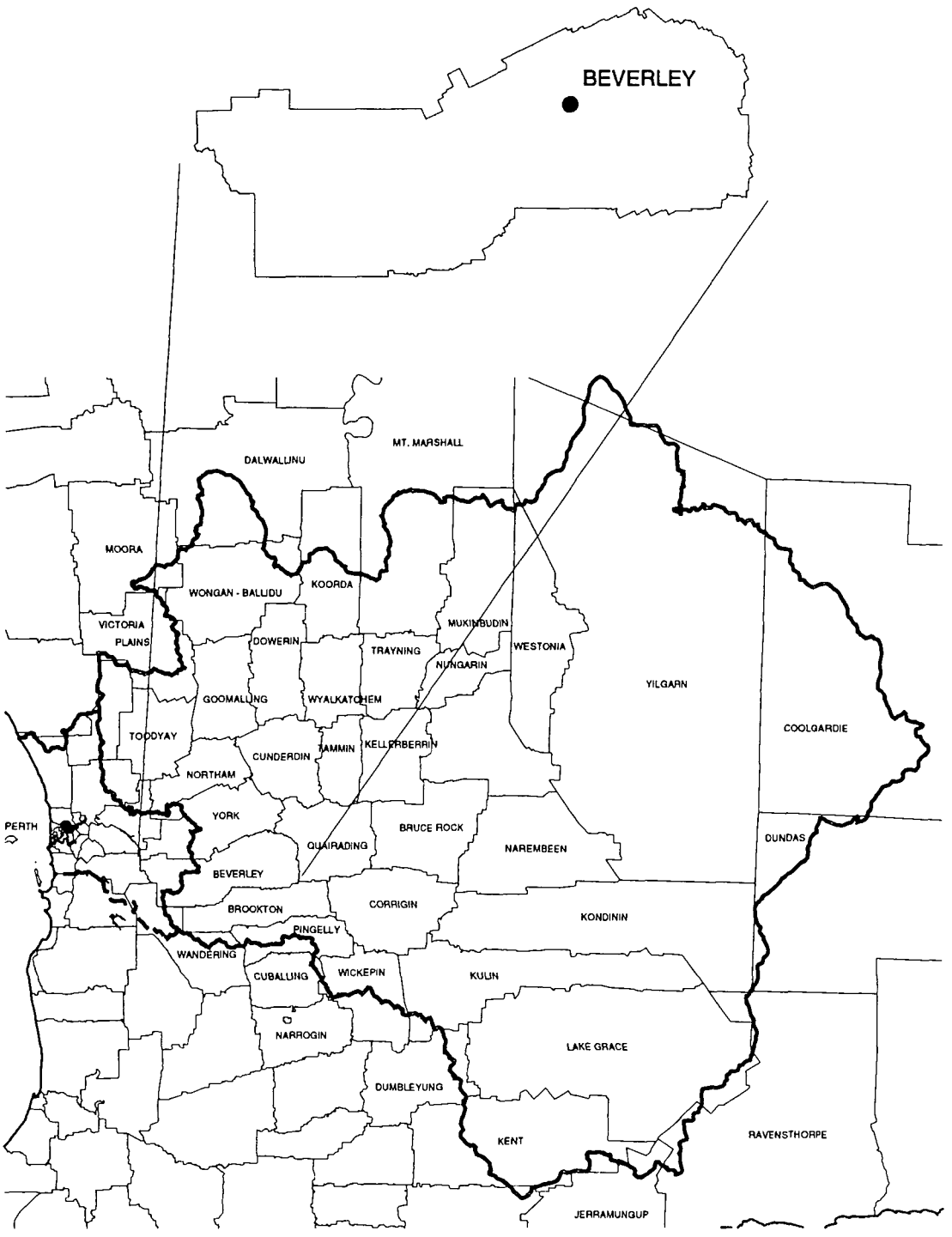
7-1997

Native Vegetation Handbook for the Shire of Beverley

Rod Safstrom

Native Vegetation Handbook for the Shire of Beverley



Agriculture
WESTERN AUSTRALIA

Environment Australia
Biodiversity Group

Acknowledgments

I would like to thank members of the Beverley LCDC for their assistance with preparation and Penny Hussey (CALM, Como), Colma Keating (Greening Western Australia) and Denise True (Threatened Species Network) for proof reading parts of this handbook and for their useful suggestions. Further proof reading and text amendments were made by Sarah Weaving.

Digital data was provided for mapping by the Pastoral and Agricultural Geographic Information System (PAGIS) at Agriculture Western Australia. For cartographic work I would like to thank Michael Andacich.

Thank you to Julian Coker for Geographic Information Systems (GIS) information and to the Natural Resource Assessment Group for soils informtion.

Copies of the Native Vegetation Handbook for the Shire of Beverley are available by contacting:

The Spatial Resources Information Group
Agriculture Western Australia
Baron-Hay Court
South Perth 6151
Telephone (08) 9368 3333

ISBN: 0 7309 8759 0

Cover: The Shire of Beverley in relation to the Avon River Catchment (indicated by a bold line) and the Swan River Catchment (indicated by a dotted line)

NATIVE VEGETATION HANDBOOK FOR THE SHIRE OF BEVERLEY

Rod Safstrom

Spatial Resources Information Group
Division of Regional Operations
Agriculture Western Australia

July 1997

Produced by Agriculture Western Australia and Greening Western Australia with the assistance from the Commonwealth Government through Environment Australia's Save the Bush program.

Contents

List of Figures

The Native Vegetation Handbook for the Shire of Beverley is one of a series covering the agricultural region of Western Australia. Other Handbooks in the series are:

The Shire of Augusta-Margaret River
The Shire of Boyup Brook
The Shire of Bridgetown-Greenbushes
The Shire of Brookton
The Shire of Broomhill
The Shire of Bruce Rock
The Shire of Corrigin
The Shire of Cunderdin
The Shire of Dumbleyung
The Shire of Katanning
The Shire of Kellerberrin
The Shire of Kent
The Shire of Kojonup
The Shire of Merredin
The Shire of Mingenew
The Shire of Northam
The Shire of Pingelly
The Shire of Narrogin
The Shire of Tammin
The Shire of Toodyay
The Shire of Trayning
The Shire of Wagin
The Shire of West Arthur
The Shire of Wickepin
The Shire of Williams
The Shire of Woodanilling
The Shire of Wyalkatchem
The Shire of York

The Shire of Beverley

Introduction

Purpose of this Handbook

The purpose of this Handbook is to bring to people in the Shire of Beverley, particularly farmers, land managers, Land Conservation District Councils, Catchment Groups and local government authorities, information to assist in revegetation and - management of remnant native vegetation within agricultural systems.

This Handbook is one of a series covering the agricultural region of Western Australia. The Handbook aims to assist the development of sustainable farming systems which combine agricultural production and nature conservation as depicted in Figure 1. Information is provided on the natural resources of the Shire of Beverley, including the existing vegetation, drainage systems and soils. Problems in managing these resources are described and community initiatives to tackle the problems are summarised.

It is hoped this Handbook will contribute to the long term viability of the agricultural landscape and the conservation of native vegetation within the Shire.

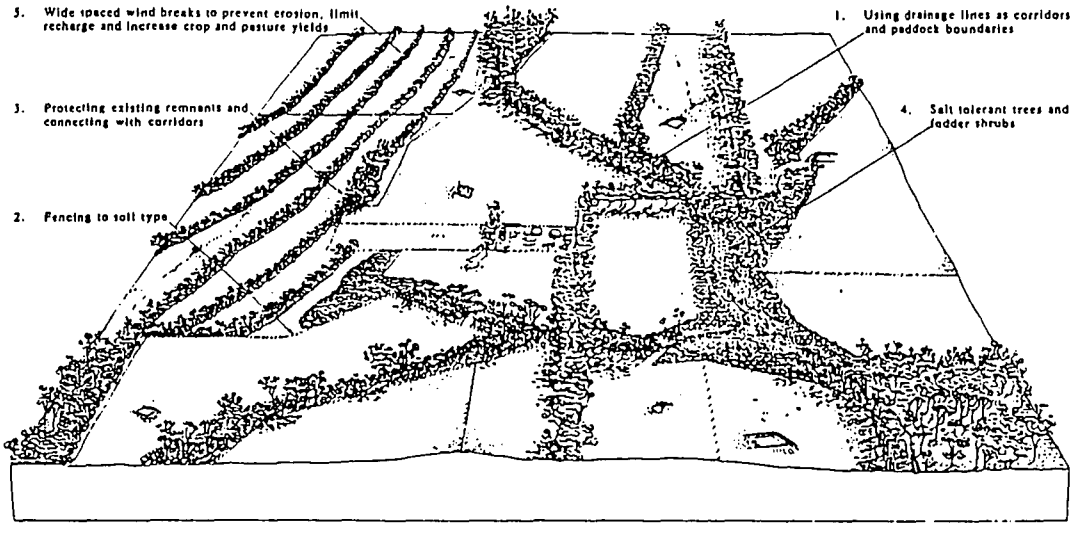


Figure 1. A stylised representation of a central wheatbelt farm illustrating a mosaic of agricultural, natural and semi natural systems. Key elements are:
1. Reinstated drainage lines used as conservation corridors and field boundaries.
2. Coincidence between soil types and management unit.
3. Protection of existing remnants in vegetation corridors.
4. Productive revegetation of land effected by secondary salinity.
5. Alley farming; a network of wide spaced shelterbelts (10 15 x their height apart) to prevent wind erosion, limit recharge of groundwater, increase crop and pasture yield and act as conservation corridors.

Source: Lefroy and Hobbs (1991).

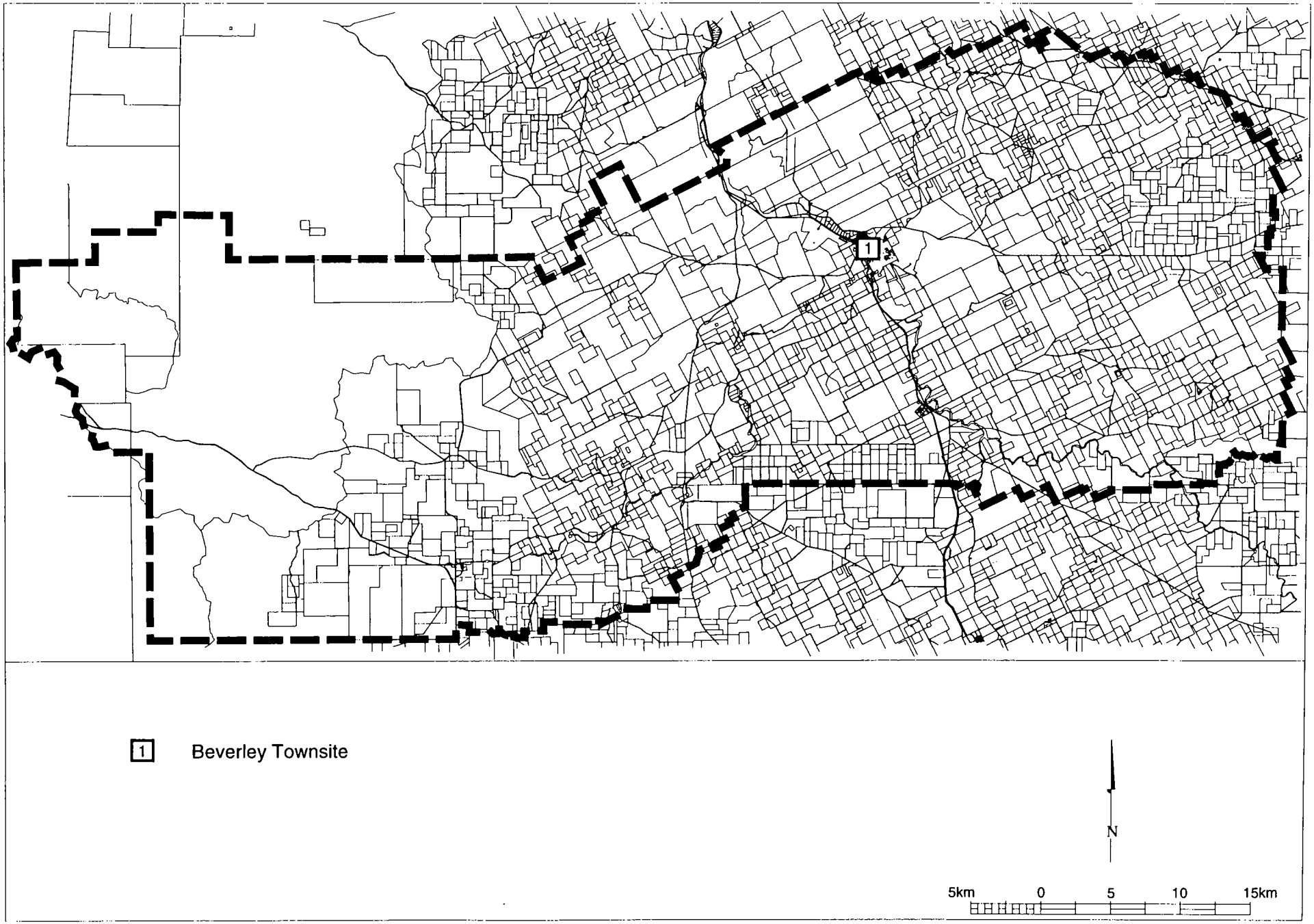


Figure 2: Cadastral Boundaries for the Shire of Beverley.

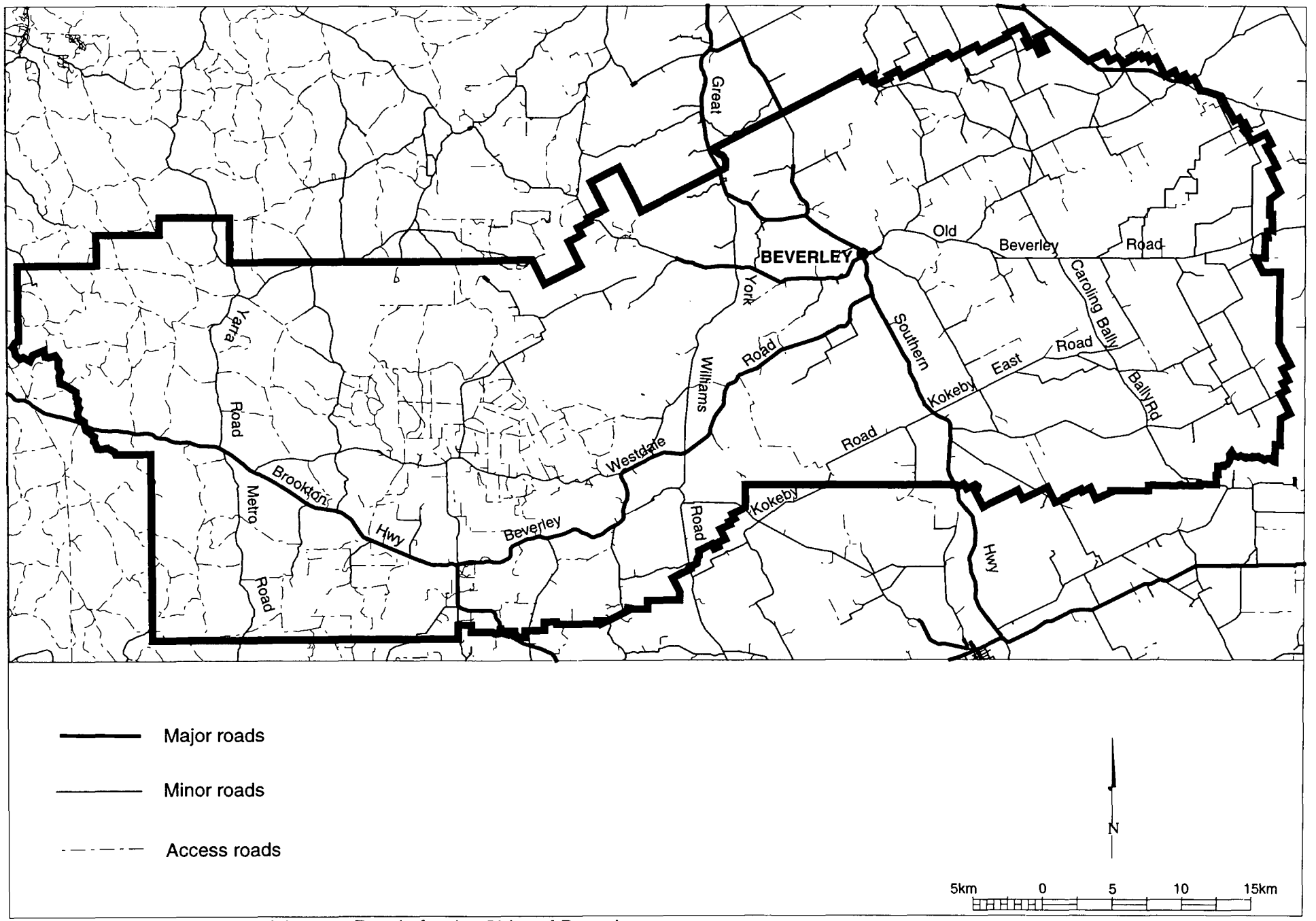


Figure 3: Major, Minor and Access Roads for the Shire of Beverley.

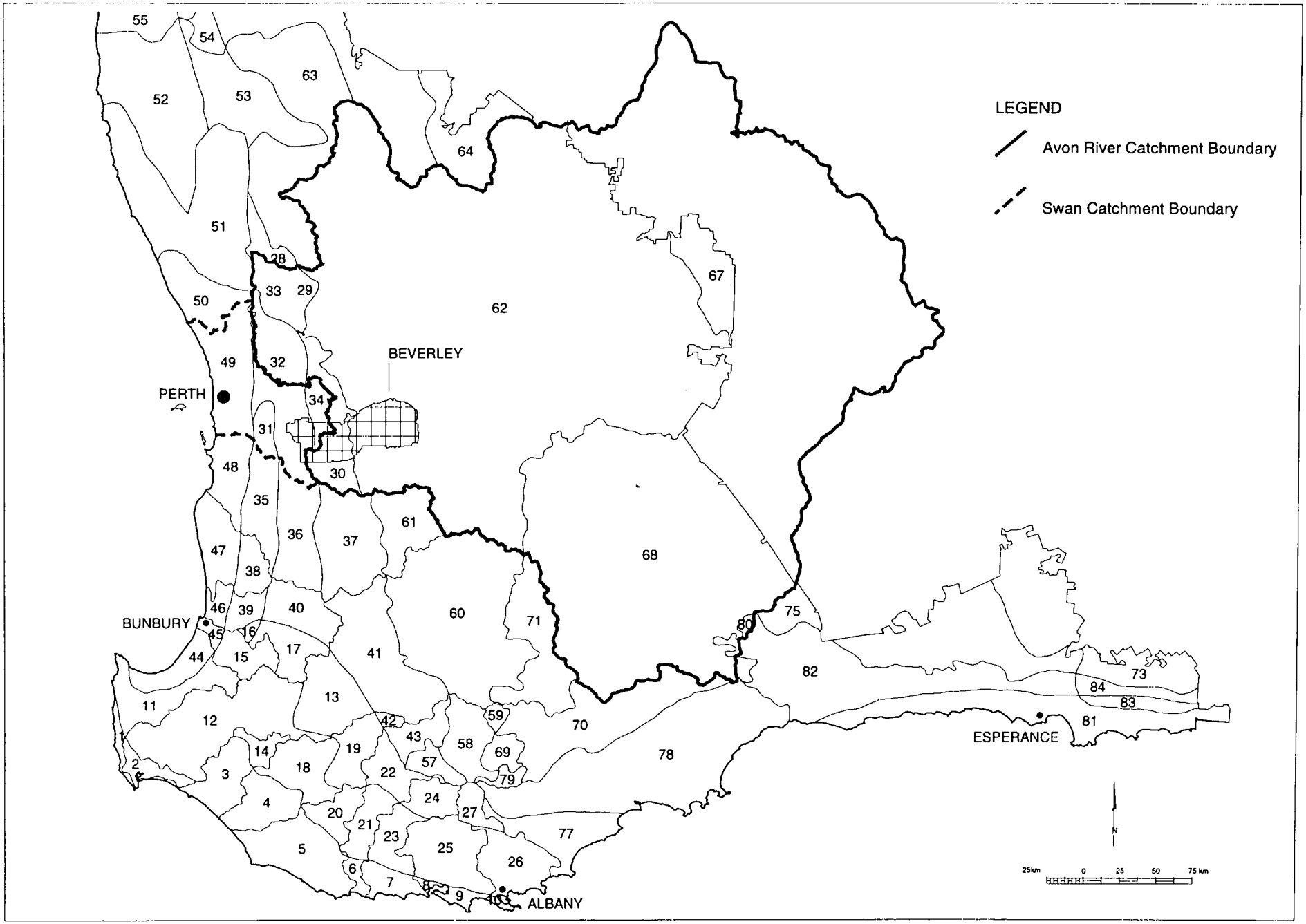


Figure 4: The Shire of Beverley in Relation to the Natural Resource Zones of the South - West Land Division of Western Australia.

The Shire of Beverley

The Shire of Beverley covers an area of 231,000 hectares and is located in the Avon River Catchment (see cover map). The Avon River and one of its major tributaries, the Dale River, run through the centre of the Shire. Parts of the Mundaring and Jarrahdale State Forests cover the eastern part of the Shire, occupying 53,703 hectares or nearly a quarter of the total Shire area. The cadastral boundaries in the Shire are shown in Figure 2, while all 614 kilometres of road network in the Shire are shown in Figure 3. The only major townsite in the Shire is Beverley (Figure 2). The population of the Shire was 1,460 in 1994 (Municipal Directory, 1995/96).

Climate

The Shire's climate is regarded as Mediterranean, with cool, moist winters and hot, dry summers. Beverley receives on average, 420mm rainfall per annum. Average maximum temperatures range from 34.1°C in January to 16.7°C in July, while average minimum temperatures range from 16.7°C in February to 4.9°C in August.

Agricultural production and revegetation

In 1993/94, a total of 41,371 hectares of the Shire was sown with crops, 83,450 hectares sown with pasture and 10,826 hectares of native pastures (ABS, 1993/94). In 1994/95, there were at least 186,569 trees planted from seedlings and 111 hectares revegetated with seed (ABS, 1994/95).

Natural Resource Zones

The south-west of Western Australia has been divided into districts (called Natural Resource Zones) on the basis of their vegetation type, drainage/catchment system and rainfall (Allison *et al.*, 1993). The Shire of Beverley is very diverse and contains parts of four Natural Resource Zones [numbers 30, 32, 34 and 62] (Figure 4). The Shire is within the Swan/Avon catchment, includes the northern Jarrah Forest and wheatbelt vegetation districts (Darling and Avon), and receives between 1,100 mm rainfall in the west and less than 500 mm rainfall in the east.

Land Conservation District Committee and Catchment Groups

The Beverley Land Conservation District Committee (LCDC) was formed in 1990 and is based on the Shire's boundary.

There are currently eight Catchment Groups active in the Shire: Morbinning Gully, Monjerducking (incorporating Turkeycock and Bally Bally catchments), Kettlerock, Kokendin, Waterhatch, Beverley Central, West Dale and Mackie. Mackie may be split in two at a later date. Geedapping Creek and Kokeby are proposed catchment groups yet to be established. There are two catchment groups which are based in Brookton Shire but include farms in the Shire of Beverley, being Sherlock Gully and Connelly's Creek Catchment Groups. Talbot Brook catchment is linked to the York LCDC.

