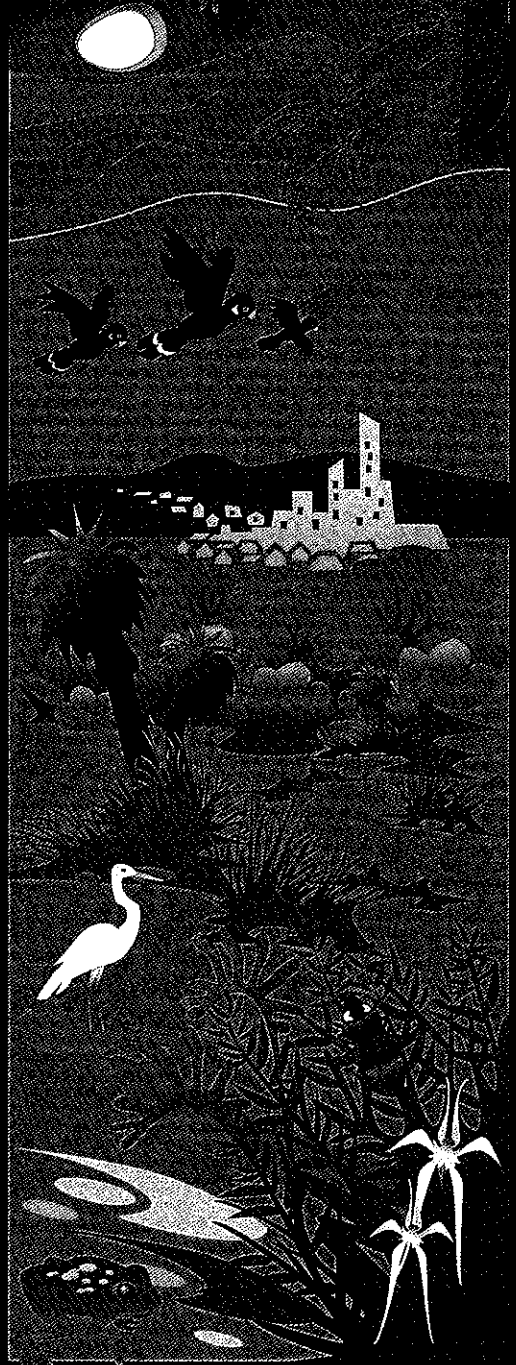
For Public Comment
VOLUME 2
PART A

DECEMBER 1998

306

'KEEPING THE BUSH IN THE CITY



PERTH'S BUSHPLAN

THE GOVERNMENT OF WESTERN AUSTRALIA

B. CROSS

PERTH'S BUSHPLAN

VOLUME TWO
PART A

PREPARED BY

Environmental Protection Authority

WESTERN AUSTRALIAN
PLANNING COMMISSION

National Parks and
Nature Conservation Authority

WATER AND RIVERS
COMMISSION

DECEMBER 1998

Perth's Bushplan is jointly prepared by the

Western Australian Planning Commission – Ministry for Planning
Environmental Protection Authority – Department of Environmental Protection
National Parks and Nature Conservation Authority – Department of Conservation and Land Management
Waters and Rivers Commission Board – Waters and Rivers Commission

This volume is published by the
Department of Environmental Protection
141 St Georges Terrace
Perth, Western Australia 6000
on behalf of the above.

Published December 1998

ISBN 0 7309 8117 7

Printed on recycled paper

Perth's Bushplan is in two volumes, each in a series of parts. The two volumes are bound as four separate documents - Volume 1, and Volume 2, Parts A, B and C.

Volume 1: The Report Text

Summary and General Recommendations containing: a foreword from the Ministers for Planning, Environment and Water Resources; a letter of transmittal from the chairs of the Environmental Protection Authority, National Parks and Nature Conservation Authority, Western Australian Planning Commission and Water and Rivers Commission; a summary of the Perth's Bushplan project; and the general recommendations covering implementation of Perth's Bushplan, followed by:

A. Introduction: an outline of the scope of Perth's Bushplan, the background to its preparation, accounts of the regional planning context and the ecological setting of the Swan Coastal Plain portion of the Perth Metropolitan Region.

B. Developing Perth's Bushplan: covering contributory studies, methodologies of assessment, and area selection.

Volume 2: Directory of Bushplan Sites

A. Guide to Bushplan Site Descriptions: an outline of each of the categories of information used to describe the Bushplan Sites. This part complements Volume 1 giving greater detail of the contributory sources.

B. Bushplan Site Descriptions: descriptions of each of the Bushplan Sites.

C. Bushplan Site Maps: maps at 1:36 000 showing each of the Bushplan Sites.

CONTENTS

Page No

Part A: Guide to Bushplan Site Descriptions

Maps

Figures

Tables

Appendices

The following appendices are not included in PERTH'S BUSHPLAN. *They will be included in a supplementary volume which will be available on request. If you would like a copy contact the Department of Environmental Protection.*

Part A
GUIDE TO BUSHPLAN SITE DESCRIPTIONS

1. Introduction

Perth's Bushplan identifies a series of Bushplan Sites on the Swan Coastal Plain (SCP) portion of the Perth Metropolitan Region (PMR) that contain natural areas of regional conservation value (see Map 1). These Sites were identified on their bushland and wetland conservation values as outlined in Volume 1 (sections 2.2 and 2.3). This Directory gives details of the location and currently identified boundaries of all of the Sites.

2. Bushplan Site Boundaries

The Bushplan Site boundaries circumscribe areas of bushland, bushland being defined as: 'land on which there is vegetation which is either a remainder of the natural vegetation of the land or, if altered, is still representative of the structure and floristics of the natural vegetation, and provides the necessary habitat for fauna' (after Keighery, BJ, and Gray 1993, and Connell 1995, adapted from the Government of New South Wales State Environmental Planning Policy No. 19 — Bushland in Urban Areas).

Areas of native vegetation where the structure and the floristics have been altered to the extent that the vegetation cannot practically be restored to be 'representative of the structure and floristics of the natural vegetation' are not considered bushland (see 4.5.3 Vegetation Condition). While these areas have conservation value, as they provide habitat for some fauna, they are not generally considered the prime conservation areas.

The initial bushland mapping by the Ministry for Planning (MfP) was done as part of the Perth Environment Project (PEP) and was based on the interpretation of 1989-1993 1:20 000 aerial photography (Dixon *et al.* 1994). The approximate extent of the bushland remnants was drawn on 1:10 000 base maps and entered into a computer-based geographic information system (GIS). Combined SPOT (from 22 January 1993) and LANDSAT (from 6 April 1993) satellite images were classified to assist interpretation. The 1:10 000 computer maps were checked in the field and updated between September and December 1994. The field check involved checking the accuracy of the bushland mapping and collecting mapping information on vegetation condition (see 4.5.3 Vegetation Condition). A further review of the data was made from January 1996 1:20 000 aerial photography (MfP GIS 1996).

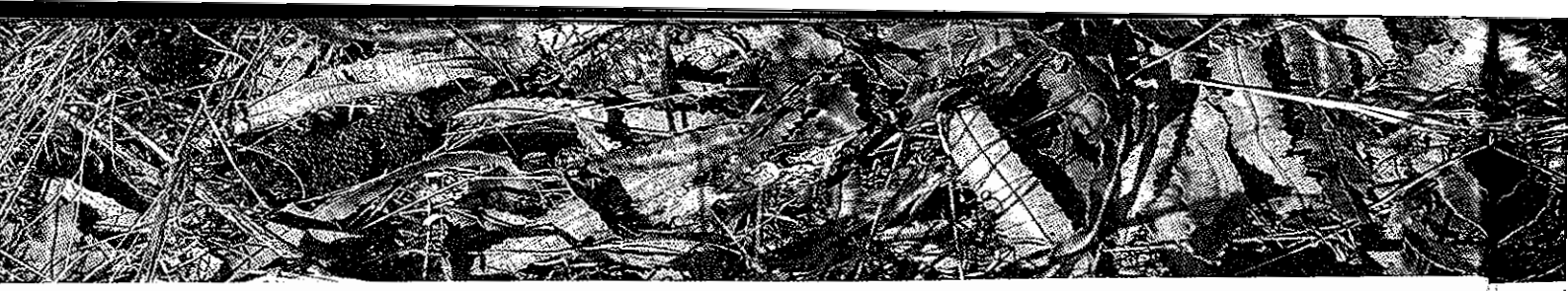
Since 1995 two local government studies, City of Gosnells (Trudgen and Keighery 1995) and City of Wanneroo (Trudgen 1996) have used the MfP remnant bushland mapping of the Perth Metropolitan Region as the base for documentation of the bushland within the local government area. These studies have involved further, more recent aerial photography interpretation and extensive (Gosnells) to limited (Wanneroo) ground-truthing. As would be expected, these studies found some discrepancies between the local government and Perth Metropolitan Region mapping related to misinterpretation, clearing and changed land use (leading to condition changes). MfP found similar discrepancies between the 1995 MfP remnant bushland map and the 1996 review.

A final review of the base mapping was done by Agriculture Western Australia (AgWA) in 1998 (AgWA 1998 GIS) from the first digital colour orthophotography of the Perth Metropolitan Region produced by the Department of Land Administration (DOLA). This digital colour orthophotography allows for a more accurate location of vegetation, as the boundaries can be interpreted at a resolution of +/– 1 metre. This improves on the +/– 30 metres resolution of the base SPOT/LANDSAT image used in 1995 and updated in 1996 and allows for more accurate location of bushland areas.

