A	A	A	F	F	A	A
*_Conyza bonariensis_	F	O	-	F	F	F	F	F	F	F	-
Cotula australis	F	F	-	O	O	O	F	F	F	F	F
*_C. bipinnata_	O	O	-	-	O	O	O	-	O	-	-
*_C. coronopifolia_	O	O	-	-	-	O	O	-	O	O	O
Craspedia glauca	O	-	-	O	O	O	O	-	-	-	-
C. globosa (+)				-	O	O	-	-	-	-	-
C. pleiocephala	-	O	-	-	-	O	-	-	O	-	-
*_Crepis foetida_ (+)				-	-	O	-	-	-	-	-
Cymbonotus lawsonianus	O	O	-	-	O	O	O	O	-	-	-
*_Dittrichia graveolens_	O	O	-	-	O	O	-	O	O	O	-
Eclipta platyglossa	F	O	-	F	F	F	F	F	F	F	F
Elachanthus glaber (+)	-	-	O	-	-	-	-	O	-	-	-
Epaltes australis	F	O	-	-	-	-	O	F	F	O	-
E. cunninghamii (+)				-	-	-	-	O	-	-	-
*_Gazania linearis_	O	-	-	-	-	-	-	O	O	-	-

RedGm BlkBx Rises 1 2 3 4 5 6 7 8

Species	Vegetation zone			River section							
	RedGm	**BlkBx**	**Rises**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Gnaphalium gymnocephalum	O	-	-	O	O	O	O	-	-	-	-
G. indutum (+)				-	O	-	-	-	-	-	-
G. involucratum	F	-	-	-	-	O	-	-	-	-	F
G. polycaulon (+)				-	-	O	-	-	-	-	-
**G. purpureum* s.l.	O	-	-	O	O	O	-	-	-	-	-
G. sphaericum	O	O	O	-	O	O	O	O	O	O	-
**Hedypnois rhagadioloides*	O	-	O	-	O	O	O	O	O	-	-
Helichrysum apiculatum	O	-	-	-	-	O	-	-	O	-	-
H. bracteatum	O	O	-	-	-	-	O	O	O	-	-
H. leucopsideum (+)				-	-	-	O	-	-	-	-
H. rutidolepis	O	-	-	O	-	-	-	-	-	-	-
H. scorpioides (+)				-	-	O	-	-	-	-	-
H. semipapposum	-	-	O	-	-	O	-	-	-	-	-
Helipterum albicans (+)				-	O	O	-	-	-	-	-
H. corymbiflorum	O	O	-	-	-	-	O	O	O	-	-
H. moschatum (+)				-	-	O	-	-	-	-	-
H. strictum (+)				-	-	O	-	-	-	-	-
H. stuartianum	-	O	-	-	-	-	-	-	O	-	-
**Hypochoeris glabra*	A	A	A	-	F	A	A	A	A	A	-
**H. radicata*	A	O	O	A	A	F	O	-	O	O	O
Isoetopsis graminifolia	-	O	-	-	-	O	-	O	O	-	-
Ixiolaena chloroleuca (+)				-	-	-	-	O	-	-	-
I. tomentosa (+)				-	-	-	-	-	O	-	-
**Lactuca saligna*	O	O	-	O	O	O	O	-	-	O	-
**L. serriola*	A	O	O	A	A	A	A	A	A	F	-
Lagenifera huegelii (+)				-	-	O	-	-	-	-	-
L. stipitata (+)				-	-	O	-	-	-	-	-
**Leontodon taraxacoides*	F	O	F	F	F	F	F	-	-	-	-
Leptorhynchos panaetioides (+)				-	-	O	-	-	-	-	-
L. squamatus (+)				-	O	O	-	-	-	-	-
L. tenuifolius (+)				-	-	O	-	-	-	-	-
Millotia myosotidifolia (+)	O	-	-	-	-	-	-	O	-	-	-
Minuria cunninghamii	-	O	-	-	-	-	-	-	O	-	-
M. integerrima	-	O	-	-	-	O	-	O	-	-	-
Myriocephalus rhizocephalus	-	O	-	-	O	O	-	O	-	-	-
M. stuartii	O	O	O	-	-	O	-	O	O	O	-
Olearia muelleri (+)	-	O	-	-	-	-	-	O	-	-	-
O. pimeleoides	-	O	-	-	-	-	-	-	O	-	-
**Onopordum acaulon*	O	O	-	-	-	O	-	O	O	-	-
Othonna gregorii (+)				-	-	O	-	-	-	-	-
**Picris echioides*	F	O	-	-	-	O	O	-	-	O	A
P. squarrosa	A	O	-	-	-	-	O	O	O	A	O
Pogonolepis muelleriana	O	F	-	-	-	-	-	O	F	-	-
Pseudognaphalium luteo-album	A	O	O	O	O	O	A	A	A	F	-
**Reichardia tingitana*	A	A	-	-	-	-	-	F	A	A	O
Senecio cunninghamii	O	-	-	-	-	-	O	-	O	-	-
S. glossanthus	O	A	-	-	-	-	O	O	A	O	-
S. lautus	A	A	-	-	-	-	-	O	A	A	O
**S. pterophorus*	O	-	-	-	-	-	-	-	-	O	O
S. quadridentatus	A	O	O	O	F	A	A	A	O	-	-
S. runcinifolius	O	O	-	-	O	O	O	O	O	O	-
**Scorzonera laciniata*	O	-	-	-	-	-	O	-	-	-	-
**Silybum marianum*	O	-	-	O	-	-	-	-	-	-	-
Solenogyne gunnii	O	-	O	-	O	O	-	-	-	-	-
**Soliva stolonifera* (+)				-	-	O	-	-	-	-	-
**Sonchus asper*	A	O	F	A	A	A	A	A	O	-	-
S. hydrophilus	A	F	-	-	-	-	O	O	A	A	A
**S. oleraceus*	A	A	F	A	A	A	A	A	A	A	A
Stuartina muelleri (+)				-	-	O	-	-	-	-	-
**Taraxacum* spp.	F	-	-	-	-	-	-	-	-	O	F
Toxanthes perpusillus (+)	O	-	-	-	-	-	-	-	O	-	-
Triptilodiscus pygmaeus	O	-	-	-	O	O	-	-	-	-	-
**Urospermum picroides*	F	O	O	-	-	-	-	O	O	F	O
	RedGm	**BlkBx**	**Rises**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**

Species	Vegetation zone			River section							
	RedGm	BlkBx	Rises	1	2	3	4	5	6	7	8
Vittadinia cervicularis	O	O	-	-	-	-	O	O	O	-	-
V. condyloides (+)	-	O	-	-	-	-	-	-	O	-	-
V. cuneata	F	O	-	-	-	O	O	F	F	F	O
V. dissecta	F	F	F	-	-	-	O	F	O	O	-
V. gracilis	O	O	-	-	O	O	O	O	O	-	-
**Xanthium californicum*	F	O	-	-	-	-	-	-	F	F	F
**X. occidentale*	O	-	-	-	-	O	-	O	-	-	-
**X. spinosum*	O	-	-	-	-	O	O	O	-	O	O
Boraginaceae											
**Amsinckia calycina*	-	-	O	-	-	O	-	-	-	-	-
Cynoglossum suaveolens (+)				-	-	O	-	-	-	-	-
**Echium plantagineum*	F	O	F	F	F	F	F	O	O	-	-
**Heliotropium curassavicum*	O	O	-	-	-	-	-	-	O	O	-
**H. europaeum*	-	O	-	-	-	O	O	-	O	-	-
**H. supinum*	-	O	-	-	-	-	-	O	O	-	-
Omphalolappula concava	-	O	-	-	-	-	-	-	O	-	-
Plagiobothrys elachanthus	O	O	-	-	O	O	-	O	-	-	-
P. plurisepalus (+)				-	-	O	-	-	-	-	-
Brassicaceae											
**Alyssum linifolium*	-	O	-	-	-	-	-	-	O	-	-
**Brassica tournefortii*	O	F	O	-	-	-	-	F	F	F	F
**Capsella bursapastoris*	O	O	-	-	O	O	O	-	-	-	-
Cardamine gunnii (+)				-	-	O	-	-	-	-	-
**C. hirsuta* (+)				-	-	O	-	-	-	-	-
C. tenuifolia (+)				-	-	O	-	-	-	-	-
**Carrichtera annua*	O	O	-	-	-	-	-	-	-	O	-
**Coronopus didymus* (+)				-	-	O	-	-	-	-	-
**Diplotaxis tenuifolia* (+)				-	-	O	-	-	-	-	-
Geococcus pusillus (+)	-	O	-	-	-	-	-	O	-	-	-
**Lepidium africanum*	F	F	-	-	-	O	O	O	F	F	F
**L. bonariense*	O	-	-	-	-	-	-	-	-	O	-
L. fasciculatum (+)				-	-	O	-	-	-	-	-
L. monoplocoides (+)				-	-	-	O	-	-	-	-
L. papillosum (+)	-	O	O	-	-	-	-	O	-	-	-
L. phlebopetalum (+)				-	-	-	-	O	O	-	-
L. pseudohyssopifolium (+)				-	-	-	-	-	O	-	-
L. pseudopapillosum (+)				-	-	-	-	-	O	-	-
Menkea crassa (+)				-	-	O	-	-	-	-	-
Pachymitus cardaminoides	O	-	-	-	-	-	-	O	-	-	-
**Rapistrum rugosum*	O	-	-	-	-	-	-	-	-	-	O
Rorippa eustylis	O	-	-	-	-	-	O	-	O	-	-
R. laciniata	O	-	-	-	-	O	O	-	-	-	-
**R. palustris*	O	-	-	O	O	O	O	-	-	O	O
**Sisymbrium erysimoides*	O	O	-	-	-	O	O	O	O	O	-
**S. irio*	O	O	-	-	-	O	O	-	O	-	-
**S. officinale*	O	-	-	-	-	O	-	-	-	-	-
**S. orientale*	O	O	-	-	-	O	O	-	O	-	-
Stenopetalum lineare (+)	O	O	-	-	-	-	O	O	-	-	-
Cabombaceae											
Brasenia schreberi (+)				O	-	-	-	-	-	-	-
Cactaceae											
**Opuntia* spp.	-	-	O	-	-	-	-	O	-	-	-
Caesalpiniaceae											
Cassia nemophila	O	O	-	-	-	O	-	O	O	-	-
Callitrichaceae											
Callitriche cyclocarpa (+)				-	-	-	O	-	-	-	-
C. sonderi	O	-	-	-	-	-	O	-	-	-	-
**C. stagnalis*	O	-	-	-	O	O	O	-	O	-	O
	RedGm	BlkBx	Rises	1	2	3	4	5	6	7	8

Species	Vegetation zone			River section							
	RedGm	BlkBx	Rises	1	2	3	4	5	6	7	8
Campanulaceae											
Hypsela tridens	O	-	-	-	O	O	-	-	-	-	-
Isotoma fluviatilis	O	-	-	-	O	O	-	-	-	-	-
Lobelia pratioides	O	-	-	-	-	-	O	-	-	-	-
Pratia concolor	O	O	-	-	O	O	O	O	O	O	O
Wahlenbergia communis	O	-	O	-	O	O	O	-	-	-	-
W. fluminalis	A	O	O	F	A	A	A	A	A	A	O
W. gracilenta	-	F	O	-	O	O	-	O	F	-	-
W. gracilis	O	-	-	O	O	O	O	-	-	-	-
W. graniticola	-	-	O	O	-	O	-	-	-	-	-
W. litticola	-	O	-	-	-	-	-	-	O	-	-
W. luteola	-	-	O	O	-	-	-	-	-	-	-
W. multicaulis	O	-	-	-	-	O	-	-	-	-	-
W. tumidifructa	O	F	O	-	-	-	-	O	F	-	-
Caryophyllaceae											
**Cerastium glomeratum*	O	-	-	O	O	O	O	-	-	-	O
**Herniaria hirsuta* (+)	O	O	-	-	-	-	-	-	O	-	-
**Moenchia erecta* (+)				-	-	O	-	-	-	-	-
**Petrorhagia velutina*	O	O	O	O	O	O	O	-	-	-	-
**Polycarpon tetraphyllum* (+)	-	O	-	-	-	-	-	O	-	-	-
**Sagina apetala* (+)				-	-	O	-	-	-	-	-
Scleranthus minusculus	-	-	O	-	-	-	-	O	-	-	-
Silene* spp. (S. apetala*, **S. longicaulis* & **S. nocturna*)	O	O	O	-	-	-	O	O	O	O	O
**Spergula arvensis* (+)				-	-	O	-	-	-	-	-
**Spergularia diandra*	O	O	-	-	-	O	-	-	O	-	-
**S. rubra*	F	F	-	-	O	O	F	F	F	F	O
Stellaria angustifolia	O	-	-	-	-	O	O	-	-	-	-
**S. media*	O	-	-	-	O	O	O	-	-	-	-
S. sp. 'C' (Jacobs & Pickard 1981)	O	O	-	-	O	O	O	-	-	-	-
Casuarinaceae											
Allocasuarina luehmannii	-	O	O	-	-	O	O	O	-	-	-
Casuarina cristata	-	-	O	-	-	-	-	O	O	-	-
C. obesa (+)	-	O	-	-	-	-	O	-	-	-	
Chenopodiaceae											
Atriplex angulata (+)				-	-	-	-	O	-	-	-
A. eardleyae	O	O	-	-	-	-	-	-	O	O	-
A. leptocarpa	O	A	-	-	-	-	A	A	A	A	-
A. limbata	-	O	-	-	-	-	-	-	O	O	-
A. lindleyi	O	A	-	-	-	-	-	A	A	A	-
A. nummularia	-	F	-	-	-	-	-	O	F	-	-
A. prostrata (+)				-	-	-	-	-	O	-	-
A. pseudocampanulata	-	O	-	-	-	-	-	O	-	-	-
A. rhagodioides	O	A	-	-	-	-	-	-	A	O	-
A. semibaccata	F	F	-	-	-	O	-	-	F	F	F
A. spongiosa	-	O	-	-	-	-	-	-	O	-	-
A. stipitata	O	-	-	-	-	-	-	-	-	O	-
A. suberecta	O	O	-	-	-	O	-	-	O	O	-
A. vesicaria	-	F	-	-	-	-	-	-	F	-	-
**Chenopodium album*	O	-	-	-	-	-	-	-	O	O	O
C. cristatum (+)	-	O	-	-	-	-	-	O	-	-	-
C. desertorum (+)				-	-	O	-	-	-	-	-
**C. glaucum*	-	O	-	-	-	O	-	-	O	-	-
**C. murale*	-	O	O	-	-	O	-	O	-	-	-
C. nitrariaceum	O	A	-	-	-	-	O	A	A	-	-
C. pumilio (+)				-	-	O	-	-	O	-	-
Dissocarpus biflorus	-	O	-	-	-	-	-	O	O	-	-
D. paradoxus	-	O	-	-	-	-	-	-	-	O	-
Dysphania glomulifera	O	-	-	-	-	O	-	O	-	-	-
Einadia hastata	O	-	-	-	-	O	O	-	-	-	-
E. nutans	F	A	F	O	O	O	A	A	A	A	F
	RedGm	BlkBx	Rises	1	2	3	4	5	6	7	8

Species	Vegetation zone			River section							
	RedGm	BlkBx	Rises	1	2	3	4	5	6	7	8
Enchylaena tomentosa	A	A	F	-	-	-	O	A	A	A	A
Eriochiton sclerolaenoides (+)				-	-	-	-	-	O	-	-
Halosarcia indica	O	F	-	-	-	-	-	-	F	F	-
H. pergranulata	O	F	-	-	-	-	-	F	F	F	-
Maireana aphylla (+)	O	-	-	-	-	-	-	O	-	-	-
M. appressa	O	O	-	-	-	-	-	-	O	-	-
M. brevifolia	O	F	-	-	-	-	-	-	F	F	-
M. ciliata (+)	-	O	-	-	-	-	-	O	O	-	-
M. decalvans (+)				-	-	O	-	-	-	-	-
M. enchylaenoides	-	O	O	-	-	O	O	-	-	-	-
M. pentagona	O	O	-	-	-	-	-	O	O	-	-
M. pentatropis	-	O	-	-	-	-	-	-	-	O	-
M. pyramidata	-	O	-	-	-	-	-	-	O	-	-
M. turbinata (+)	O	-	O	-	-	-	-	-	O	-	-
Malacocera tricornis	-	O	-	-	-	-	-	O	O	-	-
Neobassia proceriflora (+)				-	-	-	-	O	O	-	-
Osteocarpum acropterum	-	O	-	-	-	-	-	O	O	-	-
O. salsuginosum	O	O	-	-	-	-	-	-	O	O	-
Pachycornia triandra	-	F	-	-	-	-	-	O	F	O	-
Rhagodia spinescens	O	F	O	-	-	-	O	F	F	-	-
**Salsola kali*	O	O	-	-	-	O	O	-	O	O	-
Scleroblitum atriplicinum (+)	-	O	-	-	-	-	-	O	O	-	-
Sclerochlamys brachyptera	O	A	-	-	-	-	-	A	A	O	-
Sclerolaena decurrens (+)				-	-	-	-	-	O	-	-
S. diacantha	-	O	-	-	-	-	-	-	O	-	-
S. divaricata (+)				-	-	O	-	-	-	-	-
S. muricata	O	F	-	-	-	O	O	O	O	O	-
S. obliquicuspis	O	O	-	-	-	-	-	-	O	O	-
S. patenticuspis	-	O	-	-	-	-	-	-	O	-	-
S. tricuspis	-	A	-	-	-	-	F	A	A	F	-
Sclerostegia tenuis (+)				-	-	-	-	O	O	-	-
Stelligera endecaspinis	-	O	-	-	-	-	O	O	O	O	-
Suaeda australis	-	O	-	-	-	-	-	-	O	O	-
Threlkeldia diffusa (+)	-	O	-	-	-	-	-	O	-	-	-
Clusiaceae											
Hypericum gramineum	O	-	-	O	O	O	O	-	-	-	-
**H. perforatum*	O	-	-	O	-	O	-	-	-	-	-
Convolvulaceae											
Calystegia marginata (+)				-	-	O	-	-	-	-	-
C. sepium	O	-	-	-	-	O	-	-	-	-	O
Convolvulus erubescens	O	O	O	O	O	O	O	O	-	O	-
**Cressa cretica*	-	O	-	-	-	-	-	O	O	O	-
Dichondra repens	F	-	-	F	F	O	-	-	-	-	-
Wilsonia humilis				-	-	-	-	-	O	-	-
Crassulaceae											
Crassula colorata	O	F	O	-	-	O	O	F	F	-	-
C. decumbens	-	O	-	-	O	O	O	-	-	-	-
C. helmsii	O	-	-	-	-	O	-	-	O	-	O
C. peduncularis	O	-	-	-	O	O	O	-	-	-	-
C. sieberiana	F	F	F	-	O	O	O	F	F	F	-
Cucurbitaceae											
**Citrullus lanatus*	-	O	-	-	-	O	-	-	O	-	-
**Cucumis myriocarpus* (+)				-	O	O	-	-	O	-	-
Mukia micrantha (+)				-	-	-	-	-	O	-	-
Cuscutaceae											
**Cuscuta* spp.	O	-	-	-	-	-	O	-	O	-	-
	RedGm	BlkBx	Rises	1	2	3	4	5	6	7	8