Morbinning and West Dale were the first Catchment Groups to start in the Beverley district in 1989 and have progressed at a faster rate than most because of a large injection of funds from Alcoa. The company offered to sponsor rehabilitation in these two catchments over a period of five years so that the work would be done in half the normal time. Part of Alcoa's sponsorship offer required the Catchments to open demonstration sites to other interest groups to show what can be done if the effort is made and funds are available. Pamphlets to publicise their achievements are being produced by each group. In the case of Morbinning catchment, the participants are making 6 to 10 demonstration sites available for viewing and have 3 or 4 volunteers on call to explain what has taken place to visiting groups. Morbinning Catchment Group's commitment to integrated catchment management was recognised at the 1996 National Landcare Awards when it won the BP National Catchment Award.

The information on catchment groups has been sourced from *Information on land use and current status within the Beverley Shire* by the Beverley Land Conservation District Committee, June 1996.

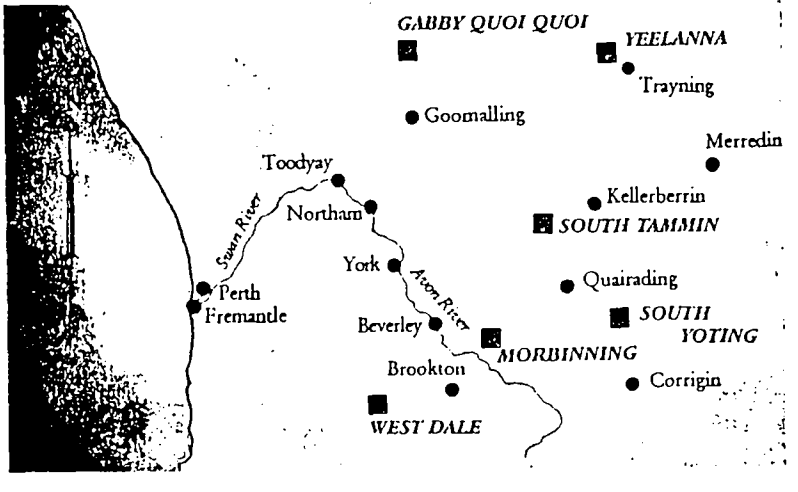


Figure 5. Farmer demonstration catchment groups involved in the Landcare Vision Project sponsored by Alcoa of Australia Limited and Agriculture Western Australia

Natural Resources of the Shire of Beverley-Past and Present

Forming the landscape and soils

The original vegetation in the Shire of Beverley developed over millions of years as the climate changed and soils formed and eroded. It is helpful to reflect on this history when looking at the current vegetation. Information source: Lantzke (1993).

"During the Tertiary period (60-10 million years ago) Western Australia had a moist, temperate tropical climate which led to the formation of deep soils with accumulations of iron, aluminium and quartz in their upper parts and several distinct zones (Figure 6).

In the Pleistocene period (2-10 million years ago) the sea level dropped and/or uplift of the south west of Western Australia occurred. This resulted in erosion of the lateritic mantle to varying degrees exposing the lateritic profile and in places, the bedrock below.

The extent of the dissection of this lateritic profile can be used to explain the development of the landform, soils and the vegetation. Where little or no erosion of the lateritic profile has occurred, fossil soils have been preserved as sandplain or as 'buckshot gravels' above breakaway hills. Where the laterite profile has been dissected to reveal the pallid zone, loamy sand and sandy loam over clay soils have developed. Where removal of the laterite profile has been complete the soils are shallow, gritty soils on granite or red loams on dolerite."

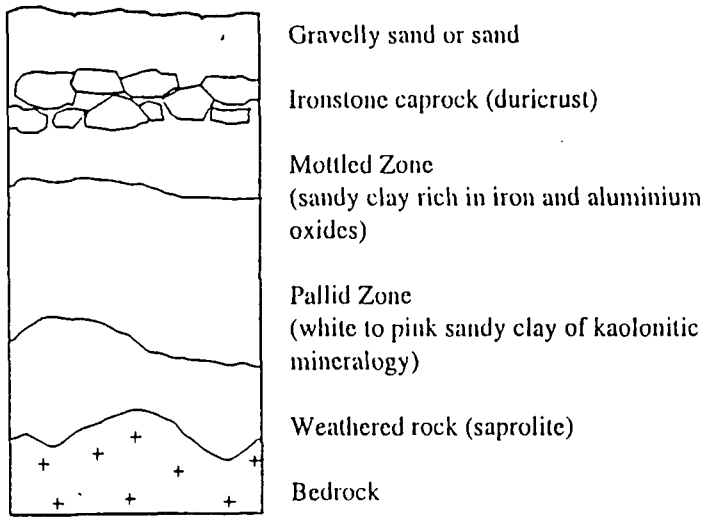


Figure 6. The lateritic profile (above) formed in the Tertiary period during a moist temperate tropical climate has since been eroded to varying degrees
Source: Lantzke (1993)

The vegetation and landscape in the Shire of Beverley reflects the topography and soils and the rainfall as it declines from west to east. A broad landscape picture is presented in the following section, followed by descriptions of the current and original plant communities.

Landscape

Landscape descriptions have been adapted from Reading the Remote, *Landscape Characters of Western Australia*, CALM (1994). A Digital Elevation Map of the Shire of Beverley may be seen in Figure 7.

Beverley Shire has strongly contrasting landscapes from west to east. In the west, the landscape is forested with jarrah *(Eucalyptus marginata)*, marri *(Corymbia calophylla)* and sometimes wandoo *(Eucalyptus wandoo)* on a deeply dissected, rolling landscape with an ancient laterized land surface. Further east, the land has been cleared and the undulating agricultural landscape is broken by granite hills, scattered remnant vegetation and meandering streams. The remnant vegetation is usually York gum (*Eucalyptus loxophleba*) with rough, grey bark, often mixed with the low, bushy jam tree (*Acacia acuminata*) on the lower slopes, and featuring along the drainage lines and roadsides or as scattered clumps. Wandoo, with its pale silver grey or mottled creamy yellow bark, mainly occurs on the middle and lower slopes.

Moving further east beyond Beverley there are sweeping views over wide shallow ancient drainage channels and distant low cresting hills. York gum predominates as the remnant vegetation with wandoo on the higher areas. Occasional stands of salmon gum *(Eucalyptus salmonophloia)* and red morrel *(Eucalyptus longicornis)* occur on heavy and calcareous soils and there are outcroppings of granite or breakaways - terracotta coloured hills of lateritic gravel with powder-bark wandoo (*Eucalyptus accedens*) and brown mallet (*Eucalyptus astringens*).

The Yenyenning Lakes are an interesting feature, low in the landscape, in the south east corner of the Shire. These are a long chain of naturally saline lakes which empty in wet years into the Avon River.

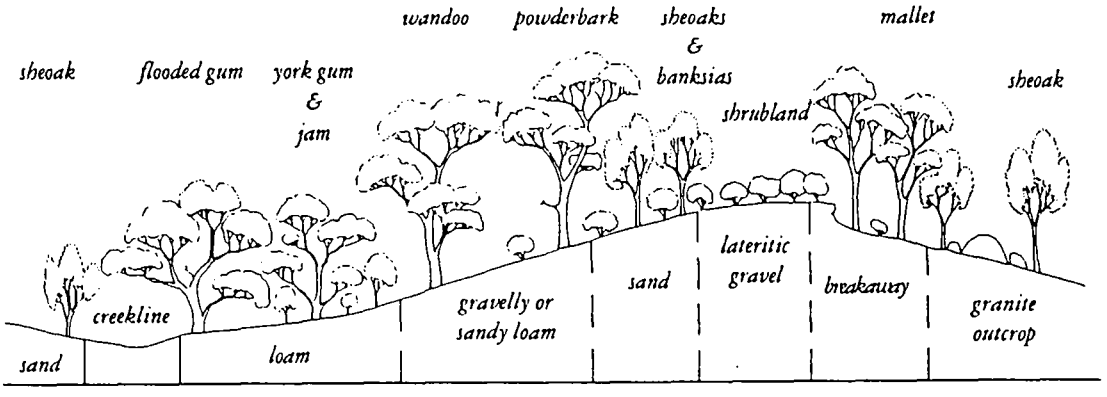


Figure 8. A typical landscape sequence in central and eastern parts of the Shire of Beverley showing the relationship of vegetation and soils
Source: Bamford (1995)

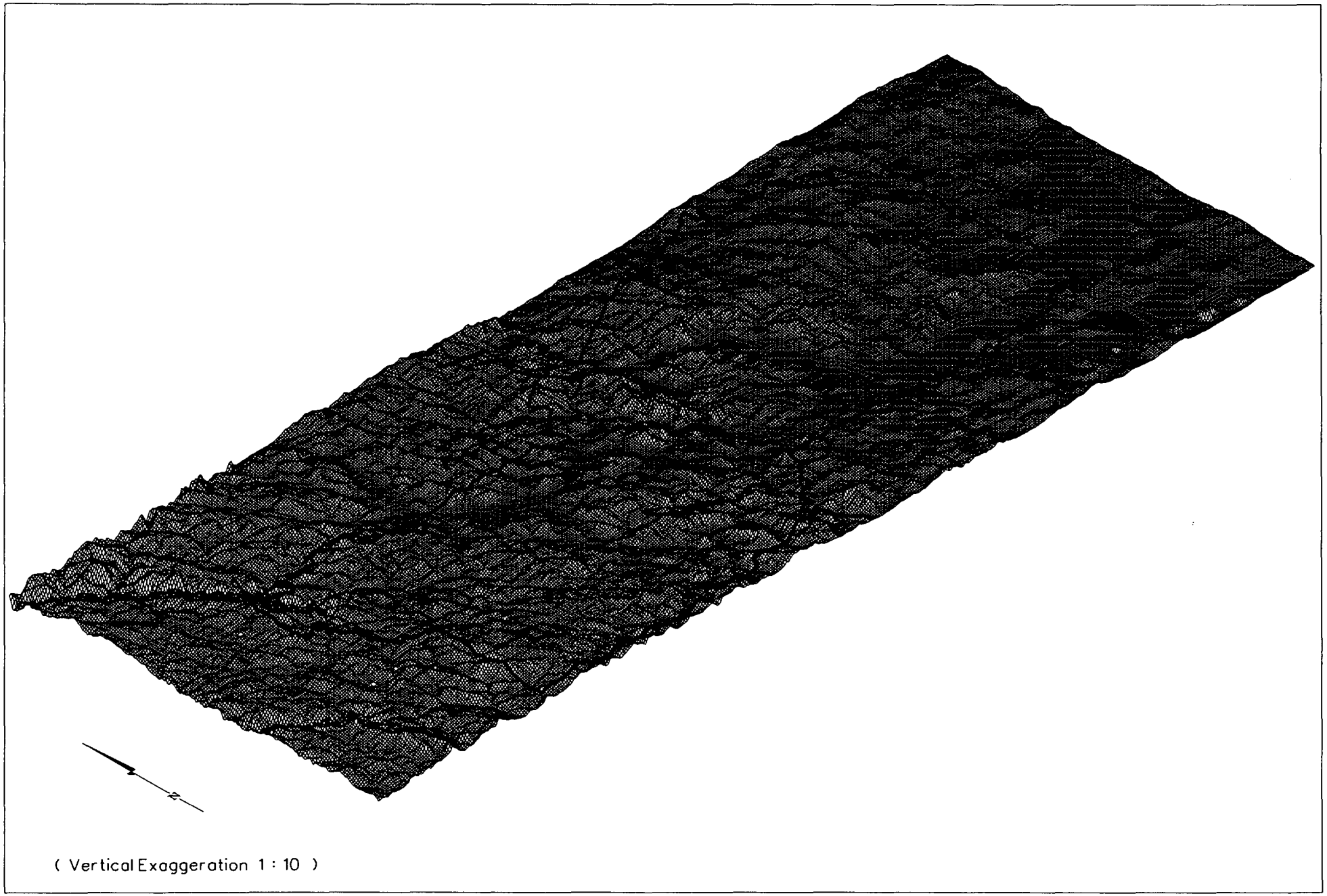


Figure 7: Topographical view for the Shire of Beverley

Original plant communities

The following descriptions of plant communities are based on plant distribution studies by J. S. Beard who described the vegetation which may have existed if European settlement and clearing had not occurred. Further detail can be obtained from Beard J. S., (1979) and Beard J. S., (1980). An estimation of the original distribution of the dominant vegetation types based on the work by Beard is shown in Figure 9 (Hopkins *et al.*, 1996). Appendix 1 lists plant species commonly found in each plant community.

Jarrah and marri forest

The jarrah forest occurs on the lateritic plateau and screes descending its edges and is composed of trees 25 - 30 metres tall in the western sector and 21 - 26 metres in the eastern sector. The virgin forest originally contained mainly mature trees but because of logging, most stands now contain smaller immature trees. In addition, many stands have been thinned by dieback disease caused by *Phytophthora cinnamomi*. Jarrah is the principal dominant tree, normally accompanied by marri on the mid slopes in proportions up to 50%, and by blackbutt (*Eucalyptus patens*) in lower lying wet areas, wandoo and powderbark wandoo on upper slopes. There is frequently a lower layer of small trees of 10-15 metres, Bull banksia *(Banksia grandis)*, sheoak *(Allocasuarina fraseriana)* and snottygobble *(Persoonia longifolia)* and a layer of sclerophyllous shrubs 1-2 metres tall.

It is an apparent anomaly that the jarrah forest is taller and more dense than the woodland on the lower slopes despite it growing on the inhospitable laterite on the plateau. The explanation is that the root systems of the jarrah can penetrate the laterite to the deep weathered zone below, tapping reserves of water during the dry periods. Soils of the scarp and valleys where the deep weathered zone has been stripped off actually provide much less water storage than the plateau.

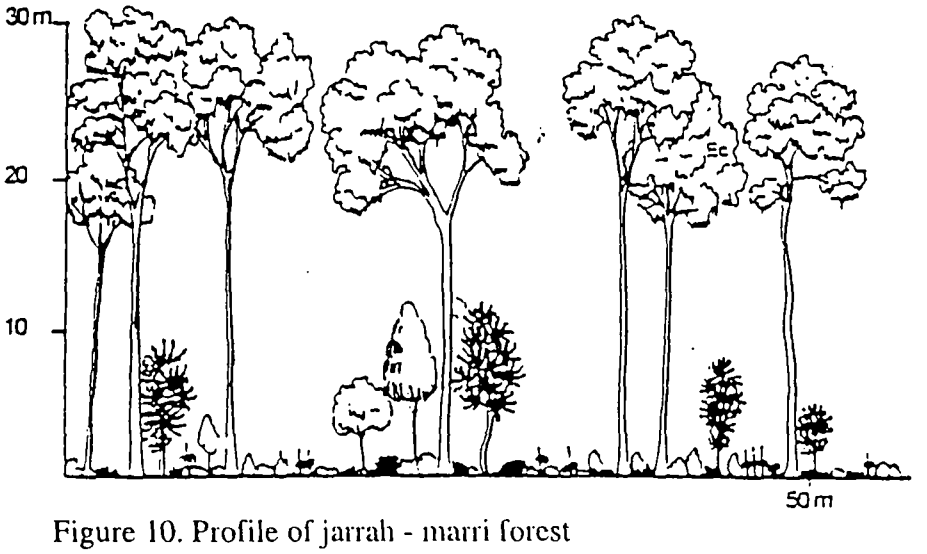
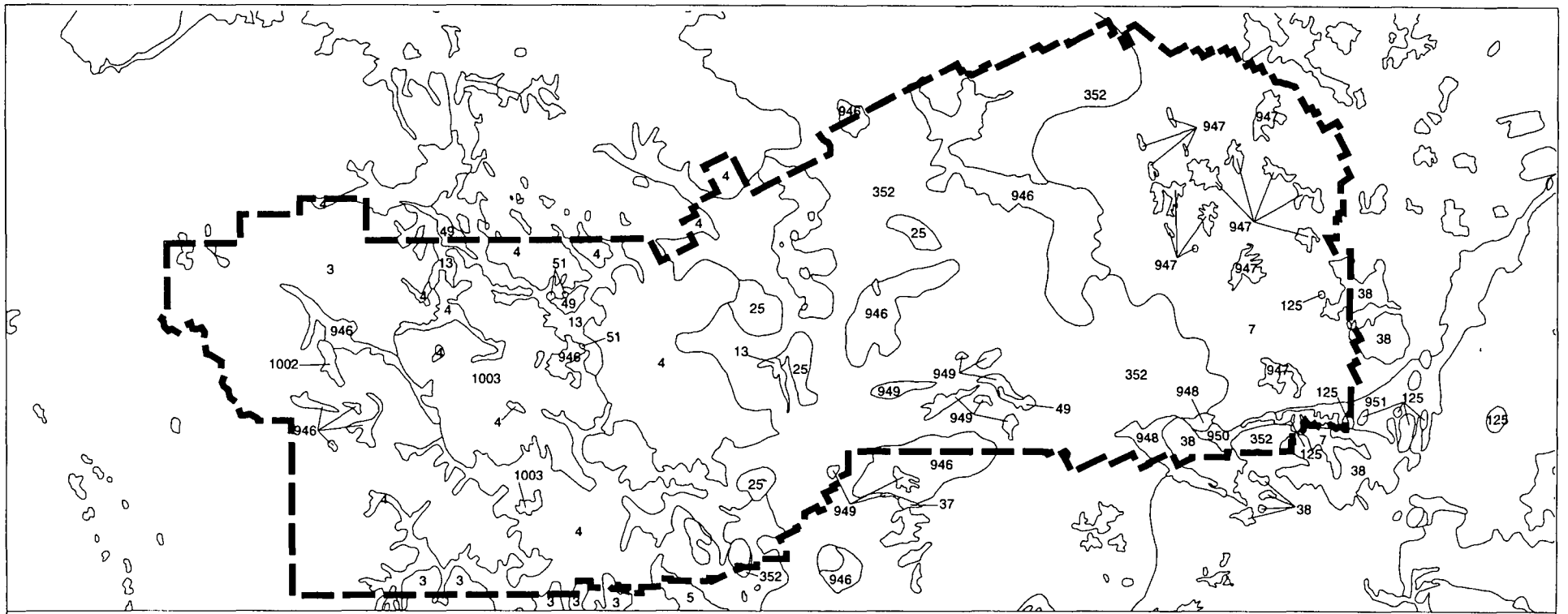


Figure 10. Profile of jarrah - marri forest
Source: Beard (1981).



3	Medium Forest; jarrah - marri	951	Succulent Steppe; York gum & Kondinin blackbutt sparse woodland, teatree scrub
4	Medium Woodland; marri - wandoo		
5	Medium Woodland; wandoo - powderbark	946	Medium Woodland; wandoo
7	Medium Woodland; York gum - wandoo	1002	Medium Open Woodland; jarrah
13	Medium Open Woodland; wandoo	1003	Medium Forest; jarrah - marri - wandoo
25	Low Woodland; *Allocasuarina huegeliana* & York gum		Rock outcrops
38	Shrublands; thicket, mixed		
125	Bare areas; salt lakes		
352	Medium Woodland; York gum		
947	Medium Woodland; powderbark & mallet		
949	Low Woodland; banksia		
950	Medium Woodland; *Casuarina obesa*		

N

5km 0 5 10 15km

Figure 9: Major Vegetation Types in the Shire of Beverley.

Jarrah - Marri - Wandoo - Powderbark Wandoo - Brown Mallet Woodlands

On the eastern edge of the laterite plateau, woodland replaces the jarrah forest because of declining rainfall. The woodland initially comprises jarrah - wandoo and powderbark wandoo on the plateau and laterite residuals with marri - wandoo woodland on the slopes below the plateau becoming mixed with blackbutt in the valleys and finally flooded gum (*Eucalyptus rudis*) with York gum on drainage lines.

Further east, with lower rainfall, a typical sequence of plant communities comprises scattered shrubs and rock sheoak (*Allocasuarina huegeliana*) on the granite outcrops, woodland of powderbark wandoo and brown mallet on laterite plateaus, woodlands of wandoo and powderbark on upper slopes with gravel wash below the breakaways, marri and wandoo on the middle slopes, with York gum on the lower slopes close to the major drainage channels, flooded gums line the creeks and are at times scattered on the slopes.

In the most eastern parts of the Shire, powderbark wandoo and brown mallet are at the limit of their range and occur on moister lower slopes with heath occurring on the plateaus. Stands of powderbark wandoo become lower and more open.

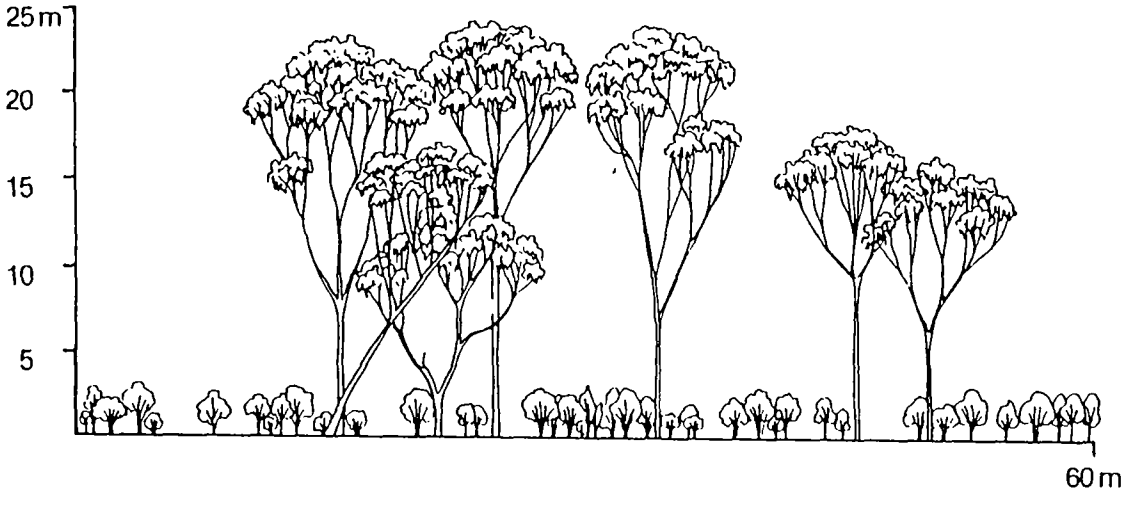


Figure 11. Salmon gum woodlands, often with a succulent understorey, sometimes occur on heavy red soils low in the landscape
Source: Beard (1981)

Woodlands of York Gum and Wandoo

As rainfall reduces in the east of the Shire, the bulk of the country below the brown mallet and powderbark woodland of the breakaways is covered by woodland of York gum (Figure 12) and wandoo. York gum and wandoo are usually in mixture but often with wandoo on the middle and upper slopes and York gum on the red soils of the lower slopes. Salmon gum sometimes occurs on heavier red soils (Figure 11) with flooded gum on the drainage lines or with swamp sheoak (*Casuarina obesa*) if these are saline.

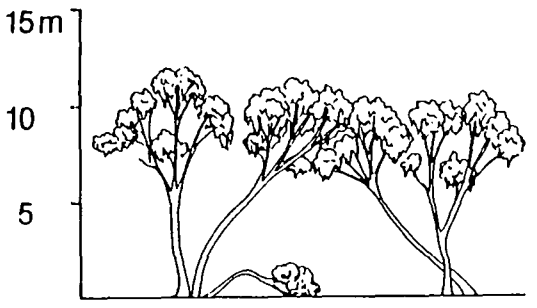


Figure 12. Example of height and form of York gum woodland
Source: Beard (1981)

Heath

Heath vegetation takes over from the brown mallet and powderbark woodlands on the laterite plateaus as the rainfall decreases in the east. The soils can be gravelly or sandy overlaying the laterite, determining the vegetation type.

Banksia Low Woodland

Banksia woodlands (Figure 13) can occur on sandsheets on lower ground which may contain swampy pockets of tea tree and reeds. They can range from scrub heaths to low woodland when long unburnt.