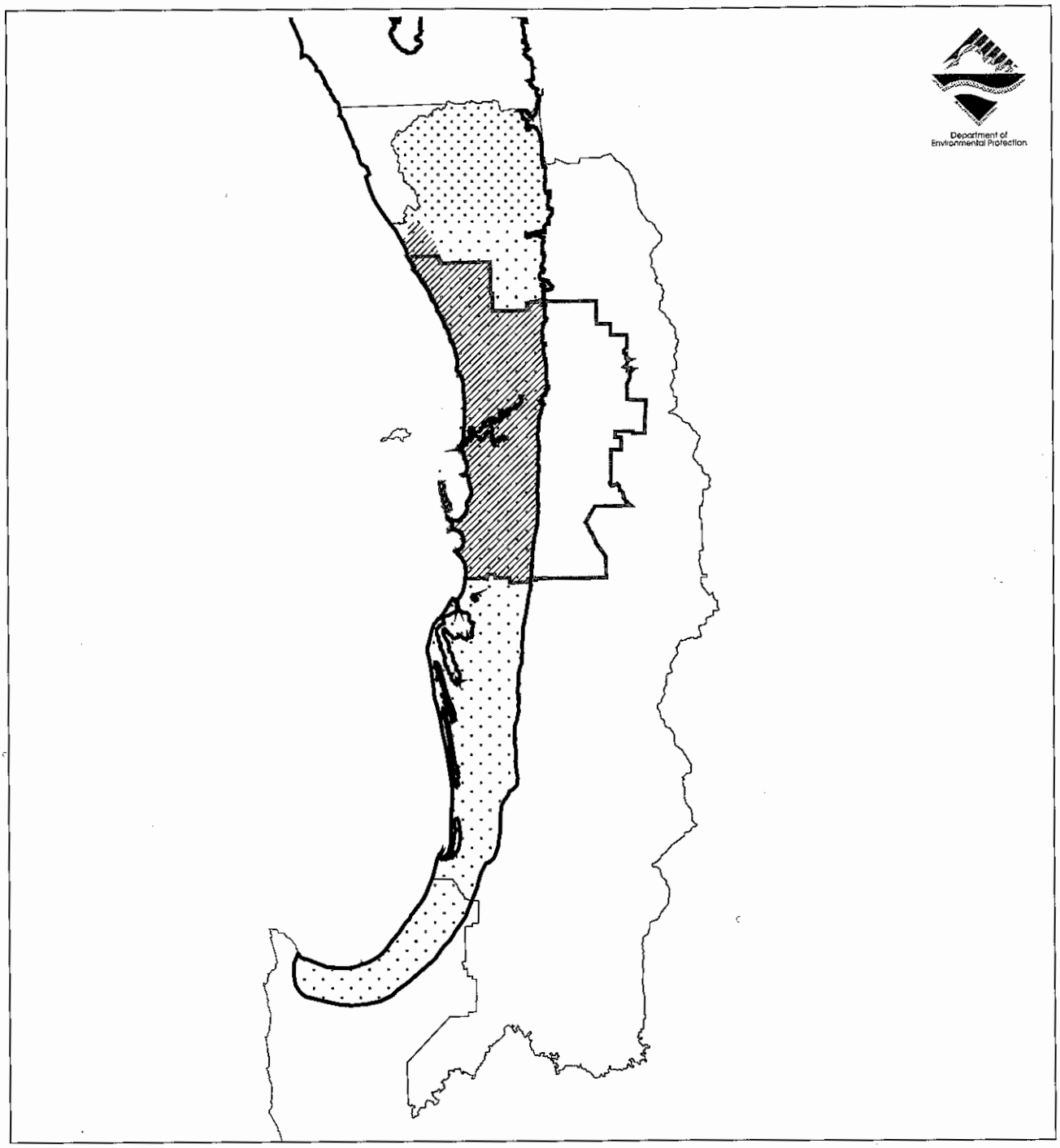
AgWA Spatial Resource Information Group has mapped vegetation throughout the south-west of Western Australia. Three basic vegetation classes (Beeston *et al.* 1995) are mapped from visual interpretation of aerial photographs. These three classes are:

Remnant vegetation

- most closely resembles the natural state of vegetation for a given area
- most similar to identifiable remnant areas of similar vegetation types
- understorey intact



Map 1: The boundaries of the various study areas referred to in Volume 2



Area covered in *Perth's Bushplan*
Perth Metropolitan Region (PMR)

System 6 Area boundary* and boundary of the vegetation complex mapping (Heddle *et al* 1980)
(*except where north-western boundary follows the Moore River on the Swan Coastal Plain)

Swan Coastal Plain (SCP) boundary

Area of floristic survey – Gibson *et al* 1994.

Additional area of floristic survey – System 6 Update

- of the greatest structural diversity/complexity in comparison to disturbed vegetation in the region
- minimal disturbance by agents of human activity.

Modified vegetation

- degraded understorey
- obvious human disturbance
- saline incursions
- high perimeter-to-area ratio
- narrow corridors of vegetation along roads, railway lines.

Scattered trees

- cleared parkland
- no canopy continuity
- no significant opportunity for regeneration.

These classes can be further divided into more descriptive units. Fifteen units were used by Van Gool (1994) in the mapping of the Peel-Harvey Catchment Area.

AgWA mapping for Perth's Bushplan is based on the visual interpretation of the 1996-1997 digital colour orthophotos (DOLA 1997 GIS, provided by Land Information Branch at MfP) or black and white orthophotos for the same period where colour images were not available. The vegetation was digitised directly from 3.8 x 3.5 digital orthophoto images with 1-metre resolution using IntergraphTM IRASC software.

Vegetation was mapped where its condition was considered to fall into either the 'remnant' or 'modified' vegetation classes. For the purposes of Perth's Bushplan vegetation in this context is termed 'native vegetation' (see Volume 1, Map 2 and Volume 2, Part C Maps). Vegetation in the 'scattered trees' class has not been mapped. It is intended that sub-categories similar to those mapped by Van Gool (1994) will be mapped at a later stage.

Of the 4,565 individual bushland areas (polygons) mapped by AgWA, 1,880 (41 per cent) represent vegetation remnants not mapped previously. These discrepancies between the AgWA vegetation mapping and the MfP bushland mapping are related to a series of factors such as resolution of the photography, differences in the mapping units (native vegetation versus bushland), misinterpretation and condition changes (for example, regrowth after partial clearing and/or fire).

The AgWA vegetation mapping is shown as the base vegetation mapping used in Volume 1, Map 2 and Volume 2, Part C. However, the selection of regionally significant bushland areas, was based on the 1995 MfP ground-truthed remnant bushland mapping, as updated in 1996 (MfP 1996 GIS). As a consequence the Bushplan Site boundaries shown in Volume 1, Map 2 and Volume 2, Part C were determined by comparing:

- AgWA vegetation mapping
- 1995 MfP ground-truthed remnant bushland mapping, as updated in 1996 (MfP 1996 GIS)
- 1997 Metropolitan Street Directory aerial photography and 1997 Perth Metropolitan Region digital colour orthophotography
- DEP survey records (DEP 1996, 1998)
- the boundaries of Conservation Category Wetlands (Hill et al. 1996b) and verified Conservation Category Wetlands (after Semeniuk, V&C Research Group 1997; see section 4.3.3 for a description of these two categories).

At times there were discrepancies between the mapped vegetation (AgWA 1998 GIS) and survey records of bushland areas in the Bushplan Site (for example Bushplan Site 74). In these cases Bushplan Site boundaries were drawn to reflect the survey records. As time permits the AgWA mapping will be amended to account for this.

While boundaries of the Bushplan Sites are as accurate as possible and the mapped vegetation for the Perth Metropolitan Region (Volume 1, Map 2 and Volume 2, Part C) is a good guide, a detailed determination of the bushland boundaries will depend on individual ground-truthing of each bushland boundary.

The final determination of boundaries of the area to be identified and managed for conservation will involve consideration of:

- individual area ground-truthing of bushland boundaries
- management design criteria such as
  - reducing the bushland edge-to-area ratio
  - establishing a foreshore reserve or management buffer area
  - connectivity with other Sites and natural areas
- cadastral boundaries
- existing planning constraints.

3. Bushplan Site Maps

A series of maps has been produced to show the Bushplan Sites (Volume 2, Part C). The map grid is based on the 1: 25 000 standard map sheet series used in the Australian 1: 25 000 Topographic Survey. Four A4 size maps will represent each 1: 25 000 map sheet. This scale is the smallest practical scale to show sufficient detail of the Bushplan Sites. Larger Bushplan Sites may be found on several maps.

Layers of mapped information have been overlaid on the Bushplan Site maps to define each Bushplan Site and individual lots within each Bushplan Site, namely: Bushplan Site boundaries, Bushplan Site Number (the arbitrary number assigned to each Bushplan Site for use of identification in Perth's Bushplan), mapped vegetation (AgWA 1998 GIS), cadastre (DOLA 1998 GIS) and rivers, creeks and/or artificial channels collectively referred to as water courses (WRC 1996 GIS). Australian Map Grid coordinates are shown on the margins of the maps to allow for the location of the Bushplan Sites.

When mapped information sets (data sets) are overlaid in this way there can be some discrepancy between boundaries, the magnitude of this discrepancy being related to the resolution of each data set. The original SPOT/LANDSAT image used for the base of the MfP bushland mapping can be interpreted at resolutions of +/– 30 metres compared with the +/– 1-metre resolution of the base digital colour orthophotography of the AgWA native vegetation mapping. Using the AgWA native vegetation mapping as the base vegetation data set facilitates a more accurate identification of other mapped data sets with the individual regionally significant bushland areas. For Perth's Bushplan mapped data sets have been used to source information on cadastre (lot numbers, reserve status, street name), zoning, landform and soil, vegetation complex, floristic community type, water courses and threatened ecological communities. Details of each of these categories of information are given in section 4.

Part C of this Volume contains maps produced to show the Bushplan Sites. Map 2 is an annotated example of one of these maps. The tables at the beginning of Part C cross-reference the Bushplan Site number to the page on which the relevant Bushplan Site description and map may be found.

4. Bushplan Site Descriptions

4.1 Introduction

Bushplan Sites are described according to the regional and individual attributes of the bushland and wetlands identified within the Site boundaries.

A standard format was developed to provide comparable descriptions of each Bushplan Site. Appendix 1 contains the standard outline used for describing each Bushplan Site. The descriptions are ordered in the following broad categories:

Name

All the Bushplan Sites have been named.