Species	Vegetation zone RedGm	BlkBx	Rises	River section 1	2	3	4	5	6	7	8
Elatinaceae											
Elatine gratioloides (+)				-	-	O	-	-	-	-	-
Euphorbiaceae											
Euphorbia drummondii	F	F	O	O	O	O	F	F	F	F	-
E. parvicaruncula (+)				-	-	-	-	-	O	-	-
**E. peplus*	O	-	-	-	-	O	-	-	-	-	-
E. tannensis (+)				-	-	-	-	-	O	-	-
**E. terracina*	F	O	-	-	-	-	-	-	-	F	F
Phyllanthus lacunarius	-	O	-	-	-	-	-	-	O	-	-
Fabaceae											
Dillwynia cinerascens (+)				-	-	O	-	-	-	-	-
Eutaxia microphylla	O	-	-	-	-	O	O	-	-	-	-
**Genista monspessulana* (+)				-	-	O	-	-	-	-	-
Glycine clandestina	O	-	O	O	-	O	-	-	-	-	-
G. tabacina	O	-	O	O	-	O	-	-	-	-	-
Glycyrrhiza acanthocarpa	O	O	-	-	-	-	O	-	O	O	-
**Lathyrus angulatus*	O	-	-	-	O	-	-	-	-	-	-
Lotus australis	O	-	-	-	-	-	-	O	-	-	-
L. cruentus	O	-	O	-	-	O	-	O	O	O	-
**L. pedunculatus* (+)				-	-	O	-	-	-	-	-
**Medicago minima*	O	O	O	-	-	O	O	O	O	O	-
**M. polymorpha*	F	F	O	-	O	O	F	F	F	F	F
**M. truncatula*	O	-	-	-	-	-	-	-	-	O	O
**Melilotus alba*	O	-	-	-	-	-	-	-	-	-	O
**M. indica*	O	-	-	-	-	-	-	-	O	O	O
Psoralea cinerea (+)				-	-	-	-	O	-	-	-
P. pallida	-	-	O	-	-	-	-	O	-	-	-
P. parva (+)	-	-	O	-	-	O	-	-	-	-	-
P. tenax (+)	O	O	O	-	-	-	O	O	-	-	-
Swainsona greyana	O	-	-	-	-	-	-	-	O	O	-
S. microcalyx (+)	O	-	-	-	-	O	-	-	-	-	-
S. microphylla	O	-	O	-	-	-	-	O	O	O	-
S. phacoides	-	-	O	-	-	-	O	O	-	-	-
S. procumbens (+)				-	O	O	-	-	-	-	-
Templetonia egena (+)											
T. stenophylla (+)				-	-	O	-	-	-	-	-
**Trifolium angustifolium*	F	-	F	F	F	O	O	-	-	-	-
**T. arvense*	F	-	F	F	F	F	O	-	-	-	-
**T. campestre*	F	-	F	F	F	F	F	-	-	-	-
**T. cernuum*	F	-	F	F	F	O	O	-	-	-	-
**T. dubium*	F	-	O	F	O	O	O	-	-	-	-
**T. glomeratum*	F	O	F	F	F	F	F	-	-	-	F
**T. ornithopodioides*	O	-	-	O	-	-	-	-	-	-	-
**T. repens*	O	-	-	O	O	O	O	-	-	-	O
**T. striatum*	F	-	F	F	F	O	O	-	-	-	-
**T. subterraneum*	F	-	-	F	O	O	O	-	-	-	-
**T. suffocatum* (+)				-	-	O	-	-	-	-	-
**T. tomentosum*	F	-	F	O	O	F	F	-	-	-	-
**Vicia hirsuta*	O	-	-	O	-	O	O	-	-	-	-
**V. monantha*	O	-	-	-	-	-	-	-	-	O	-
**V. sativa*	O	-	O	O	O	O	O	-	-	O	-
**V. tetrasperma*	O	-	-	-	-	O	-	-	-	-	-
Frankeniaceae											
Frankenia serpyllifolia s.l.	-	O	-	-	-	O	-	O	O	-	-
Fumariaceae											
**Fumaria bastardii*	O	-	-	-	-	-	-	-	-	O	O
**F. capreolata*	O	-	-	-	-	-	O	-	-	-	-
**F. densiflora*	-	O	-	-	-	-	-	O	-	-	-
**F. muralis*	O	-	-	-	-	-	O	-	-	-	-
**F. officinalis* (+)				-	-	O	-	-	-	-	-
	RedGm	**BlkBx**	**Rises**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**

Species	Vegetation zone			River section							
	RedGm	BlkBx	Rises	1	2	3	4	5	6	7	8
Gentianaceae											
**Centaurium erythraea*	O	-	-	-	O	-	-	-	-	-	-
**C. spicatum*	O	O	-	O	-	-	-	O	-	-	-
**C. tenuiflorum*	O	-	-	O	-	O	-	-	-	-	-
**Cicendia quadrangularis* (+)				-	O	O	-	-	-	-	-
Geraniaceae											
**Erodium cicutarium*	-	O	O	-	-	O	O	-	-	O	-
E. crinitum	-	O	-	-	-	O	-	O	-	-	-
**E. moschatum* (+)	-	-	-	-	-	O	-	-	-	-	-
Geranium retrorsum	O	O	O	O	O	O	O	O	-	-	-
G. solanderi	O	-	-	-	O	O	-	-	-	-	O
Pelargonium australe (+)				-	-	-	-	-	O	-	-
Goodeniaceae											
Goodenia elongata (+)				-	-	O	-	-	-	-	-
G. fascicularis	O	O	-	-	-	O	O	O	O	-	-
G. glauca	O	O	-	-	-	-	O	O	O	O	-
G. gracilis	O	O	O	O	O	O	O				
G. heteromera	O	-	-	-	-	-	-	O	-	-	-
G. pinnatifida	-	O	-	-	O	O	-	O	-	-	-
G. pusilliflora	-	O	-	-	-	-	-	O	O	-	-
Scaevola spinescens (+)	-	-	O	-	-	-	-	O	-	-	-
Haloragaceae											
Gonocarpus elatus (+)				-	-	O	-	-	-	-	-
Haloragis aspera	O	O	-	O	O	O	O	O	O	O	-
H. odontocarpa (+)											
**Myriophyllum aquaticum*	O	-	-	-	-	-	-	-	-	-	O
M. crispatum	F	-	-	O	F	F	O	-	O	-	-
M. verrucosum	O	-	-	-	O	O	O	-	O	-	O
Lamiaceae											
Ajuga australis	O	O	O	-	-	O	-	O	O	-	-
**Lamium amplexicaule*	O	-	-	-	-	O	O	-	-	-	-
Lycopus australis	O	-	-	-	-	-	-	-	-	O	O
**Marrubium vulgare*	O	O	O	O	-	O	O	O	-	O	O
Mentha australis	O	-	-	-	O	O	-	-	O	-	-
M. diemenica	O	-	-	O	-	O	-	-	-	-	-
**M. pulegium*	O	-	-	O	O	O	-	-	-	-	-
M. satureioides (+)				-	O	O	-	-	-	-	-
**M. spicata*	O	-	-	O	-	-	-	-	-	-	-
**Salvia verbenaca* (+)				-	-	O	-	-	-	-	-
Teucrium racemosum	O	O	O	-	-	-	O	O	O	O	-
Lentibulariaceae											
Utricularia dichotoma (+)				-	O	-	-	-	-	-	-
Linaceae											
Linum marginale	O	-	-	-	O	O	-	-	-	-	-
Loranthaceae											
Amyema linophyllum	-	O	-	-	-	O	O	O	-	-	-
A. miquelii	O	O	O	O	O	O	O	O	O	O	-
A. miraculosum (+)				-	-	O	-	-	-	-	-
A. pendulum (+)				-	O	O	-	-	-	-	-
A. preissii	-	O	O	-	-	-	-	O	-	-	-
Muellerina eucalyptoides (+)				-	-	O	-	-	-	-	-
Lythraceae											
Ammania multiflora (+)				-	-	-	-	O	O	O	-
**Lythrum hyssopifolia*	F	O	-	F	F	O	O	-	-	-	-
L. salicaria (+)				-	-	O	-	-	-	O	-
	RedGm	BlkBx	Rises	1	2	3	4	5	6	7	8

Species	Vegetation zone			River section							
	RedGm	BlkBx	Rises	1	2	3	4	5	6	7	8
Malvaceae											
**Abutilon theophrasti* (+)											
Lavatera plebeia	-	O	-	-	-	-	-	-	O	O	-
**Modiola caroliniana*	O	-	-	-	-	O	-	-	-	-	-
Sida ammophila (+)	-	O	-	-	-	-	-	O	O	O	-
S. corrugata	O	O	O	-	O	O	O	O	O	-	-
S. fibulifera (+)	-	O	O	-	-	-	-	O	-	-	-
S. intricata (+)	-	-	O	-	-	-	-	-	O	-	-
S. trichopoda	O	O	-	O	-	-	O	O	-	-	-
Menyanthaceae											
Nymphoides crenata	O	-	-	-	O	O	O	-	-	-	-
Mimosaceae											
Acacia acinacea	O	-	O	-	O	O	O	-	-	-	-
A. dealbata	F	-	O	F	F	F	F	-	-	-	-
A. genistifolia (+)				-	O	-	-	-	-	-	-
A. implexa (+)				-	O	O	-	-	-	-	-
A. ligulata	O	O	O	-	-	-	-	-	O	O	-
A. loderi (+)	-	-	-	-	-	-	-	-	O	-	-
A. nyssophylla (+)	-	-	O	-	-	-	-	O	-	-	-
A. oswaldii	-	O	-	-	-	-	O	O	-	-	-
A. salicina	O	-	-	-	-	O	O	O	-	-	-
**A. saligna*	O	-	-	-	-	-	-	-	-	-	O
A. stenophylla	F	O	-	-	-	-	O	F	F	F	-
A. victoriae (+)				-	-	-	-	O	-	-	-
Moraceae											
**Maclura pomifera* (+)				-	-	O	-	-	-	-	-
Myoporaceae											
Eremophila bignoniiflora (+)				-	-	-	-	O	O	-	-
E. divaricata	-	O	-	-	-	-	-	O	O	O	-
E. longifolia (+)				-	-	O	-	-	-	-	-
E. maculata (+)				-	-	-	-	-	O	-	-
E. polyclada (+)				-	-	-	-	O	O	-	-
E. sturtii (+)				-	-	-	-	-	O	-	-
Myoporum montanum	O	-	-	-	-	O	-	-	-	O	O
M. parvifolium	O	O	-	-	-	-	-	O	-	-	-
M. platycarpum (+)											
Myrtaceae											
Callistemon brachyandrus	O	-	-	-	-	-	-	-	-	O	-
C. sieberi	O	-	-	O	-	-	-	-	-	-	-
Calytrix tetragona	-	-	O	-	-	O	-	-	-	-	-
Eucalyptus camaldulensis	A	O	O	A	A	A	A	A	A	A	F
E. largiflorens	O	A	O	-	-	O	A	A	A	A	-
E. melliodora	-	-	F	O	O	F	-	-	-	-	-
E. microcarpa	-	-	F	-	O	F	O	-	-	-	-
Melaleuca lanceolata	-	F	-	-	-	-	O	-	F	-	-
Nyctaginaceae											
Boerhavia dominii (+)				-	-	O	-	-	-	-	-
Oleaceae											
**Fraxinus rotundifolia*	O	-	-	-	-	-	-	-	-	-	O
Onagraceae											
Epilobium billardierianum	O	O	-	O	O	O	O	-	-	-	-
**E. ciliatum* (+)				-	O	-	-	-	-	-	-
E. hirtigerum	O	-	-	O	O	O	O	-	-	-	-
**Ludwigia palustris* (+)				-	O	-	-	-	-	-	-
**L. peploides*	O	-	-	O	O	O	O	-	O	-	-
**Oenothera stricta*	O	-	-	O	O	O	-	-	-	-	-
	RedGm	BlkBx	Rises	1	2	3	4	5	6	7	8

Species	Vegetation zone			River section							
	RedGm	BlkBx	Rises	1	2	3	4	5	6	7	8
Orobanchaceae											
***Orobanche minor**	-	-	O	O	-	-	-	-	-	-	-
Oxalidaceae											
Oxalis perennans	A	A	A	A	A	A	A	A	O	-	-
**O. pes-caprae*	O	-	-	-	-	-	-	-	-	-	O
O. radicosa	-	-	O	-	-	O	-	-	-	-	-
Papaveraceae											
**Papaver hybridum* (+)				-	-	O	-	-	-	-	-
Pittosporaceae											
Pittosporum phylliraeoides	O	O	-	-	O	O	O	-	-	-	-
Plantaginaceae											
**Plantago coronopus* (+)				-	O	-	-	-	-	-	-
P. cunninghamii	O	O	-	-	-	-	-	O	O	O	-
P. debilis	O	-	-	-	-	-	O	-	-	-	-
P. drummondii	-	O	-	-	-	O	-	-	O	-	-
**P. lanceolata*	O	-	-	O	-	O	O	-	-	-	-
P. turrifera	O	O	-	-	-	-	-	-	O	O	-
P. varia (+)				-	-	O	-	-	-	-	-
Polygonaceae											
**Acetosella vulgaris* s.l.	O	-	-	O	-	-	-	-	-	-	-
Muehlenbeckia cunninghamii	F	A	-	-	-	O	A	A	A	A	F
M. horrida	-	O	-	-	-	-	-	-	-	O	-
Persicaria decipiens	O	-	-	O	O	O	O	-	O	-	O
P. hydropiper	F	-	-	F	F	F	-	-	-	-	-
**P. lapathifolia*	O	-	-	-	-	-	-	O	O	O	-
P. prostrata	A	-	-	A	A	A	A	A	O	-	-
**Polygonum aviculare*	O	O	-	O	O	O	O	-	-	-	-
P. plebeium	O	-	-	-	O	O	O	O	O	O	-
Rumex bidens	O	-	-	-	-	-	-	-	O	-	-
R. brownii	A	O	F	A	A	A	A	A	A	A	-
**R. crispus*	F	-	-	F	O	-	-	-	-	O	F
R. crystallinus	O	-	-	O	O	O	O	-	O	-	-
**R. pulcher*	O	-	-	O	-	O	-	-	-	-	-
Portulacaceae											
Calandrinia calyptrata	-	O	-	-	-	O	O	O	-	-	-
C. eremaea	-	F	O	-	-	O	-	O	F	O	-
C. volubilis	-	O	-	-	-	-	-	O	O	-	-
Portulaca oleracea (+)				-	-	O	-	-	-	-	-
Primulaceae											
**Anagallis arvensis*	O	O	-	O	O	O	O	O	O	O	-
Proteaceae											
Hakea leucoptera	-	-	O	-	-	-	-	O	-	-	-
H. tephrosperma	-	O	-	-	-	-	O	-	-	-	-
Ranunculaceae											
Myosurus minimus	O	O	-	-	-	O	O	O	O	-	-
Ranunculus inundatus	F	-	-	O	O	F	F	-	-	-	-
R. lappaceus	O	-	-	-	O	O	O	-	-	-	-
**R. muricatus*	O	-	-	O	O	O	O	-	-	-	O
R. pentandrus	O	O	-	-	-	-	-	O	O	O	-
R. pumilio	O	O	-	O	O	O	O	-	-	-	-
R. rivularis	O	-	-	-	-	O	-	-	-	-	O
**R. sceleratus*	O	O	-	-	O	O	O	-	-	-	-
R. sessiliflorus	O	-	-	-	-	O	O	-	-	-	-
**R. trilobus*	O	-	-	-	-	-	-	-	-	-	O
R. undosus (+)				-	-	-	O	-	-	-	-
	RedGm	**BlkBx**	**Rises**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**