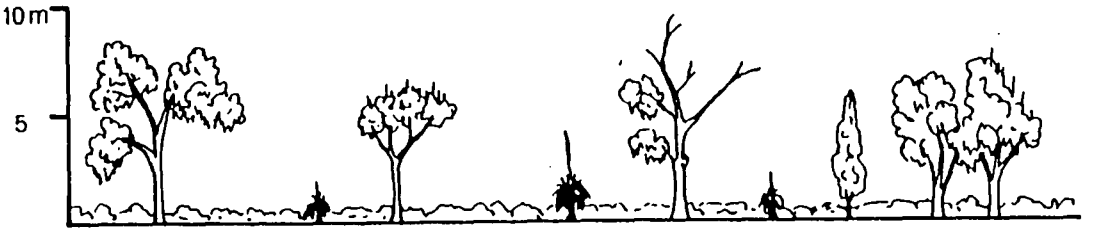


Figure 13. Profile of Banksia low woodland
Source: Beard (1981)

Salt Flats

Salt flats may be bare or vegetated with samphires, there are often low sandy dunes in the vicinity with scattered York gum and shrubs including broom bush *(Melaleuca uncinata)* and a range of other Melaleucas.

There has been more recent work into the dominant vegetation types on different soil types in the north east of the shire by Lantzke and Fulton (1993). See 'Soils' section.

Current vegetation

The westerly part of the Shire of Beverley is still covered with the original forest vegetation. Part is managed for forestry and water catchment and there are two Conservation Parks, the Dale and Wandoo. These areas and the Nature Reserves in the Shire are managed by the Department of Conservation and Land Management. This comprises 23% of the Shire area.

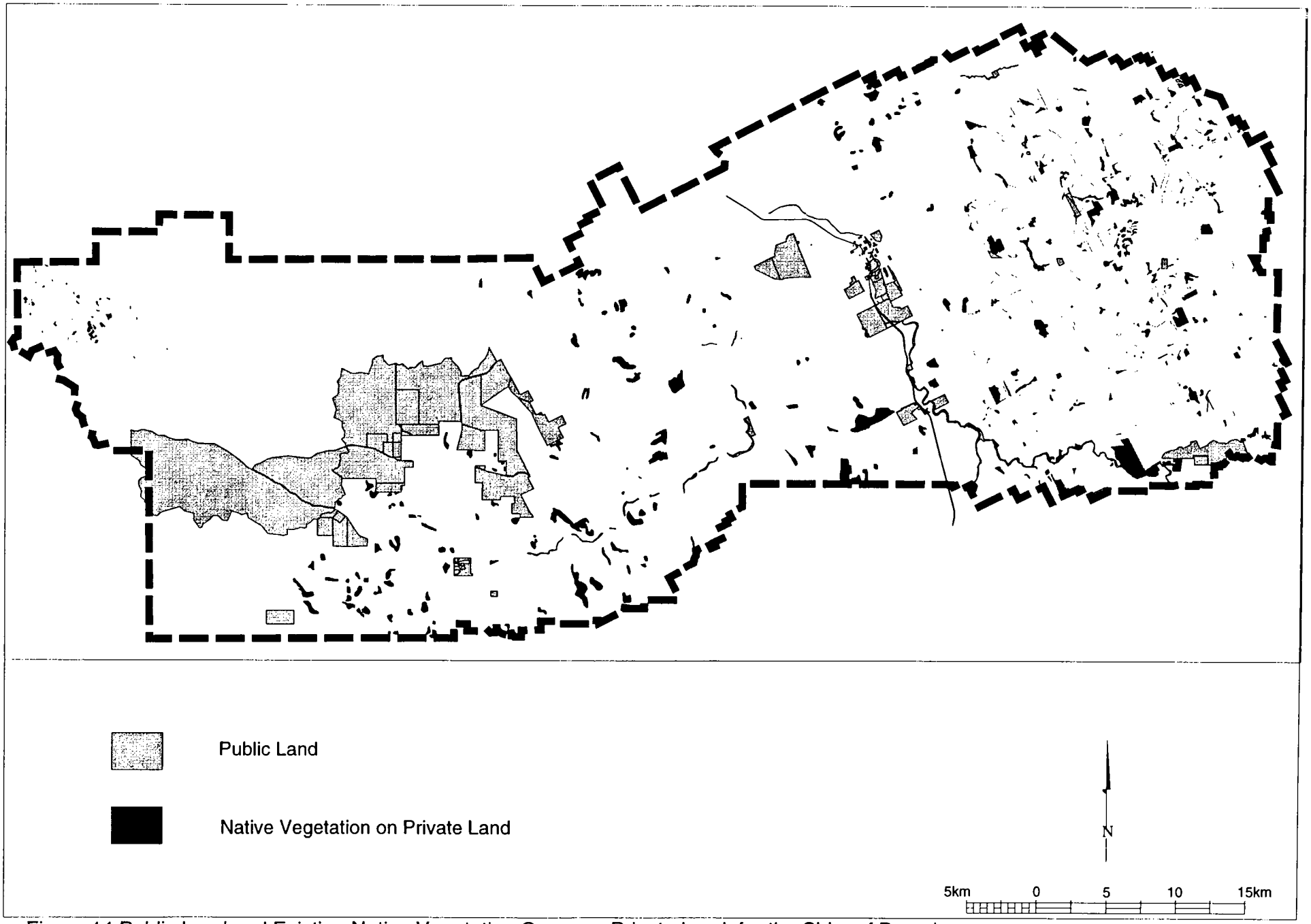


Figure 14:Public Land and Existing Native Vegetation Cover on Private Land for the Shire of Beverley.

The agricultural district was first settled in the 1830's and the best country for agriculture, the woodlands on heavier soils in the valleys, were cleared by hand. Much of the sandplain was cleared post 1950 with the advent of bulldozers and trace elements, some in the last twenty years. Remnant areas were often cleared in the early days as they were seen to harbour rabbits. The remaining remnants of native vegetation are mostly the areas unsuitable for agriculture: granite outcrops and breakaway country. Woodlands are very poorly represented in Reserves and much of the woodlands that do remain on private land have been degraded by grazing and weed invasion. In particular, there are very few intact areas of York gum woodland and Nature Reserves are small and isolated.

Approximately 27% of the Shire remains covered by relatively intact native vegetation, 2.4% (5,709 hectares) of which is found on private land. The remaining 25% (60,108.1 hectares) exists as public reserves, water reserves, crown land, gravel pits etc, not all of which has a cover of native vegetation (Figure 14).

There are 484 bush remnants, of which 244 (50%) are regarded as being "remnant vegetation" (closely resembling the original vegetation) and 240 (50%) as being "scattered trees" (parkland with no understorey). There were no mapped areas of "modified vegetation" (vegetation with a degraded understorey, disturbed, salt affected or narrow lines of vegetation). More than 84% of all bush remnants in the Shire are less than 20 hectares in area (Beeston *et al.,* 1994).

In 1992, Ted Griffin and Frans Mollemans undertook a botanical survey to further investigate the status of remnant vegetation in shires in the wheatbelt including the Shire of Beverley (Griffin, 1995) Copies of the findings of this survey are available by contacting the Spatial Resource Information Group, Agriculture Western Australia (08) 9368 3272. 169 bush remnants in the Shire were surveyed briefly and two bush remnants, numbered 05026 and 07061, were surveyed in detail (Griffin, 1995). The study found that 8% of all the bush areas surveyed were fenced and five of the eight areas classified as Remnant Vegetation were fenced. The results of the detailed survey are included in Appendix 2.

Nature Reserves

There are seven Nature Reserves in the Shire of Beverley which are vested in the National Parks and Nature Conservation Authority (NPNCA) for the conservation of flora and fauna. They are managed by the Department of Conservation and Land Management on behalf of the NPNCA.

Notes on some of the Reserves are provided below. In addition, there are a number of vested Reserves under the control of the Shire and other authorities.

Yenyenning Lakes. Reserve numbers 3183 and 28088.
Source: CALM Narrogin and Lane (1994)

The most significant reserve, at approximately 1700 hectares, is Yenyenning Lakes. It is a natural salt lake system which provides valuable wildlife habitat and considerable recreation use. The Lakes are part of a natural salt lake system stretching east to Lake Debra, north of Southern Cross and south towards Lake Grace and in exceptional years substantial flows of salt water are received. The Lakes normally receive most of their inflow from farming country to the east and the Lake discharges into the north branch of the Avon River. Sometimes, the Lakes receive water as backflow from the Avon River when it is flowing at high levels. The Lakes were always seasonally brackish with salinity depending on whether saline water was received via the salt lakes or fresher water from farming country. The Lakes have gradually become more saline since the 1940's, with the death of fringing vegetation (Roger Underwood, personal communication). Water levels in the Lake have been controlled since 1928 by a series of man-made alterations to the outflow, primarily to raise water levels to conserve water in the Lakes for summer recreation use and wildlife. This is reported to have affected salinity levels in the Lakes (Lane, 1994).

A bird list for the Lakes may be found in Appendix 4.

Reserve Number 26897
Source: Muir (1979)

This reserve was set aside for Conservation of Flora in 1963. It had previously been used as part of the adjacent farmland, stock having grazed it for a long period. It consists of wandoo woodland on the higher ground, with York gum woodland on the lower slopes. The wandoo woodland also includes salmon gum and scattered jam and rock sheoak. There is no understorey. The York gum includes scattered jam but there is no understorey.

Yandilling Nature Reserve. Number 16412.
Source: Muir (1979)

This reserve, of 65.48 hectares, was originally set aside as a Rifle Range and its purpose was changed to Flora and Fauna in 1952. It consists of a central area of Leptospermum Dense Heath with northerly and southerly areas of wandoo low woodland. There are numerous weeds particularly in the woodland areas.

Wandoo woodland
The woodland consists of wandoo (3-10m tall) with 10-30% canopy cover over bullock poison *(Gastrolobium trilobum)* and white myrtle *(Hypocalymma angustifolium)* shrubs (1 m tall) with 10-30% cover. There is some scattered wandoo emergent to 15m, with some rock sheoak to 6 m tall. Other species recorded were manna wattle *(Acacia microbotrya)*, prickly Moses *(A. pulchella), Bossiaea preissii, Calytrix* affin. *fraseri,* honeybush *(Hakea lissocarpha), Lepidosperma tenue,* scented matrush *(Lomandra effusa), Loxocarya pubescens,* wiry podalepsis *(Podolepis capillaris)* and grasstree *(Xanthorrhoea preissii).* Some open areas are present where roadside teatree *(Leptospermum erubescens)* dominates (1.5 m tall) with 70-100% cover. In these areas, manna wattle, *Allocasuarina campestris, Lepidosperma drummondii* and grasstree are prominent. The soil is pink, sandy clay, with poor drainage.

Leptospermum Heath
The Leptospermum Heath comprises roadside teatree shrubs 1.5 m tall with 70-100% cover over *Melaleuca seriata, Eremaea pauciflora* and mixed shrubs, 0.5 m tall with 2 -10% cover.

Other plants recorded were:
wilyurwur *(Acacia lasiocalyx),* prickly Moses, *Andersonia lehmanii,* slender banksia *(Banksia attenuata),* round-fruited banksia *(B. sphaerocarpa),* pindak *(Calothamnus sanguineus),* downy dodder-laurel *(Cassytha pubescens),* on *Melaleuca scabra,* rock sheoak, dwarf sheoak *(Allocasuarina humilis), Caustis dioica, Daviesia daphnoides,* parrot bush *(Dryandra sessilis),* mottlecah *(Eucalyptus macrocarpa),* black marlock *(Eucalyptus subangusta), Glischrocaryon flavescens,* variable-leaved hakea *(Hakea varia), Hibbertia enervia, H.* affin *verrucossa,* holly pea *(Jacksonia floribunda), Loxocarya pubescens,* curry flower *(Lysinema ciliatum),* rough honeymyrtle *(Melaleuca scabra),* climbing lignum *(Muehlenbeckia adpressa), Persoonia striata.* The soils are excessively drained white sands.

Quajabin Reserve. Number 3218
Source: CALM Narrogin

This is a York gum and wandoo woodland. The following other species have been listed: jam, wilyurwur, panjang *(Acacia lassiocarpa),* narrow-winged wattle *(Acacia stenoptera),* rock sheoak, *Acacia microstachya, Allocasuarina campestris, Atriplex* sp., prickly dryandra *(Dryandra armata),* small-leaf bluebush *(Maireana brevifolia),* bright podolepsis *(Podolepis canescens), Schoenus* sp., feather speargrass *(Stipa elegantissima)* and grasstree.

Reserve Number 41180
Source: CALM, Narrogin and Beard and Hnatiuk (1981)

This reserve of 49,864 hectares was reserved for Conservation of Flora and Fauna in 1990. The vegetation comprises slender banksia *(Banksia attenuata)* - acorn banksia *(Banksia prionotes)* - sandplain woody pear *(Xyomelum angustifolium)* low woodland on broad low hill with a thick deposit of yellow sand save in two areas where the lateritic base is exposed. The understorey is a thicket understorey with 98 species of plants being recorded.

Dale Conservation Park. Number 39824

No information is currently available on this reserve.

Wandoo Conservation Park. Number 43281

The Wandoo Conservation Park was announced in October 1995. It combines a number of small Nature Reserves into one park of 29,765.3 hectares. Information on the whole park is not yet available but the flora of part of the Park, comprising the former Dobaderry Swamp and Mount Westdale Reserves totalling 4,005 hectares, has been studied by M. Trudgen. The following information is a summary of his findings.

From a limited study, 347 plant species were recorded for the area but it is considered that this represents no more than 60% of the flora of the reserve. There were 14 species collected of special interest because they are known to be rare, poorly known or previously unknown. The gazetted rare species collected was *Hydrocotyle lemnoides*, an aquatic plant with floating leaves found in Dobaderry Swamp.

Sixty-two vegetation types or mixed types have been recorded and mapped. The main vegetation communities are: wandoo-15 types; flooded gum-3 types; Heath (not on granite)-5 types; powderbark wandoo-3 types; marri-2 types; jarrah-6 types; 3 granite types; 1 type of York gum woodland, Drummond's gum *(Eucalyptus drummondii)*, slender banksia, firewood banksia *(Banksia menziesii)* open woodland-1 type, slender banksia, firewood banksia open woodland-1 type; acorn banksia *(Banksia prinotes)* open woodland and 10 mixed types of the above communities.

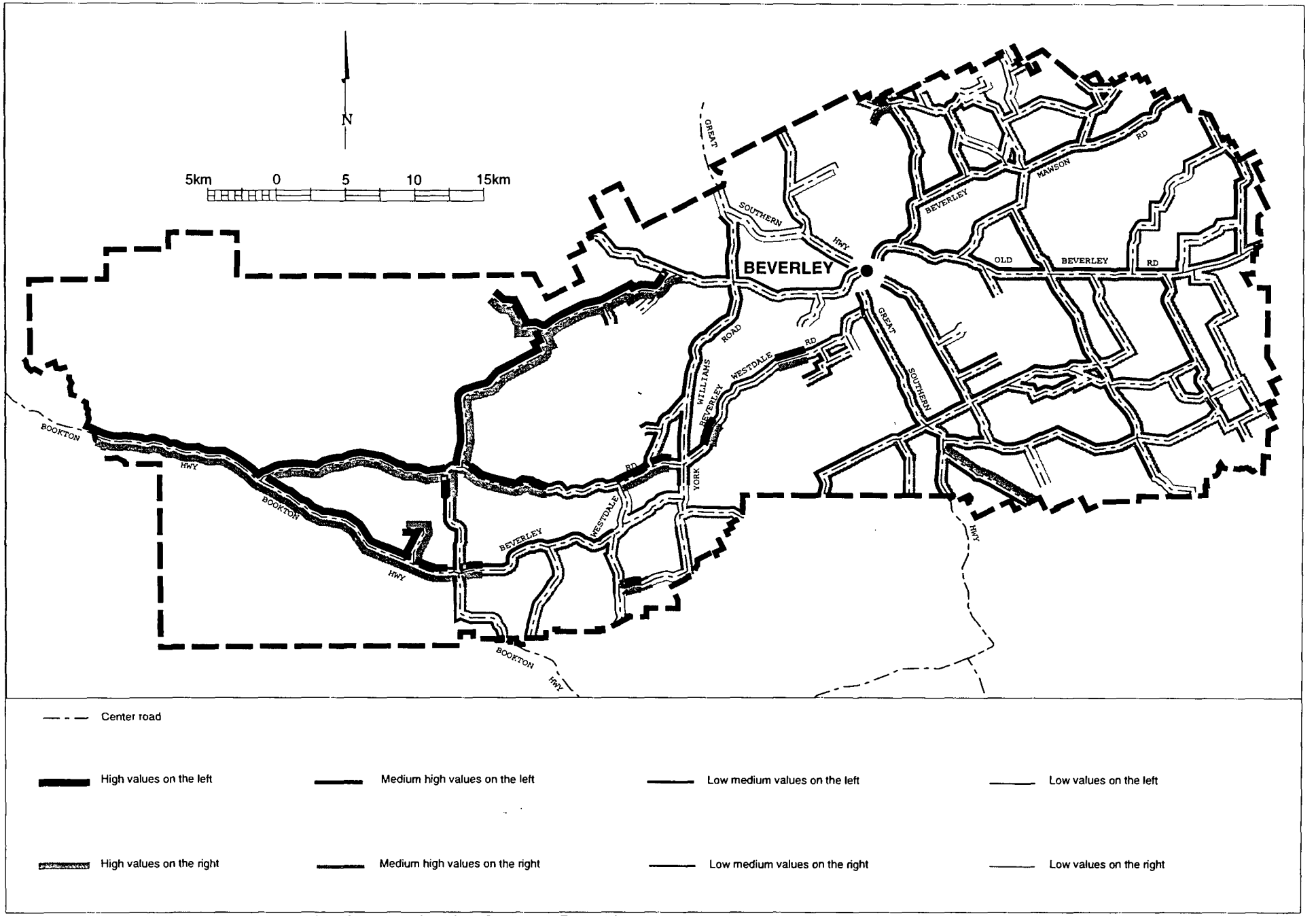


Figure 15: Roadside Conservation Values for the Shire of Beverley.

Roadsides

In 1989, the Roadside Conservation Committee organised an assessment of roadside vegetation for most of the roadsides in the Shire of Beverley (Figure 15). The field work was carried out by M. Blight, A. Fisher, W. Fleay, L. Heal and N. Mclean using the methods to assess and calculate the conservation value of roadside reserves described in Hussey (1991). A copy of the report can be made available from the Roadsides Conservation Committee, Department of Conservation and Land Management.

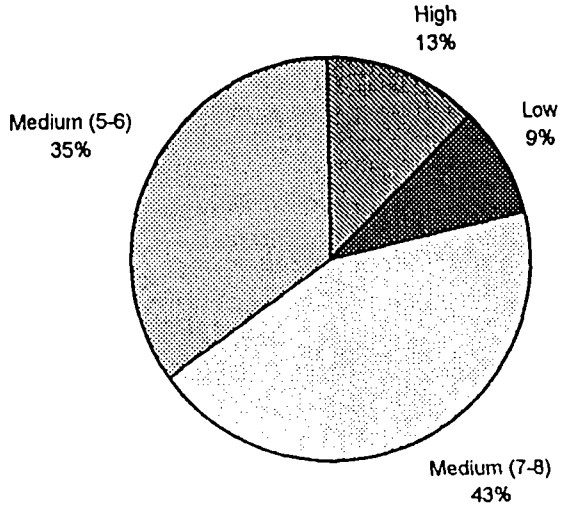
Roadsides can provide corridors between areas of remnant vegetation for the movement of wildlife and often are the only remaining areas of some vegetation types and occasionally contain threatened species. Roadsides can also be a valuable source of seed for revegetation projects. Approval of Beverley Shire and the Department of Conservation and Land Management is required prior to collection.

Well vegetated roadsides are also of benefit to agriculture. They provide windbreaks to adjacent farmland and assist with erosion and salinity control. The aesthetic value of well maintained roadsides should not be overlooked, as they have the potential to improve local tourism and provide a sense of place.

Survey results

138.5 km (12.5%) of the length of Shire controlled road surveyed was of high conservation value. Medium-high conservation value roadside accounted for 43.8%, spanning a distance of 484.6 km. Medium-low conservation value roadside covered 382.9 km or 34.6%. Areas of low conservation value occupied 99.8 km of roadside, constituting 9.0% of the length of Shire controlled road surveyed (Figure 16).

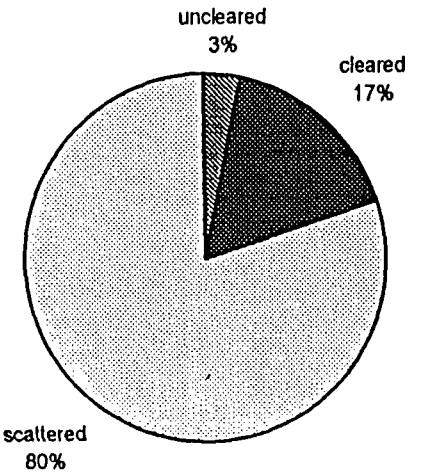
Conservation Value of Roadside Vegetation in the Shire of Beverley



Approximately 271.9 km of Shire's controlled roadside was recorded as displaying avenues of mature trees. An avenue of mature trees contributes substantially to the attractiveness of a landscape, framing the view and forming a tunnel effect over the road. Trees take many years to reach full stature, so that if an avenue is destroyed the effect can scarcely be reproduced within a lifetime. Mature trees also provide habitat for many animal species and nesting sites for hollow dependent species.

The majority of land adjoining the roadsides had at least some native vegetation remaining. A scattered distribution of native vegetation was present along 80.1% of the roadside and 3.4% was uncleared. The remaining 16.5% had been totally cleared of native vegetation (Figure 16a).

Native Vegetation Status adjoining Roadsides Controlled by the Shire of Beverley



The relative importance of a roadside section as a biological corridor is dependent upon the diversity of habitat and whether it connects uncleared land. High value biological corridor was present along 77.6% of the roadside, medium along 16.9%, and low value corridor 5.5%.

Roadside lightly affected by weeds covered 6.9% of the distance surveyed, medium level infestation 12.3%, and heavily affected areas 80.8%.

Survey sections with more than 20 native plant species spanned 21.0% of the length of roadside surveyed. Roadside with between 6-19 plant species accounted for 55.5% of the distance surveyed, with the remaining 23.5% having 5 or less plant species.