Boundary Definition

Identified boundary category/categories used to define the Bushplan Site boundary are listed.

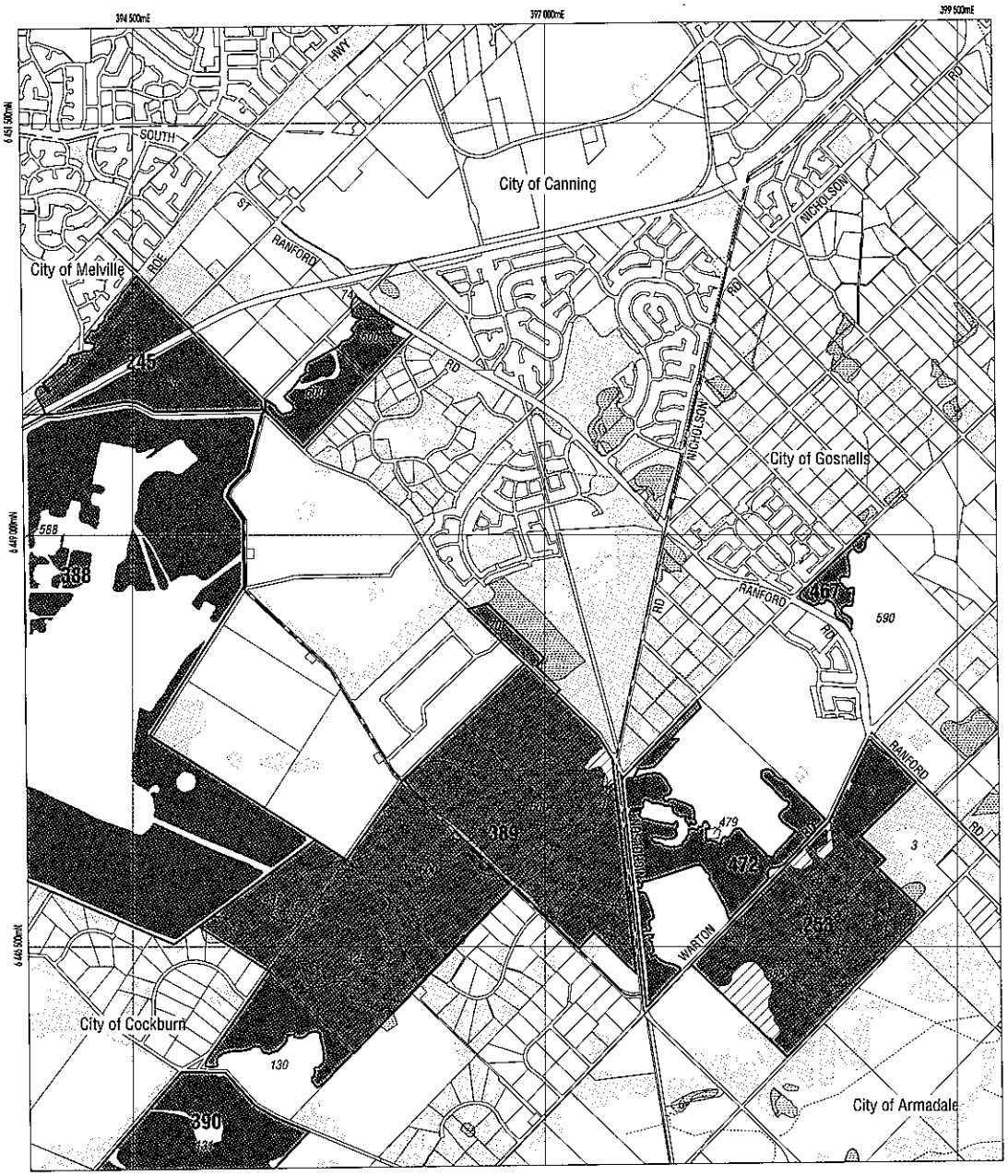
SECTION 1: CADASTRAL INFORMATION

Location, size and ownership detail.

SECTION 2: REGIONAL INFORMATION

The primary selection of the regionally significant areas encompassed in the Bushplan Sites was based on information collected and compared from across the Swan Coastal Plain (see Volume 1). These comparative regional data sets consider landforms and soils, vegetation and flora, wetlands and threatened ecological communities.

Part A



LEGEND

- 472 — Bushplan Sites With Regionally Significant Bushland
- Other Native Vegetation
- Conservation Category Wetlands
- Bushplan Sites With Some Existing Protection
- 696 — Lot Number, Location Number
- Channel Wetlands
- Local Government Boundary

2033 - I NE

IV | NW | NE
SW | SE
2033
III | II

1 : 25 000 AMG Reference Grid showing Perth's Bushplan Map Sheet Breakdown

PERTH'S BUSHPLAN MAP INDEX

N

SCALE

0 500 1000
Metres

Produced by Project Mapping Section
Land Information Branch, Ministry for Planning, Perth W.A. November 1998

ntw-map17//environ/bushplan//bushv2map2.dgn

Cadastral Data supplied by Department of Land Administration, W.A.

Wetlands Data supplied by Water and Rivers Commission

Native Vegetation Extent for Study Area supplied by Agriculture Western Australia

An Example of a Bushplan Site Map — Map 2

SECTION 3: SPECIFIC SITE DETAIL

An individual description is given of the Bushplan Site's vegetation, flora, fauna, special connectivity and significance.

SECTION 4: INTERNATIONAL AND NATIONAL SIGNIFICANCE

A listing is given of the Bushplan Site's national and international significance.

SECTION 5: SELECTION CRITERIA AND RECOMMENDATIONS

The selection criteria met by the Bushplan Site are listed together with selected opportunities for and contraints on protection of the Site and specific recommendations for each Site.

Information listed in *SECTIONS* 2 to 5 of Bushplan Site descriptions only applies to the bushland within the circumscribed boundaries.

This format is considered the 'minimal data set' for describing each Site. In many cases additional information can be gained from the references listed or from the relevant government department or local authority. In addition, there are many ongoing studies which will continue to add to this knowledge.

In general each category of information is detailed in three sections:

- **Background:** This section gives a brief description of the category of information, in other words, what information is recorded, and in some cases provides discussion of the background studies which have given rise to the information used. A more detailed account can be obtained from the original studies referred to in this section. Copies of most studies are held at the Department of Environmental Protection.
- **Information Source:** A brief summary of the particular information source, the form of the information and area of the Swan Coastal Plain to which the information relates. The information ranges from comprehensive regional studies to individual studies of varying detail and quality. As many of these sources of information as possible (within the time and resource constraints of this study) have been accessed and collated. Survey work was undertaken specifically for Perth's Bushplan by both MfP and DEP to complement existing information on the area. The information may be in the form of maps, published and unpublished written accounts and/or survey data sheets. The source of the information is referenced in each case. Information contained in these sources may also be on databases or a geographic information system (GIS). Database references are annoted with a 'D' and geographic information system references are annoted with 'GIS' and listed at the beginning of the references (see section 5).
- **Directory Descriptors:** An explanation of how the information is used and presented in the Bushplan Site account together with a listing of the descriptive phrases used in describing the information. Appendix 1 lists all Directory Descriptors. Reference is given to the page of the Appendix on which the Directory Descriptors are listed. In some cases the category of information is self-explanatory and this detail is not given.

Appendix 4: 'Introductory Guide to the Bushplan Site Descriptions', is a condensed introduction to the Site descriptions which omits the Background section outlined above.

4.2 *NAME AND BOUNDARY DEFINITION*

Background

All the Bushplan Sites have been named. At times several numbered Bushplan Sites have been grouped in a single description and the group bears an individual name.

Each Bushplan Site name is in keeping with well-used names of the area. Where an existing name is not known one has been adopted from a boundary road for the purposes of Perth's Bushplan. Other known names are listed in *SECTION 1* of the Bushplan Site description. The suburb in which it is found follows the name.

The rationale for the development of the Bushplan Site boundaries is outlined in section 2 and will not be further detailed here.

Information Source

Source	Form	Custodian	Coverage
1997 native vegetation maps, (AgWA 1998; McArthur 1998) (see Volume 1, Map 2 and Volume 2, Part C)	GIS	AgWA	Swan Coastal Plain portion of the Perth Metropolitan Region
1996 remnant bushland maps, (MfP 1996)	GIS	MfP	Perth Metropolitan Region
1998 PanAirama (aerial photography) (DOLA 1998d)	CD ROM	DOLA	South West WA
1997 Perth Metropolitan Region digital colour orthophotography	GIS	DOLA	part of the Perth Metropolitan Region
1996 black and white orthophotography	GIS	DOLA	Perth Metropolitan Region
Conservation category wetlands (Hill et al. 1996b; WRC 1996)	GIS	WRC	Perth Metropolitan Region
Verified conservation category wetlands (Semeniuk, V&C Research Group 1997)	GIS	WRC	Perth Metropolitan Region

Directory Descriptors (Appendix 1, page 98)

The Bushplan Site boundaries are at various stages of refinement according to the history of the Site's recognition and its complexity.

Boundaries of Bushplan Sites are allocated to seven categories:

- protected area boundary: boundary matches current MRS Parks & Recreation, and lands managed by the Department of Conservation and Land Management (CALM) or Crown Reserves with a conservation purpose
- management boundary: boundary selected for ease or viability of management
- management/bushland boundary: combination of management boundary and mapped bushland boundary
- bushland boundary: boundary fully encompasses mapped bushland areas
- bushland group boundary: boundary encompasses several mapped bushland areas
- conservation wetland boundary: boundary matches verified conservation category wetland boundary or boundary adjusted to include all of a conservation category wetland (WRC 1997 GIS)
- vegetation complex boundary: boundary follows boundary of the area of a single complex

Where there are discrepancies between the mapped vegetation (AgWA 1998 GIS) and survey records of bushland in the Bushplan Site, the 'boundary category' is annotated with the following statement:

> 'Areas of bushland within the boundaries of the Bushplan Site are not accurately mapped. The boundary has been drawn to include any unmapped bushland.'