Species	Vegetation zone RedGm	BlkBx	Rises	River section 1	2	3	4	5	6	7	8
Rosaceae											
Acaena novae-zelandiae	O	-	-	-	-	O	-	-	-	-	-
**Aphanes arvensis* (+)				-	O	O	-	-	-	-	-
A. australiana (+)				-	-	O	-	-	-	-	-
**Prunus spp.* (+)				-	-	O	-	-	-	-	-
**Rosa rubiginosa*	O	-	-	O	O	O	O	-	-	-	-
**R. procerus* (+)				-	-	O	-	-	-	-	-
**Rubus fruticosus* spp. agg.	O	-	-	-	O	O	-	-	-	-	-
Rubiaceae											
Asperula conferta	O	O	-	-	-	O	-	O	-	-	-
A. gemella	F	O	-	-	-	-	O	O	O	F	F
**Galium aparine*	O	O	-	O	O	O	O	O	-	-	-
**G. murale* (+)				-	O	O	-	-	-	-	-
Rutaceae											
Geijera parviflora	-	-	O	-	-	-	O	O	-	-	-
Salicaceae											
**Salix babylonica*	A	-	-	O	O	O	O	O	O	O	A
**S. Xrubens*	O	-	-	O	-	O	-	-	-	-	-
Santalaceae											
Exocarpos aphyllus	-	O	-	-	-	-	O	-	O	-	-
E. cupressiformis (+)				-	O	O	-	-	-	-	-
E. strictus	O	-	-	-	O	O	O	-	O	-	-
Santalum acuminatum (+)				-	-	-	O	-	-	-	-
Sapindaceae											
Dodonaea viscosa	O	O	F	-	-	O	-	F	F	O	-
Heterodendrum oleifolium	O	-	O	-	-	-	-	O	O	-	-
Scrophulariaceae											
Glossostigma elatinoides (+)				-	O	O	-	-	-	-	-
Gratiola pubescens s.l.	O	-	-	-	O	O	-	-	-	-	O
**Kickxia spuria*	O	-	-	O	-	-	-	-	-	-	-
Limosella australis (+)				-	-	O	-	-	-	-	-
L. curdieana (+)				-	-	O	-	-	-	-	-
Mimulus gracilis	-	O	-	-	O	O	O	-	-	-	-
M. repens	-	O	-	-	-	-	-	-	O	O	-
Morgania floribunda	F	O	-	-	-	-	-	F	F	F	O
**Parentucellia latifolia* (+)				-	O	-	-	-	-	-	-
**Verbascum blattaria* (+)				-	-	O	-	-	-	-	-
**V. virgatum*	O	-	O	-	O	O	-	-	-	-	O
**Veronica arvensis* (+)				-	-	O	-	-	-	-	-
**V. peregrina*	O	O	-	O	O	O	O	-	O	-	-
Solanaceae											
**Datura stramonium* (+)				-	-	O	-	-	-	-	-
**Lycium ferocissimum*	O	O	-	-	-	O	O	-	O	O	O
**Nicotiana glauca*	O	-	-	-	-	-	-	-	O	O	-
N. goodspeedii (+)				-	-	-	-	-	O	-	-
N. velutina	-	O	-	-	-	-	-	O	O	-	-
**Solanum americanum* (+)				-	-	O	-	-	-	-	-
S. esuriale	O	O	-	-	-	O	O	O	O	O	-
S. laciniatum (+)	-	O	-	-	-	-	-	-	O	-	-
S. lacunarium (+)	-	-	-	-	-	-	-	-	O	-	-
**S. nigrum*	O	O	-	-	O	O	O	O	O	O	O
**S. pseudocapsicum*	O	-	-	-	O	-	-	-	-	-	-
S. simile	O	-	-	-	-	-	-	O	-	-	-
Stackhousiaceae											
Stackhousia monogyna (+)				-	-	O	-	-	-	-	-
Sterculiaceae											
Brachychiton populneus (+)				-	-	O	O	O	-	-	-
	RedGm	BlkBx	Rises	1	2	3	4	5	6	7	8

Species	Vegetation zone			River section							
	RedGm	BlkBx	Rises	1	2	3	4	5	6	7	8
Stylidiaceae											
Levenhookia dubia (+)				-	-	O	-	-	-	-	-
Thymelaeaceae											
Pimelea curviflora (+)				-	-	O	-	-	-	-	-
Urticaceae											
**Urtica urens*	O	O	O	-	-	O	O	-	O	-	O
Verbenaceae											
**Phyla nodiflora*	O	O	O	-	-	-	O	O	O	O	O
**Verbena bonariensis*	O	-	-	O	-	O	-	-	-	-	-
**V. officinalis*	O	-	-	-	O	-	-	O	-	-	-
**V. supina*	O	-	-	-	-	-	-	O	O	-	-
Violaceae											
Viola betonicifolia	O	-	-	O	-	O	-	-	-	-	-
Zygophyllaceae											
Nitraria billardierei	-	F	-	-	-	-	F	O	-	-	-
**Tribulus terrestris* (+)				-	-	O	-	-	-	-	-
Zygophyllum ammophilum	-	O	-	-	-	-	-	-	O	-	-
Z. aurantiacum	O	-	-	-	-	-	-	-	-	O	-
Z. billardieri	-	O	-	-	-	-	-	-	-	O	-
Z. eremaeum (+)	-	-	O	-	-	-	-	O	-	-	-
Z. glaucum	-	O	-	-	-	-	-	O	O	-	-
Z. iodocarpum	-	O	-	-	-	-	-	-	O	-	-
MONOCOTYLEDONS											
Alismataceae											
**Alisma lanceolatum*	O	-	-	-	-	-	-	-	-	-	O
Damasonium minus	O	O	-	-	O	O	O	-	-	-	-
Amaryllidaceae											
Calostemma luteum (+)				-	-	-	-	-	O	-	-
C. purpureum (+)				-	-	-	-	O	-	-	-
Crinum flaccidum (+)	-	-	O	-	-	-	-	-	O	-	-
Arecaceae											
**Phoenix dactylifera*	O	-	-	O	-	-	-	-	-	-	-
Cyperaceae											
Bolboschoenus medianus	O	-	-	-	-	O	-	-	O	O	-
Carex appressa	O	-	-	O	-	O	-	-	-	-	O
C. bichenoviana (+)				-	-	O	-	-	-	-	-
C. chlorantha	O	-	-	O	-	-	-	-	-	-	-
C. gaudichaudiana	F	-	-	F	O	O	-	-	-	-	-
C. inversa	F	O	F	F	F	F	F	-	-	-	-
C. tereticaulis	A	O	O	F	F	A	F	-	-	-	-
Cyperus difformis (+)				-	-	O	-	-	-	-	-
**C. eragrostis*	F	-	-	F	F	F	O	-	-	-	-
C. exaltatus	F	-	-	O	O	O	F	F	F	O	-
C. flaccidus (+)				-	O	O	-	O	-	-	-
C. gunnii	O	-	-	-	-	O	O	-	-	-	-
C. gymnocaulos	A	O	-	-	-	-	O	O	A	A	A
C. pygmaeus (+)				-	-	-	O	O	O	O	-
C. squarrosus (+)				-	-	-	-	O	-	-	-
C. victoriensis (+)				-	-	O	-	-	-	-	-
Eleocharis acuta	A	O	-	F	F	A	A	O	O	O	O
**E. minuta* (+)				-	-	O	-	-	-	-	-
E. pallens (+)				-	-	-	-	O	-	-	-
E. pusilla	F	O	O	F	F	F	F	-	-	-	-
Fimbristylis aestivalis	O	-	-	-	O	O	-	-	-	-	-
Isolepis cernua	O	-	-	-	-	-	-	-	-	-	O
I. inundata	O	-	-	-	-	-	-	-	O	-	O
	RedGm	BlkBx	Rises	1	2	3	4	5	6	7	8

Species	Vegetation zone			River section							
	RedGm	BlkBx	Rises	1	2	3	4	5	6	7	8
I. marginata	-	-	O	-	-	-	-	O	-	-	-
I. platycarpa (+)	O	-	-	-	-	-	-	O	-	-	-
I. victoriensis	O	-	-	O	-	-	-	-	-	-	-
Schoenoplectus validus	F	-	-	-	-	-	-	-	-	O	F
Schoenus apogon	O	-	-	-	-	O	-	-	-	-	-
Hydrocharitaceae											
Ottelia ovalifolia (+)				-	O	-	-	-	-	-	-
Vallisneria spiralis s.l.	O	-	-	-	O	-	-	-	O	-	-
Iridaceae											
**Romulea rosea*	O	-	-	O	-	-	-	-	-	-	-
Juncaceae											
**Juncus acutus*	O	O	-	-	-	-	O	-	O	-	-
J. amabilis	F	-	-	F	F	F	F	-	-	-	-
J. aridicola	F	-	-	-	-	O	O	O	O	O	F
**J. articulatus*	O	-	-	-	-	-	O	-	-	-	-
J. bufonius	O	-	-	O	O	O	-	-	-	-	-
J. filicaulis (+)				-	-	O	-	-	-	-	-
J. flavidus	F	O	O	F	F	F	F	-	O	-	-
J. holoschoenus	O	-	-	-	-	O	-	-	-	-	-
J. ingens	O	-	-	O	O	O	-	-	-	-	-
J. radula (+)				-	-	O	-	-	-	-	-
J. sarophorus (+)				-	-	O	-	-	-	-	-
J. subsecundus (+)				-	-	O	-	-	-	-	-
J. usitatus	O	-	-	O	-	O	-	-	-	-	-
J. vaginatus	O	-	-	O	-	-	-	-	-	-	-
Juncaginaceae											
**Lilaea scilloides* (+)				-	-	O	-	-	-	-	-
Triglochin calcitrapum (+)											
T. centrocarpum	-	-	O	-	-	-	-	O	-	-	-
T. procerum	F	O	-	O	O	O	O	-	-	-	F
T. striatum	O	-	-	-	-	-	-	-	O	-	O
Liliaceae											
Arthropodium minus	O	-	O	-	O	O	O	-	-	-	-
**Asparagus officinalis*	O	O	-	O	-	-	O	O	O	-	-
**Asphodelus fistulosus*	O	O	-	-	O	-	-	O	O	O	O
Bulbine bulbosa (+)				-	O	O	-	-	-	-	-
B. semibarbata	O	F	-	-	-	-	O	O	F	O	-
Dianella longifolia	O	-	O	-	O	O	O	-	-	-	-
D. revoluta (+)				-	-	O	-	-	O	-	-
Dichopogon fimbriatus	O	-	-	-	O	O	-	-	-	-	-
D. strictus (+)				-	-	O	-	-	-	-	-
Hypoxis hygrometrica (+)				-	O	O	-	-	-	-	-
Thysanotus baueri (+)	-	-	O	-	-	-	-	O	-	-	-
Tricoryne elatior	O	-	O	O	O	-	-	-	-	-	-
Wurmbea dioica (+)				-	-	-	-	-	O	-	-
Orchidaceae											
Microtis parviflora (+)				-	-	O	-	-	-	-	-
M. unifolia	O	-	-	-	-	O	-	-	-	-	-
Prasophyllum odoratum (+)				-	-	O	-	-	-	-	-
Poaceae											
Agrostis aemula (+)				-	-	O	-	-	-	-	-
A. avenacea	A	F	-	A	A	A	A	A	A	A	A
**A. capillaris*	O	-	-	O	-	-	-	-	-	-	-
**Aira caryophyllea* (+)				-	O	O	-	-	-	-	-
**A. praecox* (+)				-	-	O	-	-	-	-	-
**Alopecurus geniculatus* (+)				-	O	O	-	-	-	-	-
Amphibromus fluitans	O	-	-	-	O	O	-	-	-	-	-
A. nervosus	O	O	-	O	O	O	O	-	-	-	-
	RedGm	BlkBx	Rises	1	2	3	4	5	6	7	8

Species	Vegetation zone			River section							
	RedGm	**BlkBx**	**Rises**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Aristida holathera (+)				-	-	-	-	-	O	-	-
A. jerichoensis	-	-	O	O	-	-	-	-	-	-	-
**Avena barbata*	F	O	O	F	F	F	F	O	O	F	F
**A. fatua*	O	-	-	O	O	O	-	-	-	-	-
**A. sativa*	O	-	-	-	O	-	-	-	-	-	-
Bothriochloa macra (+)				-	-	O	-	-	-	-	-
**Briza maxima*	O	-	-	O	-	-	-	-	-	-	-
**B. minor*	O	-	O	O	O	O	O	-	-	-	-
**Bromus alopecuroides*	O	-	-	-	O	-	O	-	-	-	-
B. arenarius	-	F	-	-	-	O	-	O	F	-	-
**B. catharticus*	F	-	O	F	O	O	O	-	-	-	F
**B. diandrus*	A	O	A	A	A	A	A	O	-	A	A
**B. hordeaceus*	A	O	A	A	A	A	A	-	-	-	-
**B. lanceolatus* (+)				-	-	O	-	-	-	-	-
**B. madritensis*	O	O	O	O	F	O	O	-	-	-	-
**B. rubens*	A	A	A	O	-	F	F	A	A	A	A
**B. sterilis* (+)				-	O	O	-	-	-	-	-
Chloris truncata	O	O	O	O	O	-	O	-	-	-	-
**Critesion hystrix*	F	-	-	F	-	-	-	-	-	-	-
**C. marinum*	O	O	-	-	-	O	O	O	O	O	-
**C. murinum*	A	A	F	A	A	A	A	A	A	A	A
**Cynodon dactylon*	A	O	-	A	A	A	A	A	A	A	A
**Cynosurus echinatus*	O	-	O	O	-	-	-	-	-	-	-
Danthonia auriculata (+)				-	-	O	-	-	-	-	-
D. caespitosa	A	A	A	A	A	A	A	A	A	A	O
D. duttoniana	F	-	O	F	F	F	F	-	-	-	-
D. induta (+)				-	-	O	-	-	-	-	-
D. linkii (+)				-	-	O	-	-	-	-	-
D. monticola (+)				-	-	O	-	-	-	-	-
D. pilosa (+)				-	-	O	-	-	-	-	-
D. racemosa (+)				-	-	O	-	-	-	-	-
D. setacea	O	O	-	-	O	O	-	O	O	-	-
**Desmazeria rigida* (+)				-	-	O	-	-	-	-	-
Deyeuxia quadriseta	O	O	O	O	O	O	O	-	-	-	-
Dichelachne crinita (+)				-	-	O	-	-	-	-	-
D. micrantha	O	-	-	O	O	-	-	-	-	-	-
Digitaria ammophila (+)	-	-	O	-	-	O	O	O	O	-	-
D. divaricatissima (+)				-	O	-	-	-	-	-	-
**D. sanguinalis* (+)				-	-	O	-	-	-	-	-
Diplachne fusca (+)											
Distichlis distichophylla (+)											
**Echinochloa colona*	O	-	-	-	-	-	O	-	-	-	-
**E. crus-galli*	O	-	-	-	-	O	-	-	O	-	-
**Ehrharta erecta*	O	-	-	-	O	O	-	-	-	-	-
**E. longiflora*	O	-	-	-	-	-	O	-	-	O	-
Elymus scabrus	F	-	F	F	F	O	O	-	-	-	-
**Elytrigia repens*	O	-	-	-	O	-	O	-	O	-	-
Enneapogon avenaceus	-	-	O	-	-	-	-	O	O	-	-
Enteropogon acicularis	O	O	-	-	O	-	O	O	O	-	-
Eragrostis australasica	O	O	-	-	-	-	-	O	O	O	-
E.brownii	O	-	-	O	-	-	-	-	-	-	-
**E. cilianensis* (+)				-	-	O	-	-	-	-	-
E. dielsii	O	-	-	-	-	-	-	-	-	O	-
E. elongata	F	-	O	F	F	O	O	O	O	-	-
E. falcata (+)				-	-	-	-	-	O	-	-
E. lacunaria	O	O	-	-	-	-	-	O	O	O	-
E. parviflora	O	-	-	O	-	O	-	-	O	-	-
E. tenellula (+)				-	-	O	-	-	-	-	-
Eulalia fulva	O	-	-	O	-	O	-	O	-	-	-
**Festuca arundinacea*	O	-	-	-	-	-	-	-	-	-	O
Hemarthria uncinata	F	-	-	F	O	O	-	-	-	-	-
**Holcus lanatus*	O	-	-	O	-	O	-	-	-	-	-
Isachne globosa	O	-	-	O	-	-	-	-	-	-	-
	RedGm	**BlkBx**	**Rises**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**

Species	Vegetation zone			River section							
	RedGm	BlkBx	Rises	1	2	3	4	5	6	7	8
**Lagurus ovatus* (+)				-	-	O	-	-	-	-	-
**Lamarckia aurea*	O	O	-	-	-	-	O	-	O	O	-
**Lolium loliaceum* (+)				-	O	O	-	-	-	-	-
**L. multiflorum*	O	-	-	O	O	O	-	-	-	-	-
**L. perenneXrigidum*	A	O	A	A	A	A	A	F	-	O	F
**L. rigidum*	F	O	O	F	F	F	O	-	-	-	-
**L. temulentum* (+)				-	-	O	-	-	-	-	-
Microlaena stipoides	O	-	-	O	-	-	-	-	-	-	-
**Panicum coloratum*	O	-	-	-	-	O	O	-	O	-	-
P. effusum	O	-	O	O	-	O	-	-	-	O	-
**P. prolutum*	O	-	-	O	-	-	O	-	-	-	-
**Parapholis incurva*	-	O	-	-	-	-	-	-	O	O	-
**Paspalidium constrictum* (+)	-	-	O	-	-	-	-	-	O	-	-
P. jubiflorum	A	F	-	F	F	A	A	A	A	A	-
**Paspalum dilatatum*	F	-	-	F	O	O	O	-	-	-	F
**P. distichum*	F	-	-	F	F	F	F	F	F	F	-
**Pennisetum clandestinum*	O	-	-	O	-	-	-	-	-	-	O
**Pentaschistis airoides*	O	O	F	O	O	O	-	F	-	-	-
**Periballia minuta* (+)				-	-	O	-	-	-	-	-
**Phalaris minor*	F	O	-	F	O	O	F	-	-	-	-
**P. paradoxa*	O	-	-	-	O	O	-	-	-	-	-
Phragmites australis	A	O	-	O	O	O	O	O	A	A	A
**Poa annua*	O	-	-	O	O	O	-	-	-	-	O
P. fordeana (+)				-	-	O	-	-	-	-	-
P. labillardieri	A	-	O	A	A	F	F	O	-	-	-
**P. pratensis*	O	-	-	O	-	O	-	-	-	-	-
P. sieberiana	O	-	O	-	O	O	-	-	-	-	-
**Polypogon monspeliensis*	O	O	-	O	O	O	O	-	O	O	-
Pseudoraphis spinescens	A	-	-	F	F	A	F	O	O	-	-
**Rostraria cristata*	O	O	-	-	O	O	-	O	-	O	-
**R. pumila*	-	O	-	-	-	-	-	-	O	-	-
**Schismus barbatus*	O	A	F	-	O	O	F	F	A	F	-
**Setaria pumila*	O	-	-	O	O	O	-	-	-	-	-
**Sporobolus indicus* (+)				-	-	O	-	-	-	-	-
S. mitchellii	A	A	-	-	-	O	-	O	A	A	-
S. virginicus (+)	-	O	-	-	-	-	-	-	O	-	-
Stipa aristiglumis (+)	-	-	-	-	-	O	-	-	-	-	-
S. drummondii	O	-	-	-	-	-	-	-	-	-	O
S. elegantissima (+)	O	-	O	-	-	-	-	O	O	-	-
S. metatoris (+)	-	-	O	-	-	-	O	-	-	-	-
S. nitida	-	-	O	-	-	-	-	O	-	-	-
S. nodosa	O	O	O	-	-	O	O	-	O	O	O
S. pilata (+)	-	-	O	-	-	-	-	-	O	-	-
S. scabra	-	-	O	-	-	O	-	-	-	-	-
Themeda australis (+)				-	O	-	-	-	-	-	-
Tripogon loliiformis (+)				-	-	O	-	-	-	-	-
**Triticum aestivum*	O	-	-	-	-	-	-	O	O	O	-
**Vulpia bromoides*	A	-	A	A	A	A	O	-	-	-	-
**V. myuros*	A	A	A	A	A	A	A	A	A	A	A
Potamogetonaceae											
Potamogeton crispus	O	-	-	-	-	-	-	-	O	O	-
P. tricarinatus	O	-	-	-	O	O	O	O	O	O	-
Typhaceae											
Typha spp. (T. domingensis & T. orientalis)	F	0	-	-	-	O	O	O	O	F	F
Xanthorrhoeaceae											
Lomandra collina	-	-	O	-	-	O	-	-	-	-	-
L. effusa (+)				-	-	O	-	-	-	-	-
L. multiflora	-	-	O	O	-	-	-	-	-	-	-
	RedGm	BlkBx	Rises	1	2	3	4	5	6	7	8

APPENDIX 4. THREATENED SPECIES

Threatened riparian and aquatic species of the Murray floodplain are listed under six categories: presumed extinct, endangered, vulnerable, rare in Australia, status uncertain, threatened at State level. The first five categories refer to species on the national list of rare plants (Briggs & Leigh 1989). The last category refers to species classified as endangered or vulnerable on rare plant lists for Victoria (Land Conservation Council 1987; Cheal 1987) and South Australia (Lang & Kraehenbuehl 1987).