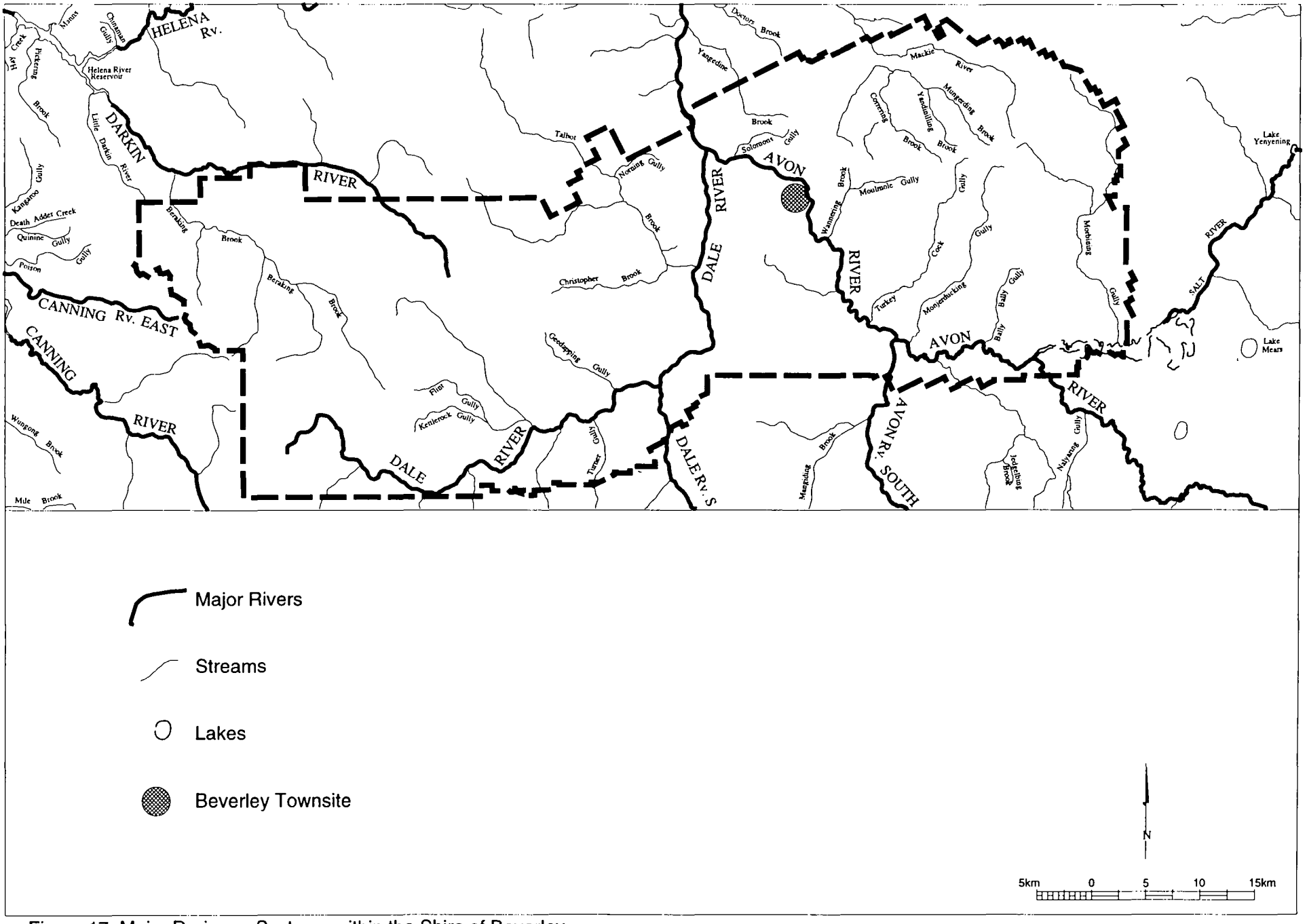


Figure 17: Major Drainage Systems within the Shire of Beverley.

Wetlands and Rivers

The Avon River system

The Avon River system drains 120,000 kilometres square of land mass. It comprises four main river systems: the Avon, the North Mortlock, the East Mortlock and the Dale. The main Avon River flows from south of Yenyenning Lakes; occasionally picks up water from the Lakes and flows downstream through Beverley Shire where it meets its major tributary, the Dale, north of Beverley. (Avon River Management Strategy, 1993). Figure 17 shows the major drainage systems in the Shire of Beverley.

Yenyenning Lakes

Source: CALM Narrogin and Lane (1994)

Yenyenning Lakes provide a good example of river management and the effects of man made alterations, including weirs to restrict water flow. The Lakes have always being seasonally brackish as they are at the end of a long chain of salt lakes but have become saltier since the 1940s and the fringing vegetation is dead or declining. Further details are included in the section on Nature Reserves in this report. A study regarding water quality and management of the Yenyenning Lakes has been commissioned by the Yenyenning Lakes Management Group and Beverley Shire and funded by the Gordon Reid Foundation for Conservation. It is an attempt to reduce salinity and to overcome the conflicts between management for natural values and recreational use. This report is now available from the Avon River Management Authority (ARMA).

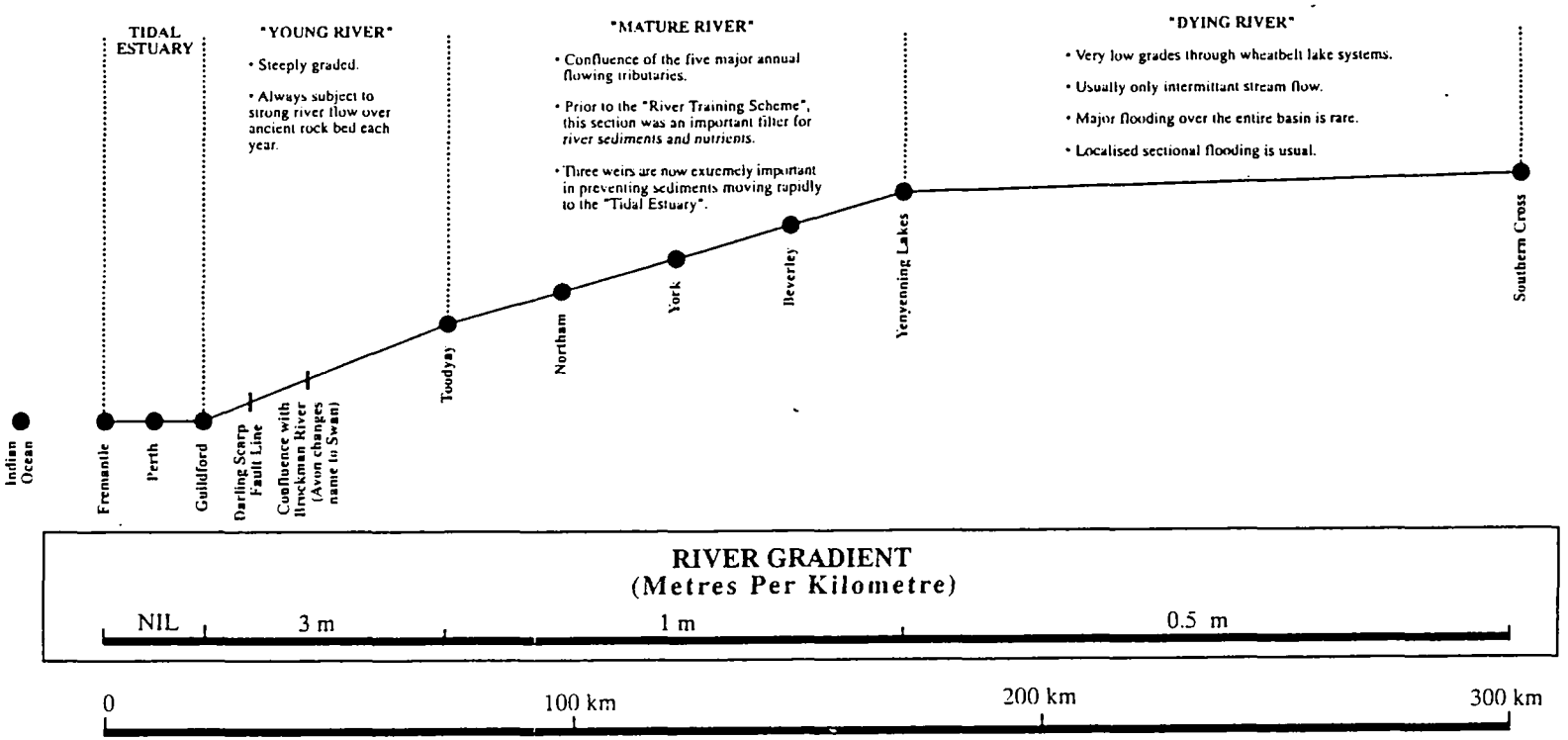
The Avon and Dale Rivers

Most of the wetlands in the Avon River catchment were fresh or near fresh until the 1930s. Originally, the wetlands were covered by sheoak, paperbark and tea tree, forming a dense canopy with low scrub below. Locals recall that horses, cattle and sheep were seen drinking from Avon Pools up to the early 1930s. Animal life in the area of the Avon was varied and quite different to that which occurs today (Sanders, 1991). Figure 18 shows four topographical divisions of the Swan/Avon River system.

There has been a rise of saline ground water as a result of the clearing of native vegetation throughout the agricultural region with salinity increasing in the Avon River catchment much earlier than other wheatbelt regions which were cleared later. The wetlands of the wheatbelt have suffered enormous changes as a result of these salinisation processes, run off, siltation and eutrophication.

Increasing river salinity was quickly followed by the death of vegetation fringing lakes and wetlands in the catchment. The freshwater aquatic weed, *Marsillea* sp. (nardoo) found in the Avon River began to disappear as a result of these changes and the appearance and increase of ribbonweed *(Ruppia maritima)* was recorded. This is a salt tolerant species (Sanders, 1991). Animal species are also good indicators of increased salinity. The clam *Westralunio carteri*, once abundant along the Avon River, has declined and all but disappeared, whereas the clam, *Anticorbula amara*, an estuarine species, is now abundant in the Avon at York (Kendrick, 1976).

Many of the vertebrate animals, including water-rats *(Hydromys chrysogaster)*, water birds, reptiles and frogs, that were once common to wetlands and the surrounding



Four topographical divisons of the Swan/Avon River System

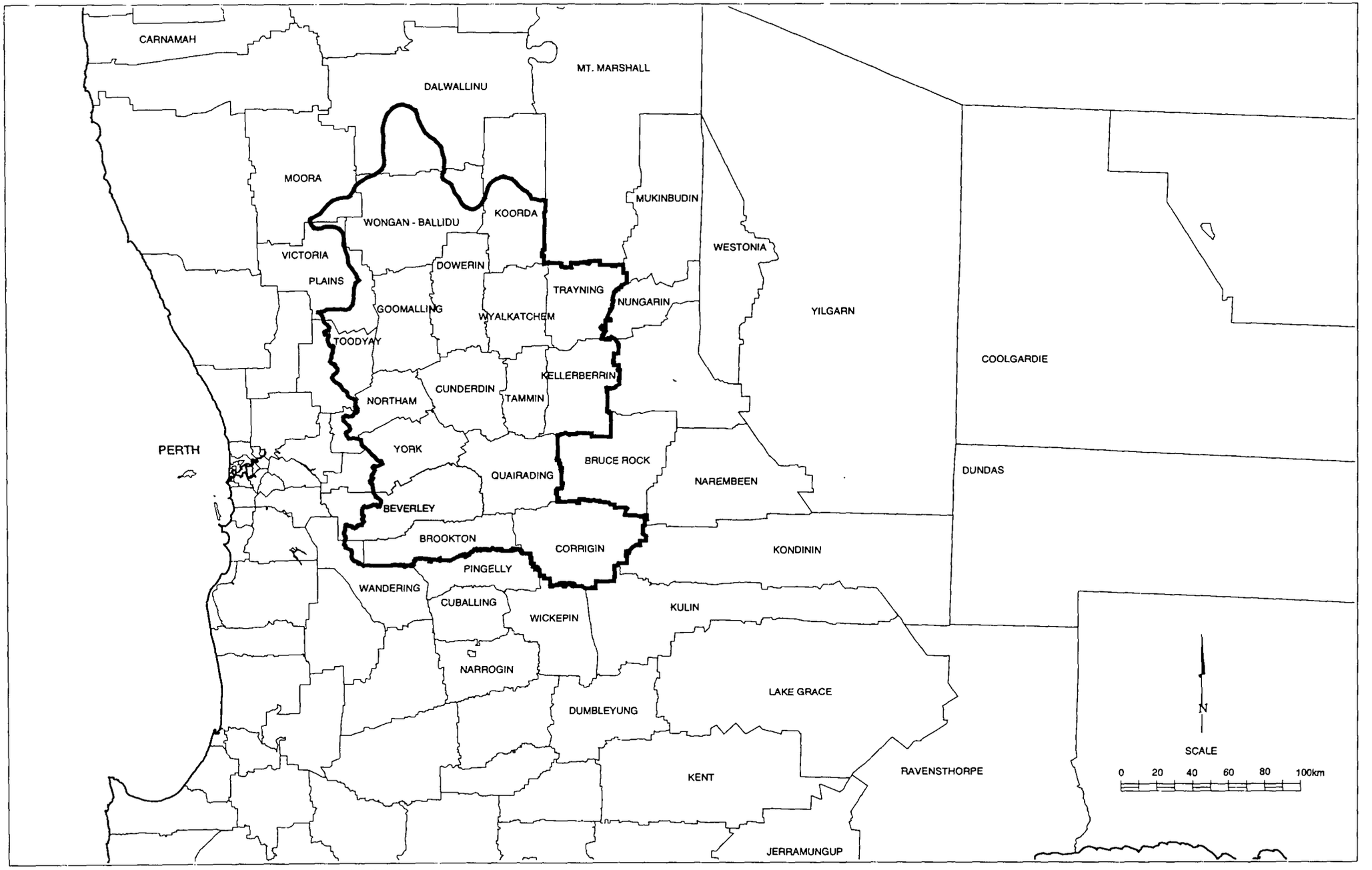


Figure 19: The Avon River Management Authority Area.

areas have now disappeared. This could be because of increased wetland salinity, the decline of their prey or related to predation by introduced animals, habitat destruction or other factors. For example, the carpet python *(Morelia spilota imbricata)* has diminished along the banks of the Avon because of the loss of hollow logs which it uses for shelter.

The Avon River was once characterised by long, deep pools separated by braided sections of the river which ran in numerous channels between islands of vegetation. The pools were important refuges and breeding sites for a range of water fowl and fauna. Flooding was a regular feature of river flow with the occasional high flood levels inundating large areas adjacent to the river. Early settlers often built close to the river and flooding became a concern with low lying settlements being subject to high flood levels in later years. This created community pressure to take action to reduce flooding.

The River Training Scheme began in 1957 to reduce flood levels to protect assets constructed on the floodplain. It involved the mechanical removal of tea tree, dead trees, logs and debris from the river to increase the speed of the flow and scour out a deeper river channel. The Scheme has reduced flooding but large amounts of sediment were mobilised and together with increased silt load entering the river from cleared catchments gradually filled the many deep pools. The Scheme ended in 1973.

The Avon Management Committee was set up in 1984 to tackle some of the problems of the Avon River system and to bring together local government representatives from each Shire along the river. One element of the management strategy was the establishment of the Avon River Management Authority (ARMA) in 1992 (under the Waterways Conservation Act of 1976-1982). The Shire of Beverley is included in the Avon River management area (Figure 19). The role of the Authority is to coordinate and advise on research, management and monitoring of the area with the help of a range of organisations including Agriculture Western Australia, the Department of Conservation and Land Management, the Department of Environmental Protection, the Water Corporation of WA, the Water and Rivers Commission and a number of community organisations such as the Land Conservation District Committees and the River Conservation Society.

The Authority is addressing some of the problems of the river with replanting of natural vegetation upstream from pools and with possible excavation of some of the pools. Foreshore vegetation protection and revegetation projects have been initiated along the length of the Avon River, fencing of areas and stock restrictions, also the control of fire, weeds and feral animals. Bank erosion from the River Training Scheme, stock damage and uncontrolled access by the public is also being eased with replanting projects and artificial walling with logs and rocks. Access to some areas is being restricted. A potential problem is that much of the foreshore is privately owned but this is being overcome with management agreements between ARMA and landowners.

The main purpose of the recommendations put forward by the Authority are that the river remain "biologically alive" and that it can be enjoyed as a source of recreation. These issues, amongst others, will be tackled over the coming years.

The pamphlet, *Principles of River Management,* Masters (1996), details the following principles:

1. Understand the nature of the river being protected.

2. Maintain the river's energy balance.

3. Base management on long term observations.

4. Protect natural resources throughout the catchment.

5. Respect the forces of nature.

Further information is available from Mr Viv Read, Water and Rivers Commission, (Northam).

Information on managing wetlands on private land can be found in Oates, N. (1994). *Managing Your Wetland. A practical guide for landholders.* Victorian Wetlands Trust and Department of Conservation and Natural Resources, Victoria 1994.

Fauna

Animals commonly seen the Shire of Beverley include the western grey kangaroo (*Macropus fuliginosus*), the western brush wallaby (*Macropus irma*), the echidna (*Tachyglossus aculeatus*) and reptiles including the bobtail (*Tiliqua rugosa*), the blue tongue lizard (*Tiliqua occipitalis*), the dugite (*Pseudonaja affinis*), the mulga snake (*Notechis australis*) and a variety of geckos. Some species such as galahs (*Cacatua roseicapilla*), ravens (*Corvus coronoides*), crested pigeons (*Ocyphaps lophotes*), magpies (*Gymnorhina dorsalis*) and the Port Lincoln parrot ('28') (*Barnardius zonarius)* have adapted to and favour the increased agricultural development and are increasing in numbers. Further information on woodland habitats and woodland species of insects, birds reptiles and mammals is available in *Exploring Wheatbelt Woodlands* by Mike Bamford (1995).

The broadscale clearing of natural bushland for agriculture, the introduction of stock and feral animals including predatory species, alterations to fire regimes and other disturbances of the wheatbelt since European settlement have caused local extinction of 17 of the 43 species (40%) of recorded mammals (excluding bats). Only 12 of the 43 species are now considered to be moderately common to abundant (Kitchener *et al.*, 1980).

The effects of the changes on bird species in the wheatbelt has been significant. Birds such as whistlers and fairy wrens have not coped well and are generally declining in numbers. Species such as Carnaby's cockatoo (*Calyptorhynchus funereus latirostris*) have undergone a significant reduction through loss of habitat (Saunders and Ingram, 1987). Several reserves examined by Kitchener *et al.*, (1982) over 15 years had lost species. Most land birds in the south-west (83%) are dependant on native vegetation for all or some of their annual requirements (Smith, 1987) and species loss is considered an inevitable response of area reduction and isolation with the rate of extinction varying amongst species (Saunders *et al.*, 1991). Further degradation and fragmentation of remnant vegetation will result in more local loss of species and other species becoming more vulnerable.

Animals which are considered to be under threat of extinction and are being monitored in the south-west include the tammar wallaby (*Macropus eugenii*), brush wallaby (*Macropus irma*) and Carnaby's cockatoo. Most of these species are under threat because of introduced predators, loss of habitat and loss of their preferred food. Control of foxes in a number of reserves south of the Shire of Beverley has resulted in increases in populations of small mammals including the numbat *(Myrmecobius fasciatus)*, chuditch (*Dasyurus geoffroii)* and red-tailed phascogale *(Phascogale calura)*. This coupled with captive breeding and reintroduction programs have added to the security of some of these species.

Threatened and Priority Fauna

Threatened and Priority Fauna need special protection. Threatened fauna means fauna which are rare or likely to become extinct or are declared to be fauna that is in need of special protection. Priority Fauna are declared to be fauna that is in need of special protection. The following Threatened and Priority Fauna are found in the Shire of Beverley:

Threatened Fauna	
Carpet python	*Morelia spilota imbricata*
Native bush cricket	*Ixalodectes flectocercus*
Priority Fauna	
Western brush wallaby	*Macropus irma*
Forest red-tailed black cockatoo	*Calyptorhynchus banksii naso*
Crested shrike-tit (south west subspecies)	*Falcunculus frontatus leucogaster*

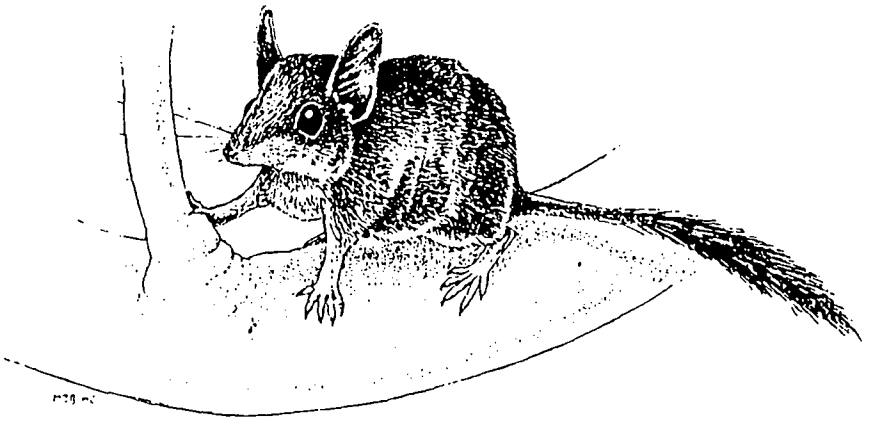


Figure: 20. The red-tailed phascogale is a nocturnal predator which eats invertebrates, small birds and mammals. It can survive in remnant vegetation areas as small as 65 hectares if foxes are controlled. Source: Bamford (1995).

Rare and Priority Flora

Declared Rare Flora are taxa which have been adequately searched for and are deemed to be either rare, in danger of extinction, or otherwise in need of special protection in the wild, and have been gazetted as such. The descriptions have been derived from *Western Australia's Endangered Flora* (Hopper *et al.*, 1990).

The following **Declared Rare Flora** have been reported in the Shire of Beverley (lists supplied by the Department of Conservation and Land Management).

Woolly sheoak *Allocasuarina fibrosa*
A dense erect lignotuberous shrub to 1.5m high with very hairy cones and flowers September to November. Grows in sandheath.

Matchstick banksia *Banksia cuneata*
A dense canopied large shrub or small tree to 4m high with erect branches and wedge shaped leaves to 4cm long with flowers June to December. Found in low woodlands of acorn banksia and woody pear on yellow sand.

Cossack spider orchid *Caladenia dorrienii*
A small spider orchid to 15cm high with two rows of calli and entire labellum margins and flowers September to October. Grows in damp wandoo flats and slopes,

Aquatic pennywort *Hydrocotyle lemnoides*
A small aquatic with ovate orbicular leaves to 5mm across and stems rooted in the soil. Found in fresh shallow water pools in clay soils. Flowers September to October.

Scarlet lechenaultia *Lechenaultia laricina*
A much branched erect bushy shrub with rather fine crowded leaves and a suckering habit. Plants produce masses of bright red flowers in late spring. Grows in sand or occasionally gravel loam in forest areas.

Cushion lechenaultia *Lechenaultia pulvinaris*
A prostrate shrub forming low cushions to 7cm tall by 30cm in diameter which are covered by masses of attractive blue flowers in early summer. Occurs on sandplain often near low lying seepage areas.

Star sun orchid *Thelymitra stellata*
A small perennial herb to 30cm high with a single ovate leaf to 9cm long. Flowers from October to December with from 1 - 10 golden brown striped flower 2.5 - 3 cm in diameter. Uncommon and scattered in lateritic soils in forest or heath.

Hill thomasia *Thomasia montana*
An upright shrub to 1m high with pale lilac flowers in September to October. Found on lateritic red clay-loam soils in open low woodland.

Shy feather flower *Verticordia fimbrilepis* subsp. *fimbrilepis.*
An erect small shrub to 60cm high with slender branches and clusters of attractive purplish pink flowers in November to December. Grows in shallow sand over gravel amongst mixed heath.

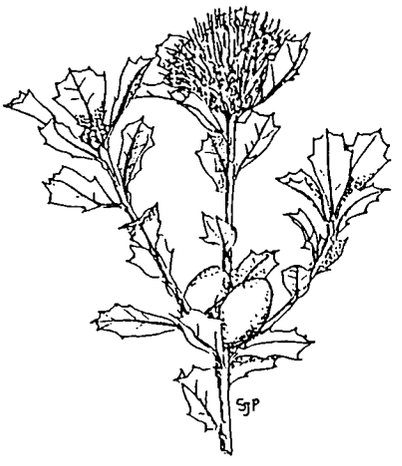


Figure 21. The matchstick banksia (*Banksia cuneata*), Declared Rare Flora, occurs in the Shire of Beverley. Drawing courtesy Sue Patrick CALM

Priority flora

The Department of Conservation and Land Management also lists Priority Flora. These are rare and poorly known, some under threat but they have not been gazetted as Declared Rare Flora. The following plants have been listed for the Shire of Beverley:

Acacia brachypoda
Acacia cuneifolia
Acacia insolita subsp. *efoliolata*
Acacia phaeocalyx
Acacia sclerophylla var. *teretiuscula*
Boronia tenuis (blue boronia)
Conospermum eatoniae
Daviesia brachyphylla
Daviesia microphylla
Drosera occidentalis subsp. *occidentalis*
Dryandra aurantia
Dryandra drummondii subsp. *Hiemalis*
Dryandra lindleyana subsp. *agricola*
Dryandra praemorsa var. *splendens*
Eucalyptus aspersa (brown mallet)
Grevillea cirsiifolia (varied-leaf grevillea)
Grevillea roycei
Grevillea scabra (rough-leaved grevillea)
Grevillea spinosissima
Grevillea thelemanniana (spider net grevillea)
Jacksonia epiphyllum
Laxmannia grandiflora subsp. *stirlingensis*
Leucopogon blepharolepis
Nemcia cyanophylla
Numicia alternifolia
Isopogon sp. Brookton Highway
Isopogon sp. Dale
Stenanthemum nanum
Stenanthemum pumilum
Synaphea acutiloba (granite synaphea)
Verticordia huegelii var. *decumbens*
Verticordia lindleyi subsp. *lindleyi*
Verticordia lindleyi subsp. *purpurea*
Verticordia multiflora subsp. *multiflora*

Land Resources

Geology

This description of the geology for the Shire of Beverley has been derived from the work of N. Lantzke and I. Fulton in *Land Resources of the Northam Region* (1993).