In general, the areas recognised for the first time in Perth's Bushplan have preliminary boundaries related to the mapped bushland. However, changes are expected to be limited.

4.3 *SECTION 1: CADASTRAL INFORMATION*

Background

This section contains a miscellany of information on the Bushplan Sites including:

- The arbitrarily assigned Bushplan Site number, the relevant map number (contained in Volume 2, Part C) and the map sheet series reference number(s).
- Reference to the recommendation areas of the System 6 report (DCE 1983). It is indicated whether the Bushplan Site coincides with all or part of a System 6 area. Appendix 2 gives a summary of all System 6 areas and their status within Perth's Bushplan; a summary of this table is included as Appendix 5 of Volume 1.
- All known names and reference codes. Such 'names' can be a guide to information on the area. Reference is also made to whether whole or part of the Bushplan Site was the subject of a public submission to the System 6 and part System 1 Update Program during 1994.
- The total area and the area of mapped native vegetation contained within the Bushplan Site. It is this mapped native vegetation that Perth's Bushplan identifies as regionally significant bushland. If open water (not vegetated) is known to occur in the Bushplan Site this is indicated. Areas of open water are not given, but generally the area of the Environmental Protection (Swan Coastal Plain Lakes) Policy (Government of Western Australia 1992b) lakes can be considered to be the area of open water.
- The local authority (government) and suburb(s) in which the Bushplan Site is located.
- Zoning under the Metropolitan Region Scheme (MRS) and Town Planning Scheme (TPS). Map 3 shows the distributions of each zoning category under the Metropolitan Region Scheme. Some Bushplan Sites may be Parks and Recreation in the TPS but have the zoning of the surrounding area in the MRS.

Lot and Reserve numbers are listed alongside ownership categories.

Information Source

Source	Form	Custodian	Coverage
Bushplan Site Boundaries	GIS	MfP/DEP	Swan Coastal Plain portion of the Perth Metropolitan Region
1997 native vegetation maps (AgWA 1998)	GIS	AgWA	Swan Coastal Plain portion of the Perth Metropolitan Region
DOLA Local Government Authorities and suburbs (DOLA 1998b&c)	GIS	DOLA	WA
WAPC MRS and TPS zonings (MfP 1998a&b)	GIS	MfP	Perth Metropolitan Region
DOLA Sept 1998 cadastre (DOLA 1998a)	GIS	DOLA	WA
System 6 areas (DCE 1983, DEP 1995b)	GIS	DEP	System 6 Region

Directory Descriptors (Appendix 1, page 98)

For each Bushplan Site the following information is listed:

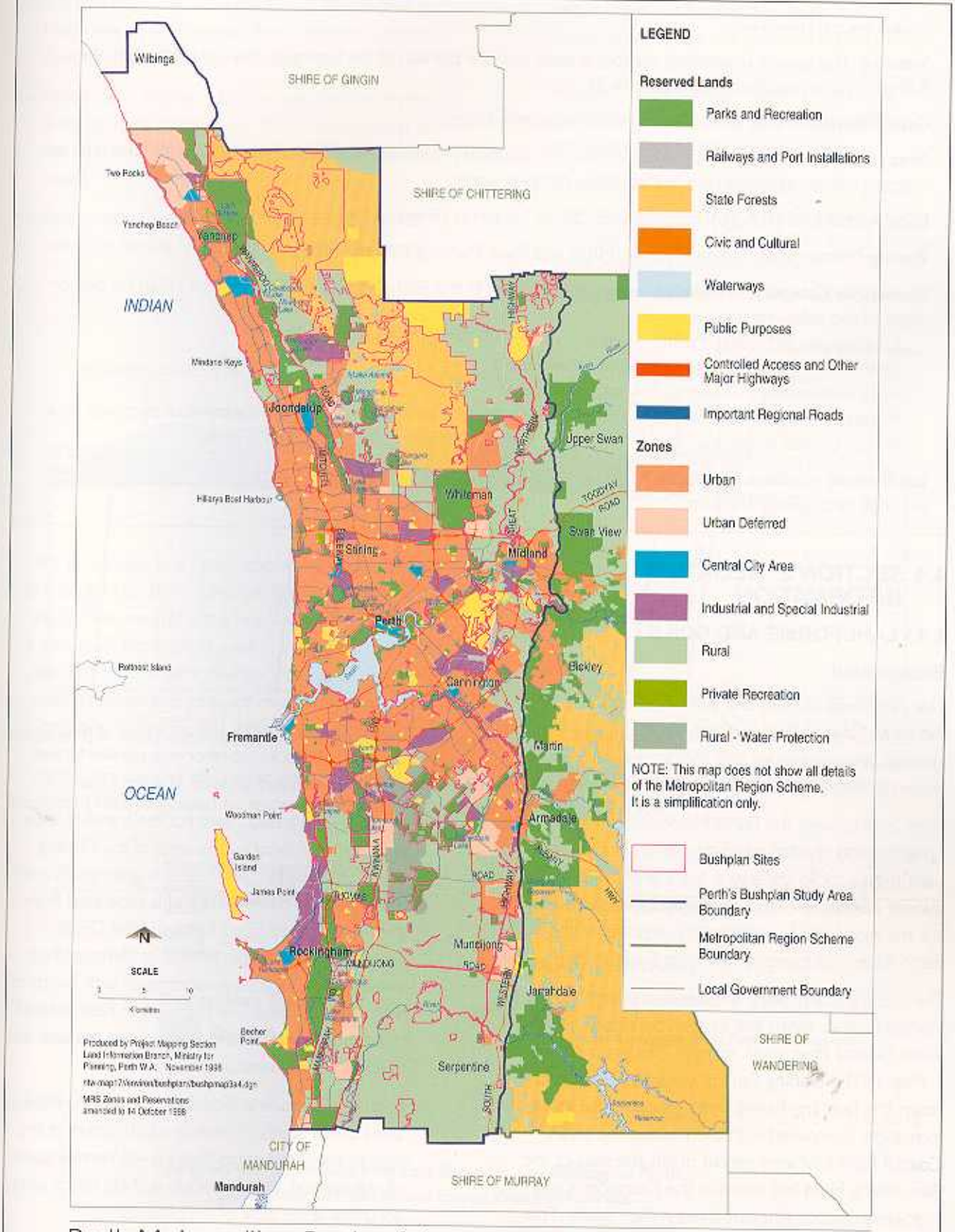
Bushplan Site number: The arbitrary number assigned to each Bushplan Site, for example, Kings Park is Bushplan Site 317. Some descriptions refer to a series of Site numbers.

Map number: Refers to the map page (see Volume 2, Part C) on which the Bushplan Site is located.

Map sheet series reference number: Refers to the Australian 1:25 000 Topographic Survey Map Sheet Series from which the map pages are derived, for example 2034 IV SW.

(continued)

Part A



Perth Metropolitan Region Scheme and Bushplan Sites Map 3

Directory Descriptors (continued)

System 6: The System 6 reference number is cited then the portion of the System 6 area included within the Bushplan Site is described (see Appendix 2).

Other Names: Any other known names or reference codes.

Area (ha): The area defined by the Bushplan Site boundary is recorded as Total Area, followed by the area of mapped native vegetation and the presence of open water.

Local Authorities (Suburb): For example, City of Nedlands (Shenton Park).

Zoning: Metropolitan Region Scheme (MRS) and Town Planning Scheme (TPS).

Ownership Category: Ownership categories identified in the Bushplan Site are listed. There could be one or more of the following:

Commonwealth Government — vested in Commonwealth Government
State Government — vested in State Government
Local Government — vested in local government
Private — owned freehold by private person(s), State or local government, for commercial purposes by a private person or company

Lot/Reserve numbers (purpose), Street name: Street names and Lot or Reserve numbers (with the Reserve purpose in brackets) are listed.

4.4 *SECTION 2: REGIONAL INFORMATION*

4.4.1 LANDFORMS AND SOILS

Background

The patterning of plant and animal distributions on the Swan Coastal Plain is closely related to the geology, geomorphology and soils of the Plain. Some understanding of these physical features is essential.

From east to west the Perth Metropolitan Region is conspicuously divided into two distinct landscape units (Figure 1). To the east is the Darling Plateau, an ancient plateau of Archaean origin, and to the west are the more recent sedimentary deposits of the Perth Basin expressed as the Swan Coastal Plain.

The Darling Scarp, being the western margin of the Darling Plateau, forms the eastern boundary of the Swan Coastal Plain south to near Dardanup (Figure 1, Map 1). The Darling Fault is just to the west of the Scarp, the fault line having been eroded since its formation. Compared with the Plateau, the Swan Coastal Plain is of very recent origin, the soils of the Plain having been laid down in the Pleistocene and Holocene periods (the last three million years). The Darling Scarp forms the eastern boundary of the study area for Perth's Bushplan.

Studies of the geomorphology and geology of the Plain (McArthur and Bettenay 1960 and Playford *et al.* 1976, see Tables 1 and 2 this Volume and Figure 3 and Map 1, Volume 1) have divided the Plain into a sequence of alluvial (water-borne) and/or colluvial (erosional) deposits in the east and aeolian (wind-borne) sands in the west. The six major landform elements identified lie more or less parallel to the coast. These, from east to west (Figure 1), are:

(i) Dandaragan Plateau (north of the transect shown in Figure 1) – *Lying to the west of the Darling* Scarp, the Dandaragan Plateau is geologically part of the Swan Coastal Plain and is separated from the five units described below by the Gingin Scarp. The Dandaragan Plateau is composed of *Jurassic and Cretaceous sandstones with bands of* siltstones and shale. The Plateau has been subject to laterite formation and erosion and the soils are laterites and colluvial sands.

(ii) Foothills (Pleistocene foothills of the Darling Plateau and a similar series of foothills which occurs at the base of the Dandaragan Plateau) – A narrow band of colluvial and alluvial deposits and old beach sands occurring at the base of the plateaus.