PRESUMED EXTINCT

1. *Acanthocladium dockeri* (Asteraceae)

Only known from collections on the River Murray at Overland Corner (Section 7) in 1910, and the Darling River near Menindee in 1860. Habitat noted as sandhills near river. No other records, in spite of recent searches at both localities.

References: Leigh *et al.* (1984); Davies (1987).

2. *Senecio behrianus* (Asteraceae)

Recorded on or near the Murray floodplain in Section 4 (Gannawarra near Koondrook, 1915; Lake Charm, 1925; Swan Hill, 1892, 1916), Section 7 (Moorundie near Blanchetown, 1847) and Section 8 (Wood's Point Station near Wellington, 1851). Also recorded from the Darling River and from Casterton on the Glenelg River. Habitat noted as river banks, river flats and swampy soils. No records since 1925, in spite of recent searches in both Victoria and South Australia.

References: Leigh *et al.* (1984); Davies (1987); Parsons & Scarlett (1987).

ENDANGERED

3. *Lepidium monoplocoides* (Brassicaceae)

Once widespread from Horsham in Victoria to Bourke in New South Wales and Berri in South Australia. Now known only from five localities, all in Victoria. Recorded on or near the Murray floodplain in Section 4 (Swan Hill, 1890; Falkiner Memorial Field Station at Deniliquin, 1945; Mystic Park, 1981; Reedy Lagoon in Gunbower Island State Forest, 1984), Section 5 (mallee scrub near the Murray-Murrumbidgee junction, 1855; Mildura 1923; Hattah Lakes, 1968, 1985) and Section 6 (Berri, 1915; Millewa Homestead, 1948). The only known extant population within the floodplain is on Gunbower Island, growing on alluvium inside a fenced area planted with various eucalypts, suggesting that protection from grazing is an important factor. The species grows both on heavy soils subject to flooding and on lighter soils above flood levels. At Hattah Lakes it has been recorded from the edge of a saline scald.

References: Hewson (1982a); Leigh *et al.* (1984); Parsons & Scarlett (1987); Lang & Kraehenbuehl (1987).

4. *Psoralea parva* (Fabaceae)

Once widespread from Sale in Victoria to Wagga in New South Wales and Adelaide in South Australia. Now known only from one locality in South Australia and six in Victoria. Recorded from the Murray floodplain in Section 2 (seedlings planted in Ulupna Island Flora and Fauna Reserve, 1981), Section 3 (Machonicies Crossing in Barmah State Forest, 1982) and Section 4 (Echuca, 1886). In Barmah State Forest it grows in two stands about 0.6 km apart, both in *Eucalyptus microcarpa* open-forest above normal flood levels. A perennial herb of grassland and grassy woodland on relatively rich soils. Grows and flowers in summer and autumn, making it more susceptible to grazing and fires than species with the typical winter-spring growth pattern.

References: Scarlett & Parsons (1982); Leigh *et al.* (1984); Parsons & Scarlett (1987); Nature Conservation Society (n.d.).

5. *Swainsona recta* (Fabaceae)

Formerly widespread from Murchison and Echuca in Victoria to Mudgee and Trangie in New South Wales. Most collections before 1939. Now known only from two localities, Wellington and Canberra. Presumed extinct along the Murray. Records last century in Section 1 (Murray River at Wodonga, 1886) and Section 4 (Murray River at Echuca, 1891, 1892) but precise localities unknown and may have been off the floodplain. Grows in grassy eucalypt woodlands.

References: Lee (1948); McBarron (1955); Scarlett & Parsons (1982); Leigh *et al.* (1984); Briggs & Leigh (1985); Parsons & Scarlett (1987).

VULNERABLE

6. *Amphibromus fluitans* (Poaceae)

Southern New South Wales, Victoria, Tasmania and New Zealand. Seldom collected and apparently rare. Recorded on or near the Murray floodplain in Section 1 (Albury, 1948, 1949, 1950), Section 2 (Dead End Lagoon on Ulupna Island, this survey) and Section 3 (Rat Castle Creek in Barmah State Forest, 1965; War Plain in Barmah State Forest, c.1979; Barmah, 1979). A species of seasonally inundated sites such as swamps and lagoon edges, where it may be locally common.

References: McBarron (1955); Chesterfield *et al.* (1984); Jacobs & Lapinpuro (1986); Parsons & Scarlett (1987); Benson (1987).

7. *Brachycome muelleroides* (Asteraceae)

Recorded from Nathalia and Benalla in Victoria north to Narrandera-Jerilderie and Wagga in New South Wales. On the Murray floodplain, recorded in Section 2 (Ulupna Island Reserve, 1968, 1980) and Section 3 (Forcing Yards in Barmah State Forest, c.1979; Machonicies Crossing in Barmah State Forest, 1980). Grows in shallow, seasonally inundated depressions with a heavy, cracking topsoil and a sparse cover of herbs and plant litter. Surrounding areas support open-forest of *Eucalyptus camaldulensis* or *E. microcarpa*.

References: Davis (1948); McBarron (1955); Muir (1972); Stuwe (1981); Chesterfield *et al.*(1984); Parsons & Scarlett (1987); Benson (1987).

8. *Brasenia schreberi* (Cabombaceae)

Queensland, New South Wales and Victoria. Also Africa, Asia and North America, and in the fossil flora of Europe. Recorded on the Murray floodplain in Section 1 (Lake Moodemere, last century; Bonegilla, 1976) and above Hume Dam (Talmalmo-Jingellic, 1976). The only other record for the Murray-Darling system this century is Nagambie on the Goulburn River, although there are a number of records east of the Great Dividing Range in New South Wales and Queensland. An aquatic species with floating leaves. Grows in still, freshwater lagoons or backwaters on sandy or muddy bottoms, at depths from a few cm to at least 2m. Prefers acid water conditions.

References: Aston (1973); Sainty & Jacobs (1981); Frood (1983b); specimen collection at NSW Herbarium.

9. *Callitriche cyclocarpa* (Callitrichaceae)

Scattered localities in Victoria and south-west New South Wales, most records pre-1920. Recorded on the Murray floodplain in Section 4 (Murray River at Swan Hill, 1890; locally abundant in floodwaters between Lakes Talpite and Poomah, 1974. The only other record since 1920 was near Mount Arapiles in 1968. Apparently aquatic, but may be amphibious.

References: Mason (1959); Aston (1973); Parsons & Scarlett (1987).

10. *Eriocaulon australasicum* (Eriocaulaceae)

Until recently known only from the type locality, along the Murray River near the Murrumbidgee junction, 1853 (Section 5). Since 1975 the species has been discovered and reserved in sites at Edenhope and Little Desert, but there have been no further records along the Murray and it is presumed extinct there. Grows in swamps.

References: Leigh *et al.* (1984); Parsons & Scarlett (1987).

11. *Lepidium pseudopapillosum* (Brassicaceae)

Recorded recently on the Murray floodplain on Lindsay Island in Section 6. Known from only a few other localities in Victoria, mainly around Bendigo, and an 1899 collection from the Flinders Ranges in South Australia. Grows in woodland and mallee. Most abundant in areas of dense litter around the stems of trees and shrubs. Unlike the introduced *L. africanum*, the species is not found in areas of soil disturbance.

References: Hewson (1982a); Parsons & Scarlett (1987); Land Conservation Council (1987).

12. *Maireana cheelii* (Chenopodiaceae)

Riverine Plain in Victoria and New South Wales, from Bendigo to Hay, with one collection near Wanaaring. Recorded on or near the Murray floodplain in Section 4 (Deniliquin, 1935; River Murray south of Moulamein, 1947). The only known surviving populations in Victoria are nearby in the Mystic Park area. The species is more frequent, though still uncommon, between Deniliquin and Hay on grey clay soils in *Atriplex vesicaria* communities. It is able to colonize scalded soils and appears to withstand heavy grazing reasonably well. Notes with the 1947 collection indicated that the species was confined to red-brown clay-loams in sites where rainwater collects - not extending to the grey river soils or the higher elevations of the red soils.

References: Wilson (1975); Cunningham *et al.* (1981); Parsons & Scarlett (1987); Benson (1987).

13. *Stipa metatoris* (Poaceae)

A recently described species, all records in New South Wales. Recorded on the Murray floodplain in Section 4 (Merran Creek, n.d.; Ten Mile Ridge north of Swan Hill, 1947; Cunninyeuk 1946, 1980; Stony Crossing, 1947; Kyalite State Forest, 1980, 1981, 1985) and Section 5 (Lake Benanee, Euston, 1947). The only other localities known are Condobolin and south-west of Nymagee. Grows on sandy rises above normal flood levels.

References: Everett & Jacobs (1983); specimen collection at NSW Herbarium.

14. *Swainsona murrayana* (Fabaceae)

Once common from the Wannon River in Victoria to the Tooma River, Moree and Broken Hill in New South Wales, with one record in South Australia west of Broken Hill. Now rare, especially in Victoria. There are two subspecies, *murrayana* and *eciliata*, both widely distributed. Recorded on or near the Murray floodplain in Section 4, although none of the recent records is within the floodplain and the precise localities of the old records are uncertain (ssp. *murrayana*: Swan Hill, 1889; lower Edward River, 1889; CSIRO Field Station at Deniliquin, 1973; Mystic Park, 1981; ssp. *eciliata*: between Echuca and Wyuna, 1982). Grows in *Eucalyptus largiflorens*, *Allocasuarina luehmannii*, *Atriplex vesicaria* and grassland communities.

References: Lee (1948); Cunningham *et al.* (1981); Scarlett & Parsons (1982); Parsons & Scarlett (1987); Benson (1987).

RARE IN AUSTRALIA

15. *Brachycome gracilis* (Asteraceae)

Mainly found in the Benalla-Wangaratta-Beechworth area of Victoria, extending into New South Wales north of Talmalmo. There are two widely disjunct records: Wamboyne Mountain, south of Condobolin, in 1956, and the Murray floodplain at King's Billabong Reserve in 1986 (Section 5). Typically a species of open-forest and scrub on shallow, rocky soils. At King's Billabong it grows on slight rises in the black box zone. The King's Billabong population may not, in fact, be *B. gracilis* but a new species. Collections with fully ripe fruit are needed for confirmation.

References: Davis (1954); Cunningham *et al.* (1981); Parsons & Scarlett (1987); specimen collection at NSW Herbarium.

16. *Elachanthus glaber* (Asteraceae)

Only known from Koonamore and Red Cliff Point in South Australia, and from several localities in the far north-west of Victoria. May have been overlooked elsewhere because of confusion with the more common *E. pusillus*. Recorded from the Murray floodplain in Bottle Bend Reserved Forest near Red Cliffs in 1984 (Section 5). Typically found on saline/gypseous soils but the Bottle Bend stand is on a non-gypseous sandy rise.

References: Jessop & Toelken (1986); Parsons & Scarlett (1987).

17. *Zannichellia palustris* (Zannichellaceae)

Recorded from the Murray floodplain in Section 6 (Lake Bonney, 1965), Section 7 (Purnong, 1958), Section 8 (Murray Bridge, 1887) and further downstream (Meningie, 1959). The only other Australian record is from the Hunter River but the species is also found in Europe, Africa, North America, Asia and New Zealand. A submerged aquatic perennial of fresh to saline waters up to 50cm deep, including ephemeral pools.

References: Aston (1973); Sainty & Jacobs (1981); Benson (1987); Lang & Kraehenbuehl (1987).

STATUS UNCERTAIN

18. *Swainsona microcalyx* (Fabaceae)

Two subspecies. Ssp. *microcalyx* known only from five localities between Yorke Peninsula in South Australia and Charlotte's Waters in the Northern Territory; no collections since 1928 and none near the Murray. Ssp. *adenophylla* known only from five pre-1928 collections in South Australia (Lake Torrens to the Warburton River), a recent collection near Menindee in New South Wales, and a collection from the Murray floodplain at Trickey's Track, Barmah State Forest, in 1979 (Section 3). Typically a species of the arid zone, but the last site was in *Eucalyptus camaldulensis* woodland on the outer floodplain.

References: Lee (1948); Cunningham *et al.* (1981); Chesterfield *et al.* (1984); Parsons & Scarlett (1987).

THREATENED AT STATE LEVEL

19. *Acacia loderi* (Mimosaceae)

New South Wales, Victoria and South Australia. Recorded from the Murray floodplain in Section 6 (Boy Creek west of Merbein). Few records in Victoria and considered vulnerable there. More common in New South Wales.

References: Beauglehole (1979); Cunningham *et al.* (1981); Jessop & Toelken (1986).

20. *Amaranthus macrocarpus* (Amaranthaceae)

Queensland, New South Wales, Victoria and South Australia. Recorded on or near the Murray floodplain in Section 4 (Echuca; 40 km SW of Deniliquin; Coonimur), Section 5 (Mildura) and Section 6 (Wallpolla Island). Considered vulnerable in Victoria. More common in New South Wales. Occurs in a wide range of vegetation types, mainly in depressions or low-lying situations, typically on clay soils.

References: Leigh & Mulham (1977); Beauglehole (1979, 1986); Cunningham *et al.* (1981).

21. *Ammania multiflora* (Lythraceae)

All States, Asia and North Africa. Considered vulnerable in Victoria but more common in New South Wales and South Australia. Recorded on the Murray floodplain in Section 5 (Lambert Island, 1986), Section 6 (Loxton, 1956; Lake Bonney, 1957; Lyrup, 1957; Renmark, 1974; Wallpolla Island, 1986) and Section 7 (Morgan, 1895; Blanchetown, 1973). Grows in moist situations, often in shallow water of swamps or on river banks with heavy clay soils.

References: Cunningham *et al.* (1981); Ashwell (1987); Lang & Kraehenbuehl (1987).

22. *Asperula gemella* (Rubiaceae)

Queensland, New South Wales, Victoria and South Australia. Known from only a few localities in Victoria and considered vulnerable there. Very common along the Murray in South Australia.

References: Ashwell (1987); this survey.

23. *Atriplex angulata* (Chenopodiaceae)

All mainland States except Western Australia. Recorded from the Murray floodplain at Boundary Bend in Section 5. Considered vulnerable in Victoria but more common further north.

References: Beauglehole (1979); Cunningham *et al.* (1981).

24. *Atriplex rhagodioides* (Chenopodiaceae)

New South Wales, Victoria and South Australia. Few records for New South Wales or Victoria and considered vulnerable in the latter State. Very common on the Murray floodplain across the border in South Australia.

References: Beauglehole (1979, 1986); Wilson (1984); this survey.

25. *Brachycome readeri* (Asteraceae)

New South Wales, Victoria and South Australia. A rare species throughout its range. Recorded from the Murray floodplain in Section 2 (Ulupna Island) and Section 3 ('Deniliquin-Tocumwal district'). Most other records are from south-west Victoria and adjacent South Australia. Grows in shallow depressions in *Eucalyptus camaldulensis* forest on Ulupna Island, and on brown clays in open *E. largiflorens* communities in the Deniliquin-Tocumwal district.

References: Davis (1948); Muir (1972); Cunningham *et al.* (1981); Beauglehole (1986).

26. *Calandrinia volubilis* (Portulacaceae)

New South Wales, Victoria and South Australia. Formerly classified as rare in Australia but recently deleted from the list. Recorded on the Murray floodplain in Section 5 (Lake Iraak; Lake Ranfurley; Merbein) and Section 6 (Wentworth; Chowilla Station; Disher's Creek), growing in the *Eucalyptus largiflorens - Atriplex rhagodioides, Atriplex vesicaria - Pachycornia triandra* and *Halosarcia* spp. communities.

References: Beauglehole (1979); Ashwell (1987); this survey.