Most of the agricultural region of Western Australia is underlain by gneiss, granite and migmatite rocks. This has been a relatively stable part of the earth's crust for 2400 million years (Geological Survey, 1990).

Gneisses are hard crystalline banded rocks which were affected by high pressures and temperatures (that is metamorphosed) when they were several kilometres below the earth's surface. The minerals present are commonly quartz and felspars.

Granites are hard crystalline rocks dominated by quartz and felspars, have very few dark minerals and are not banded. Granites form when very large masses of molten rock ('magma') are pushed up ('intruded') into the earth's crust. Here the magma cools and crystallises.

Migmatites are mixed rocks with patches of both gneissic and granitic textures.

Earth movements over hundreds of millions of years have uplifted the basement rocks and weathering has led to soil formation.

An important geological feature in the Shire is the Jimperding Gneiss Complex (Geological Survey, 1990) which crosses from north of Toodyay to east of Beverley. This zone is about 40 km wide and coincides with the Avon Valley. The rocks of this gneiss complex are some of the oldest identified anywhere in the world.

Suites of basic and quartz dykes have intruded into the gneisses, granites and migmatites. Dykes form when molten material is forced upwards into fractures within the basement rocks and cools to form a feature which is often vertical and may be from millimetres to tens of metres wide and several kilometres long. The most common rock type is dolerite which is a dark rock with a high proportion of iron and magnesium minerals. Quartz dykes are a prominent feature in many areas.

Soils

Soil-Landscape Systems

Portion of the Shire of Beverley has been mapped in detail as part of a larger study of the Northam region by Lantzke and Fulton in 1994. The region was mapped into three broad zones: the Darling Range, the Zone of Rejuvenated Drainage and the Zone of Ancient Drainage. Each zone has a characteristic suite of landforms, soils and vegetation but the boundaries between the zones are often indistinct and can merge over a distance of up to ten kilometres. The broad zones are described below and the Soil-Landscape Systems within the Shire are shown in Figure 22. Appendix 5 shows a comparison of soil types described by Lantzke (1993) and the main soil groups for Western Australia.

The Darling Range Zone

The landscape of the Darling Range Zone consists of an undulating lateritic plateau with narrow, swampy, minor valley floors. The Dale River has cut back into this plateau creating steep, gravelly and rocky valleys.

Zone of Rejuvenated Drainage

The landscape is reasonably dissected with steep narrow valleys which contain rivers and creeklines which flow every winter. Small remnants of sandplain occur, often bordered by a scarp or breakaway.

The Zone of Ancient Drainage

The south eastern area of the Shire of Beverley includes some soil landscape units in the Zone of Ancient Drainage. The landscape is a gently undulating plateau, with wide convex divides, long gentle slopes and broad valleys which contain salt lakes at their lowest point.

The soil-landscape systems are described below (Verboom and Galloway, unpublished). Further information is available from the Natural Resource Assessment Group (NRAG), Agriculture Western Australia, South Perth.

Avon Flats System (AVF): Alluvial flats, in the northern Zone of Rejuvenated Drainage, with brown loamy earth, grey non cracking clay and brown deep sand. The main vegetation is York gum-salmon gum-flooded gum-sheoak woodland.

Bilgering System (BIG): Undulating low hills of lateritic plateau largely stripped by erosion in southern areas of the Zone of Ancient Drainage. Predominant soils are gravelly and shallow duplex soils. Major vegetation types include scrub heath and casuaurina thicket on old surface and wandoo and gimlet on new surface.

Boyagin System (BOY): Major rock outcrop with duricrust remnants in the Zone of Rejuvenated Drainage. Bare rock and stony or gravelly soils predominate. Vegetation consists of casuarina woodland, jarrah-marri and wandoo forest with parrotbush understorey. There is mallet and powderbark on scarp faces.

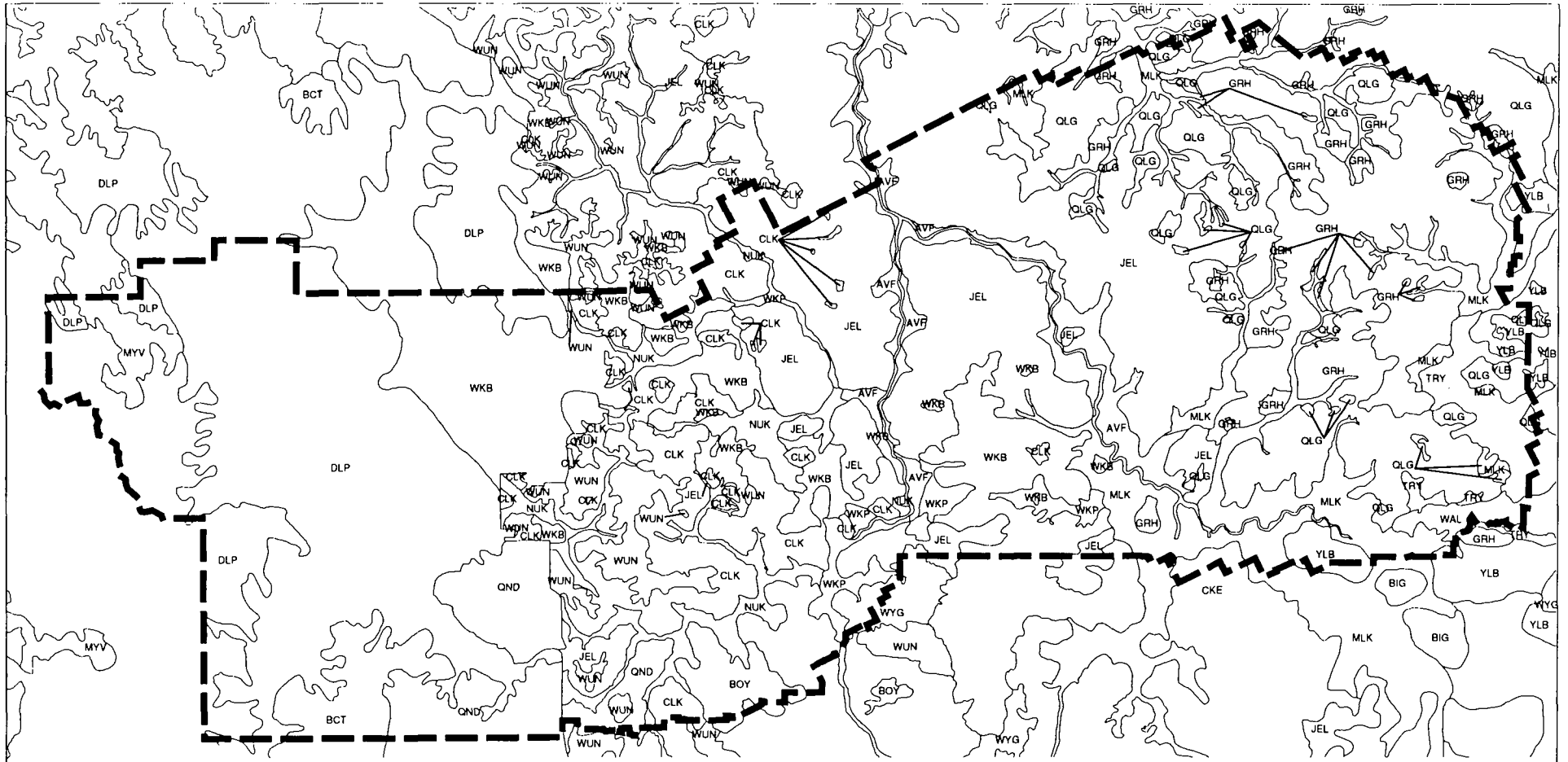


Figure 22: Soil - Landscape Systems in the Shire of Beverley.

Jelcobine System (JEL): Isolated steep low hills with undulating low granite hills and isolated lateritic remnants in the Zone of Rejuvenated Drainage. Gravels and grey shallow to deep sandy duplexes predominate. Principal vegetationtypes are wandoo, York gum, jam and casuarina woodland.

Walyuring System (WYG): Undulating low hills of largely intact lateritic surface in the Zones of Ancient and Rejuvenated Drainage. Main soils are shallow to deep sandy gravels and pale deep sand. Christmas tree, banksia and casuarina with sandplain heath predominate.

Wickepin System (WKP): Major valleys in the Zone of Rejuvenated Drainage. The main soils are grey shallow to deep sandy duplexes. Vegetation consists of wandoo, York gum, jam and casuarina woodland.

Nukaring System (NUK): valley floors. No detailed description available.

Clackline System (CLK): Steep slopes/irregular hills. No detailed description available.

Wundowie System (WUN): Lateritic plateau in the north east of the western Darling Range with deep sandy gravels. Jarrah-marri forest and woodland predominates.

Greenhills System (GRH): Undulating granitic terrain in the Northern Zone of Rejuvenated Drainage with deep sandy duplex (red and grey), red/brown deep loamy duplex, bare rock and shallow loamy duplex as the main soils. The predominant vegetation type is York gum-jam-salmon gum-wandoo-sheoak woodland.

Mortlock System (MLK): Poorly drained valley flats in the northern Zone of Rejuvenated Drainage. Major soil types are deep grey sandy duplex (sometimes alkaline) and saline wet soil. York gum-jam-wandoo-salmon gum-sheoak woodland makes up the principal vegetation.

Trayning System (TRY): Valley floors in the Zone of Ancient Drainage with alkalne red shallow loamy duplex, alkaline grey sandy duplex (shallow and deep), calcareous loamy earth and hard cracking clay as the major soil types. Main vegetation types include salmon gum-gimlet-wandoo-York gum woodland.

Yelbeni System (YLB): Gently undulating sandplain plain in the central Zone of Rejuvenated Drainage with yellow sandy earth (occasionally acid), deep yellow sand, gravel and pale deep sand. Heath, shrubland and mallee scrub predominate.

Quailing System (QLG): Undulating sandplain remnants, breakaways and slopes in the northern Zone of Rejuvenated Drainage. The main soils are grey deep sandy duplex (often alkaline), pale deep sand and yellow sandy earth. The major vegetation type is wandoo-jam-salmon gum woodland and heath.

West Kokeby System (WKB): Gently undulating sandy and swampy terrain in the northern Zone of Rejuvenated Drainage with pale deep sand, grey deep sandy duplex and non-saline wet soils. The principal vegetation is wandoo-marri-flooded gum-paperbark woodland.

Darling Plateau System (DPL):Lateritic plateau in the Western Darling Range with sandy gravel, loamy gravel, deep sand and wet soil as the main soil types. Jarrah-marri-wandoo forest and woodland is the predominant vegetation.

Quindanning System (QND): Deep granitic valleys in the northern and central Eastern Darling Range with deep sandy duplex soils, shallow sand, loamy duplex and bare rock as the major soil types. Major vegetation type is marri-wandoo-York gum-jam woodland.

Bowercutty System (BCT): Gravelly valleys in the north of the East Darling Range, with sandy gravel and loamy gravel. Principal vegetation is marri-jarrah-wandoo woodland.

Wallambin System (WAL): Salt lake chains in the central Zone of Ancient Drainage with salt lake soil and calcareous loamy earth. Mallee, morrel woodland and saltbush-bluebush-samphire flats predominate.

Murray Valley System (MYV): Deep granitic valleys in the north of the Western Darling Range with loamy earth, loamy duplex soil, stony soil and sandy duplex. The main vegetation type is jarrah-marri forest.

Cooke System (CKE): Low granitic hills in the north of the Western Darling Range with rock outcrop, stony soil, grey deep sandy duplex, loamy earth and gravel. The major vegetation types include jarrah-marri woodland, heath and lichens.

Land Management and Land Degradation Issues

History

Source: Lantzke N. and Fulton I. (1993)

The first European farmers settled in the Avon valley in 1831 and established themselves as pastoralists, grazing sheep on the native herbage and cropping small areas of the better soil types.

For the next fifty years, the region developed at a steady rate as new areas of land were released, settled and cleared. In the second half of 1880, the railway came to the Avon Valley reducing the isolation of the farmers. Large advances in agriculture were made in the early 1900s. Superphosphate came into general use, together with the seed drill, the stripper harvester and large horse teams. The jam and York gum soils were found to produce excellent crops when superphosphate was applied.

The most notable farming developments in the study area in the 1920s were the introduction of the farm tractor and the first attempts to introduce subterranean clover. In 1936, the first sidings for bulk wheat handling were built. The years following the second world war saw a rapid increase in the area established to improved pasture.

Advances in soil nutrition in the 1950s allowed trace element deficiencies on sandplain soils to be corrected thus opening up large areas of land. In the 1970s, a range of herbicides became available for weed control allowing the development of reduced tillage systems.

Current land uses

The dominant land use in the Shire is agricultural production. The type of production practised changes in a gradual trend from sheep grazing on subterranean clover based pastures and some cropping where rainfall is higher in the west to broadscale cropping and sheep grazing on subterranean clover and medic based pastures in the east.

A significant and growing proportion of rural land in the west of the Shire is being used for rural residential and hobby farm development. A small number of extractive industries exist with blue metal mined for road construction, ironstone gravel extracted from shallow pits and sand removed from the rivers.

Figure 23. A horse-drawn cart with a load of hay

Land Management and Land Degradation Issues

History

Source: Lantzke N. and Fulton I. (1993)

The first European farmers settled in the Avon valley in 1831 and established themselves as pastoralists, grazing sheep on the native herbage and cropping small areas of the better soil types.

For the next fifty years, the region developed at a steady rate as new areas of land were released, settled and cleared. In the second half of 1880, the railway came to the Avon Valley reducing the isolation of the farmers. Large advances in agriculture were made in the early 1900s. Superphosphate came into general use, together with the seed drill, the stripper harvester and large horse teams. The jam and York gum soils were found to produce excellent crops when superphosphate was applied.

The most notable farming developments in the study area in the 1920s were the introduction of the farm tractor and the first attempts to introduce subterranean clover. In 1936, the first sidings for bulk wheat handling were built. The years following the second world war saw a rapid increase in the area established to improved pasture.

Advances in soil nutrition in the 1950s allowed trace element deficiencies on sandplain soils to be corrected thus opening up large areas of land. In the 1970s, a range of herbicides became available for weed control allowing the development of reduced tillage systems.

Current land uses

The dominant land use in the Shire is agricultural production. The type of production practised changes in a gradual trend from sheep grazing on subterranean clover based pastures and some cropping where rainfall is higher in the west to broadscale cropping and sheep grazing on subterranean clover and medic based pastures in the east.

A significant and growing proportion of rural land in the west of the Shire is being used for rural residential and hobby farm development. A small number of extractive industries exist with blue metal mined for road construction, ironstone gravel extracted from shallow pits and sand removed from the rivers.

Land degradation

European settlement in the south-west of Western Australia and the subsequent clearing of native vegetation and replacement with crops and pastures have given rise to problems of land degradation, the loss of agricultural production and loss of conservation values. The most obvious problems are associated with changes in hydrology, for example, the rising water table with salinity and waterlogging.

The State's south-west agricultural region produces agricultural goods worth over $4.5 billion annually on around 18 million hectares of cleared land. Already, about 1.8 million hectares (about 10%) of productive land has been affected by salinity. The total loss of production is in the order of $1445 million. If the current rate of salinity expansion continues there will be a resulting annual loss to agriculture of $64 million each year. In the past, farmers largely adapted to the cost of salinity and land degradation by increasing production on unaffected land and developing uncleared land. This will be increasingly difficult in the future as the resource base continues to deteriorate (Western Australia Salinity Action Plan, 1996).

Within the Shire of Beverley, the most prevalent land degradation problems are ones of waterlogging, salinity and salt scalding, wind and water erosion and top and sub-soil acidification. A brief summary of these problems is provided below.

Rising water tables and salinity

The principal cause for increased soil surface salinisation in much of the wheatbelt has been the removal of native deep-rooted perennial vegetation and its replacement with annual shallow-rooted crops and pasture. Less water is transpired (given off via leaves) by these shallow-rooted plants resulting in the rise of groundwater, and the rise of soluble salts to the plant roots or soil surface. Quite often the effects of salinity are not seen for 15-20 years following the removal of native vegetation.

The Shire of Beverley had 2 934 hectares affected by salinity in 1979 and 4 313 hectares (2.85% of arable land) affected in 1989, an increase of 1.5% over ten years (George, 1990). However, the effect of salinity on the landscape varies from catchment to catchment. Rates of salt scald vary from a high of 13% for Morbinning Catchment with Ketterlock Catchment reporting 1% (Beverley LCDC, 1996).

Drainage and pumping methods can be used to drain limited areas of land but drainage water can be detrimental further down the catchment. Biological solutions include planting perennial deep-rooted vegetation, and adopting farming practises that utilise more water. Revegetation low in the landscape areas has been recommended (Schofield and Scott, 1991) but it is suggested that initial plantings be kept well back from saline areas with the expectation of moving into the saline areas as water tables are lowered.

Waterlogging

A soil is waterlogged when it is completely saturated by water due to poor internal and surface drainage, low permeability of the subsoil and the inability of the soil to store much water. This is exacerbated by the removal of deep-rooted vegetation, rising water tables, cultivation and soil compaction from stock trampling and use of heavy farm machinery. It reduces plant growth, particularly where soils are salt-affected.

Waterlogging is most prevalent in areas of above 400mm annual rainfall and particularly on duplex and clay soils in plains and valley floors with a high risk of inundation. Within the Shire of Beverley, waterlogging is more of a problem in the west rather than the east, possibly due to higher rainfall (Beverley LCDC, 1996).

Harry Whittington, a farmer from Brookton Shire, has over many years of practical observation and experimentation formulated an understanding of the deteriorating soil health of the farming landscape. He believes that water logging and salinity can be controlled by taking measures to retain rainfall where it falls rather than allow it to move to lower slopes. He has pioneered the construction of a system of interceptor banks on the upper slopes of the landscape and believes that where these have been constructed there is good evidence of improved productivity on the upper and lower slopes (H.S. Whittington, personal communication). Mr Whittington has had a big role in establishing the WISALTS group and "Whittington Banks" are now a feature of many landscapes in the wheatbelt. Many of these banks are now being planted with trees to provide shelter and to increase water use.

The scientific community has been at odds with the WISALTS group as it is considered that seepage from level banks can increase salinity (McFarlane *et al.*, 1990) resulting in lively debate in the community over landcare issues. Agriculture Western Australia recommends contour banks in some circumstances provided safe disposal of water can be achieved (Figure 24).

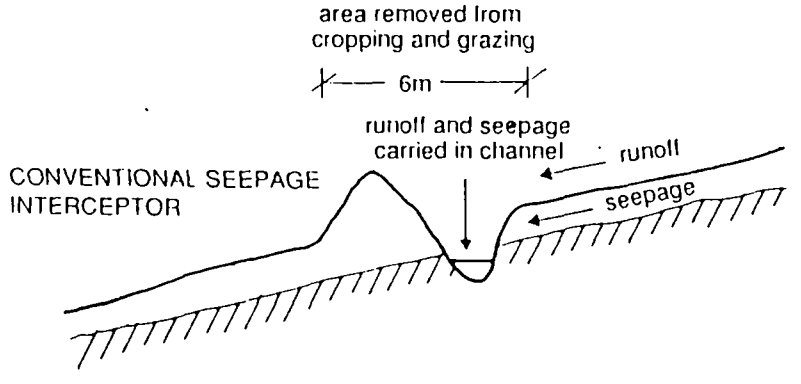


Figure 24. Cross section of a conventional seepage interceptor drain
Source: Hunt and Gilkes (1992)

Wind erosion

Wind erosion is the removal of topsoil by the wind, redepositing it elsewhere. The loose, sandy soils of Western Australia are prone to wind erosion particularly following cultivation and overgrazing and in times of sustained droughts. The three major processes of wind erosion are saltation, surface creep and suspension (Figure 25).

The Shire of Beverley, being largely comprised of sandy surfaced soils, is considered to be highly susceptible to wind erosion. Wind erosion can occur on all soil types if cover is removed, the soil is detached (loosened) and strong enough winds occur.

Appropriate grazing management, farming to soil type, modifying tillage and direct seeding into stubble and the establishment of wind breaks can reduce wind erosion. Windbreaks should be several rows wide, consist of trees and understorey at right

angles to the most damaging winds. Windbreaks, if appropriately designed, can also serve as effective wildlife corridors linking areas of existing vegetation.

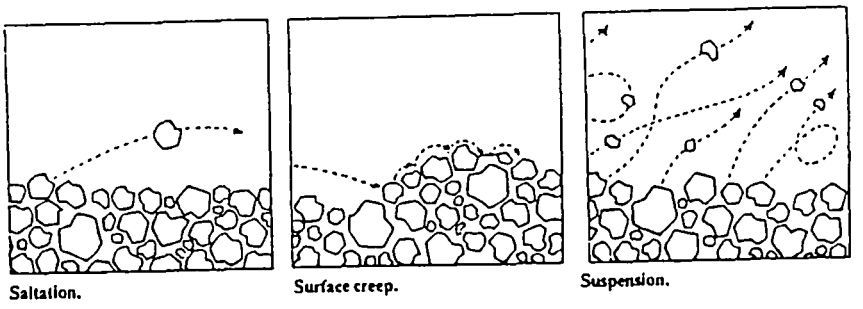


Figure 25. The three major processes of wind erosion.
Source: Hunt and Gilkes (1992).

Water erosion

Water erosion results in fertility loss, reduced crop yield and siltation of waterways. The water repellent sandy soils of Western Australian are particularly susceptible to water erosion made worse by over-cultivation, overgrazing and stock trampling. Water erosion is of most concern on steep slopes, dispersive and duplex soils. The three main types of water erosion are gully, rill and sheet (Figure 26).

Bank erosion along the Avon River, mainly caused by the removal of vegetation during the River Training Scheme and stock damage, has been a serious problem. Revegetation and fencing along the banks of the Avon and Dale Rivers and along the main feeder creeks and streams is suggested.

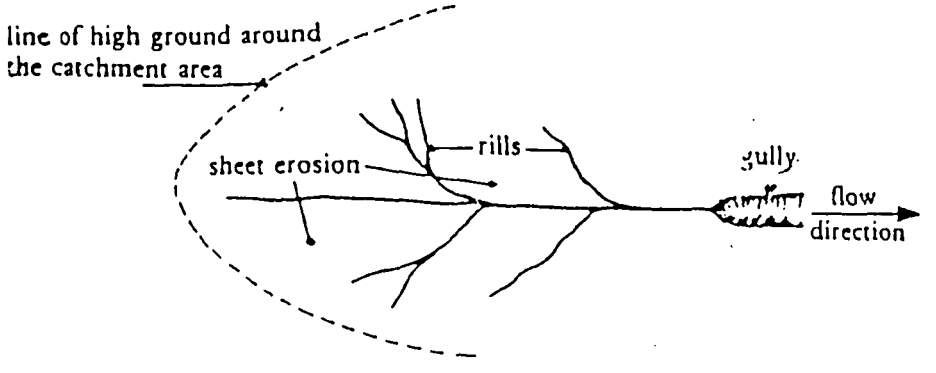


Figure 26. The three major forms of water erosion
Source: Hunt and Gilkes (1992)

Acidity

Soils in the Agricultural Zone of Western Australia are becoming more acid because of farming practices. This includes the use of ammonium-based fertilisers and clover pastures. Acidification can inhibit the growth of plant roots of both native and pasture species and render soils more susceptible to degradation by wind and water erosion (*State of the Environment Report*, 1992).