(iii) Pinjarra Plain – An alluvial plain of Pleistocene to Holocene age, originating from the river systems flowing down from the plateaus.

(iv) Bassendean Dunes – Pleistocene aeolian heavily leached sands falling from 40-80 metres relief in the north of the Plain to almost sea level in the south.

(v) Spearwood Dunes – Pleistocene aeolian sands overlying Tamala Limestone. These sands have a less leached profile than the sands of the Bassendean Dunes but generally a similar relief except where the Tamala Limestones are exposed. The exposed ridges of Tamala Limestone are the most prominent landforms on the Swan Coastal Plain.

(vi) Quindalup Dunes – These calcareous coastal Holocene sands on the western margin of the Plain are the most recent aeolian dunes. At times these overlie Tamala Limestone.

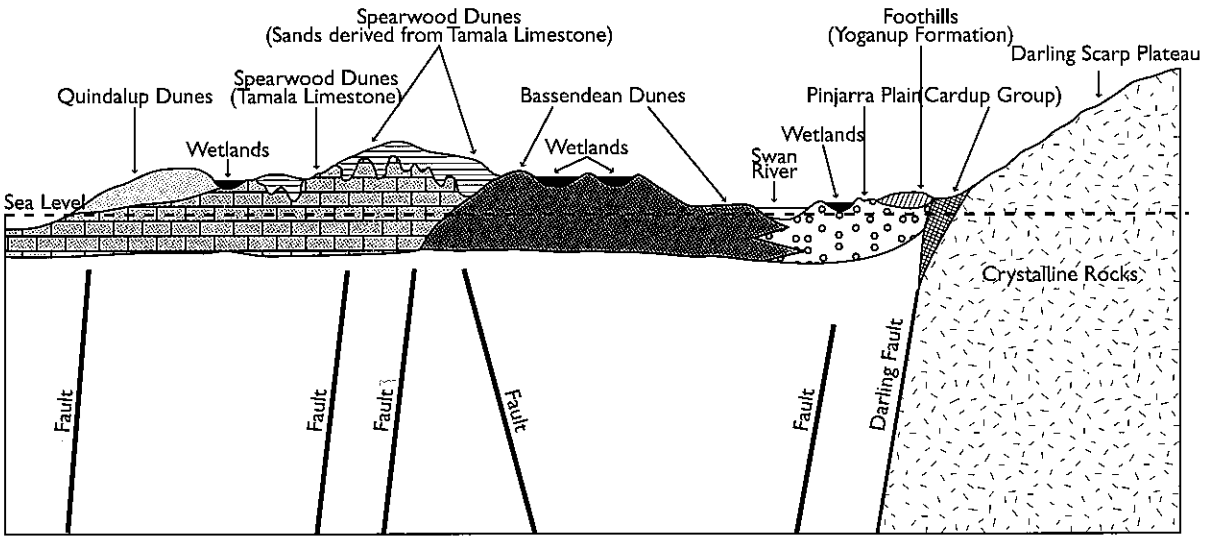


Figure 1: A cross section of the PMR showing the major landform elements

A 'typical' transect of the major geomorphological systems of the Swan Coastal Plain after McArthur and Bettenay (1960) followed by major geological systems after Playford et al. 1976

Foothills (Ridge Hill Shelf)

- Yoganup Formation
- Cardup Group

Bassendean Dunes

- Bassendean Sand

Pinjarra Plain

- Guildford Formation

Spearwood Dunes

- Tamala Limestones
- Sands derived from Tamala Limestones

Quindalup Dunes

- Safety Bay Sands

Adapted with permission from Fact Sheet 15. The Geology of Perth.
Department of Minerals and Energy, Western Australia.

Table 1: Relationship between geological and geomorphological systems identified on the Swan Coastal Plain in the Perth Metropolitan Region. The general terms used in Perth's Bushplan for describing the major landform elements are in bold italics. Column One can be used to cross-reference to groups shown in Table 2.

Major Geological Systems (after Playford *et al.*, 1976)	Major Geomorphological Systems (after McArthur and Bettenay, 1960)	Detailed Geomorphological Units (after Churchward and McArthur, 1980)
Plateaus Darling Plateau (not covered in *Perth's Bushplan*) Dandaragan Plateau	Darling Plateau (not covered in *Perth's Bushplan*) ***Dandaragan Plateau***	not applicable Mogumber
Scarps Darling Scarp Gingin Scarp	Darling Scarp Gingin Scarp	Darling Scarp (Darling Plateau) Reagan (Gingin Scarp)
Foothills	Ridge Hill Shelf, the ***Foothills*** of the Darling and Dandaragan Plateaus	Forrestfield (on foothills of the Darling Plateau) Coonambidgee (foothills Dandaragan Plateau)
Guildford Formation	***Pinjarra Plain***	Guildford Beermullah Yanga Serpentine Swan Dardanup
Bassendean Sand	***Bassendean Dunes***	Bassendean
Bassendean Sand/Guildford Formation and other combinations	Not applicable	Southern River Cannington
Tamala Limestone and ***Sands derived from Tamala Limestone***	***Spearwood Dunes***	Cottesloe Karrakatta
Safety Bay Sands	***Quindalup Dunes***	Quindalup
Wetlands (within the Guildford Formation, Bassendean Sand, Tamala Limestone)	Not applicable	Herdsman
Lagoonal and Estuarine Deposits (within the Guildford Formation, Bassendean Sand, Tamala Limestone)	Not applicable	Vasse Yoongarillup

Table 2: Relationship between geological units identified in the Environmental Geology Maps and soils described on these maps on the Swan Coastal Plain in the Perth Metropolitan Region. Column One can be used to cross-reference to groups shown in Table 1.

Major Geological Systems (after Playford et *al.*, 1976; *Major Geomorphological Systems, after McArthur and Bettenay, 1960)	Major Units in the Environmental Geology Maps (after various authors)	Soils associated with each unit (after units described in the Environmental Geology Maps)
Dandaragan Plateau *Dandaragan Plateau	Colluvial sand Laterites Leederville Formation Osborne Formation	light grey or pale brown quartz sands with some felspar; ferruginous gravel in a clay-sand matrix overlying cemented laterite up to 4m thick; brown laterised granite pebbles in a clay-silt matrix and pale brown quartz and felspar sands in a siltstone matrix
Gingin Scarp *Gingin Scarp	Gingin Scarp	not distinguished, as above
Foothills *Ridge Hill Shelf	Colluvial deposits Colluvial sand Yoganup Formation Ridge Hill Sandstone Armadale Shales	quartz sands with differing amounts of silt, gravel and clay; light grey quartz sands and white quartz sands
Guildford Formation *Pinjarra Plain	Guildford Formation Alluvial/colluvial deposit Alluvial/colluvial deposit (Pinjarra Plain over Ridge Hill) Muchea Limestones	clays with silts, sands and peat; also areas of ironstone at depth or surface associated with red/brown silts and limestones associated with clays and orange sands
Bassendean Sand *Bassendean Dunes	Bassendean sands	light grey quartz sands
Bassendean Sand/Guildford Formation *Bassendean Dunes /Pinjarra Plain	Bassendean sands over Guildford Formation	light grey quartz sands over silty sands
Tamala Limestone *Spearwood Dunes	Sands derived from Tamala limestone Tamala Limestone	white to pale yellow sands limestone and associated light yellowish brown sands
Safety Bay Sands *Quindalup Dunes	Safety Bay Sands	white calcareous sands, sometimes limestone deposits
Wetlands – within the Guildford Formation, Bassendean Sand, Tamala Limestone	Holocene swamp deposits	peats associated with clays, sands and silts in various proportions
Lagoonal and Estuarine Deposits – within the Guildford Formation, Bassendean Sand, Tamala Limestone	Lagoonal and estuarine deposits	silts, sands and calcareous deposits in various associations

Table 3: Landform and Soils Directory Descriptors with examples of the soil units associated with these. A key to the symbols is given in Table 4.

Dandaragan Plateau/Gingin Scarp
Colluvial Sand (Qs: S6)
Laterite (Ql: G2, LA1)
Leederville Formation (Klb: ST1)
Osborne Formation (Ko: ST2)

Darling Plateau (Darling Range)/Darling Scarp
Laterite (Ql: G2, LA1)
Darling Scarp – gravels and laterite (Czl: for example G2, LA1)
Even-grained Granite (Ae, Aes: M3, GR) (Am: GN)

Foothills
Colluvial deposits (Qc: for example Msg, Csg, Ms3, Smg, S5)
Colluvial sand (Qs: for example S6)
Yoganup Formation (Qpr: for example S12)
Ridge Hill Sandstone (Qph: S5)
Armadale Shale (Pa: SH)

Pinjarra Plain
Guildford formation (Qpa: for example FS, Ms2, Mgs1, Cs, Sc) (Qha: for example Cp, S14, Msc1)
Alluvial/colluvial deposit (Qha/Qc: for example G1)
Alluvial/colluvial deposit (Pinjarra Plain / Ridge Hill) (Qha/Qc: for example FS3)
Muchea Limestone (Qpm: for example LS5)

Bassendean Dunes
Bassendean sands (Qpb: S8)

Bassendean Dunes/Pinjarra Plain
Bassendean sands over Guildford Formation (Qpb/Qpa: S10)

Spearwood Dunes
Sands derived from Tamala limestone (Qts: S7)
Tamala limestone (Qtl: for example LS1, LS2)

Quindalup Dunes (Holocene dunes)
Safety Bay Sands (Qhs: for example S1, S2, S13, LS4)

Wetlands (within the Quindalup, Spearwood, Bassendean Dunes or Pinjarra Plain)
Holocene swamp deposits (Qhw: for example Cps, Scp, Spc, Spm, Ms5) (Qrw: for example Sp1, Sp2)

Lagoonal and estuarine Deposits (within the Quindalup Spearwood Bassendean Dunes Pinjarra Plain)
Lagoonal and estuarine deposits (Vasse) (Qhg: for example M5, Sm2)
Lagoonal deposits in Bassendean Dunes (Qpw: for example S9)