27. *Casuarina obesa* (Casuarinaceae)

A common species in Western Australia. Also recorded from New South Wales, Victoria and South Australia, but in very few localities and highly endangered in this part of its range. Recorded on the Murray floodplain in Section 5 (Lake Benanee at Euston, 1951, 1955; Karadoc Swamp, 1987). The stand at Lake Benanee has since been cleared. The stand at Karadoc Swamp is on heavy grey clay around the western edge of the intermittent lake. The lake was originally slightly saline but has become more so with surrounding irrigation developments and less frequent flooding of the lake. The stand is dying as a result of salinisation and is unlikely to survive, in spite of efforts to preserve it. As far as is known, there is only one other surviving population in eastern Australia (near Natimuk).

References: Jessop & Toelken (1986); Parsons & Scarlett (1987); specimen collection at NSW Herbarium

28. *Crinum flaccidum* (Amaryllidaceae)

All mainland States. Recorded on the Murray floodplain in Section 6 (Wallpolla Island; Lock 9; Ned's Corner; Lake Walla Walla; Lindsay Island; Chowilla; Pike River; Katarapko Game Reserve). Considered vulnerable in Victoria but common further north. On the Murray floodplain it grows mainly on sand dunes.

References: Beauglehole (1979); Barratt & Choate (1983); Cunningham *et al.* (1981); National Parks & Wildlife Service (1983); Bond (1983b); Ashwell (1987)

29. Cyperus flaccidus (Cyperaceae)

Northern Territory, Queensland, New South Wales and Victoria. Recorded on the Murray floodplain in Section 2 (Cobram), Section 3 (Rowe's Swamp in Barmah State Forest) and Section 5 (King's Billabong Reserve). Considered vulnerable in Victoria.

References: Beauglehole (1979; 1986); Chesterfield *et al.* (1984).

30. *Cyperus pygmaeus* (Cyperaceae)

All mainland States and cosmopolitan. Considered vulnerable in Victoria. Recorded from the Murray floodplain in Sections 4 to 7 (Nyah State Forest; Byerley's Bend; Murray-Kulkyne State Park; Colignan; Mildura; and seven collections between Lyrup and Blanchetown). Grows in wet, often only temporarily wet places.

References: Beauglehole (1979); Frood (1983a); Lang & Kraehenbuehl (1987).

31. *Cyperus squarrosus* (Cyperaceae)

All mainland States and cosmopolitan. Recorded on the Murray floodplain in Section 5 (King's Billabong Reserve). Considered vulnerable in Victoria. More typical of inland regions further north.

Grows on the margins of lakes and watercourses, on clays or sands, often in relatively dry situations.

References: Beauglehole (1979); Cunningham *et al.* (1981).

32. *Damasonium minus* (Alismataceae)

All States. Moderately common along the Murray on the Riverine Plain but considered a vulnerable species in South Australia, where there have been only two records, one of which was on the Murray at Mannum in 1883. Grows in still or slowly flowing, ephemeral or permanent, fresh water up to 30 cm deep.

References: Sainty & Jacobs (1981); Lang & Kraehenbuehl (1987); this survey.

33. *Digitaria ammophila* (Poaceae)

All mainland States. Recorded on the Murray floodplain in Section 3 (Buck's Sandhill in Barmah State Forest), Section 4 (Deep Creek south of Barmah), Section 5 (Murray-Kulkyne State Park; King's Billabong Reserve), Section 6 (Berri, 1919; Katarapko Game Reserve, 1976) and Section 7 (Swan Reach, 1927). Occurs mainly on sandy rises. Considered vulnerable in Victoria but more common further north.

References: Beauglehole (1979, 1986); Cunningham *et al.* (1981); Chesterfield *et al.* (1984); Lang & Kraehenbuehl (1987).

34. *Digitaria divaricatissima* (Poaceae)

Queensland, New South Wales and Victoria. Recorded on the Murray floodplain in Section 2 (opposite Tocumwal, 1985) and Section 4 (Dalton's Bridge at Cohuna, 1949). Few other records in Victoria but more common further north. Grows on sandy soils, duplex soils and red earths, often in areas subject to periodic flooding.

References: Cunningham *et al.* (1981); Frood (1983a); Beauglehole (1986).

35. *Eleocharis minuta* (Cyperaceae)

Queensland, New South Wales, Victoria and Africa. Recorded on the Murray floodplain at Goose Neck in Barmah State Forest (Section 3). Very few other Victorian records and considered vulnerable in that State, although it may, in fact, be an introduced species there.

References: Jacobs & Pickard (1981); Chesterfield *et al.* (1984).

36. *Eleocharis pallens* (Cyperaceae)

All mainland States. Recorded on or near the Murray floodplain in Section 5 (13 km SE of Robinvale). Considered vulnerable in Victoria but very common further north. Ephemeral pools, swamps and periodically inundated floodplains on heavy soils.

References: Beauglehole (1979); Sainty & Jacobs (1981); Cunningham *et al.* (1981).

37. *Eleocharis pusilla* (Cyperaceae)

All States and New Zealand. Common along the Murray on the Riverine Plain but considered an endangered species in South Australia. The only South Australian records along the Murray are old ones ('River Murray,' 1884, 1910; Mannum, 1936; Berri, 1957).

References: Lang & Kraehenbuehl (1987); this survey.

38. *Eragrostis australasica* (Poaceae)

All mainland States. Recorded on the Murray floodplain in Sections 5 to 7. Considered vulnerable in Victoria but very common further north.

References: Cunningham *et al.* (1981); Land Conservation Council (1987); this survey.

39. *Eremophila bignoniiflora* (Myoporaceae)

All mainland States. An arid zone species of heavy clay soils subject to flooding. Recorded on the Murray floodplain in Section 5 (Murray-Kulkyne State Park; Cowra Lagoon) and Section 6 (Potterwakagee Creek; Ned's Corner Station; Lake Victoria; Lake Walla Walla; Lindsay Island; Chowilla Station; Hunchee Island; Pike River; Katarapko Game Reserve). The Murray population is considered endangered in Victoria and vulnerable in South Australia. The species' main occurrences are further north.

References: Beauglehole (1979); Cunningham *et al.* (1981); National Parks & Wildlife Service (1983); Bond (1983b); Lang & Kraehenbuehl (1987); Ashwell (1987).

40. *Eremophila polyclada* (Myoporaceae)

All mainland States except Western Australia. In Victoria, restricted to the far north-west and considered vulnerable. More common in New South Wales and South Australia, particularly in northern regions. Recorded on the Murray floodplain in Section 5 (Cowra Lagoon) and Section 6 (Wallpolla Creek; Ned's Corner Station; Lake Walla Walla; Lindsay Island; also in South Australia but no details available). Grows on clay and duplex soils of inland floodplains and low-lying areas generally.

References: Beauglehole (1979); Cunningham *et al.* (1981); Jessop & Toelken (1986); Ashwell (1987).

41. *Eryngium plantagineum* (Apiaceae)

Queensland, New South Wales, Victoria and South Australia. Considered vulnerable in Victoria but common further north. Recorded on the Murray floodplain in Section 5 (Bumbang Island and Walshes Bend at Robinvale). Grows on clay soils, in floodplains and also flats between sand dunes.

References: Cunningham *et al.* (1981); Ashwell (1987).

42. *Euphorbia parvicaruncula* (Euphorbiaceae)

All mainland States. Recorded on the Murray floodplain in Section 6 (Millewa Homestead). This is the only record for Victoria and the species is considered endangered in that State. More common in arid regions further north.

References: Cunningham *et al.* (1981); Jessop & Toelken (1986); Land Conservation Council (1987)

43. *Euphorbia tannensis* (Euphorbiaceae)

All mainland States and South Pacific. Recorded on the Murray floodplain in Section 6 (Millewa Homestead). This is the only Victorian record and the species is considered endangered in that State. More common further north. Habitat variable, usually heavy clay soils on floodplains but also sand ridges and skeletal hillside soils.

References: Beauglehole (1979); Cunningham *et al.* (1981); Jessop & Toelken (1986)

44. *Fimbristylis aestivalis* (Cyperaceae)

All mainland States and Asia. The only record for South Australia is a specimen from the River Murray (no other details) in 1910. The species is now presumed extinct in that State. Still present along the Murray on the Riverine Plain.

References: Lang & Kraehenbuehl (1987); this survey.

45. *Geijera parviflora* (Rutaceae)

Queensland, New South Wales, Victoria and South Australia. The only known Victorian location is Piambie (Section 5) and the species is considered endangered in that State. However, it occurs more commonly between the Murray and Edward Rivers in Section 4 and is very common further north in New South Wales. Grows on rises within the floodplain.

References: Cunningham *et al.* (1981); Land Conservation Council (1987); this survey.

46. *Hypsela tridens* (Campanulaceae)

Recorded on the Murray floodplain in Section 2 (opposite Tocumwal, 1985; Boomanoomana State Forest, 1987), Section 3 (Barmah Island, 1978; northern Barmah State Forest, 1986) and outside the study area (Hume Reservoir). The Boomanoomana record (this survey) is the first for New South Wales. Previously known only from Victoria, where other localities are the Goulburn and Mitta Mitta Rivers, and Eildon, Yan Yean and Glenmaggie Reservoirs. Grows in wet places where water levels fluctuate. A vulnerable species but may have benefited from reservoir construction.

References: Frood (1983a); Chesterfield *et al.* (1984); Beauglehole (1986); this survey.

47. *Ixiolaena chloroleuca* (Asteraceae)

Queensland, New South Wales, Victoria and South Australia. Only recently described. Considered endangered in Victoria, where it is known only from a few plants growing on heavy soils near the Murray at Mildura (Section 5). This represents the southern limit of its known range. Elsewhere, it is usually found on sandy soils.

References: Jessop & Toelken (1986); Land Conservation Council (1987).

48. *Ixiolaena tomentosa* (Asteraceae)

New South Wales, Victoria, South Australia and Western Australia. Considered vulnerable in Victoria, where it is known from beside the Murray at Boundary Point (Section 6). However, the taxonomic distinction between this species and the variable *I. leptolepis* is not clear.

References: Beauglehole (1979); Jessop & Toelken (1986).

49. *Lepidium phlebopetalum* (Brassicaceae)

All mainland States. Recorded on or near the Murray floodplain in Section 5 (King's Billabong Reserve), Section 6 (Boundary Point) and Section 7 (Waikerie, 1963). Considered vulnerable in Victoria, where it is at the southern limit of its range. A common species of the arid zone.

References: Hewson (1982a); Land Conservation Council (1987).

50. *Lythrum salicaria* (Lythraceae)

Queensland, New South Wales, Victoria, South Australia, Tasmania and cosmopolitan. Considered vulnerable in South Australia. More common in the eastern States. Recorded on the Murray floodplain in Section 1 (Mungabareena Reserve at Albury, 1950), Section 3 (Mathoura area, n.d.; Barmah State Forest, c.1979) and Section 7 (Sinclair Flat, 1973; Blanchetown, 1973; Swan Reach, 1978). Grows in swamps and on the banks of watercourses.

References: McBarron (1955); Cunningham *et al.* (1981); Chesterfield *et al.* (1984); Lang & Kraehenbuehl (1987).

51. *Marsilea mutica* (Masileaceae)

All States and New Caledonia. The only record along the Murray is a sterile specimen from Morgan in 1894 (Section 7). This is also the only record for South Australia and the species is now presumed extinct in that State. However, there is some doubt about the identity of the specimen.

References: Jessop & Toelken (1986); Lang & Kraehenbuehl (1987).

52. *Menkea crassa* (Brassicaceae)

Queensland, Victoria and South Australia. Recorded on the Murray floodplain at Trickey's Gate in Barmah State Forest (Section 3), in a red gum - black box ecotone. This is the only record of the species for Victoria. More common in South Australia and Queensland, where it is largely restricted to the arid zone.

References: Hewson (1982b); Chesterfield *et al.* (1984)

53. *Najas tenuifolia* (Najadaceae)

All mainland States, Malaysia and New Caledonia. The only record for South Australia is from the River Murray at Mannum in 1883 (Section 8). The species is now presumed extinct in that State but is widespread along the Murray upstream. A submerged aquatic plant of still, fresh or slightly saline waters.

References: Aston (1973); Sainty & Jacobs (1981); Cunningham *et al.* (1981); Lang & Kraehenbuehl (1987).

54. *Nymphoides crenata* (Menyanthaceae)

All mainland States. Moderately common along the Murray on the Riverine Plain but believed extinct in South Australia, where there have been only two collections, one of them from the River Murray at Morgan in 1913 (Section 7). Grows in still or slowly flowing, fresh water to 1.5 m deep, usually on a mud substrate. Also frequent in temporarily inundated depressions and can persist for some time on drying mud.

References: Aston (1973); Sainty & Jacobs (1981); Jessop & Toelken (1986); Lang & Kraehenbuehl (1987); this survey.

55. Phyllanthus lacunarius (Euphorbiaceae)

All mainland States. Recorded on or near the Murray floodplain in Section 4 (Swan Hill), Section 5 (Hattah-Kulkyne National Park; Red Cliffs) and Section 6 (Wallpolla Island; Lake Walla Walla; Lindsay Island; Chowilla; Pike River; Katarapko Game Reserve). Considered vulnerable in Victoria. More common in the northern regions of New South Wales and South Australia. Found on a variety of soil types, in river and creek beds, banks and floodplains.

References: Beauglehole (1979); Cunningham *et al.* (1981); Barratt & Choate (1983); Bond (1983b); National Parks & Wildlife Service (1983); Jessop & Toelken (1986); this survey.

56. *Psoralea cinerea* (Fabaceae)

All mainland States. Recorded on the Murray floodplain in Section 5 (King's Billabong Reserve). Considered endangered in Victoria. More frequent, but still uncommon, in New South Wales. Floodplains and low-lying areas.

References: Beauglehole (1979); Cunningham *et al.* (1981).

57. *Psoralea tenax* (Fabaceae)

Queensland, New South Wales and Victoria. Recorded from the Murray floodplain in Section 4 (south-west of Deniliquin, c.1980) and Section 5 (Piambie State Forest, 1980; Brett Bend in Hattah-Kulkyne National Park, 1981; Lambert Island, 1982; Karadoc Bend, 1982; Bottle Bend, 1982; King's Billabong Reserve, 1982). Formerly widespread in Victoria but now very rare, the main occurrences being along the Murray. Also rare in south-east New South Wales. More common in north-east NSW and Queensland but these populations appear to be a different species or subspecies, as yet undescribed. Along the Murray the species grows on heavy clay soils in *Eucalyptus camaldulensis* and *E. largiflorens* woodlands, except at Piambie, where it is confined to silty sand rises supporting *E. microcarpa* woodland. The species is heavily grazed, especially as it grows in summer and autumn when feed may be scarce. Its growth pattern also makes it susceptible to fires. Considered endangered in Victoria.

References: Scarlett & Parsons (1982); Parsons & Scarlett (1987).

58. *Ptilotus nobilis* (Amaranthaceae)

All mainland States. Recorded on the Murray floodplain in Section 5 (Lambert Island; Bottle Bend; King's Billabong Reserve; White Cliffs Irrigation Settlement; Abbotsford Bridge) and Section 6 (south of Wallpolla Island). These are the only records of the species in Victoria and it is considered endangered in that State. However, it is a widespread species further north. Grows on a wide range of soils, from grey clays to red sands.

References: Beauglehole (1979); Ashwell (1987); Land Conservation Council (1987).

59. *Ranunculus papulentus* (Ranunculaceae)

Queensland, New South Wales, Victoria and South Australia. On the Murray floodplain the only record is at Wellington in 1959 (Section 8). Considered vulnerable in South Australia. Grows in moist situations.

Reference: Lang & Kraehenbuehl (1987).

60. *Ranunculus undosus* (Ranunculaceae)

New South Wales and Victoria. Recorded on the Murray floodplain in Nyah State Forest (Section 4). Considered vulnerable in Victoria. Grows in swampy sites in shallow water and in wet or drying mud. May be locally common in such sites.

References: Beauglehole (1979); Leigh & Mulham (1977); Cunningham *et al.* (1981).

61. *Santalum acuminatum* (Santalaceae)

All mainland States. Recorded from the Murray floodplain on Gunbower Island in Section 4. Widespread in northern Victoria but now uncommon to rare over most of this area as a result of clearing. Considered vulnerable in Victoria but common in New South Wales and South Australia. Grows in sandy soils in numerous woodland, mallee and scrub communities.

References: Frood (1983a); Cunningham *et al.* (1981); Jessop & Toelken (1986).

62. *Sida ammophila* (Malvaceae)

All mainland States except Western Australia. Recorded at various localities on the Murray floodplain in Sections 5, 6 and 7. An uncommon but widespread species found in numerous vegetation types and a variety of soil types, from clays to sands. On the Murray floodplain, mainly a species of the black box zone. Appears to be sensitive to grazing and regarded as a vulnerable species in Victoria.

References: Beauglehole (1979); Cunningham *et al.* (1981); Ashwell (1987); Lang & Kraehenbuehl (1987).

63. *Sida fibulifera* (Malvaceae)

All mainland States. Recorded on the Murray floodplain in Section 5 (King's Billabong Reserve, Red Cliffs Scenic Reserve and Murray-Kulkyne State Park), growing on rises and in black box woodland. These are the only Victorian records and the species is considered vulnerable in that State. A common, widespread species further north.

References: Cunningham *et al.* (1981); Land Conservation Council (1987).

64. *Solanum lacunarium* (Solanaceae)

Queensland, New South Wales, Victoria and South Australia. Recorded on the Murray floodplain in Section 6: Lake Walla Walla; Lindsay Island; Lyrup, 1921; Berri, 1921, 1957. Considered vulnerable in Victoria. Uncommon but widespread in New South Wales and South Australia. Grows only on floodplains.

References: Beauglehole (1979); Cunningham *et al.* (1981); Jessop & Toelken (1986); Lang & Kraehenbuehl (1987).

65. *Stipa pilata* (Poaceae)

South Australia and Victoria. A newly recognised species not yet formally described. Recorded from a rise on the Murray floodplain near Millewa in Section 6. This is the only Victorian record and the species is considered vulnerable in that State. More widespread, though still uncommon, in semi-arid eastern South Australia.

References: Jessop & Toelken (1986); Land Conservation Council (1987).