In the Shire of Beverley, most soils appear to have some risk of acidification, with some soils having a high risk of developing this problem.

Solutions to ameliorating soil acidity include the rotation of legume-based pastures with non-legume based pastures, reduction in the use of chemical fertilisers and it is found that acidification is less under deep rooted perennial vegetation. The only realistic treatment is applications of lime.

Soil compaction

Soil compaction by stock and heavy farm machinery is a major degradation problem experienced by many wheatbelt shires, including Beverley. Stock and heavy machinery compact the soil and prevent infiltration of both water and air that reduces root development. This results in reduced plant growth and an increase in wind and water erosion. Rectification is possible by deep ripping and using lighter farm machinery and restricting machinery traffic on the land through using minimum or zero tillage to establish crops. Fencing remnant vegetation will prevent stock causing soil compaction within the bush.

Clearing

The Shire of Beverley was one of the first shires settled in the Avon Valley and has been extensively cleared. The Avon district is recognised as the worst affected area in the wheatbelt for loss of native vegetation. In the early days, when nature conservation was not considered important, the government set aside areas of native vegetation as crown reserves for townsites, water catchments and for gravel extraction. Many of these patches of vegetation have nature conservation values and some have since been designated as nature reserves.

Current clearing guidelines recommend that for an area receiving 500 mm per annum rainfall or less (eg. most of agricultural areas in the Shire of Beverley), 20% of the catchment should remain under perennial vegetation to prevent land degradation (Clark, 1992). Currently, the Shire has 27% remnant native vegetation cover. This includes the State forest and reserves, masking the true extent of clearing over the rest of the Shire where only 2.3% of the original native vegetation remains.

Action to prevent clearing of native vegetation is being taken by the State Government. Land clearing is controlled under the Soil and Land Conservation Act requiring all landowners to give notice to the Commissioner for Soil and Land Conservation of intent to clear land greater than one hectare in area. Landscape and soils are assessed within a set of guidelines directed at protecting remnant vegetation for land degradation purposes (Select Committee into Land Conservation, 1992). The Department of Environmental Protection and Agriculture Western Australia are currently developing nature conservation criteria when assessing clearing applications.

Revegetation

Planting of trees and shrubs is being undertaken in some areas as part of the solution to land degradation and loss of water quality. A barrier to replanting has been a lack of information about revegetation methods and what to plant. Many people are now focussing on local native plants for the following reasons:

- local species provide regional identity
- a big species choice to enables matching of plants to sites and revegetation goals
- introduced plants may become weeds
- natural combinations of local plants maintain biodiversity, provide natural habitat values and are probably best for local fauna
- local species are proving to be robust in the long term

It is hoped that this Handbook, with its lists of species for different landscape types and references to other sources of information will encourage the use of local plants and that these will be increasingly demanded from and grown by plant nurseries.

Sources of information include:

The Revegetation Guide to the Central Wheatbelt (Lefroy *et al.,* 1991). This excellent resource book attempts to address land degradation problems by providing an understanding of soils and matching plants to soils. Colour photos of many of the recommended plants and revegetation hints make the book particularly useful.

Toolibin Catchment Revegetation Manual. This folder is a resource for any community with similar soils and issues to the Toolibin Catchment. Case studies give real life examples of revegetation options for commercial production and nature conservation. Comprehensive lists of plants are provided for different soil types with information on origin, usefulness in saline and waterlogged situations, size, form and uses. The manual is a guide towards achieving a balanced and healthy environment in which revegetation plays a significant role.

REX'96. Revegetation Expert software, uses modern software (CD-ROM or disc) to make choosing plants easier and more efficient, while giving comprehensive information on almost 2500 plants from right across Australia. REX'96 is an encyclopedia on particular plants (many with colour photographs) which allows sorting to choose the right plants for particular situations. In addition there are articles on revegetation and conservation issues. REX'96 is available from CALM Narrogin and from Greening Western Australia (08) 9481 2144. RRP is $89.95.

Managing existing vegetation

Protecting remnants of the original vegetation communities in all their complexity is considered to be a greater priority than revegetation. These remnants of natural systems will be the building blocks for future revegetation and it is considered impossible to reconstruct all the elements of natural systems.

Survival of existing vegetation, which is often in small, fragmented patches, requires more than just fencing out stock. Active management is often required where natural processes such as fire are not possible or where weeds have invaded through disturbance or increased nutrients from past grazing and fertiliser drift.

Specific recommendations on how to manage existing bush are provided in *Managing Your Bushland: A Guide for Western Australian Landowners* Hussey and Wallace, 1993. The book *Managing Perth's Bushlands* Scheltema, M. and Harris, J. (eds) (1995). provides much useful management information.

Bringing It All Together

Landcare progress

Five catchment groups in the Shire of Beverley have made significant progress in combating land degradation. A survey by the Beverley Land Conservation District Committee (June 1996) has produced the following results.

The extent of salt scald within the five catchments surveyed was not as high as may have been expected. However, the area of salt affected land was quite extensive, with the Morbinning catchment reporting the highest level of 13% compared to Kettlerock at 1%. Kettlerock reported the highest level of salt scald of the five catchments.

Saltland reclamation is fairly constant between the catchments with Morbinning having the most success at 4.6% (965 hectares) of their catchment. Kokendin results in this area were interesting in that individual farmers have already reclaimed some 370 hectares (3.7%) of salt affected land before the catchment group was formed. Similarly, this catchment has significant results for revegetation with 2.8% of the catchment area planted out.

The area under contour banks was notable with 50% of West Dale covered and 40% of Kettlerock and Kokendin catchments. Contoured land percentage is not quite as high in Morbinning and Monjerducking catchments but still represents a sizeable area covered and could also relate to the terrain being less hilly.

The area of fenced remnant vegetation was small in all catchments while unfenced remnant vegetation represented a considerable area. This possibly reflects many farmers unwillingness to utilise a fencing subsidy under the Remnant Vegetation Protection Scheme (AgWA), which requires a 30 year covenant to safeguard the land against grazing and other uses.

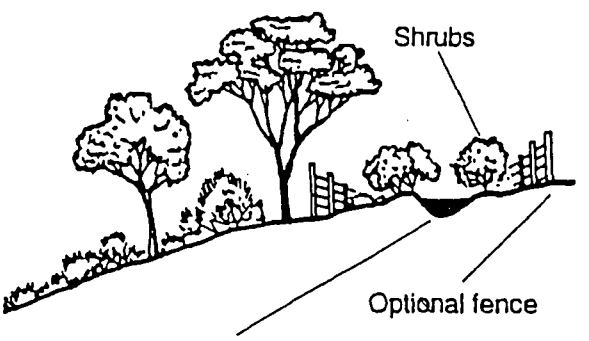


Figure 27. Fencing remnant vegetation to exclude stock and measures to minimise nutrient and seed inputs are required if the natural vegetation is to be viable. Source: Hussey and Wallace (1993). *Managing Your Bushland: A Guide for Western Australian Landowners*. CALM.

Morbinning Catchment

The Morbinning Catchment Group consists of twenty families on sixteen farming holdings, covering an area of 25,673 hectares, 24 kilometres east of Beverley. The Group formed in 1989, united in their concerns about the effects of gully flooding, increasing salinity and poor drainage. They believed that these problems could be tackled by planning and cooperation across farm boundaries. In 1990, Morbinning successfully attracted sponsorship from Alcoa of Australia Limited, and in a three way partnership with Agriculture Western Australia, the group agreed to condense a 10-12 year program into 5 years, in order to become a demonstration group for other catchment groups in the State (Morbinning Landcare Vision).

In 1995, Scott Brain and the farmers of Morbinnning developed the Morbinning Catchment Strategy. The group studied and mapped the districts soil types in to seven Land Management Units and have provided comprehensive descriptions, outlined management problems and identified solutions. The Morbinning Catchment strategy is not only a valuable resource for Morbinning Catchment but also for farmers with similar soils and concerns.

The following land management issues were identified as being the most significant in the catchment: soil structure decline, wind erosion, salinity, poor deep sands, water logging, acid soils and remnant vegetation decline. The group decided that the following aims needed to be achieved:

- implement sustainable agriculture on whole catchment and maximise profitability.
- create new income sources.
- address all degradation issues in the catchment.
- improve landscapes and aesthetics.
- share resources and ideas with neighbours.
- develop a co-ordinated approach to landcare.
- show the world that Morbinning farmers are environmentally responsible. (Morbinning Catchment Strategy, 1995)

Morbinning is one of six farmer catchment groups in the Avon region which have worked together with Alcoa of Australia Limited and Agriculture Western Australia, to form a Landcare Vision project for Western Australia. They offer a program of tours and farm visits so that other catchment groups can benefit from the accelerated development.

Alcoa landcare activities are designed to raise awareness of the problems of land degradation; demonstrate the results of sustainable farming practices; and co-ordinate the efforts and expertise of landholders, government agencies, community groups and industry. The emphasis is on ground works (Alcoa Landcare Project *Reclaiming Our Future*).

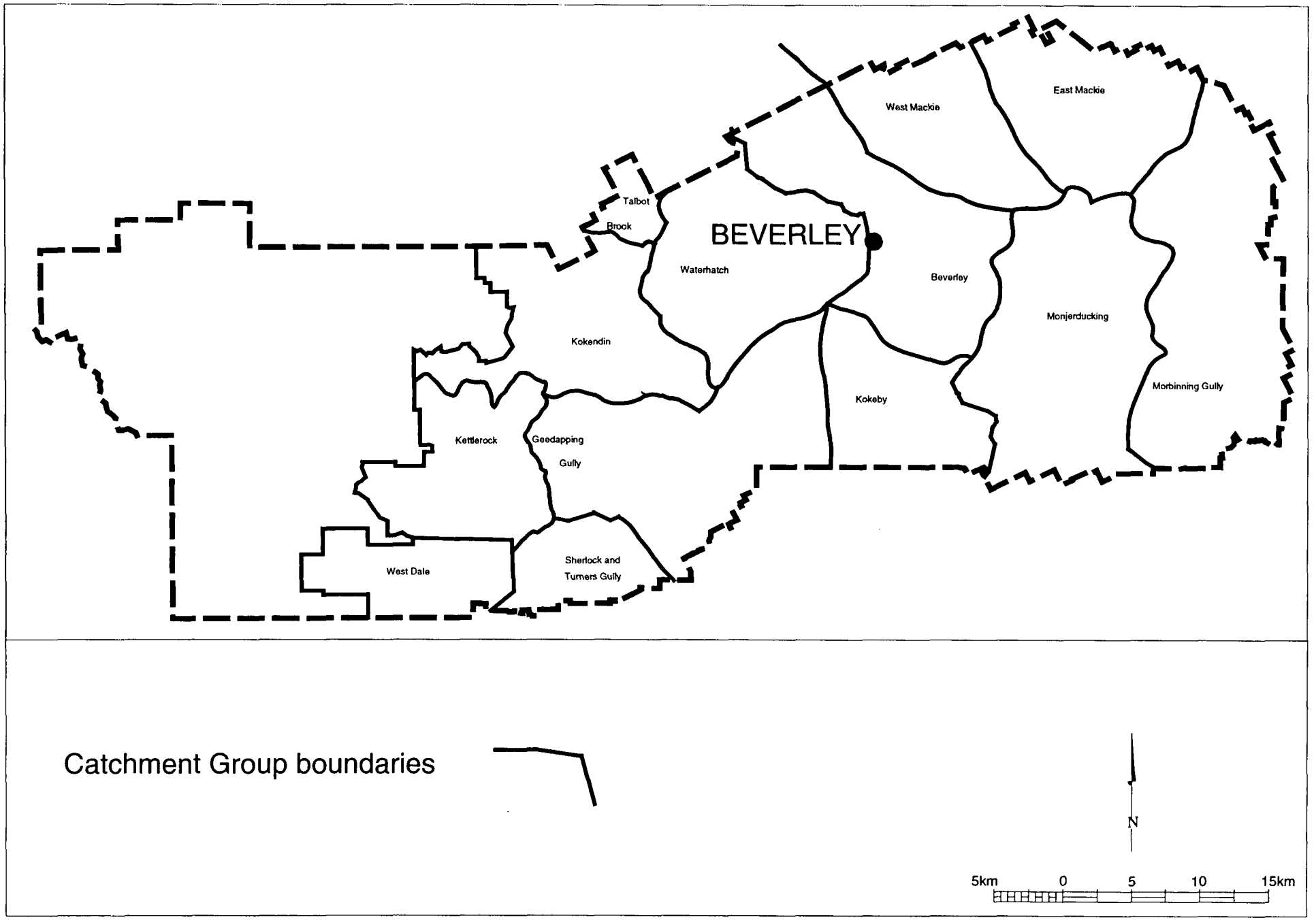


Figure 28: Catchment Groups in the Shire of Beverley

Landcare Support

The Beverley Land Conservation District Committee is the focus for improving land management for both agricultural sustainability and nature conservation in the Shire of Beverley. The Morbinning and Westdale Catchment Groups (Figure 28), with the support of ALCOA, have been leaders in implementing conservation measures with farms in this area available for visits by interested people. The Morbinning Group has developed a catchment strategy and an attractive information booklet and are the proud winner of the 1995/96 BP State Landcare Award at both State and National levels. There are six other catchment groups and a Management Group for Yenyenning Lakes.

There are a number of other groups and funding bodies working constructively towards a sustainable future.

The Avon Catchment Landcare Program was established in 1990 and initiated by Alcoa and Agriculture Western Australia as part of the National Decade of Landcare. The program provides financial, human and technical resources to undertake catchment planning, farm planning and demonstration of rehabilitation techniques to tackle soil and water degradation problems.

The Remnant Vegetation Protection Scheme (RVPS) was developed by the State Government in 1988 to enhance soil and nature conservation by protecting native vegetation on farm land. Figure 29 indicates the locations of RVPS and One Billion Trees grants to assist in the fencing of native vegetation on farm land. The aim is that these remnants will not be grazed and that the nature conservation values will gradually improve.

The National Landcare Program (NLP) has primarily had the role of providing funding for the One Billion Trees and Save the Bush programs which have provided: extension services, coordinators, demonstration projects, workshops and training.

The Yenyenning Lakes Management Group have received a grant of $18,000 from the Gordon Reid Foundation for Conservation, a funding arm of the Lotteries Commission, towards the Yenyenning Lakes Management Plan; and in conjunction with the Morbinning Catchment Group a grant of $29,000 for fencing and revegetation of the northern side of the lake, through the Western Australian State Government Revegetation Scheme.

Westdale Catchment Group have received a grant from Save the Bush to fence three remnant vegetation sites.

A list of programs of funding aimed at land and nature conservation together with contacts is found in Appendix 6.

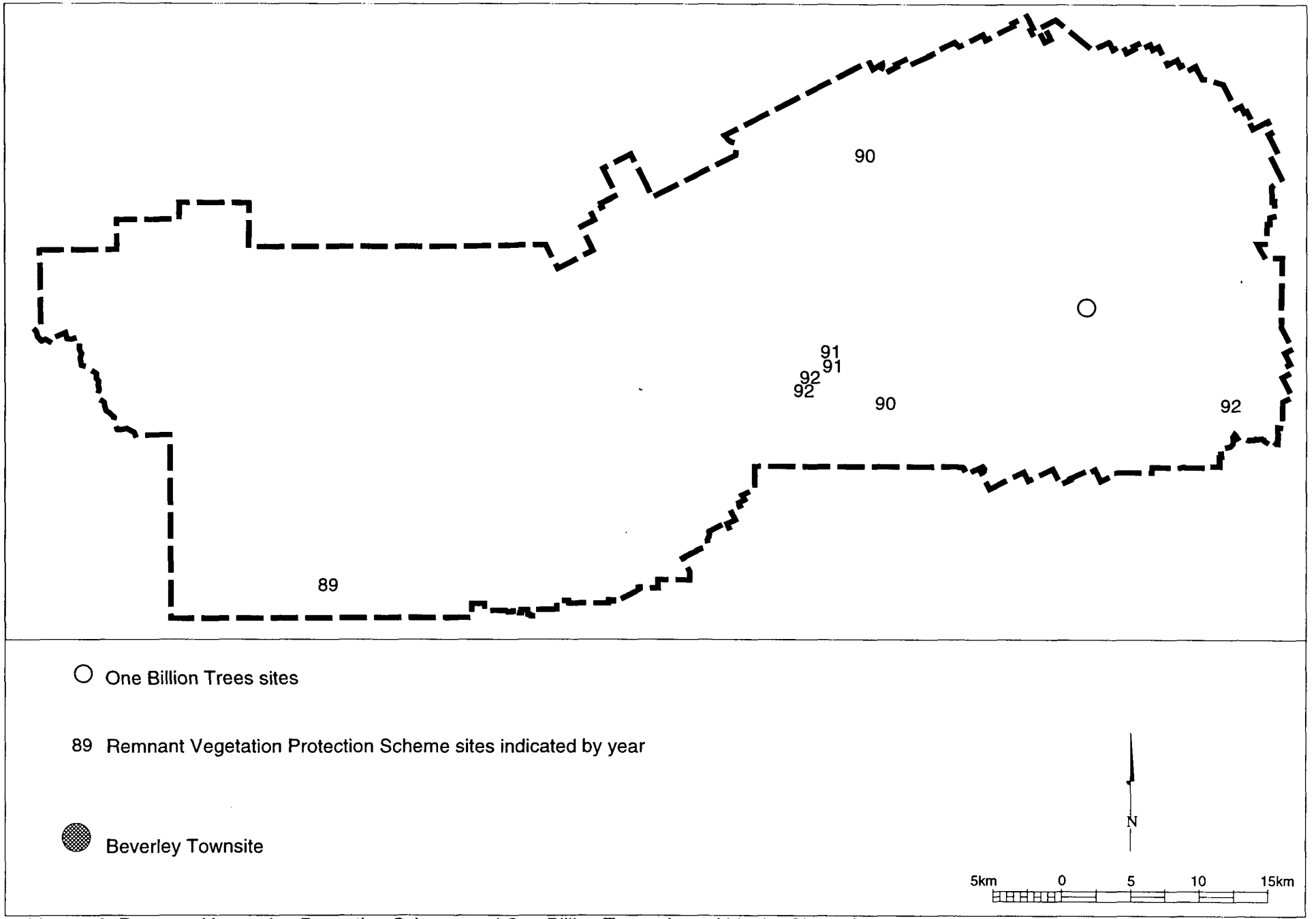


Figure 29: Remnant Vegetation Protection Scheme and One Billion Trees sites within the Shire of Beverley.

Future directions

The future is likely to see innovative measures to create sustainable farming systems integrated with nature conservation to sustain viable native flora and fauna populations.

Protection and management of existing areas of native vegetation will be very important. These areas are the last remaining examples of the original plant communities, habitat for our fauna and are a rich resource for future revegetation. These areas will need to be managed as many are steadily declining due to weed proliferation and rising water tables.

Using smoke to aid regeneration of native species is an exciting initiative. It has been found that the seed of many species responds to smoke rather than heat from a fire as the trigger for germination. Smoke can be applied when dissolved in water and could assist the regeneration of many areas where the use of fire is difficult. Further information is available from Kings Park and Botanic Garden (see Local Contacts).

Planting native trees and shrubs can remedy some land degradation problems but is a relatively expensive practice. The high cost of planting seedlings is also recognised as a constraint to revegetation. Direct seeding produces a more natural distribution of plants and can be cost effective. Unfortunately, direct seeding is currently constrained by lack of information on successful techniques and by lack of seed. It is anticipated that seed orchards will be required and that this may present a commercial opportunity. Useful references for direct seeding are provided under Further Reading in this Handbook.

Deep rooted perennial vegetation is being used in some areas to increase water use and to provide farmers with an additional source of income. Many farmers are looking at use of natural fertilisers, alley farming is increasing changing the landscape, tagasaste is a possibility particularly on sandy soils. Olives, tea tree oil and eucalyptus oil industries are being trialed or developed. Tannins from acacia and eucalypt species; cut wildflowers and wildflower seeds; and value-added wood products are all possibilities. Care must be taken that such species do not become environmental weeds.

The Salinity Action Plan states that the Government will ensure:

- another three million hectares of trees and shrubs are planted across the agricultural area;
- other commercially viable water management practices complement these plantings to maximise water use and economic benefits;
- remnant vegetation is protected and managed to maintain it in perpetuity.

Local Contacts

Beverley Land Conservation District Committee
Secretary - Ian Nicholson, PO Box 20, Beverley 6304.
Phone (08) 96461 200. Fax (08) 96461 409.

Kokendin Catchment Group, Jenny Oliver (08) 96481 050

Kettle Rock Catchment Group, Brett Hutchinson (08) 96471 027

Mackie River Catchment Group

Monjerducking Catchment Group, Patrick Butterworth (08) 96464 020

Morbinning Catchment Group, Evelyn Mclean, (08) 96464 026

Waterhatch Catchment Group, Bruce Mann (08) 96481 027

West Dale Catchment Group, Judy Schilling (08) 96471 012.

Beverley Central Catchment Group, Colin Price (08) 96461 543

Yenyenning Lakes Management Group, Trevor Mclean, (08) 96461 381.

Shire of Beverley
136 Vincent Street, Beverley. PO Box 20 Beverley 6304
Phone (08) 96461 200. Fax (08) 96461 409.

Department of Conservation and Land Management.
Narrogin Regional & District Office
Hough Street Narrogin. PO Box 100, Narrogin 6312.
Phone District: (08) 98811 113. Fax (08) 98811 645.
Regional: (08) 98811 444

Agriculture Western Australia. Northam Regional Office
Lot 12 York Road, Northam. PO Box 483, Northam 6401.
Phone: (08) 96226 100.

King's Park and Botanic Garden - General Enquires
Fraser Ave, West Perth
Phone: (08) 9480 3600

Refer to Appendix 4 for funding program contacts.

References

Alcoa. *Alcoa Landcare Project. Reclaiming Our Future.* Alcoa. Western Australia

Allison, H.E., Brandenburg, S.A. and Beeston, G.R. (1993). *Natural Resource Zones for the South-West Land Division of Western Australia.* Technical Series No. 55. Environmental Protection Authority Report, Perth.

Australian Bureau of Statistics.(1993/94 and 1994/95) *Agricultural Census Data.*

Baxter, A. (1996). *Toolibin Catchment Revegetation Manual.* Agriculture Western Australia, Perth.

Bamford, M. (1995). *Exploring Wheatbelt Woodlands.* Department of Conservation and Land Management. Western Australia.

Beard, J.S., (1979). *The Vegetation of the Pinjarra Area: Vegetation Map and Explanatory Memoir (1:250,000 series).* VegMap Publications, Perth.

Beard, J.S., (1980). *The Vegetation of the Corrigin Area: Vegetation Map and Explanatory Memoir (1:250,000 series).* VegMap Publications, Perth.

Beard, J.S., (1981). *Explanatory notes to Sheet 7. Vegetation Survey of Western Australia,* SWAN 1:1,000,000 Vegetation series. University of Western Australia Press.