Table 4: Key to Environmental Geology Series Symbols

Geology Units

Ae and Aes	Even-grained Granite
Am	Migmetite
Czl	Laterite
Klb	Leederville Formation
Ko	Osborne Formation
Pa	Armadale Shale
Qc	Colluvium
Qha	Alluvium – Holocene
Qhg	Lagoonal and Estuarine Deposits
Qhs	Safety Bay Sands
Qpa	Alluvium – Pleistocene
Qpb	Bassendean Sand
Qph	Ridge Hill Sandstone
Qpm	Muchea Limestone
Qpr	Yoganup Formation
Qpw	Lagoonal Deposits in Bassendean Sand
Qrw	Swamp Deposits
Qtl	Tamala Limestone
Qs	Colluvial Sand
Qts	Sand derived from Tamala Limestone

Soil Units

- Letters

The main 'soil fraction' is given first in capitals, followed by fractions in decreasing importance in lower case

- Numbers indicate mappable units of a similar character

C	clay
M	silt
G	gravel
P	organic material
S	sand
ST	siltstone
SH	shale

Rocks

Double capitals

DO	dolerite
FS	ironstone
GN	gneiss
GR	granite
LA	laterite
LS	limestone

Each of the six major landform elements has a characteristic suite of soils, generally bearing similar names. These soils are mapped at various scales in a series of maps. The Urban Geology and Environmental Geology Series (Gozzard 1982a&b, 1983a&b, 1986; Jordan 1986a&b; Smurthwaite 1986a&b) give the most complete coverage of the Swan Coastal Plain and use consistent mapping units (Tables 2, 3 and 4). These mapping units can be directly compared with the major geomorphological systems (McArthur and Bettenay 1960) and, to a lesser extent, to the units identified by Churchward and McArthur (1980) (Table 1). The units identified by Churchward and McArthur were used as the basis for the mapping of the vegetation complexes (Heddle *et al.* 1980, see 4.4.2 Vegetation Complexes). The first column in Tables 1 and 2 (after Playford *et al.* 1976) can be used as a basis for comparing the various units.

The majority of the regional data on the Plain has been broadly grouped with reference to the six major landform elements, the interleaving of these elements and the wetlands (Appendix 1, *SECTION 2).*

Information Source

Source	Form	Custodian	Coverage
Urban and Environmental Geology Series (Gozzard 1982a&b, 1983a&b, 1986; Jordan 1986a&b; Smurthwaite 1986a&b; (Geological Survey of WA 1989)	printed maps	DOME	majority of Swan Coastal Plain
	part GIS	MfP	selected maps

Directory Descriptors (Appendix 1, page 98, 99)

Urban and Environmental Geology Series subunits are grouped according to the major landform units, namely: Darling Plateau (Darling Range)/Darling Scarp; Dandaragan Plateau/Gingin Scarp; Pinjarra Plain; Bassendean Dunes; Combinations of the Bassendean Dunes/Pinjarra Plain/Spearwood Dunes; Spearwood Dunes; Quindalup Dunes; Wetlands and Lagoonal and Estuarine Deposits (Table 3). Each sub-unit heading is followed by the symbol which denotes the geological unit and, in most cases, the broad soil characteristics as described in Table 4.

Table 5: Vegetation complexes in the Perth Metropolitan Region (after Heddle *et al,* 1980, arranged in major geomorphic units (see Landforms and Soils))

Dandaragan Plateau

MOGUMBER COMPLEX – SOUTH : Open woodland of *Eucalyptus calophylla,* with some admixture of *E. marginata* and a second storey of *E. todtiana – Banksia attenuata – B. menziesii – B. ilicifolia.*

Gingin Scarp

REAGAN COMPLEX : Vegetation ranges from low open woodland of *Banksia* species – *E. todtiana* to closed heath depending on the depth of soil.

Foothills (Ridge Hill Shelf)

COONAMBIDGEE COMPLEX : *Vegetation ranges from* a low open forest and low woodland of *E. todtiana – B. attenuata – B. menziesii – B. ilicifolia* with localised admixtures of *B. prionotes* to an open woodland of *E. calophylla – Banksia* species

FORRESTFIELD COMPLEX : Vegetation ranges from open forest of E. calophylla – E. wandoo – E. marginata to open forest of *E. marginata – E. calophylla – C. fraseriana – Banksia* species. Fringing woodland of *E. rudis* in the gullies that dissect this landform.

Pinjarra Plain

GUILDFORD COMPLEX : A mixture of open forest to tall open forest of *E. calophylla – E. wandoo – E. marginata* and woodland of *E. wandoo* (with rare occurrences of *E. lane-poolei).* Minor components include *E. rudis – M. rhaphiophylla.*

SWAN COMPLEX : Fringing woodland of *E. rudis – M. rhaphiophylla* with localised occurrence of low open forest of *Casuarina obesa* and *M. cuticularis.*

Table 5 *(continued)*: Vegetation complexes in the Perth Metropolitan Region (after Heddle *et al*, 1980, arranged in major geomorphic units (see Landforms and Soils))

DARDANUP COMPLEX : Mosaic of vegetation types characteristic of adjacent vegetation complexes such as Serpentine River, Southern River and Guildford.

SERPENTINE RIVER COMPLEX : Closed scrub of *Melaleuca* species and fringing woodland of *E. rudis – M. rhaphiophylla* along streams.

BEERMULLAH COMPLEX : Mixture of low open forest of *C. obesa* and open woodland of *E. calophylla – E. wandoo – E. marginata*. Minor components include closed scrub of *Melaleuca* species and occurrence of *Actinostrobus pyramidalis*.

YANGA COMPLEX : Predominantly a closed scrub of *Melaleuca* species and low open forest of *C. obesa* on the flats subject to inundation. On drier sites the vegetation reflects the adjacent vegetation complexes of Bassendean and Coonambidgee.

Bassendean Complex

BASSENDEAN COMPLEX – NORTH : Vegetation ranges from a low open forest and low open woodland of *Banksia* species – *E. todtiana* to low woodland of *Melaleuca* species and sedgelands which occupy the moister sites.

BASSENDEAN COMPLEX – CENTRAL AND SOUTH : Vegetation ranges from woodland of *E. marginata – C. fraseriana – Banksia spp.* to low woodland of *Melaleuca* species, and sedgelands on the moister sites. This area includes the transition of *E. marginata* to *E. todtiana* in the vicinity of Perth.

BASSENDEAN COMPLEX – NORTH – TRANSITION VEGETATION COMPLEX : A transition complex of low open forest and low woodland of Banksia species – E. todtiana on a series of high sand dunes. The understorey species reflect similarities with both the Bassendean-North and Karrakatta-North vegetation complexes.

BASSENDEAN COMPLEX – CENTRAL AND SOUTH – TRANSITION VEGETATION COMPLEX : Woodland of *E. marginata – E. calophylla* with well defined second storey of *Allocasuarina fraseriana* and *B. grandis* on the deeper soils and a closed scrub on the moister sites. The understorey species reflect similarities with the adjacent vegetation complexes.

Combinations of Bassendean Dunes/Pinjarra Plain/Spearwood Dunes

SOUTHERN RIVER COMPLEX : Open woodland of *E. calophylla – E. marginata – Banksia* species with fringing woodland of *E. rudis – M. rhaphiophylla* along creek beds.

CANNINGTON COMPLEX : Mosaic of vegetation from adjacent vegetation complexes of Bassendean, Karrakatta, Southern River and Vasse.

Spearwood Dunes

KARRAKATTA COMPLEX – NORTH : Predominantly low open forest and low woodland of *Banksia – E. todtiana*, less consistently open forest of *E. gomphocephala – E. todtiana – Banksia* species.

KARRAKATTA COMPLEX – NORTH – TRANSITION VEGETATION COMPLEX : A transition complex of low open forest and low woodland of *Banksia* species – *E. todtiana* on the transition zone of a series of high sand dunes between Bassendean-North and Karrakatta-North.

KARRAKATTA COMPLEX – CENTRAL AND SOUTH : Predominantly open forest of *E. gomphocephala – E. marginata – E. calophylla* and woodland of *E. marginata – Banksia* species.

COTTESLOE COMPLEX – NORTH : Predominantly low open forest and low woodland of *B. attenuata – B. menziesii – E. todtiana*; closed heath on the limestone outcrops.

COTTESLOE COMPLEX – CENTRAL AND SOUTH : Mosaic of woodland of *E. gomphocephala* and open forest of *E. gomphocephala – E. marginata – E. calophylla*; closed heath on the limestone outcrops.

Quindalup Dunes

QUINDALUP COMPLEX : Coastal dune complex consisting mainly of two alliances – the strand and fore-dune alliance and the mobile and stable dune alliance. Local variations include the low closed forest of *M. lanceolata – Callitris preissii* and the closed scrub of *Acacia rostellifera*.

Wetlands

HERDSMAN COMPLEX : Sedgelands and fringing woodland of *E. rudis – Melaleuca* species.

PINJAR COMPLEX : Vegetation ranges from woodland of *E. marginata – Banksia* species to a fringing woodland of *E. rudis – M. preissiana* and sedgelands.

Marine (lagoonal and estuarine) Deposits

YOONGARILLUP COMPLEX : Woodland to tall woodland of *E. gomphocephala* with *Agonis flexuosa* in the second storey. Less consistently an open forest of *E. gomphocephala – E. marginata – E. calophylla*.

VASSE COMPLEX : Mixture of the closed scrub of *Melaleuca* species fringing woodland of *E. rudis – Melaleuca* species and open forest of *E. gomphocephala – E. marginata – E. calophylla*.

4.4.2 VEGETATION AND FLORA

Vegetation Complexes

Background

The vegetation complexes (Heddle *et al.* 1980) were defined in relation to the landform-soil units determined by Churchward and McArthur (1980, see Table 1). The vegetation complexes were delineated on the basis of data on vegetation and some floristic information collected from information current at the time, ground surveys (both plots and transects on small scale areas), road traverses, aerial photographs and from previous interpretations of the vegetation.