66. *Swainsona greyana* (Fabaceae)

Queensland, New South Wales, Victoria and South Australia. Grows in heavy clay soils on inland floodplains, particularly along the Darling River and its tributaries. Extends to the Murray floodplain in Sections 6 and 7. Considered a vulnerable species in Victoria, known only from Potterwakagee Creek and Lindsay Island, but more common along the Murray in South Australia.

References: Lee (1948); Ashwell (1987); this survey.

67. *Swainsona phacoides* (Fabaceae)

All mainland States. Considered vulnerable in Victoria but more common further north. Recorded on or near the Murray floodplain in Section 4 (Gunbower; Swan Hill; Piangil) and Section 5 (King's Billabong Reserve; Lake Ranfurley). Usually grows on sandplains, sand dunes and stony hillsides. Along the Murray, mostly found on sandy rises above flood levels.

References: Beauglehole (1979, 1986); Cunningham *et al.* (1981); Jessop & Toelken (1986); this survey.

68. *Triglochin hexagonum* (Juncaginaceae)

Victoria, South Australia, Northern Territory and Western Australia. Considered vulnerable in Victoria and rare in South Australia. The only record on the Murray floodplain is at Blanchetown in 1965 (Section 7).

Reference: Lang & Kraehenbuehl (1987).

APPENDIX 5.

TABLE 1. Structural Vegetation Class Areas (ha) by Geographic Section for the Murray River and Anabranches (Edward, Niemur, Wakool Rivers)

Structural Vegetation Class		Geographic Section								
		1	2	3	4	5	6	7	8	Total
1	RG-FOR	3372	8711	62137	88482	23851	13291	444	0	200288
2	RG-WOOD	2891	1082	3177	10402	1793	6243	5919	347	31854
3	RG/BOX	331	378	958	10604	8302	2587	128	0	23288
4	MIX BOX	816	730	7624	50151	0	0	0	0	59321
5	BB-WOOD	0	0	78	3631	45712	29414	4997	8	83840
6	BB MALLEE	0	0	0	10	14783	13197	2175	13	30178
7	CASUARINA	3	131	298	99	3760	350	0	0	4641
8	RVR COOBA	0	0	0	0	139	21	0	0	160
9	M FG WOOD	0	0	0	272	18118	6268	12601	0	37259
10	MALLEE	0	0	0	595	19171	9301	10544	0	39611
11	LIGNUM	0	0	120	13018	10576	9418	3462	36	36630
12	SAL SHRUB	3	0	3	0	2434	46527	3102	0	52069
13	OPEN	826	569	7725	61010	42194	34469	5245	314	152352
14	EXOTIC	657	299	30	200	298	35	154	706	2379
15	PASTURE	35224	20678	35498	129193	43810	11686	15294	10801	302184
16	ORCHARD	354	2231	11	2988	26040	15590	13092	8266	68572
17	URBAN	2482	1434	1355	2223	1876	869	495	882	11616
18	QUARRY	169	3	10	12	313	12	0	0	519
19	SAND DUNE	0	0	50	0	355	3124	129	107	3765
20	WATER	31256	1991	3815	25061	15160	25827	16094	50038	169242
Total		78384	38237	122889	397951	278685	228229	93875	71518	1309768

TABLE 2 Structural Vegetation Class Areas (ha) by Condition Class for Severely Degraded Areas along Geographic Section 1, Murray River

Structural Vegetation Class	Salt	Drowning	Drowned	Water Stress	Grazing	Fire	Clearing	Recreation	Unexplained	Total
1 RG-FOR	0	55	0	0	0	0	0	0	0	55
2 RG-WOOD	0	14	0	0	0	0	0	0	5	19
3 RG/BOX	0	0	0	0	0	0	0	0	0	0
4 MIX BOX	0	0	0	0	0	0	0	0	0	0
5 BB-WOOD	0	0	0	0	0	0	0	0	0	0
6 BB MALLEE	0	0	0	0	0	0	0	0	0	0
7 CASUARINA	0	0	0	0	0	0	0	0	0	0
8 RVR COOBA	0	0	0	0	0	0	0	0	0	0
9 M FG WOOD	0	0	0	0	0	0	0	0	0	0
10 MALLEE	0	0	0	0	0	0	0	0	0	0
11 LIGNUM	0	0	0	0	0	0	0	0	0	0
12 SAL SHRUB	0	0	0	0	0	0	0	0	0	0
13 OPEN	0	0	0	0	0	0	0	0	0	0
14 EXOTIC	0	0	0	0	0	0	0	0	0	0
15 PASTURE	0	0	0	0	0	0	0	0	0	0
16 ORCHARD	0	0	0	0	0	0	0	0	0	0
17 URBAN	0	0	0	0	0	0	0	0	0	0
18 QUARRY	0	0	0	0	0	0	0	0	0	0
19 SAND DUNE	0	0	0	0	0	0	0	0	0	0
20 WATER	0	0	259	0	0	0	0	0	0	259
Total	0	69	259	0	0	0	0	0	5	333

TABLE 3 **Structural Vegetation Class Areas (ha) by Condition Class for Severely Degraded Areas along Geographic Section 2, Murray River**

Structural Vegetation Class	Salt	Drowning	Drowned	Water Stres	Grazing	Fire	Clearing	Recreation	Unexplained	Total
1 RG-FOR	0	0	0	0	0	0	0	0	0	0
2 RG-WOOD	0	0	0	0	0	0	0	0	0	0
3 RG/BOX	0	0	0	0	0	0	0	0	0	0
4 MIX BOX	0	0	0	0	0	0	0	0	0	0
5 BB-WOOD	0	0	0	0	0	0	0	0	0	0
6 BB MALLEE	0	0	0	0	0	0	0	0	0	0
7 CASUARINA	0	0	0	0	0	0	0	0	0	0
8 RVR COOBA	0	0	0	0	0	0	0	0	0	0
9 M FG WOOD	0	0	0	0	0	0	0	0	0	0
10 MALLEE	0	0	0	0	0	0	0	0	0	0
11 LIGNUM	0	0	0	0	0	0	0	0	0	0
12 SAL SHRUB	0	0	0	0	0	0	0	0	0	0
13 OPEN	0	0	0	0	0	0	0	0	0	0
14 EXOTIC	0	0	0	0	0	0	0	0	0	0
15 PASTURE	0	0	0	0	0	0	0	0	0	0
16 ORCHARD	0	0	0	0	0	0	0	0	0	0
17 URBAN	0	0	0	0	0	0	0	0	0	0
18 QUARRY	0	0	0	0	0	0	0	0	0	0
19 SAND DUNE	0	0	0	0	0	0	0	0	0	0
20 WATER	0	0	0	0	0	0	0	0	0	0
Total	0	0	0	0	0	0	0	0	0	0

TABLE 4 Structural Vegetation Class Areas (ha) by Condition Class for Severely Degraded Areas along Geographic Section 3, Murray River

Structural Vegetation Class	Salt	Drowning	Drowned	Water Stress	Grazing	Fire	Clearing	Recreation	Unexplained	Total
1 RG-FOR	0	79	0	137	0	0	0	0	0	216
2 RG-WOOD	0	0	0	0	0	0	0	0	0	0
3 RG/BOX	0	0	0	57	0	0	0	0	0	57
4 MIX BOX	0	0	0	0	0	0	0	0	0	0
5 BB-WOOD	0	0	0	0	0	0	0	0	0	0
6 BB MALLEE	0	0	0	0	0	0	0	0	0	0
7 CASUARINA	0	0	0	0	0	0	0	0	0	0
8 RVR COOBA	0	0	0	0	0	0	0	0	0	0
9 M FG WOOD	0	0	0	0	0	0	0	0	0	0
10 MALLEE	0	0	0	0	0	0	0	0	0	0
11 LIGNUM	0	0	0	0	0	0	0	0	0	0
12 SAL SHRUB	0	0	0	0	0	0	0	0	0	0
13 OPEN	0	132	105	0	0	0	0	0	0	237
14 EXOTIC	0	0	0	0	0	0	0	0	0	0
15 PASTURE	0	0	0	0	0	0	0	0	0	0
16 ORCHARD	0	0	0	0	0	0	0	0	0	0
17 URBAN	0	0	0	0	0	0	0	0	0	0
18 QUARRY	0	0	0	0	0	0	0	0	0	0
19 SAND DUNE	0	0	0	0	0	0	0	0	0	0
20 WATER	0	0	23	0	0	0	0	0	0	23
Total	0	211	128	194	0	0	0	0	0	533

TABLE 5 Structural Vegetation Class Areas (ha) by Condition Class for Severely Degraded Areas along Geographic Section 4, Murray River

Structural Vegetation Class	Salt	Drowning	Drowned	Water Stress	Grazing	Fire	Clearing	Recreation	Unexplained	Total
1 RG-FOR	15	101	0	3	0	0	74	0	4	197
2 RG-WOOD	4	14	0	2	0	0	8	0	0	28
3 RG/BOX	0	0	0	0	0	0	58	0	0	58
4 MIX BOX	0	76	0	0	0	0	0	0	0	76
5 BB-WOOD	0	0	0	0	0	0	0	0	0	0
6 BB MALLEE	0	0	0	0	0	0	0	0	0	0
7 CASUARINA	0	0	0	0	0	0	0	0	0	0
8 RVR COOBA	0	0	0	0	0	0	0	0	0	0
9 M FG WOOD	0	0	0	0	0	0	0	0	0	0
10 MALLEE	0	0	0	0	0	0	0	0	0	0
11 LIGNUM	0	0	0	0	0	0	0	0	0	0
12 SAL SHRUB	0	0	0	0	0	0	0	0	0	0
13 OPEN	324	62	0	0	0	0	25	0	0	411
14 EXOTIC	0	0	0	0	0	0	0	0	0	0
15 PASTURE	0	0	0	0	0	0	0	0	0	0
16 ORCHARD	0	0	0	0	0	0	0	0	0	0
17 URBAN	0	0	0	0	0	0	0	0	0	0
18 QUARRY	0	0	0	0	0	0	0	0	0	0
19 SAND DUNE	0	0	0	0	0	0	0	0	0	0
20 WATER	0	0	97	0	0	0	0	0	0	97
Total	343	253	97	5	0	0	165	0	4	867

TABLE 6 Structural Vegetation Class Areas (ha) by Condition Class for Severely Degraded Areas along Geographic Section 5, Murray River

Structural Vegetation Class	Salt	Drowning	Drowned	Water Stress	Grazing	Fire	Clearing	Recreation	Unexplained	Total
1 RG-FOR	494	195	0	96	0	9	105	0	54	953
2 RG-WOOD	109	0	0	575	0	0	0	0	0	684
3 RG/BOX	0	9	0	0	0	0	0	0	0	9
4 MIX BOX	0	0	0	0	0	0	0	0	0	0
5 BB-WOOD	1550	32	0	93	0	0	24	35	44	1778
6 BB MALLEE	46	0	0	0	0	0	0	0	0	46
7 CASUARINA	34	0	0	0	0	0	0	0	0	34
8 RVR COOBA	0	0	0	0	0	0	0	0	0	0
9 M FG WOOD	35	17	0	0	0	0	20	0	0	72
10 MALLEE	0	0	0	0	0	0	0	0	0	0
11 LIGNUM	1045	0	0	0	0	0	0	0	0	1045
12 SAL SHRUB	0	0	0	0	0	0	0	0	0	0
13 OPEN	499	0	0	0	0	0	0	0	0	499
14 EXOTIC	0	0	0	0	0	0	0	0	0	0
15 PASTURE	0	0	0	0	0	0	0	0	0	0
16 ORCHARD	0	0	0	0	0	0	0	0	0	0
17 URBAN	0	0	0	0	0	0	0	0	0	0
18 QUARRY	0	0	0	0	0	0	0	0	0	0
19 SAND DUNE	0	0	0	0	0	0	0	0	0	0
20 WATER	0	0	712	0	0	0	0	0	0	712
Total	3812	253	712	764	0	9	149	35	98	5832

TABLE 7 Structural Vegetation Class Areas (ha) by Condition Class for Severely Degraded Areas along Geographic Section 6, Murray River

Structural Vegetation Class	Salt	Drowning	Drowned	Water Stress	Grazing	Fire	Clearing	Recreation	Unexplained	Total
1 RG-FOR	135	630	0	0	244	0	0	0	0	1009
2 RG-WOOD	1438	918	0	0	0	0	0	0	0	2356
3 RG/BOX	17	96	0	0	0	0	0	0	0	113
4 MIX BOX	0	0	0	0	0	0	0	0	0	0
5 BB-WOOD	312	189	0	0	0	0	0	0	0	501
6 BB MALLEE	965	234	0	0	0	0	0	0	0	1199
7 CASUARINA	0	0	0	0	0	0	0	0	0	0
8 RVR COOBA	0	0	0	0	0	0	0	0	0	0
9 M FG WOOD	0	0	0	0	0	0	0	0	0	0
10 MALLEE	0	3	0	0	0	0	0	0	0	3
11 LIGNUM	53	17	0	0	0	0	0	0	0	70
12 SAL SHRUB	0	0	0	0	0	0	0	0	0	0
13 OPEN	0	0	0	0	33	0	0	0	0	33
14 EXOTIC	0	0	0	0	0	0	0	0	0	0
15 PASTURE	0	0	0	0	0	0	0	0	0	0
16 ORCHARD	0	0	0	0	0	0	0	0	0	0
17 URBAN	0	0	0	0	0	0	0	0	0	0
18 QUARRY	0	0	0	0	0	0	0	0	0	0
19 SAND DUNE	0	0	0	0	0	0	0	0	0	0
20 WATER	0	0	1195	0	0	0	0	0	0	1195
Total	2920	2087	1195	0	277	0	0	0	0	6479

TABLE 8 **Structural Vegetation Class Areas (ha) by Condition Class for Severely Degraded Areas along Geographic Section 7, Murray River**

Structural Vegetation Class	Salt	Drowning	Drowned	Water Stres	Grazing	Fire	Clearing	Recreation	Unexplained	Total
1 RG-FOR	0	0	0	0	0	0	0	0	0	0
2 RG-WOOD	983	328	0	75	0	0	0	0	0	1386
3 RG/BOX	0	0	0	0	0	0	0	0	0	0
4 MIX BOX	0	0	0	0	0	0	0	0	0	0
5 BB-WOOD	0	6	0	0	251	0	0	0	0	257
6 BB MALLEE	414	0	0	0	0	0	0	0	0	414
7 CASUARINA	0	0	0	0	0	0	0	0	0	0
8 RVR COOBA	0	0	0	0	0	0	0	0	0	0
9 M FG WOOD	0	0	0	0	0	0	0	0	0	0
10 MALLEE	0	0	0	0	0	0	0	0	0	0
11 LIGNUM	0	0	0	0	0	0	0	0	0	0
12 SAL SHRUB	0	0	0	0	0	0	0	0	0	0
13 OPEN	16	0	0	0	0	0	0	0	0	16
14 EXOTIC	0	0	0	0	0	0	0	0	0	0
15 PASTURE	0	0	0	0	0	0	0	0	0	0
16 ORCHARD	0	0	0	0	0	0	0	0	0	0
17 URBAN	0	0	0	0	0	0	0	0	0	0
18 QUARRY	0	0	0	0	0	0	0	0	0	0
19 SAND DUNE	0	0	0	0	0	0	0	0	0	0
20 WATER	0	0	565	0	0	0	0	0	0	565
Total	1413	334	565	75	251	0	0	0	0	2638

TABLE 9 **Structural Vegetation Class Areas (ha) by Condition Class for Severely Degraded Areas along Geographic Section 8, Murray River**

Structural Vegetation Class	Salt	Drowning	Drowned	Water Stress	Grazing	Fire	Clearing	Recreation	Unexplained	Total
1 RG-FOR	0	0	0	0	0	0	0	0	0	0
2 RG-WOOD	44	0	0	0	0	0	0	0	0	44
3 RG/BOX	0	0	0	0	0	0	0	0	0	0
4 MIX BOX	0	0	0	0	0	0	0	0	0	0
5 BB-WOOD	0	0	0	0	0	0	0	0	0	0
6 BB MALLEE	0	0	0	0	0	0	0	0	0	0
7 CASUARINA	0	0	0	0	0	0	0	0	0	0
8 RVR COOBA	0	0	0	0	0	0	0	0	0	0
9 M FG WOOD	0	0	0	0	0	0	0	0	0	0
10 MALLEE	0	0	0	0	0	0	0	0	0	0
11 LIGNUM	0	0	0	0	0	0	0	0	0	0
12 SAL SHRUB	0	0	0	0	0	0	0	0	0	0
13 OPEN	0	0	0	0	0	0	0	0	0	0
14 EXOTIC	0	0	0	0	0	0	0	0	0	0
15 PASTURE	0	0	0	0	0	0	0	0	0	0
16 ORCHARD	0	0	0	0	0	0	0	0	0	0
17 URBAN	0	0	0	0	0	0	0	0	0	0
18 QUARRY	0	0	0	0	0	0	0	0	0	0
19 SAND DUNE	0	0	0	0	0	0	0	0	0	0
20 WATER	0	0	0	0	0	0	0	0	0	0
Total	44	0	0	0	0	0	0	0	0	44

TABLE 10 Structural Vegetation Class Areas (ha) by Condition Class for Severely Degraded Areas along the Murray River in New South Wales

Structural Vegetation Class	Salt	Drowning	Drowned	Water Stress	Grazing	Fire	Clearing	Recreation	Unexplained	Total
1 RG-FOR	235	669	0	88	0	9	172	0	43	1216
2 RG-WOOD	109	38	0	575	0	0	8	0	0	730
3 RG/BOX	17	105	0	0	0	0	58	0	0	180
4 MIX BOX	0	0	0	57	0	0	0	0	0	57
5 BB-WOOD	24	209	0	3	0	0	24	0	44	304
6 BB MALLEE	46	194	0	0	0	0	0	0	0	240
7 CASUARINA	0	0	0	0	0	0	0	0	0	0
8 RVR COOBA	0	0	0	0	0	0	0	0	0	0
9 M FG WOOD	0	17	0	0	0	0	0	0	0	17
10 MALLEE	0	0	0	0	0	0	0	0	0	0
11 LIGNUM	0	0	0	0	0	0	0	0	0	0
12 SAL SHRUB	0	0	0	0	0	0	0	0	0	0
13 OPEN	69	0	105	0	33	0	25	0	0	232
14 EXOTIC	0	0	0	0	0	0	0	0	0	0
15 PASTURE	0	0	0	0	0	0	0	0	0	0
16 ORCHARD	0	0	0	0	0	0	0	0	0	0
17 URBAN	0	0	0	0	0	0	0	0	0	0
18 QUARRY	0	0	0	0	0	0	0	0	0	0
19 SAND DUNE	0	0	0	0	0	0	0	0	0	0
20 WATER	0	0	1820	0	0	0	0	0	0	1820
Total	500	1232	1925	723	33	9	287	0	87	4796