Beard, J.S., Hnatiuk R. J. (1981). *A Large Remnant of Yellow-Sand Kwongan near Brookton, Western Australia.* Western Australian Herbarium Research Notes No. 5, pp 1-4.

Beeston, G.R., Mlodawski, G., Sanders, A. and True, D. (1994). *Remnant Vegetation Inventory in the Southern Agricultural Areas of Western Australia.* Agriculture Western Australia, Perth.

Beverley Land Conservation District Committee (1996). *Information on land use and current status within the Beverley Shire.* Beverley Land Conservation District Committee. PO Box 20, Beverley 6304.

Cox, J. and McFarlane, D. (1990). *The Causes of Waterlogging.* Western Australian Journal of Agriculture. Vol. 31. pp 58-61.

Department of Conservation and Land Management WA (1994). *Reading the Remote, Landscape Characters of Western Australia,* pp 34-38, 53-56.

George, R. (1990). *The 1989 Saltland Survey.* Western Australia Journal of Agriculture, Vol. 31, pp,159-166.

Government of Western Australia (1992). State of the Environment Report.

Government of Western Australia (1996). Western Australia salinity action plan.

Griffin, E. A. (1995). *Distribution and ecological significance of on-farm bush remnants in the southern wheatbelt region of Western Australia.* Agriculture Western Australia.

Halse, S.A., Pearson, G.B. and Patrick, S. (1993). *Vegetation of Depth-gauged Wetlands in Nature Reserves of South-west of Western Australia.* Technical Report No. 30. Department of Conservation and Land Management, Perth.

Hopkins A. J. M., Coker J., Beeston G. R., Bowen P. and Harvey J. M. (1996). *Conservation Status of Vegetation Types throughout Western Australia.* Australian Nature Conservation Agency National Reserves Systems Co-operative Program. Project Number N 703. CALM, Perth.

Hopper, S.D., van Leeuwin, S., Brown A.P. and Patrick, S. (1990). *Western Australia's Endangered Flora and Other Plants Under Consideration for Declaration.* Department of Conservation and Land Management, Wanneroo.

Holm, A. (1994). *Procedures for the Administration and Assessment of Clearing and Protection of Native Vegetation in Western Australia.* Department of Agriculture Western Australia, South Perth.

Hunt, N. and Gilkes R. (1992). *Farm Monitoring Handbook. A practical down-to-earth manual for farmers and other land users.* The University of Western Australia, Nedlands.

Hussey, B.M.J. (1991). *The Flora Roads Survey - volunteer recording of roadside vegetation in Western Australia.* In Nature Conservation 2: The Role of Corridors, ed by Saunders D. A. and Hobbs, R. J. Surrey Beatty and Sons, NSW. Pp 41 - 48.

Hussey, B.M.J. and Wallace, K.J. (1993). *Managing Your Bushland: A Guide for Western Australian Landowners.* Department of Conservation and Land Management, Como.

Kitchener, D.J., Dell, J., Muir, B.G. and Palmer, M. (1982). Birds in Western Australian Wheatbelt reserves - implications for conservation. Biological Conservation 22, 127-163.

Lane, J. A. K. (1994). *The Yenyenning Lakes System: A report on experimental management of outflows at Qualandary Crossing from 1985 - 1990 and recommendations for future management.* Yenyenning Catchment Group.

Lantzke, N. and Fulton, I. (1993). *Land Resources of the Northam Region,* Land Resource Series No. 11. Agriculture Western Australia, Perth.

Lefroy, E.C. and Hobbs, R.J. (1991). *Ecological indicators for sustainable agriculture.* The Role of Trees in Sustainable Agriculture. A National Conference. Resource Management Technical Report 138. Department of Agriculture, Western Australia.

Lefroy, E.C., Hobbs, R.J. and Atkins, L.J. (1991). *Revegetation Guide to the Central Wheatbelt.* Bulletin No. 4231. Agriculture Western Australia, Perth.

Masters, J. (1996). *The Principles of River Management.* Avon River Management Authority, Northam.

McFarlane, D., Engel, R., Ryder, A. and Eales M. (1990). *Level Banks Used to Decrease Water Logging can Increase Salinity.* Journal of the Department of Agriculture, Western Australia, Perth. Vol. 31, 74-77.

Northcote, K.H., Bettenay, E. Churchwood, H.M. and McArthur, W.N. (1967). *Atlas of Australian Soils: Explanatory Data for Sheet 5-Perth-Albany-Esperance Area.* CSIRO. Melbourne University Press.

Oates, N. (1994). *Managing Your Wetland. A practical guide for landholders.* Victorian Wetlands Trust and Department of Conservation and Natural Resources, Victoria.

Roadsides Conservation Committee. *Assessment of the conservation value of roadside vegetation within the Shire of Beverley.* C/- Department of Conservation and Land Management, Perth.

Sanders, A. (1991). *Oral Histories Documenting Changes in Wheatbelt Wetlands.* Occasional Paper 2/91. Department of Conservation and Land Management, Como.

Saunders, D.A. and Ingram, J.A. (1987). *Factors affecting survival of breeding populations of Carnaby's cockatoo Calyptorhynchus funereus latirostris in remnants of native vegetation.* Nature Conservation: the role of remnants of native vegetation. Eds. D. A. Saunders, G. W. Arnold, A. A. Burbridge and A. J. M. Hopkins. Surrey Beatty and Sons, Sydney. pp. 249 -58.

Saunders, D.A. and Ingram, J.A. (1994). *Birds of Southwestern Australia.* Surrey Beatty and Sons, Sydney.

Saunders, D. A., Hobbs, R. J. and Margules C. R. (1991). Biological consequences of ecosystem fragmentation: a review. Conservation Biology Volume 5, No 1, 18-32.

Schofield, N.J., Ruprecht, J.K. and Loh, I.C. (1988). *The Impact of Agricultural Development on the Salinity of Surface Water Resources of South-West Western Australia.* Report WS 27. Water Authority of Western Australia, Perth.

Schofield, N.J. and Scott, P. (1991). *Planting trees to control salinity.* Journal of the Department of Agriculture, Western Australia. Vol. 32, 3-10.

Select Committee into Land Conservation (1992) *Discussion Paper No. 2: Agricultural Region of Western Australia.* Western Australian Government Press.

Smith, G.T. (1987). *The Changing Environment for Birds in the South-West of Western Australia: Some Management Implications.* Nature Conservation: The Role of Remnants of Native Vegetation. Eds. D. A. Saunders, G. W. Arnold, A. A. Burbridge and A. J. M. Hopkins. Surrey Beatty and Sons, NSW.

Trudgen, M.E. *Flora and Vegetation Survey of the Mount Westdale - Dobaderry Swamp Reserve System.* Department of Fisheries and Wildlife. Perth.

Further Reading

Rural nature conservation

Bamford, M. (1995). *Exploring Wheatbelt Woodlands.* Department of Conservation and Land Management, WA.

Brechwoldt, R. (1984). *Wildlife in the Home Paddock- Nature Conservation for Australian Farmers.* Angus and Robertson. Sydney.

Frith, H. J. (1970) *Wildlife Conservation.* Angus and Robertson. Sydney.

McMillan, P. (1990). *Exploring Granite Outcrops.* Department of Conservation and Land Management, Perth.

Wilson, A. and Lindenmayer, D. B. (1995). *Wildlife Corridors and the Conservation of Biodiversity: A review.* Greening Australia.

Bush regeneration, remnant vegetation and weeds

Brodie, L., Roxburgh, J., Whiley, L. (1991). *Bush Regenerators Handbook.* The National Trust of Australia (NSW).

Buchanan, R.A. (1989). *Bush Regeneration: Recovering Australian Landscapes.* TAFE Student Learning Publications, Sydney NSW.

Dodd, J., Martin, R.J. and Malcolm Howes, K. (1993). *Management of Agricultural Weeds in Western Australia.* Bulletin 4243. Agriculture Western Australia, Perth.

Hussey, B.M.J. and Wallace, K.J. (1993). *Managing your Bushland: A Guide for Western Australian Landowners.* CALM, Perth.

Scheltema, M. and Harris, J. (eds) (1995). *Managing Perth's Bushland.* Greening Western Australia, Perth.

Seed growing and collection

Seabrook, J.(1989). *Collection of Seed of Australian Native Plants. "Seeds for sowing".* Occasional Publication No 2. WA Wildflower Society - Eastern Hills Branch. Western Australia.

Seabrook, J. (1994). *Growing Understorey Seed.* Greening Western Australia and WA Wildflower Society, Perth.

Seabrook, J. *Seeds of the Future. How to establish a native seed orchard.* WA Wildflower Society - Eastern Hills Branch. Western Australia.

Direct seeding

Dalton, G. (1993). *Direct Seeding of Trees and Shrubs. A Manual for Australian Conditions*. Department of Primary Industries (SA), Adelaide.

Scheltema, M. (1993). *Direct Seeding of Trees and Shrubs.* Greening Western Australia, Perth.

Farm Investigation

Hunt, N and Gilkes R. (1992). *Farm Monitoring Handbook. A practical down-to-earth manual for farmers and other land users.* The University of Western Australia, Perth.

Revegetation

Barrett-Lennard, E.G. and Malcolm, C. V. (1995). *Saltland Pastures in Australia, A Practical Guide.* Bulletin Number 4312. Agriculture Western Australia, Perth.

Baxter, A. (1996). *Toolibin Catchment Revegetation Manual.* Agriculture Western Australia, Perth.

Casey, M and Chalmers, I. (1993) *Tree Tops - the tree planting book for farmers.* Kondinin Group. Western Australia.

Heinjus, D. (1992). *Farm Tree Planting:* Department of Agriculture, South Australia.

Lefroy, E.C., Hobbs, R.J. and Atkins, L.J. (1991). *Revegetation Guide to the Central Wheatbelt.* Bulletin No. 4231. Agriculture Western Australia, Perth

Oats, N. (1990). *Regreening Australia. Caring for Young Trees* 2. CSIRO. Australia.

Revegetation Expert Software (REX) (1996). Copyright CALM, Agriculture Western Australia, Greening WA and Robin Road Software. Direct order on 1800 244 060. Cost is less than $100.

Venning, J. (1988). *Growing Trees: for Farms, Parks and Roadsides.* Lothian Publishing Co. Ltd.

Wetlands

Oates, N. (1994). *Managing Your Wetland. A practical guide for landholders.* Victorian Wetlands Trust and Department of Conservation and Natural Resources, Victoria.

Masters J. (1996). *The Principles of River Management Based on the Avon River Experience.* Avon River Management Authority, Northam.

Whole farm planning

Sandilands, J. (1990). *On Borrowed Time. The Potter Farmland Plan in Action* (video and guide). The Ian Potter Foundation. Available through Trust for Nature, Victoria, 49 Spring Street Melbourne 3000, (03) 9651 4040, fax (03) 9651 4048.

Plant identification

Beard, J.S. (1970). *Western Australian Plants.* Kings Park Board. Perth.

Blackall, W.E. and Grieve, B.J. (1974). *How to Know Western Australian Wildflowers. Parts 1, 2 and 3.* University of Western Australia Press. Nedlands.

Brooker, M.I.H. and Kleinig, D.A. (1990). *Field Guide to Eucalypts. Volume 2.* Inkata Press. Sydney.

Chippendale, G.M. (1973). *Eucalypts of the Western Australian Goldfields and the Adjacent Wheatbelt.* Australian Government Publishing Service. Sydney.

Erikson *et al.* (1973). *Flowers and Plants of Western Australia.* Reed. NSW.

Gardner, C.A. (1978). *Wildflowers of Western Australia.* West Australian Newspapers Ltd. Perth.

Gardner, C.A. (1979). *Eucalypts of Western Australia.* Bulletin No. 4013. Agriculture Western Australia, Perth.

George, A.S. *The Banksia Book.* Kangaroo Press. NSW.

Grieve, B.J. and Blackall, W.E. (1975). *How to Know Australian Wildflowers. Part 4.* University of Western Australia Press. Nedlands.

Holliday, I. (1989). *A field guide to Melaleucas.* Hamlyn Australia. Melbourne.

Maslin, B.R. and Pedley, L. (1982). *Distribution of Acacias in Australia.* In WA Herbarium Research Notes No 6. Department of Agriculture Western Australia. Perth.

Sainsbury, R.M. (1991) *A Field Guide to Smokebushes and Honeysuckles (Conospermum and Lambertia).* University of Western Australia Press. Nedlands.

Simmons, M. (1991). *Acacias of Australia.* Vol. 1. Nelson. Melbourne.

Simmons M. (1988). *Acacias of Australia.* Vol. 2. Viking O'Neil. South Yarra. Australia.

General Reading

Beard, J.S. (1990). *Plant Guide to Western Australia.* Kangaroo Press.

Department of Conservation and Land Management (1994). *Reading the Remote, Landscape Characters of Western Australia*, CALM

Saunders, D., Arnold, G., Burbidge, A. and Hopkins, A. (1987) Eds. *Nature Conservation: The Role of Remnants of Native Vegetation.* Surrey Beatty and Sons. Sydney.

Saunders, D.A. and Hobbs, R.J. (1991) Eds. *Nature Conservation: The Role of Corridors.* Surrey Beatty and Sons. Sydney.

Saunders, D., Hobbs, R. and Ehrlich, P. (1993) Eds *Nature Conservation 3: The Reconstruction of Fragmented Ecosystems.* Surrey Beatty and Sons. Sydney.

Saunders, D., Craig, J. L. and Mattiske, E. M. (1995) Eds. *Nature Conservation 4: The Role of Networks.* Surrey Beatty and Sons. Sydney.

Appendix 1. Local plants for Shire of Beverley landscapes

This appendix lists the major vegetation types and some of the plants in Beverley Shire. Source: Beard, J.S., (1979) (1980). Additional local species and species from other areas which maybe suitable for revegetation for many of the soil types in Beverley Shire, together with detailed site and use classifications, can be sourced in the Toolibin Catchment Revegetation Manual, Baxter, A. (1996), available for $10.00 plus postage from Lake Toolibin Catchment Committee, catchment Co-ordinator. PO Box 36 Wickepin WA 6370.

Jarrah Forest

Botanical name	Common name (if known)	Notes
Allocasuarina fraseriana	sheoak	Small tree
Banksia grandis	bull banksia	Small tree
Eucalyptus accedens	powderbark wandoo	Tree, some sites only
Corymbia calophylla	marri	Tree, usually < 50% of tree cover
Eucalyptus marginata	jarrah	Dominant tree
Eucalyptus patens	blackbutt	Tree, some sites
Eucalyptus wandoo	wandoo	Tree, some sites
Grevillea wilsonii	native fuchsia	
Persoonia longifolia	snottygobble	Small tree

Jarrah - Marri - Wandoo - Powderbark - Brown Mallet Woodlands

Botanical name	Common name (if known)	Notes
Acacia acuminata	jam	Small tree in drier eastern areas
Acacia pulchella	prickly Moses	Medium shrub, wetter western parts
Calothamnus quadrifidus	one sided bottlebrush	Tall shrub, drier eastern parts
Daviesia horrida	prickly bitter pea	Tall shrub, wetter western parts
Dryandra cirsioides		Medium shrub, drier eastern parts
Dryandra nivea	couch honeypot	Small shrub, wetter western parts
Dryandra sessilis	parrot bush	Tall shrub, wetter western parts
Eucalyptus accedens	powderbark wandoo	Tree in drier eastern parts
Eucalyptus astringens	brown mallet	Tree in drier parts on laterite
Corymbia calophylla	marri	Tree, wetter western parts
Eucalyptus drummondii	Drummond's mallee	Mallee, on poorest driest sites
Eucalyptus laeliae	Darling Range ghost gum	Tree, occasional on granite outcrops
Eucalyptus marginata	jarrah	Occasional, western parts
Eucalyptus patens	Swan River blackbutt	Tree, in some valleys
Eucalyptus wandoo	wandoo	Tree, wetter western parts
Gastrolobium microcarpum	sandplain poison	Small shrub, drier eastern parts
Gastrolobium spinosum	prickly poison	Medium shrub, drier eastern parts
Hakea cristata	thick leaved hakea	Tall shrub, wetter eastern parts
Hakea trifurcata	two leaved hakea	Tall shrub, wetter eastern parts
Hibbertia hypericoides	yellow buttercups	Small shrub, wetter eastern parts
Hibbertia montana	mountain primrose	Small shrub, wetter eastern parts
Leptospermum erubescens	roadside tea tree	Tall shrub, drier eastern parts
Macrozamia riedlei	zamia	Wetter eastern parts
Nuytsia floribunda	Christmas tree	Small tree, wetter eastern parts
Oxylobium parviflorum	box poison	Shrub, drier eastern parts
Xanthorrhoea preissii	grass tree	

Riverine Woodland

Botanical name	Common name (if known)	Notes
Eucalyptus loxophleba	York gum	In drier areas on and close to drainage
Eucalyptus rudis	flooded gum	Along streams in wetter areas
Melaleuca rhaphiophylla	swamp paperbark	Narrow strips along streams

Granite Outcrops in drier areas

Botanical name	Common name (if known)	Notes
Acacia acuminata	jam	Tall shrub
Acacia truncata	.	Shrub
Allocasuarina huegeliana	rock sheoak	Small tree, peripheral groves
Calothamnus sanguineus	silky leaved blood flower	Small shrub
Dodonea viscosa subsp. *angustissima*	hop bush	Medium shrub
Dryandra fraseri		Low shrub
Hakea incrassata	marble hakea	Low shrub
Hakea lissocarpha	honey bush	Low shrub
Hakea petiolaris	sea urchin hakea	Tall shrub
Hakea prostrata	harsh hakea	Tall shrub
Kunzea pulchella	granite kunzea	Medium shrub
Melaleuca cordata		Low shrub
Melaleuca elliptica	granite bottlebrush	Tall shrub
Melaleuca fulgens	scarlet honeymyrtle	Medium shrub
Stypandra imbricata	cluster leaved blindgrass	Low shrub

York Gum, Wandoo and Salmon Gum Woodlands

Botanical name	Common name (if known)	Notes
Acacia acuminata	jam	Small tree
Allocasuarina campestris	tamma	Shrub
Allocasuarina huegeliana	rock sheoak	Medium tree
Casuarina obesa	swamp sheoak	Small tree, along streams
Eucalyptus accedens	powderbark wandoo	Tree, associated with breakaways.
Eucalyptus loxophleba	York gum	Tree
Eucalyptus longicornis	red morrel	Tree
Eucalyptus rudis	flooded gum	Tree, along streams
Eucalyptus salmonophloia	salmon Gum	Tree
Eucalyptus wandoo	wandoo	Tree
Gastrolobium spinosum	prickly poison	Shrub
Hakea priessii	needle tree	Small tree
Pericalymma ellipticum	swamp tea-tree	Shrub
Xanthorrhoea preissii	grass tree	

Heath

Botanical name	Common name (if known)	Notes
Adenanthos cygnorum	common woollybush	Tall shrub
Banksia attenuata	slender banksia	
Calothamnus quadrifidus	one-sided bottlebrush	Tall shrub
Allocasuarina humilis	dwarf sheoak	Medium shrub
Conospermum stoechadis	smoke bush	Medium shrub
Dryandra nivea	couch honeypot	Small shrub
Eucalyptus drummondii	Drummond's gum	Mallee
Eucalyptus macrocarpa	mottlecah	Small tree
Hakea scoparia		Medium shrub
Hakea cyclocarpa	ramshorn	
Hakea ruscifolia	candle spike Hakea	Medium shrub
Hakea ceratophylla	horned leaf Hakea	
Hakea lissocarpha	honey bush	Low shrub
Hakea varia	variable leaf Hakea	Tall shrub
Hibbertia polystachya		
Hypocalyma angustifola	white myrtle	Medium shrub
Isopogon dubius	pincushion coneflower	Small shrub
Lasiopetalum floribundum	free flowering lasiopetalum	
Leptocarpus scariosus		
Leptomeria cunninghamii		
Leucopogon capitellatus		
Leucopogon cordatus		
Leucopogon propinquus		
Lyginia tenax		
Macrozamia riedlei	zamia	
Mesomelaena tetragona	semaphore sedge	
Patersonia rudis	hairy flag	
Pericalymma ellipticum	swamp tea tree ,	
Phyllanthus calycinus	false boronia	
Sphaerolobium medium		
Stirlingia latifolia	blueboy	
Styphelia tenuiflora	common pinheath	
Synaphea petiolaris	synaphea	
Trymalium ledifolium		

Banksia Low Woodland

Botanical name	Common name (if known)	Notes
Actinostrobus arenarius	sand plain cypress	Small tree
Adenathos cygnorum	common woolybush	
Banksia attenuata	slender banksia	Small tree
Banksia menziesii	firewood banksia	Small tree
Banksia prionotes	acorn banksia	Medium tree
Allocasuarina huegeliana	rock sheoak	Small tree
Eremaea pauciflora		Shrub
Melaleuca preissiana	moonah	
Mesomelaena stygia		Ground cover
Pericalymna erubescens	roadside tea-tree	
Xylomelum angustifolium	sandplain woody pear	Small tree

Salt Flats

Botanical name	Common name (if known)	Notes
Halosarcia bidens	samphire	
Halosarcia halocnemoides	samphire	
Callistemon phoeniceus	inland bottlebrush	Medium to large shrub
Casuarina obesa	swamp sheoak	Small tree, adjacent salt flats
Melaleuca hamulosa		Medium to large shrub
Melaleuca lateriflora	gorada	Medium to large shrub
Melaleuca thyoides		Medium to large shrub
Melaleucca uncinata	broombush	Medium shrub
Melaleuca viminea	mohan	Large shrub

Appendix 2. Detailed botanical information for two bush remnants

Information from sites surveyed in detail during the study: E.A. Griffin (1995). *Distribution and Ecological Significance of On-Farm Bush Remnants in the Southern Wheatbelt Region of Western Australia- Phase II.* Refer Figure 13 for locations.

Survey of site BEV 05026

Beverley Shire [BEV05] Pinjarra SH50-02 1:250 000.

Surveyed: 07.09.92
Location: "Wyalgima Hill" bush; 11.5 km north of Beverley, 86.25 km east of Kelmscott, and 97.5 km NNE of Boddington; 32^00'36"S, 116^55'48"E; 320 m.

a Powderbark wandoo (±wandoo) woodland over scrub.

Species List (a1)

glowing wattle *(Acacia celastrifolia),* common brown pea *(Bossiaea eriocarpa),* blue squill *(Chamaescilla corymbosa), Dampiera lindleyi, Dillwynia sp., Dodonaea bursariifolia, Dodonaea* sp., *Gastrolobium microcarpum,* common popflower *(Glischrocaryon aureum), Hakea aff. Sulcata,* Lindley's everlasting *(Helichrysum lindleyi), Hemigenia ?incana , Hibbertia commutata, Hibbertia enervia,* white myrtle *(Hypocalymma angustifolium),* spreading coneflower *(Isopogon divergens), Lepidosperma angustatum,* pithy sword-sedge *(Lepidosperma longitudinale), Lepidosperma tenue, Loxocarya* sp., *Melaleuca pungens, Melaleuca sp., Mesomelaena stygia, Nemcia cuneatá,* short-leaf bog rush *(Schoenus breviculmis), Schoenus sp., Stackhousia monogyna,* large flowered thomasia *(Thomasia grandiflora),* fringed lily *(Thysanotus manglesianus),* native parsnip *Trachymene pilosa), Trymalium ledifolium.*

Species List (a2)

Acacia myrtifolia, Conospermum sp., sparse-leaved dampiera *(Dampiera oligophylla), Darwinia sp.neildiana gp, Daviesia rhombifolia, Dryandra aff. Nobilis, Eucalyptus sp., Gahnia ?drummondii,* wavy-leaved hakea *(Hakea undulata), Lasiopetalum membranaceum* sticky sword sedge *(Lepidosperma viscidum), Melaleuca pungens, Petrophile heterophylla, Petrophile striata.*

b Scrub/thicket ± powderbark wandoo.