The delineation of vegetation complexes is based on the concept of a series of plant communities forming regularly repeating complexes associated with a particular soil unit as identified by Churchward and McArthur (1980, see Table 1). In this mapping the plant communities may occur in more than one complex but the relative proportions of communities in the complex are different. A total of 38 vegetation complexes are described on the Plain (including the Dandaragan Plateau, Heddle *et al.* 1980), 26 of these occurring in the Perth Metropolitan Region (Table 5). Nine of the 38 complexes are confined to the Dandaragan Plateau, Gingin Scarp and foothills of the Dandaragan Plateau, only three of these occurring on the Swan Coastal Plain in the Perth Metropolitan Area.

Maps of the vegetation complexes at a scale of 1:250 000 digitised by the Department of Conservation and Land Management were refined for use by PEP. By intersecting the two map sets — remnant bushland (MfP 1996 GIS) and vegetation complexes — the present occurrence of bushland in the various vegetation complexes has been determined. The scale of this mapping needs to be taken into consideration when the vegetation complexes in an individual bushland area are determined, especially when the area is near the boundary between complexes. Trudgen (1996) considered this issue when looking at mapped bushland areas in the City of Wanneroo and documents more accurate boundaries between the complexes in the Wanneroo area.

Information Source

Source	Form	Custodian	Coverage
vegetation complex maps (Heddle et al. 1980, DCE 1990 GIS)	GIS	DEP	System 6 area plus area from most northern point Moore River west to coast (see Map 1)

Directory Descriptors (Appendix 1, page 99, 100)

Mapped units (Table 5) occurring in each Site are listed. Units are grouped according to major landform elements, namely: Plateaus, Scarps, Foothills, Pinjarra Plain, Bassendean Dunes, Combinations of the Bassendean Dunes/Pinjarra Plain/Spearwood Dunes, Spearwood Dunes, Quindalup Dunes, Wetlands and Marine Deposits.

Floristic Community Types

Background

The most recent regional floristic work on public lands over the entire Swan Coastal Plain (Gibson *et al.* 1994) was used as the basis for the regional comparison of bushland areas. This study considered the patterning of plant distribution on the Plain and relates to the total flora of the Plain. The presence or absence of individual species in standard areas (plots, sites or quadrats) is used to define floristic groupings based on shared species with the aid of various multivariant analysis techniques. The vegetation complex mapping (Heddle *et al.* 1980, see above) was based in part on earlier plot-based studies undertaken by Havel (1968).

Gibson *et al.* (1994) located 509 100-square-metre plots across the Swan Coastal Plain (Map 1). Plots were confined to public lands and located so as to sample the geomorphological/soil units and plant community patterning identified by previous studies. Plots were placed in bushland areas to sample vegetation in the best available condition. Within each plot all vascular plants were recorded and information collected on various physical parameters, vegetation structure and vegetation condition (see data sheets in Appendix 5). Most plots (more than 95 per cent) were visited on at least two occasions.

Not all the geographical or geomorphological variation was sampled by Gibson *et al.* (1994). The Foothills, Pinjarra Plain and Quindalup Dunes were under-sampled and the Dandaragan Plateau was not sampled at all. The Foothills and the Pinjarra Plain have been largely cleared (and hence the chance to study them on crown lands was limited) while few reserves occur on the Quindalup Dunes. It was not possible to cover fully the estuarine and riverine vegetation in the time available for the study. These restricted habitat types have been documented elsewhere (Pen 1983, 1993; Siemon *et al.* 1993).

Analysis of the 509 plots distinguished four 'super' groups, three related to the major landform elements and a wetland group found across all the major landform elements (Figures 1 and 2).

More detailed classification established 30 floristic community types, with a further 13 subdivisions evident, making 43 types (Table 6), that is:

Supergroup 1: Foothills/Pinjarra Plain — six floristic community types — 1 (a & b), 2 and 3 (a, b & c).

Supergroup 2: Seasonal Wetlands — 17 floristic community types — 4, 5, 6, 7, 8, 9, 10 (a & b), 11, 12, 13, 14, 15, 16, 17, 18 and 19.

Supergroup 3: Uplands, centred on Bassendean Dunes — nine floristic community types — 20 (a, b & c), 21 (a, b & c), 22 and 23 (a & b)

Supergroup 4: Uplands centred on Spearwood and Quindalup Dunes — 11 floristic community types — 24, 25, 26 (a & b), 27, 28, 29 (a & b), 30 (a, b & c).

The seasonal wetland group (Supergroup 2) is the most heterogeneous of the groups, containing the largest number of floristic community types and the lowest average number of plots per community type. As a consequence seasonal wetlands were under-sampled in the study.

As evident in the supergroups, the major environmental correlates with the classification were seasonal moisture regime and geomorphology. Within the seasonal wetland group some geomorphic patterning was also evident.

Using this classification as a basis, a further 613 100-square-metre plots were analysed for the System 6 and Part System 1 Update Program. These additional plots came from several additional sources: 291 plots from the System 6 and Part System 1 Update Program (DEP 1996, including 13 from Trudgen and Keighery 1995); 32 plots established by GJ Keighery (1996 D) for a study of Tuart (*Eucalyptus gomphocephala*) woodlands on the Plain; and 290 plots or relevees (approximately located areas) from Griffin (1994) on floristic variation on the sandplains to the north of Perth. These additional plots were located on private

lands, Quindalup Dunes, Dandaragan Plateau and some System areas (Map 1). Information for these plots was directly comparable with that collected in the Gibson *et al.* (1994) study (see data sheets in Appendix 5).

Classification of these plots against the Gibson *et al.* (1994) data identified a further 23 floristic community types. Greater sampling density lead to a reclassification of floristic groups 19, 20, 23 and 30 (new subgroups being distinguished in three of these groups). Fifteen supplementary groups were identified, namely:

Supergroup 1: Foothills/Pinjarra Plain — a single group, floristic community type S8, associated with the Darling Scarp.

Supergroup 2: Seasonal Wetlands — eleven groups, floristic community types S1 to 7, S17, S19 and S20, and 19a and 19b from the reclassification of 19.

Supergroup 3: Uplands, centred on the Bassendean Dunes and the Dandaragan Plateau — six groups, floristic community types 20d, 23c, S9, S10, S16, S18 (all centred on the Dandaragan Plateau)

Supergroup 4: Uplands centred on the Spearwood and Quindalup Dunes — four groups, floristic community types S11 to 14, centred on the Quindalup Dunes. Floristic community type 30 was further sampled and reclassified to identify 30a2 and 30c2.

Group S15 could not be allocated to any supergroup.

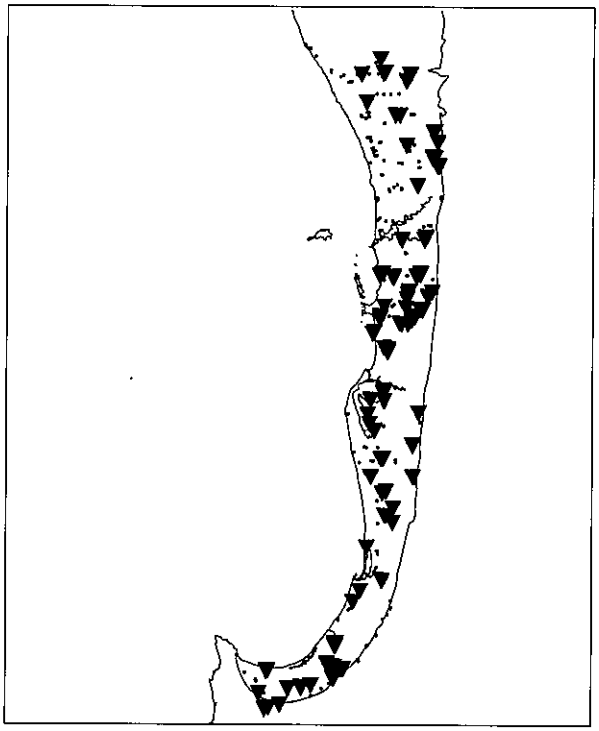
A total of 66 floristic community types are now recognised (Table 6). The additional floristic community types were to be expected as they are centred on major landform elements either not sampled (Dandaragan Plateau) or under-sampled (wetlands, Quindalup Dunes) in the base study (Gibson *et al.* 1994). The 1996 extension of the 1994 study also

- located further occurrences of some community types,
- extended the geographic range of some types,
- located vegetated areas of Muchea Limestone (presumed extinct in Gibson et al. 1994) and identified the floristic community types associated with these limestones (Keighery, GJ, and Keighery 1995),
- identified the floristic community types associated with the Perth to Gingin Ironstone Association.

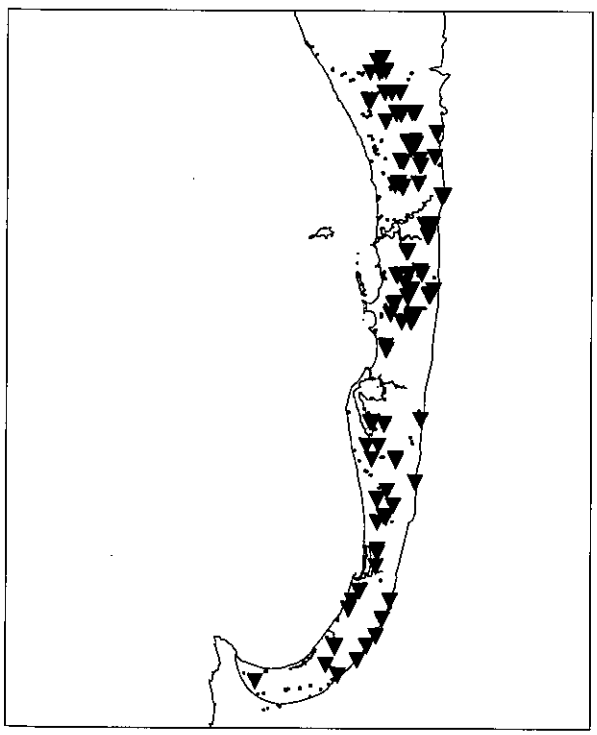
Of the 66 types currently identified, five floristic community types are apparently confined to the Perth Metropolitan Region (Table 6) and eight are absent from the Perth Metropolitan Region.