TABLE 11 Structural Vegetation Class Areas (ha) by Condition Class for Severely Degraded Areas along the Murray River in Victoria

Structural Vegetation Class	Salt	Drowning	Drowned	Water Stress	Grazing	Fire	Clearing	Recreation	Unexplained	Total
1 RG-FOR	409	374	0	148	244	0	7	0	15	1197
2 RG-WOOD	4	28	0	2	0	0	0	0	5	39
3 RG/BOX	0	0	0	0	0	0	0	0	0	0
4 MIX BOX	0	76	0	0	0	0	0	0	0	76
5 BB-WOOD	1550	0	0	90	0	0	0	35	0	1675
6 BB MALLEE	0	0	0	0	0	0	0	0	0	0
7 CASUARINA	34	0	0	0	0	0	0	0	0	34
8 RVR COOBA	0	0	0	0	0	0	0	0	0	0
9 M FG WOOD	35	0	0	0	0	0	20	0	0	55
10 MALLEE	0	0	0	0	0	0	0	0	0	0
11 LIGNUM	1045	0	0	0	0	0	0	0	0	1045
12 SAL SHRUB	0	0	0	0	0	0	0	0	0	0
13 OPEN	754	194	0	0	0	0	0	0	0	948
14 EXOTIC	0	0	0	0	0	0	0	0	0	0
15 PASTURE	0	0	0	0	0	0	0	0	0	0
16 ORCHARD	0	0	0	0	0	0	0	0	0	0
17 URBAN	0	0	0	0	0	0	0	0	0	0
18 QUARRY	0	0	0	0	0	0	0	0	0	0
19 SAND DUNE	0	0	0	0	0	0	0	0	0	0
20 WATER	0	0	317	0	0	0	0	0	0	317
Total	3831	672	317	240	244	0	27	35	20	5386

TABLE 12 Structural Vegetation Class Areas (ha) by Condition Class for Severely Degraded Areas along the Murray River in South Australia

Structural Vegetation Class	Salt	Drowning	Drowned	Water Stres	Grazing	Fire	Clearing	Recreation	Unexplained	Total
1 RG-FOR	0	17	0	0	0	0	0	0	0	17
2 RG-WOOD	2465	1208	0	75	0	0	0	0	0	3748
3 RG/BOX	0	0	0	0	0	0	0	0	0	0
4 MIX BOX	0	0	0	0	0	0	0	0	0	0
5 BB-WOOD	539	18	0	0	0	0	0	0	0	557
6 BB MALLEE	1379	40	0	0	0	0	0	0	0	1419
7 CASUARINA	0	0	0	0	0	0	0	0	0	0
8 RVR COOBA	0	0	0	0	0	0	0	0	0	0
9 M FG WOOD	0	0	0	0	0	0	0	0	0	0
10 MALLEE	0	3	0	0	0	0	0	0	0	3
11 LIGNUM	53	17	0	0	0	0	0	0	0	70
12 SAL SHRUB	0	0	0	0	0	0	0	0	0	0
13 OPEN	16	0	0	0	0	0	0	0	0	16
14 EXOTIC	0	0	0	0	0	0	0	0	0	0
15 PASTURE	0	0	0	0	0	0	0	0	0	0
16 ORCHARD	0	0	0	0	0	0	0	0	0	0
17 URBAN	0	0	0	0	0	0	0	0	0	0
18 QUARRY	0	0	0	0	0	0	0	0	0	0
19 SAND DUNE	0	0	0	0	0	0	0	0	0	0
20 WATER	0	0	714	0	0	0	0	0	0	714
Total	4452	1303	714	75	0	0	0	0	0	6544

.APPENDIX 6. BIBLIOGRAPHY

The bibliography has been divided into three sections as follows:

- Vegetation - descriptions, species lists, ecology, rare species.
- Environment - geology, geomorphology, soils, climate.
- Impact of man - Aboriginal impact, land and water use history, environmental changes and their effects.

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APPENDIX 7. LIST OF AERIAL PHOTOGRAPHS

The aerial photo projects used in this study are listed by NATMAP 1:100 000 scale mapsheet, state, scale, date and colour type.

ALBURY
Victoria 1:25 000 1982 B & W
Rural Water Commission (Vic.) 1:25 000 1981 Colour Photo mosaic

BALRANALD
New South Wales 1:50 000 1982 B & W

BERRIGAN
Victoria 1:25 000 1981 B & W
Rural Water Commission (Vic.) 1:25 000 1981 Colour Photo mosaic

BURAJA
1:45 000 1977 B & W
Rural Water Commission (Vic.) 1:25 000 1981 Colour Photo mosaic

COHUNA
New South Wales 1:45 000 1976 B & W
Victoria 1:50 000 1978-1981 B & W

DOOKIE
Victoria 1:25 000 1981 B & W
Rural Water Commission (Vic.) 1:25 000 1981 Colour Photo mosaic

ECHUCA
Victoria 1:25 000 1977-1981 B & W

KERANG
Victoria 1:25 000 1979 B & W

LAKE VICTORIA
New South Wales 1:58 500 1965 B & W

LINDSAY
Victoria 1:25 000 1980 B & W

MATHOURA
New South Wales 1:45 000 1976 B & W

NOWINGI
Victoria 1:25 000 1980-1982 B & W

NYAH
Victoria 1:25 000 1983 B & W

ROBINVALE
Victoria 1:25 000 1978-1980 B & W

SWAN HILL
New South Wales 1:45 000 1976 B & W

TALLANGATTA
Victoria 1:25 000 1982 B & W
Rural Water Commission (Vic.) 1:25 000 1981 Colour Photo Mosaic

TUPPAL
New South Wales 1:45 000 1976 B & W
Victoria 1:25 000 1981 B & W
Rural Water Commission (Vic.) 1:25 000 1981 Colour Photo Mosaic

WALBUNDRIE
New South Wales 1:50 000 1973 B & W
Rural Water Commission (Vic.) 1:25 000 1981 Colour Photo Mosaic

WANGARATTA
Victoria 1:25 000 1982 B & W
Rural Water Commission (Vic.) 1:25 000 1981 Colour Photo Mosaic

WANGANELLA
New South Wales 1:45 000 1976 B & W

WEIMBY
Victoria 1:25 000 1983 B & W

WENTWORTH
Victoria 1:25 000 1980 B & W

SOUTH AUSTRALIA
All mapsheets:
River Murray Project 1:20 000 1985

APPENDIX 8. LIST OF EXISTING MAP SOURCES

The following existing vegetation maps were used during this study:

NEW SOUTH WALES

- Forest type maps of Central Murray area, prepared 1947-1953, scale 1:15 840 of the following State Forests; Millewa, Tuppal, Gulpa, Moira, Bama, Peericoota, Koondrook, Campbell's Island and Werai (Forestry Commission)

- Forest type classification survey of Lower Murray, Murrumbidgee and Lachlan Rivers, 1954, scale 1:31 680 (Interim Map No.5, Forestry Commission)

- Murray River Red Gum Resources Survey, 1956, scale 1:31 680 (Interim Map No.7a, Forestry Commission)

VICTORIA

- Forest type/site quality map Gunbower Island State Forest, 1959, scale 1:15 840 (Forests Commission)

- Vegetation Map Barmah State Forest, 1979, Scale 1:63 360 (Forests Commission)

- Land Conservation Council Mallee Study Area Review, 1987, scales 1:25 000 to 1:100 000 (Land Conservation Council, Department of Conservation, Forests and Lands)

APPENDIX 9. MAPPING PRODUCTS, COSTS AND AVAILABILITY

All maps are available through the Murray-Darling Basin Commission (MDBC). The digital database will be maintained by the Department of Conservation Forests and Lands, Victoria, on behalf of the MDBC.

The following standard maps are available in print form for the entire study area:

1. 1:50 000 scale Structural Vegetation Map showing Condition Classes (colour). 46 maps in the series.

   Approximate cost per mapsheet: $110

2. 1:50 000 scale Structural Vegetation Map showing condition classes (black and white). 46 maps in the series.

   Approximate cost per stable base (transparency): $110
   Approximate cost per dyeline print: $10

3. 1:50 000 scale Condition Class Map showing condition classes in colour and structural vegetation classes in black and white.

   Approximate cost per mapsheet: $110

Custom-made maps of any scale (commensurate with the quality of the raw data), location and combination of classes are available on request. Their cost of production is subject to the nature of the request. Common requests may comprise:

4. 1:500 000 scale Structural Vegetation Map (colour).

5. 1:250 000 scale Structural Vegetation Map (colour).

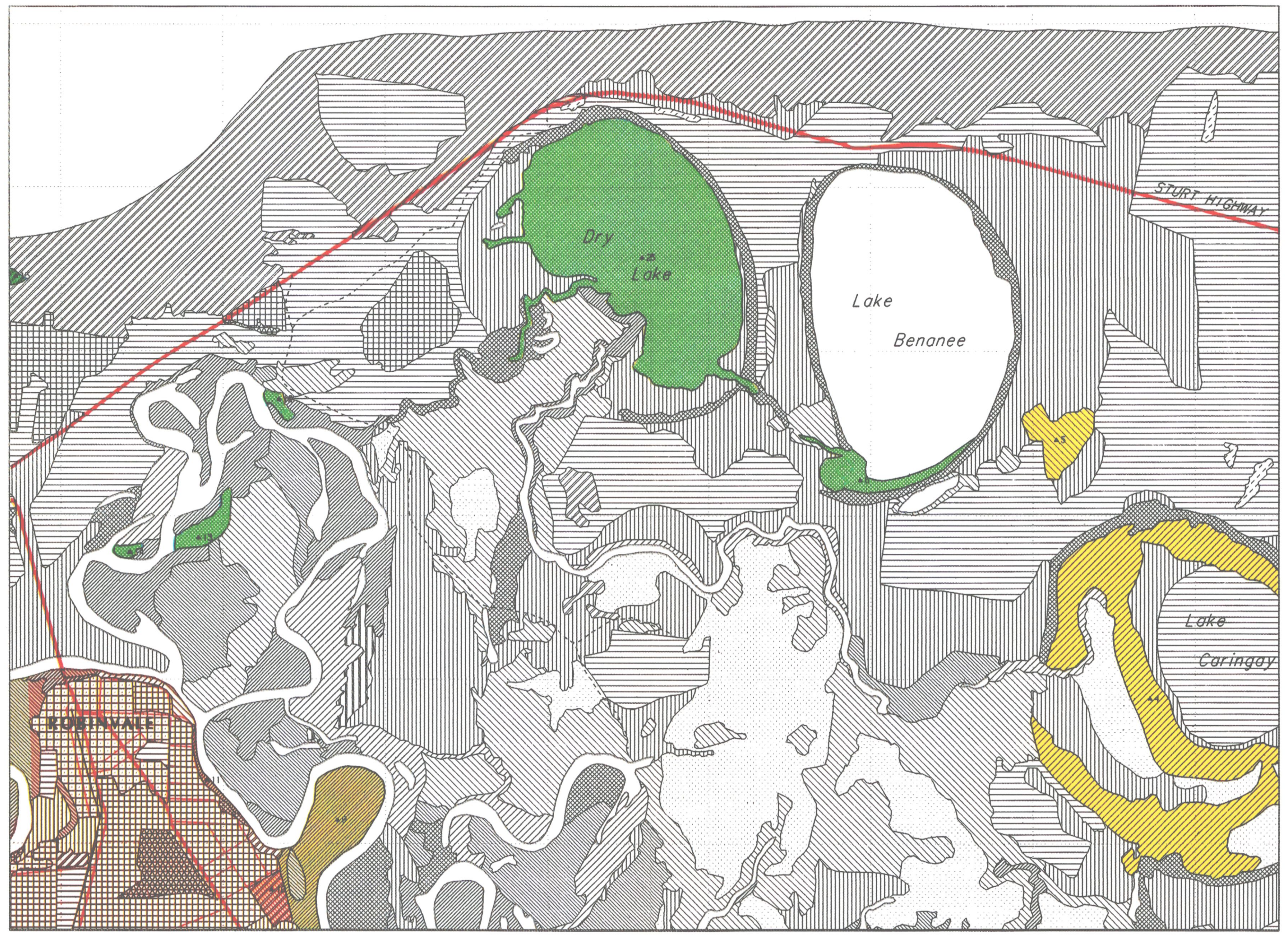
6. 1:25 000 scale Structural Vegetation and Condition Map (colour or black and white).

7. Digital copies of part or all of the database on computer compatible tape or floppy disk.

8. Area statements, tables and brief reports.

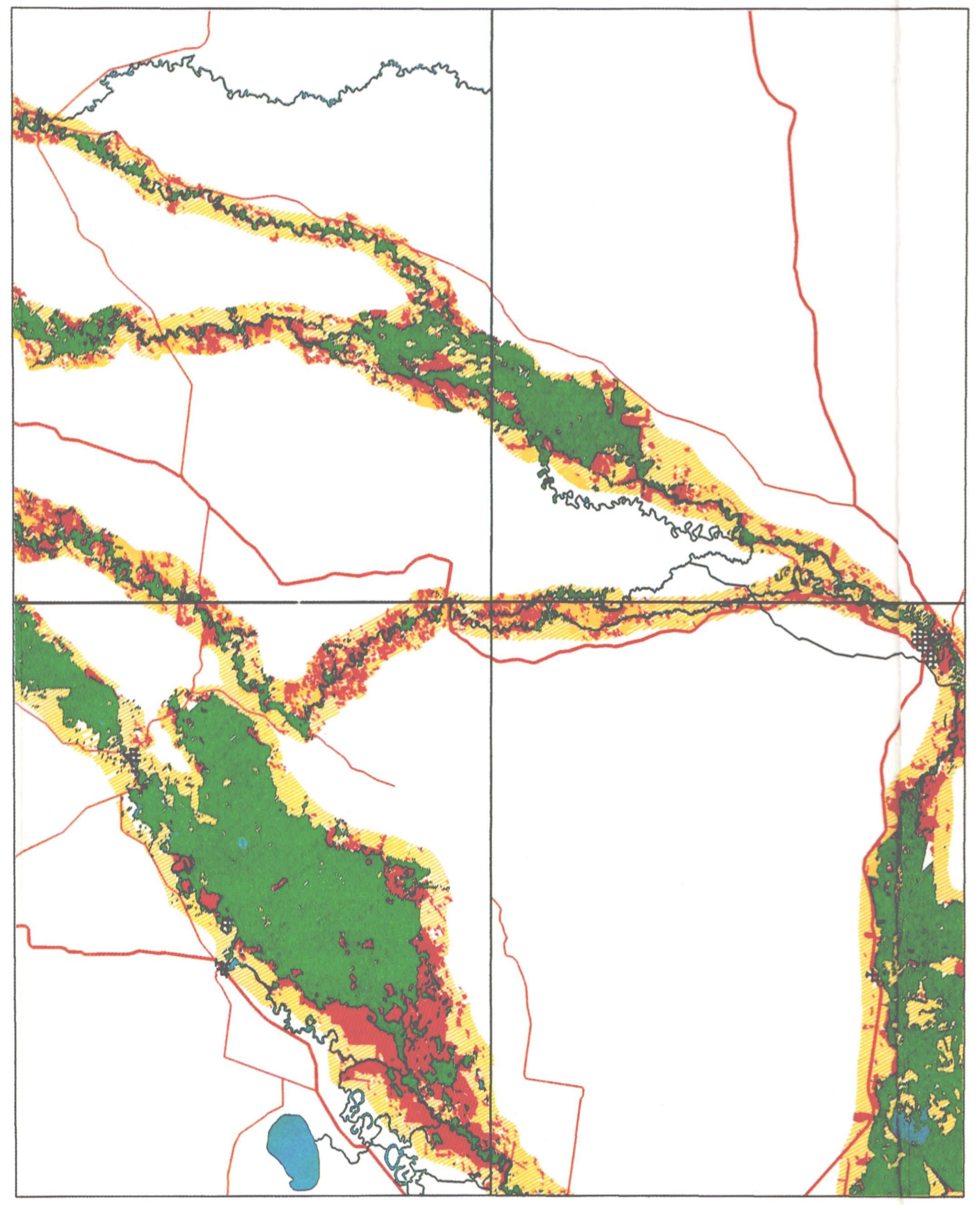
Corrections, alterations and additions can be made to the database upon request. To maintain the currency of the data the maps need to be regularly updated and suggestions from map users are welcomed.