Species List (b)

Astroloma prostratum, blue squill *(Chamaescillia corymbosa),* pingle*(Dryandra carduacea),* woolly-flowered grevillea *(Grevillea pilulifera),* snakebush *(Hemiandra pungens), Hibbertia commutata, Laxmannia grandiflora, Leucopogon revolutus,* banded greenhood *(Pterostylis vittata), Stackhousia monogyna.*

c Brown mallet woodland over sparse to open shrubland over ± herbaceous ground layer.

d Wandoo woodland over *Hypocalymma angustifolium* shrubland.

Species List (c and d)

Blennospora drummondii?, blueberry lily *(Dianella revoluta)*, Australian bluebell *(Sollya heterophylla)*, purple tassels *(Sowerbaea laxiflora)*, native parsnip *(Trachymene pilosa)*, *Trymalium ledifolium.*

e Wandoo ± powderbark wandoo woodland over ± mallee over ± tall shrubland over shrubland.

Species List (e)

horned sheoak *(Allocasuarina thuyoides)*, love creeper *(Comesperma volubile)*, dense stonecrop *(Crassula colorata)*, *Daviesia hakeoides.*

Species List (f)

Billardiera sp, hook-leaved mallee *(Eucalyptus uncinata)*, *Trymalium sp.*

Survey of site BEV 07061

Beverley Shire [BEV07] Corrigin SI50-03 1:250 000.

Surveyed: 23.09.92
Location: "County Peak" (= Quajabin Peak - 354 m); 24.5 km NE of Brookton, 22 km NW of Alderside, and 22.5 km SW of Dangin; 32^12'00"S, 117^10'50"E; c. 354 m.

a Summit ridge White gum woodland over scrub on skeletal soil.

b White gum ± Brown mallet woodland with scattered shrubs at upper slope fringe, and an otherwise sparse herbaceous ground layer.

c Salmon gum - Morrel woodland over grass and *Cotula* sp. + *Eucalyptus calycogona* in association with boulder outcrop.

d York gum ± Jam woodland all over grass and capeweed ± a few shrubs.

Species List

Acacia lineata, Billardiera sp., Bossiaea peduncularis, tiny daisy *(Brachycome perpusilla)*, leek lily *(Bulbine semibarbata)*, dense stonecrop *(Crassula colorata)*, rufous stonecrop *(Crassula decumbens)*, *Dampiera haematotricha*, chocolate lily *Dichopogon fimbriatus*, *Eucalyptus redunca gp*, *Gnephosis* sp., elegant goodenia *(Goodenia concinna)*, *Helichrysum leucopsideum*, *Helichrysum* sp., *Hydrocotyle plebeja*, *Hylospema venustum*, common bartsia *(Parentucella latifolia)*, *Podolepis lessonii*, *Rhodanthe corymbosa*, *Rhodanthe pygmaea*, *Stenopetalum robustum*, *Trymalium angustifolium*, annual bluebell *(Wahlenbergia gracilenta).*

Appendix 3. Bird list for a farm in the West Dale catchment

Birds seen on Judy and Brett Schilling's farm in the Shire of Beverley.
Source: Judy Schilling.

Common Name	Scientific Name
Black Swan	*Cygnus atratus*
White-faced Heron	*Ardea noveahollandiae*
Mountain Duck	*Tadorna tadornoides*
Black Duck	*Anas superciliosa*
Grey Teal	*Anas gibberifrons*
Maned Duck	*Chenonetta jubatta*
Black-shouldered Kite	*Elanus notatus*
Wedge-tailed Eagle	*Aquila audax*
Whistling Kite	*Haliastur sphenurus*
Painted Button-quail	*Turnix varia*
Bush Stone-curlew	*Burhinus grallarius*
Common Bronzewing	*Phaps chalcoptera*
Crested Pigeon	*Ocyphaps lophotes*
Laughing Dove	*Streptopelia senegalensis*
White-tailed Black Cockatoo	*Calyptorhynchus latirostris*
Purple-crowned Lorikeet	*Glossopsitta porphyrocephala*
Red-capped Parrot	*Platycerus spurius*
Western Rosella	*Platycerus icterotis*
Twentyeight Parrot	*Barnardius zonarius*
Elegant Parrot	*Neophema elegans*
Fan-tailed Cuckoo	*Cuculus flabelliformis*
Boobook Owl	*Ninox novaeseelandiae*
Tawny Frogmouth	*Podargus strigoides*
Kookaburra (introduced)	*Dacelo gigas*
Sacred Kingfisher	*Halycon sancta*
Raven	*Corvus coronoides*
Australian Magpie	*Gymnorhina tibicen*
Black-faced Cuckoo shrike	*Coracina novaeseelandiae*
Welcome Swallow	*Hirundo neoxena*
Tree Martin	*Hirundo nigricans*
Richard's Pipit	*Anthus novaeseelandiae*
Western Yellow Robin	*Eopsaltria georgiana*
Scarlet Robin	*Petroica multicolor*
Golden Whistler	*Pachycephala pectoralis*
Rufous Whistler	*Pachycephala rufiventris*
Grey Shrikethrush	*Colluricincla harmonica*
Grey Fantail	*Rhipidura fuliginosa*
Willie Wagtail	*Rhipidura leucophrys*
Splendid Fairy-wren	*Maluris splendens*
Weebill	*Smicrornis brevirostris*
Yellow-rumped Thornbill	*Acanthiza chrysorrhoa*
Rufous Tree-creeper	*Climacteris rufa*
Red Wattlebird	*Anthochaera carunculata*
Little Wattlebird	*Anthochaera chrysoptera*
Singing Honeyeater	*Lichenostomus virescens*
Western Spinebill	*Acanthorhynchus superciliosus*

White-naped Honeyeater	*Melithreptus lunatus*
Brown-headed Honeyeater	*Melithreptus brevirostris*
Brown Honeyeater	*Lichmera indistincta*
New Holland Honeyeater	*Phylidonyris novaehollandiae*
White-cheeked Honeyeater	*Phylidonyris nigra*
Tawny-crowned Honeyeater	*Phylidonyris melanops*
Striated Pardalote	*Pardalotus striatus*
Spotted Pardalote	*Pardalotus punctatus*
Silvereye	*Zosterops lateralis*
Black-faced Woodswallow	*Atramus cinereus*
Grey Butcherbird	*Cracticus torquatus*
Pied Butcherbird	*Cracticus nigrogularis*

Appendix 4. Bird List for Yenyenning Lakes

Bird species observed at Yenyenning Lakes
Source: CALM Narrogin

Common Name	Scientific Name
Restless Flycatcher	*Myiagra inquieta*
Willie Wagtail	*Rhipidura leucophrys*
White-browed Babbler	*Pomatotomus superciliosus*
Little Grassbird	*Megalurus gramineus*
Brown Songlark	*Cincloramphus cruralis*
Splendid Fairy-wren	*Malurus splendens*
White-winged Fairy-wren	*Malurus leucoptera*
Chestnut-rumped Thornbill	*Acanthiza uropygialis*
Yellow-rumped Thornbill	*Acanthiza chrysorrhoa*
Red Wattlebird	*Anthochaera carunculata*
Little Wattlebird	*Anthochaera chrysoptera*
Singing Honeyeater	*Lichenostomus virescens*
Brown Honeyeater	*Lichmera indistincta*
Yellow-throated Miner	*Manorina flavigula*
White-fronted Honeyeater	*Phylidonyris albifrons*
Crimson Chat	*Epithianura tricolor*
White-fronted Chat	*Epithianura albifrons*
Silvereye	*Zosterops lateralis*
Zebra Finch	*Taeniopygia guttata*
Magpie Lark	*Grallina cyanoleuca*
Black-faced Woodswallow	*Artamus cinereus*
Grey Butcherbird	*Cracticus torquatus*
Australian Magpie	*Gymnorhina tibicen*
Australian Raven	*Corvus coronoides*
Great Crested Grebe	*Podiceps cristatus*
Hoary-headed Grebe	*Podiceps poliocephalus*
Australasian Grebe	*Podiceps novaehollandiae*
Australian Pelican	*Pelecanus conspicillataus*
Darter	*Anhinga melenogaster*
Pied Cormorant	*Phalacrocorax varius*
Little Pied Cormorant	*Phalacrocorax melanoleucos*
Little Black Cormorant	*Phalacrocorax sulcirostris*
Pacific Heron	*Ardea pacifica*
White-faced Heron	*Ardea novaehollandiae*
Great Egret	*Egretta alba*
Straw Necked Ibis	*Threskiornis spinicollis*
Black Swan	*Cygnus atratus*
Australian Shelduck	*Tadorna tadornoides*
Pacific Black duck	*Anas superciliosa*
Grey Teal	*Anas gibberifrons*
Chestnut Teal	*Anas castanea*
Australasian Shoveler	*Anas rhynchotis*
Pink-eared duck	*Malacorhynchus membrananceus*
Hardhead	*Aythya australis*
Maned Duck	*Chenonetta jubata*
Musk Duck	*Biziura lobata*

Black-shouldered Kite	*Elanus caeruleus*
Marsh Harrier	*Circus aeruginosus*
Stubble Quail	*Coturnix novaezelandiae*
Spotless Crake	*Porzana tabuensis*
Black-tailed Native-hen	*Gallinula ventralis*
Dusky Moorhen	*Gallinula tenebrosa*
Eurasian Coot	*Fulica atra*
Red-kneed Dotteral	*Erythrogonys cinctus*
Black-fronted Plover	*Charadrius melanops*
Hooded Plover	*Charadrius cucullatus*
Red-capped Plover	*Charadrius dubius*
Black-winged Stilt	*Himantopus himantopus*
Banded Stilt	*Cladorhynchus leucophalus*
Red-necked Avocet	*Recurvirostra novaehollandiae*
Common Sandpiper	*Tringa hypoleucos*
Greenshank	*Tringa nebularia*
Sharp-tailed Sandpiper	*Calidris acuminata*
Red-necked Stint	*Calidris ruficollis*
Curlew Sandpiper	*Calidris ferruginea*
Silver Gull	*Larus novaehollandiae*
Whiskered Tern	*Sterna hydrida*
Gull-billed Tern	*Gelochelidon nilotica*
Laughing Turtle-Dove	*Streptopelia senegalensia*
Common Bronzewing	*Phaps chalcoptera*
Crested Pigeon	*Ocyphaps lophotes*
Galah	*Cacatua roseicapilla*
Port Lincoln Ringneck	*Barnardius zonarius*
Mulga Parrot	*Platycerus varius*
Elegant Parrot	*Neophema elegans*
Pallid Cuckoo	*Cuculus pallidus*
Horsfield's Bronze-Cuckoo	*Chrysococcyx basalis*
Sacred Kingfisher	*Halycon sancta*
Rainbow Bee-eater	*Merops ornatus*
Richard's Pipit	*Anthus novaeseelandiae*
Welcome Swallow	*Hirundo neoxena*
Tree Martin	*Hirundo nigricans*
Black-faced Cuckoo-shrike	*Coracina novaehollandiae*
Ground Cuckoo-shrike	*Coracina maxima*
White-winged Triller	*Lalage sueurii*
Red-capped Robin	*Petroica goodenovi*
Hooded Robin	*Petroica cucullata*

Appendix 5. Comparison of soil types described by Lantzke (1993) and the main soil groups for Western Australia.

The soil groups have been prepared to describe the main soils of Western Australia using simple and consistent terminology. Further information can be obtained the Natural Resources Assessment Group.

Lantzke (1993) soil type	Soil Group for WA
Alluvial loam	Brown loamy earth
Breakaway face and ironstone cap	Shallow gravel
Brownish grey granitic loamy sand	Grey deep sandy duplex
Buckshot gravel	Deep sandy gravel
Coarse granitic sand	Pale deep sand
Deep pale sand	Pale deep sand
Deep sandy surfaced duplex	Grey deep sandy duplex
Deep sandy surfaced valley soil	Alkaline grey deep sandy duplex
Deep yellow acid sand	Acid yellow sandy earth
Deep yellow sand	Yellow deep sand
Grey alluvial clay	Grey non-cracking clay
Grey alluvial self-mulching clay	Self-mulching cracking clay
Grey clay valley soil	Grey non-cracking clay
Grey to brown cracking clay	Self-mulching cracking clay
Hardsetting gritty quartzitic soil	Grey/brown shallow loamy duplex
Loamy sand over clay	Grey deep sandy duplex
Loamy sand surfaced valley soil	Alkaline grey deep sandy duplex/ Grey/brown deep sandy duplex
Loamy sand surfaced duplex	Grey deep sandy duplex
Orange alluvial loamy sand	Brown deep sand
Pale sand over gravel/loamy sand	Pale deep sand
Pale valley floor sand	Pale deep sand/Grey deep sandy duplex
Poorly drained sandy loam duplex	Saline and non-saline wet soil
Powdery surfaced calcareous soil	Calcareous loamy earth
Red brown alluvial loam	Brown loamy earth
Red brown doleritic clay loam	Self-mulching cracking clay/Red/brown non-cracking clay
Red brown sandy loam over clay valley soil	Alkaline red shallow loamy duplex
Red clay valley soil	Red/brown non-cracking clay
Rocky red brown loamy sand/sandy loam	Red deep sandy duplex/ Red/brown deep loamy duplex
Salt lakes	Salt lake soil
Sandy loam over clay	Alkaline grey shallow loamy duplex/ Grey/brown shallow loamy duplex
Sandy loam over pinkish clay below breakaways	Acid shallow loamy duplex
Sandy surfaced valley duplex	Grey deep sandy duplex
Shallow hardsetting grey sandy loam over clay	Alkaline grey shallow loamy duplex/ Grey/brown shallow loamy duplex
Shallow mottled zone soil	Shallow gravel
Shallow sandy surfaced duplex	Grey shallow sandy duplex
Shallow sandy surfaced valley soil	Alkaline grey shallow sandy duplex
Soils fringing the salt lakes	Salt lake soil/ Other soil
Stony soils	Stony soil
Waterlogged greyish loamy sand/sandy loam	Saline and non-saline wet soil
Waterlogged sand	Non-saline wet soil
Yellow alluvial sand	Brown deep sand
Yellow gradational loamy sand	Yellow sandy earth
Yellow gravelly loamy sand	Moderately deep sandy gravel/ Loamy gravel

Appendix 6. Programs Aimed at Land and Nature Conservation

Remnant Vegetation Protection Scheme
The Remnant Vegetation Protection Scheme (RVPS) was developed by the Western Australian State Government in 1988 to enhance soil and nature conservation by protecting native vegetation on farm land. The scheme (which is jointly administered by CALM and Agriculture Western Australian (AgWA), with AgWA as the lead agency) provides a 50% subsidy towards the cost of protective fencing of native vegetation on farms, with landowners giving an undertaking by covenant on title that the fenced vegetation will be managed for nature conservation for a period of at least thirty years.

To be granted a subsidy, the area of vegetation to be fenced must be five hectares or more, and must be in good condition or able to be rehabilitated to good condition. Regular botanical surveys of RVPS fenced areas are undertaken to monitor the condition of the vegetation. This not only provides an excellent, objective measure of the longer term success of the Scheme, but also an opportunity for land owners to improve their management practices by providing them with a measure of the impact of their management actions.

Since 1989, 326 hectares of remnant vegetation in Beverley have been fenced using RVPS grants. According to the Australian Bureau of Statistics, Agricultural Survey 1993/94, the landholders of Beverley reported a further 3,374 hectares of native vegetation which was fenced or inaccessible to stock. This shows the commitment of the landholders of Beverley to fencing their remnant vegetation.

Applications: RVPS Coordinator, Locked Bag No. 3 South Perth WA 6151.
Further information and forms: Phone (08) 9368 3573 and all offices of Agriculture Western Australia or the Department of CALM.

The National Heritage Trust
The National Heritage Trust (NHT), established in 1996, aims to take an integrated, long-term approach to the conservation and sustainable management of land, water and biodiversity. It will seek to foster cooperation between Commonwealth, State, Territory and the community. Community groups and individuals will be able to apply for funding with one application form and the source of funding will then be decided at the administrative level.

Assistance through the NHT will be delivered at a number of levels:
- Community groups
- Regional strategies
- National partnerships eg. The Endangered Species Program
- Commonwealth

The Community groups component is made up of five programs: the National Vegetation Initiative, National Landcare Program, Murray-Darling 2001, National Rivercare Initiative and the National Wetlands Program.

The National Vegetation Initiative

The National Vegetation Initiative (NVI) is one of five components of the National Heritage Trust, and aims to address Australia's land and water degradation problems. The primary objective of NVI is to reverse the long term decline in the extent and quality of Australia's native vegetation through:

- the conservation of remnant vegetation
- the conservation of Australia's biodiversity
- the restoration, through revegetation, of the environmental values and productive capacities of Australia's degraded land and water.

The National Vegetation Initiative builds on the work of former vegetation programs including One Billion Trees and Save the Bush, details of which follow. The National Landcare Initiative commenced in 1997. **Details are available through Agriculture Western Australia offices, The Department of Conservation and Land Management and from Anne Brandenburg, Greening Western Australia.**

National Landcare Program

The National Soil Conservation Program (NSCP) was established by the Federal Government in 1983 with the aim of developing and implementing a national strategy for the rehabilitation and sustainable use of the nation's land and water resources. The program provided funds to government, education institutions, research institutions, landcare and other community groups for soil conservation projects. There was particular emphasis given to fostering co-operation and co-ordination amongst government agencies and those in the local community working on land degradation problems.

In 1991 the NSCP changed to the National Landcare Program (NLP). In 1992/93, the NLP, the One Billion Trees Prográm (OBT) and the Save the Bush Program (STB) were incorporated into a One-Stop-Shop for Community Grants under the National Landcare Program. The NLP aim was to encourage community groups to responsibly manage and conserve land, water, biological diversity and cultural heritage in their area.

The National Landcare Program is now a component of the National Heritage Trust and incorporates the former programs, Land and Water and the community grants. The aim of the program is still to encourage cooperative implementation of projects which contribute to the ecologically sustainable development of land, water and vegetation resources.

Contact and further information:

National Heritage Trust Coordinator, Agriculture Western Australia. Telephone (08) 9368 3333

Anne Brandenburg, Greening Western Australia. Telephone (08) 9481 2144

Ken Atkins, Department of Conservation and Land Management. Telephone (08) 9334 0333

One Billion Trees
The One Billion Trees (OBT) program was initiated in 1989 by the Federal Government with the aim of catalysing revegetation. It was administered in Western Australia by Greening Western Australia. The program provided grants for revegetation projects through the One-Stop-Shop for Community Grants under the National Landcare Program. It has now become part of the National Vegetation Initiative.

Contact and information on past projects: Anne Brandenburg, Greening Western Australia. Telephone (08) 9481 2144

Save the Bush
The Save the Bush Program (STB) was established by the Federal Government in 1989 to assist with the preservation of biological diversity by the protection and management of remnant vegetation. It was administered by the Australian Nature Conservation Agency (ANCA), now called Environment Australia and by CALM in Western Australia. Grants from this scheme aimed to encourage, facilitate and support programs, actions and activities associated with the protection, management and investigation of remnant bush. The program is now a part of the National Vegetation Initiative.

Contact and further information: Ken Atkins, Department of Conservation and Land Management. Telephone (08) 9334 0333.

State Landcare Program
The State Government introduced the State Landcare Program in 1987 to support Land Conservation District Committees and catchment groups in combating land degradation problems in rural areas. Financial support is provided to LCDCs to undertake projects in catchment planning, demonstrate conservation practices and for communications and training.

Contact and further information: Marnie Lebourne, Soil and Land Conservation Council, PO Box 483 Northam 6401. Phone (08) 96226 100. Fax (08) 96221 902.

The Roadside Conservation Committee
The Roadside Conservation Committee (RCC) was set up by the Western Australian Government in 1985 to coordinate and promote conservation and the effective management of rail and roadside vegetation. The program is administered by the Department of Conservation and Land Management (CALM) and relevant data is administered by the Main Roads Department. In 1989, the Roadside Conservation Committee (RCC) organised an assessment of roadside vegetation involving community volunteers on a shire basis, using a proforma designed by the RCC (Hussey, 1991).

Contact and information: David Lamont (Executive Officer), Department of Conservation and Land Management, Locked Bag No. 104, Bentley Delivery Centre 6983

Ribbons of Green

Ribbons of Green is a community based Greening Western Australia project sponsored by Alcoa which started in 1989 with the aim of replanting and regenerating cleared strips of land with native plants and trees. The 'ribbons' are corridors along roads, rail reserves, waterways or linking patches of bush. These 'ribbons' are important for the conservation of wildlife, by providing bush corridors. The details of what, where and when to plant, are developed by the local community in consultation with Greening Western Australia, government departments (AgWA, CALM), local government authorities, consultants and community groups.

Contact and further information: Dorothy Redreau, Greening Western Australia. Telephone (08) 9481 2144.

Trees and Seeds for Diversity (Formally, Plants for Conservation)

Plants for Conservation was managed by Greening Western Australia and sponsored by ALCOA Australia and the Hamel Nursery. The aim of the project was to support groups and individuals undertaking revegetation projects, by providing more than 300,000 seedlings each year. Participating groups and individuals provide additional seedlings, tools and labour towards the project. It is now called Trees and Seeds for Diversity which has developed as a program to develop partnerships involving the use of local provenance seedlings and direct seeding in revegetation. The program is managed by Greening Western Australia and sponsored by Alcoa of Australia through their Marrinup Nursery. Related to this project are the **Understorey Seed Farms.**

Contact and further information: Dorothy Redreau, Greening Western Australia. Telephone (08) 9481 2144.

Gordon Reid Foundation for Conservation

The Gordon Reid Foundation for Conservation aims to provide funds or other support for the purposes of enhancing community involvement in conservation within Western Australia. Funds are provided for:

- the conservation of the Western Australian environment with emphasis on native flora and fauna;
- the identification and conservation of critical habitats and ecosystems;
- the conservation of rare, threatened and endangered species in WA;
- public education and awareness of environmental issues within WA;
- and research or other studies into other matters related to any of the above.

Contact and further information: Michael Crouch, Executive Officer, Gordon Reid Foundation for Conservation. PO Box 6725 East Perth WA 6892. Phone/Fax (08) 9322 1850.

Australian Trust for Conservation Volunteers (ATCV)
ATCV is a national, non profit, non political, community based organisation which seeks to assist landholders with practical conservation projects. ATCV supplies teams of up to ten volunteers with an ATCV team leader to co-ordinate and supervise volunteers and liaise with project managers. A vehicle, basic tools and camping equipment and first aid equipment are available. A fee is charged to cover administrative costs and the land manager is responsible for project planning, preparation including materials and specialised tools and basic accommodation. Teams are available on a daily, weekly or weekend basis. Projects include fencing, tree planting, seed collection, flora and fauna surveys, walking track construction and historic building restoration.

Contact and further information: ATCV Box 1092 South Perth 6151. Phone (08) 9474 3445. Fax. (08) 9368 2160.

Land for Wildlife
Land for Wildlife is a voluntary scheme that aims to encourage and assist private landholders in Western Australia to provide habitats for wildlife on their property. Land for Wildlife is free, there are no legal binds and there is no limitation on property size or use for registration.

Land for Wildlife offers:

- on site advice to each landholder who applies for Land for Wildlife registration
- information about other forms of assistance and incentives
- contact with like minded landholders
- regular newsletters and more detailed publications
- help to create healthy ecosystems

On full registration, the landholder receives a sign to put up on his/her property showing a numbat, knob-tailed gecko and pink rainbow plant.

Contact and further information: Land for Wildlife Coordinator (Ms Penny Hussey), Wildlife Branch, Department of Conservation and Land Management, Locked Bag 104, Bentley Delivery Centre, WA 6983. Phone (08) 9334 0530. Fax (08) 9334 0278.