A SELECTION OF POSSIBLE MAPPING PRODUCTS FROM THE RIVER MURRAY RIPARIAN VEGETATION STUDY , 1989



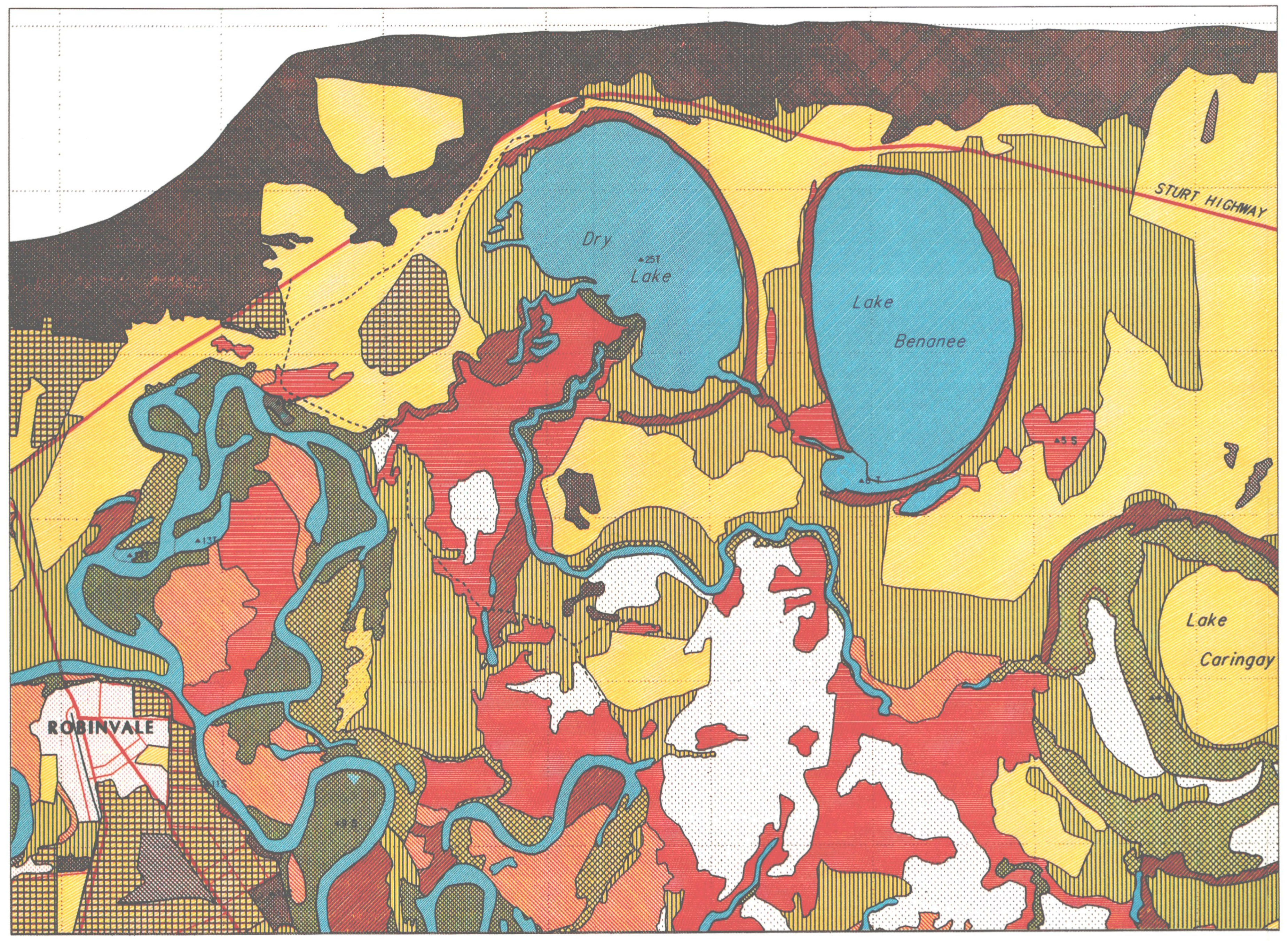
MAP 5 : Vegetation Condition Map

Scale 1 : 50 000. Similar to Map 2, although the 9 condition classes are shown in identifying colours, and the 20 vegetation classes are shown in black and white. Note that on some mapsheets no severely degraded areas were detected.



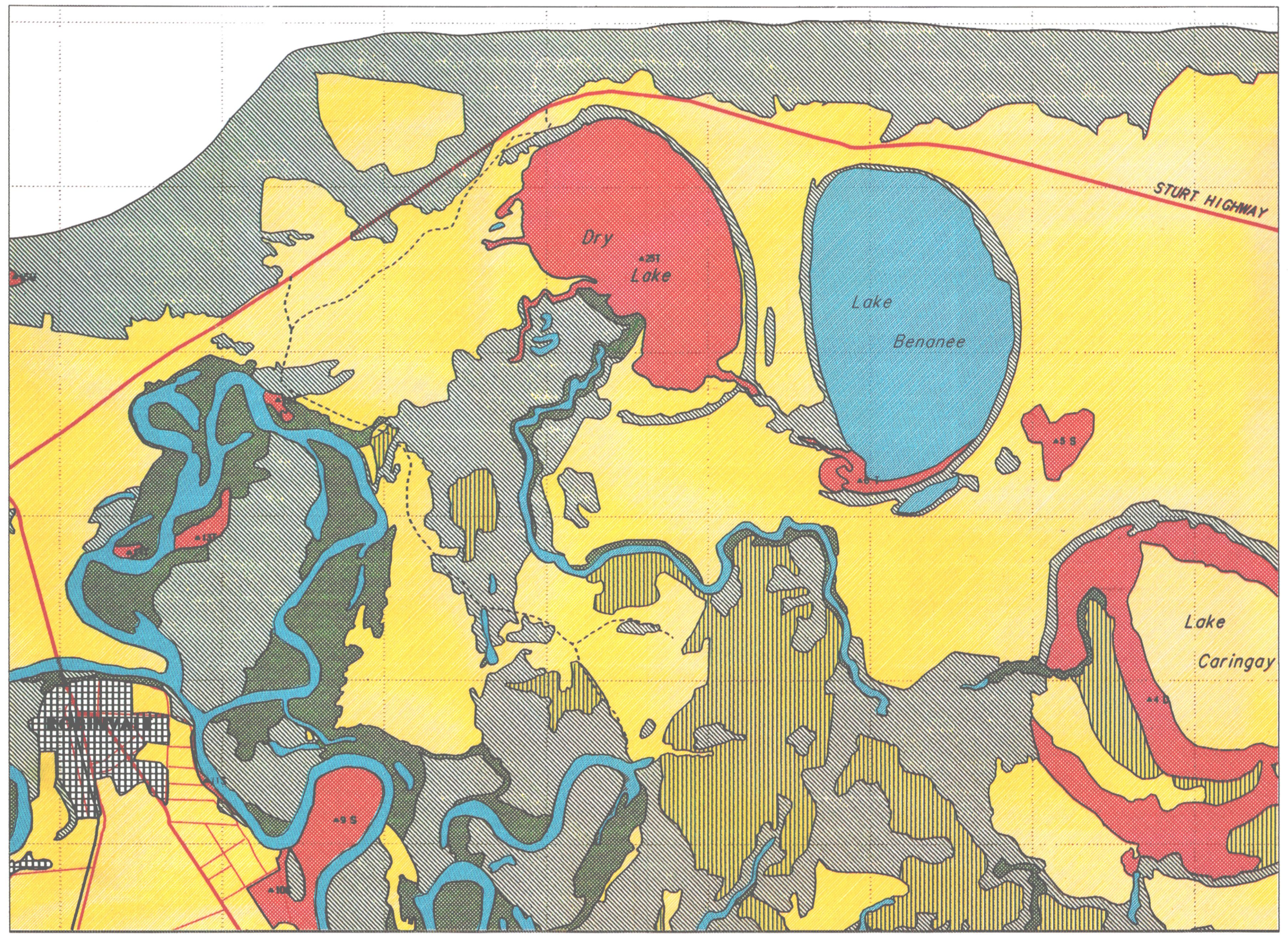
MAP 3 : Structural Vegetation Map (colour)

Scale 1 : 500 000. A reduced scale version of Map 1 showing 8 generalised structural vegetation classes. No condition mapping is present.



MAP 1 : Structural Vegetation and Condition Map (colour)

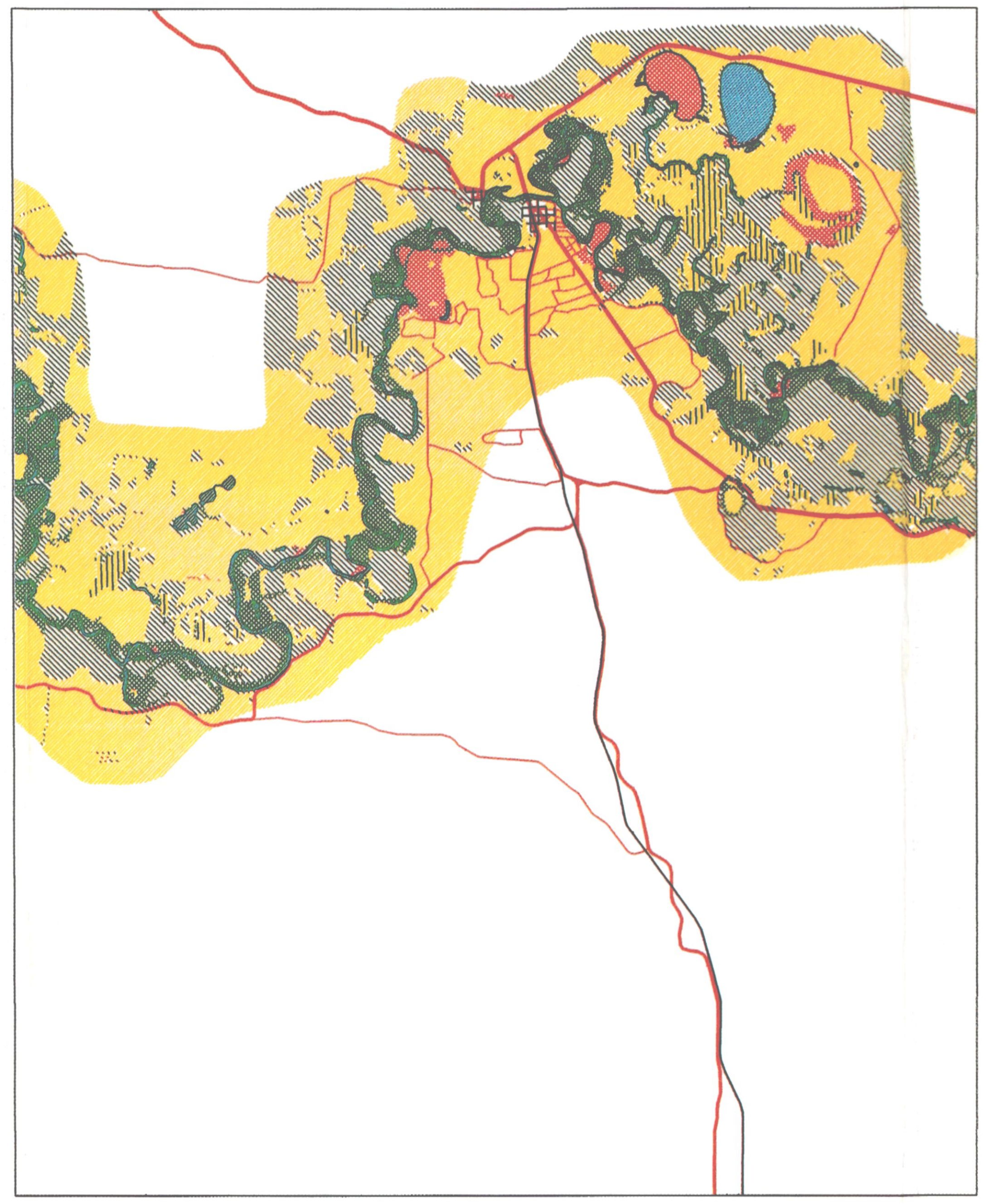
Scale 1 : 50 000. 20 vegetation classes (in colour), 9 condition classes showing causal factors for severe degrade (as annotation), 46 maps in the series. An example of the legend is shown at right.



Map 6 : Simplified Condition Locality Map (colour)

Scale 1 : 50 000. The 20 vegetation classes of Map 1 have been generalised to 6 classes.

All 9 condition classes are shown in red and annotated for identification.



MAP 4 : Simplified Condition Locality Map (colour)

Scale 1 : 250 000. A reduced scale version of Map 6.

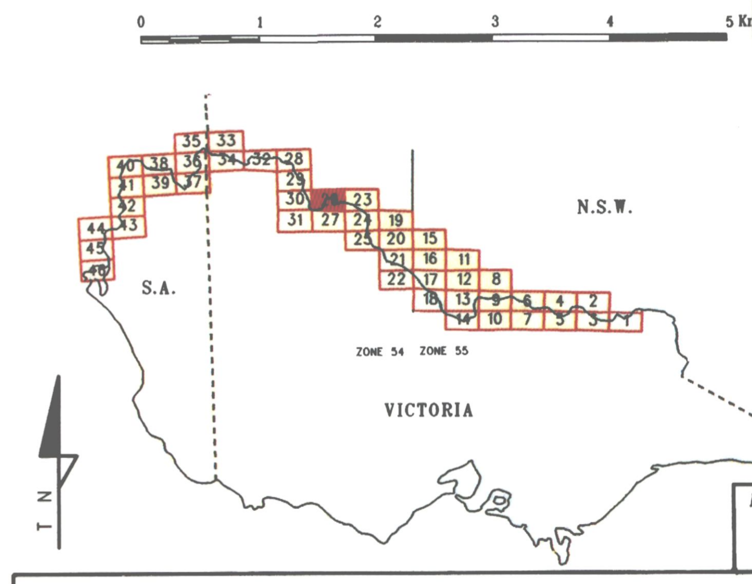
MAP 2 : Structural Vegetation and Condition Map (black & white)

Scale 1 : 50 000. A black and white version of Map 1.

RIVER MURRAY RIPARIAN VEGETATION STUDY

SAMPLE MAP

SCALE 1 : 50 000



Map No	Of
26	46

STRUCTURAL VEGETATION CLASSES

Trees

Red Gum Forest	Eucalyptus camaldulensis (river red gum)	Eucalyptus blakelyi (blakely's red gum)
Red Gum Woodland	Eucalyptus camaldulensis (river red gum)	
Red Gum/Box Forest and Woodland	Eucalyptus camaldulensis (river red gum) Eucalyptus blakelyi (blakely's red gum) Eucalyptus microcarpa (grey box)	Eucalyptus largiflorens (black box) Eucalyptus melliodora (yellow box)
Mixed Box Woodland	Eucalyptus melliodora (yellow box) Eucalyptus microcarpa (grey box)	Eucalyptus largiflorens (black box) Eucalyptus albens (white box)
Black Box Woodland	Eucalyptus largiflorens (black box)	
Black Box (mallee form)	Eucalyptus largiflorens (black box)	
Cypress Pine /Casuarina Woodland	Callitris preissii (murray cypress pine) Callitris glaucophylla (white cypress pine)	Casuarina cristata (belah) Allocasuarina leuhmannii (buloke)
River Cooba	Acacia stenophylla (river cooba)	
Mallee Fringe Woodland	Casuarina cristata (belah) Myoporum platycarpum (sugarwood) Dodonaea spp (hopbush)	Heterodendron oleifolium (cattlebush) Eucalyptus spp (mallee types and black box)
Mallee	Eucalyptus spp (mallee types)	

Shrubs, Grasses, Herbs

Lignum	Muehlenbeckia cunninghamii (lignum)	
Saline Shrubland	Halosarcia spp (samphires) Atriplex vesicaria (bladder salt-bush) Atriplex nummularia (old-man salt-bush)	Maireana pyramidata (black bluebush) Chenopodium nitrariaceum (nitre-goosefoot)
Open Areas	(grassland, sedges, salinas)	

Non-Native Vegetation

Exotic Trees and Shrubs	pines, poplars, willows, pepper-trees, amenity plantings
Cultivated Pasture and Cropping	(irrigated and non-irrigated)
Orchards and Vineyards	(irrigated)

Non-Vegetated Areas

Urban	(includes semi-urban, golf courses, hobby farms)
Quarries and Sand-pits	(includes naturally occurring lunettes)
Sand Dunes	
Water Bodies	(permanent and semi-permanent)

Principal road and highway
Secondary road
Minor road
Vehicular track
Railway or tramway
Stream, perennial

CONDITION CLASSES

Those areas that are identified as suffering from long term and severe degradation and are unlikely to support viable, long term regeneration under the current management practices are delineated on the map according to the following generalised causal factors:

- S Saline Ground Water – seepage, drainage from irrigation etc.
- W Drowning – high surface water table
- T Drowned – dead trees (stags) in permanent or near permanent water
- D Water Stress – prolonged lack of watering on local sites
- G Overgrazing – domestic, feral and native animals
- F Fire – resulting in absence of regeneration
- C Clearing/Logging – followed by absence of regeneration
- R Recreation – excessive traffic and roading
- U Unexplained

Note: Each condition polygon on each mapsheet is uniquely numbered for reference purposes, eg. ▲ 2 S

NOTES FOR THE MAP USER

This map is one of a series compiled using information obtained from a number of sources including black & white and colour aerial photographs colour photomosaics and existing vegetation maps. The topographic base has been derived in part from the NATMAP 1:100 000 map series. Land tenure has not been delineated in this series and the mapping has been consistently applied to both freehold and public land.

Differences in detail on or between maps in the series may be due to the variable source of the the original information – refer to the Map Reliability Guide below.

The data was processed and drafted using ARC/INFO (reg.TM) – a computerised Geographic Information System. Data is available in several formats:
- colour prints at 1 : 50 000 scale
- colour prints at 1 : 250 000 scale
- black & white transparencies at 1 : 50 000 scale
- computer compatible magnetic tape
- customised format according to users needs.

MAP RELIABILITY GUIDE

DATA SOURCE	SCALE 1:	YEAR OF ORIGIN	FIELD CHECKED FOR THIS STUDY
Dept. Property & Services, VIC. B & W Aerial Photography	25000	1980	YES
Land Conservation Council, VIC. Mallee Area Review – Floristic Vegetation Map	100000	1987	NO
NATMAP Sheet 7428 (Edition 1), Topographic Information	100000	1979	NO

Aerial Photograph Interpretation:
Hugh Dunchue (NSW/VIC)
Keith Forrest (NSW/VIC)
Frank van der Sommen (SA)

Computer Mapping:
Adam Choma
Lucille Turner

Mapping Coordination:
Peter Woodgate

Prepared for: MURRAY-DARLING BASIN COMMISSION

by: Margules & Partners Pty. Ltd.
Conservation Forests & Lands
P. & J. SMITH ECOLOGICAL CONSULTANTS

July 1989

Grid lines are 2000 metre intervals of the Australian Map Grid, Zone 54/55

MURRAY-DARLING
BASIN
COMMISSION