Figure 2: Distribution of the four major floristic groups (Supergroups) across the Swan Coastal Plain (Gibson *et al.*, 1994)

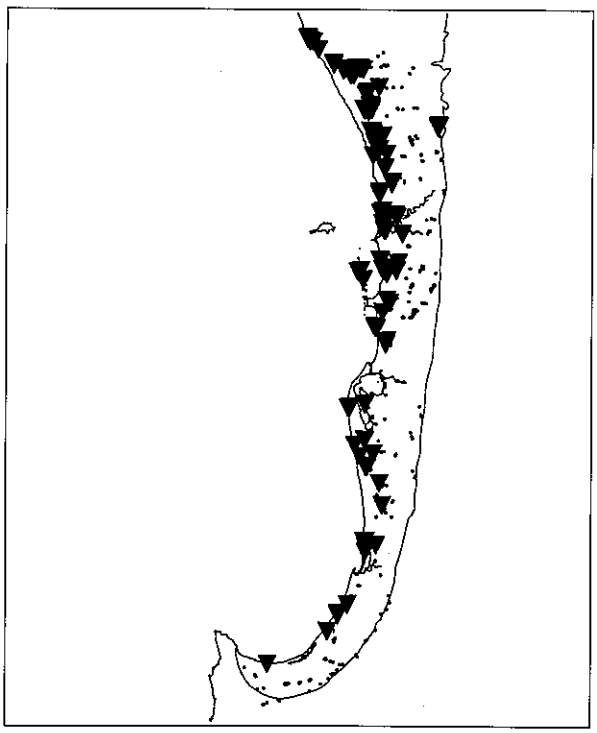
Supergroup 1 – Foothills/Pinjarra Plain



Supergroup 2 – Seasonal Wetlands



Supergroup 3 – Uplands, centred on Bassendean Dunes



Supergroup 4 – Uplands, centred on Spearwood and Quindalup Dunes

Table 6: Floristic Community Types (identified in Gibson *et al.*, 1994, and in the System 6 and Part 1 Update, DEP, 1996)

Key

Column 1: Floristic Community Type Codes

The numbers of the types additional to Gibson *et al.* (1994) are italicised if they are subsets of an existing group (in types 19, 20, 23 and 30) and *italicised* and preceded by an S if they are supplementary groups.

Column 2: General Description of Floristic Community Types

Descriptions are based on generalised information from all plots in the group. Structural units are categorised into forest, woodlands, shrublands, sedgelands and herblands after Gibson *et al.* (1994).

Column 3: Distribution in relation to the Perth Metropolitan Region

PMR	confined to PMR		
PMR+	predominantly PMR	N	Northernmost location in the PMR
(PMR)	rare in PMR	S	Southernmost location in the PMR
blank	outside PMR	C	PMR central to distribution
>PMR	distribution goes well beyond the PMR		
	* except for isolated occurrence outside normal range		

Column 4: Average Species Richness per Floristic Community Type

Average species richness per 10m x 10m plot, less those species only occurring in a single plot (single records). Some community types can have a high proportion of single records and these estimates of average species richness are underestimates in some cases.

Supergroup 1 – Foothills/Pinjarra Plain			
1a	*Eucalyptus haematoxylon – E. marginata* woodlands on Whicher foothills	(PMR)/N	66.2
1b	Southern *Eucalyptus calophylla* woodlands on heavy soils		65.0
2	Southern wet shrublands	(PMR)/N	50.3
3a	*Eucalyptus calophylla – Kingia australis* woodlands on heavy soils	PMR+	58.2
3b	*Eucalyptus calophylla – Eucalyptus marginata* woodlands on sandy clay soils	>PMR/N	57.3
3c	*Eucalyptus calophylla – Xanthorrhoea preissii* woodlands and shrublands	>PMR/N	47.7
S8	*Eucalyptus wandoo* woodlands (Scarp)	PMR+/N	44.0
Supergroup 2 – Seasonal Wetlands			
4	*Melaleuca preissiana* damplands	>PMR/C	33.2
5	Mixed shrub damplands	PMR+	38.4
6	Weed dominated wetlands on heavy soils	>PMR	28.3
7	Herb rich saline shrublands in clay pans	>PMR/C	44.8
8	Herb rich shrublands in clay pans	>PMR/C	50.8
9	Dense shrublands on clay flats	PMR+/N	34.8
10a	Shrublands on dry clay flats	>PMR/N	45.9
10b	Shrublands on southern ironstones		53.3
11	Wet forests and woodlands	>PMR/C	28.0
12	*Melaleuca teretifolia* and/or *Astartea* aff. *fascicularis* shrublands	>PMR/N	27.3
13	Deeper wetlands on heavy soils	>PMR/C	16.9
14	Deeper wetlands on sandy soils	PMR+	16.5
15	Forests and woodlands of deep seasonal wetlands	>PMR/C	16.8
16	Highly saline seasonal wetlands	PMR	11.2
17	*Melaleuca rhaphiophylla – Gahnia trifida* seasonal wetlands	>PMR/N*	13.4

Table 6 *(continued)*: Floristic Community Types (identified in Gibson *et al.*, 1994, and in the System 6 and Part 1 Update, DEP, 1996)

18	Shrublands on *calcareous* silts	PMR+/C	36.6
19a	Sedgelands in Holocene dune swales	PMR	25.0
19b	Woodlands over sedgelands in Holocene dune swales	PMR	26.3
S1	Astartea aff. *fascicularis/Melaleuca* species dense shrublands	>PMR/N	22.4
S2	Northern *Pericalymma ellipticum* dense low shrublands	PMR+	17.7
S3	Wet sedgelands on sandy clays	PMR+	10.6
S4	*Regelia ciliata* Dandaragan Plateau wetlands		22.0
S5	*Acacia saligna* wetlands	(PMR)	23.3
S6	Northern dense low shrublands	(PMR)	35.4
S7	Northern woodlands to forests over tall sedgelands alongside permanent wetlands	PMR+	17.7
S17	*Eucalyptus rudis/Agonis linearifolia* wetlands in Bassendean Dunes	(PMR)	15.2
S19	Dense tall shrublands		11.5
S20	Northern shrublands on sandy clays		12.4
	Supergroup 3 – Uplands centred on Bassendean Dunes and Dandaragan Plateau		
20a	*Banksia attenuata* woodlands over species rich dense shrublands	PMR+/S	64.5
20b	Eastern *Banksia attenuata* and/or *Eucalyptus marginata* woodlands	PMR+/N	59.7
20c	Eastern shrublands and woodlands	PMR	60.4
20d	Dandaragan Plateau shrublands and woodlands		67.6
21a	Central *Banksia attenuata – Eucalyptus marginata* woodlands	PMR/N	52.0
21b	Southern *Banksia attenuata* woodlands		57.5
21c	Low lying *Banksia attenuata* woodlands or shrublands	PMR+	38.5
22	*Banksia ilicifolia* woodlands	>PMR/C	30.0
23a	Central *Banksia attenuata – Banksia menziesii* woodlands	PMR	59.0
23b	Northern *Banksia attenuata – Banksia menziesii* woodlands	>PMR/S	47.0
23c	North-eastern *Banksia attenuata – Banksia menziesii* woodlands	(PMR)	53.0
S9	*Banksia attenuata* woodlands over dense low shrublands	(PMR)/S	38.9
S10	*Calothamnus sanguineus* dense low shrublands on sandy laterites	(PMR)/S	44.2
S16	Mixed dense shrublands on yellow brown sands		38.8
S18	*Eucalyptus marginata/Eucalyptus calophylla* woodlands on laterites	(PMR)/S	35.7
	Supergroup 4 – Uplands centred on Spearwood and Quindalup Dunes		
	Spearwood Dunes		
24	Northern Spearwood shrublands and woodlands	PMR*	38.9
25	Southern *Eucalyptus gomphocephala – Agonis flexuosa* woodlands	>PMR/S	48.1
26a	*Melaleuca huegelii – Melaleuca acerosa* shrublands on limestone ridges	PMR+	49.6
26b	Woodlands and mallees on limestone	PMR+	49.8
27	Species poor mallees and shrublands on limestone	>PMR	37.3
28	Spearwood *Banksia attenuata* or *Banksia attenuata – Eucalyptus* woodlands	>PMR/S	55.1
	Quindalup Dunes		
29a	Coastal shrublands on shallow sands	>PMR/C	33.7
29b	*Acacia* shrublands on taller dunes	>PMR/N*	34.2
30a2	*Callitris preissii* and/or *Melaleuca lanceolata* forests and woodlands	PMR	17.5
30c2	Woodlands and shrublands on Holocene dunes (re-allocated from 30c)	PMR	23.9
30b	Quindalup *Eucalyptus gomphocephala* and/or *Agonis flexuosa* woodlands	(PMR)	35.0
S11	Northern *Acacia rostellifera – Melaleuca acerosa* shrublands	PMR	21.0
S12	Rottnest Island *Melaleuca lanceolata* and/or *Callitris preissii* forests and woodlands		16.0
S13	Northern *Olearia axillaris – Scaevola crassifolia* shrublands	>PMR/S	18.8
S14	*Spinifex longifolius* grassland and low shrublands	PMR	8.6
S15	Weed group Not allied with any supergroup	n/a	n/a

Information Source

Source	Form	Custodian	Coverage
CALM flora survey 1991 – 1993 (Gibson *et al.* 1994)	Database, GIS*	CALM	Swan Coastal Plain (see Map 1)
DEP flora survey 1994 and 1995 (DEP 1996)	Database, GIS*	DEP	Swan Coastal Plain
flora survey (Griffin 1994)	Database GIS*	AgWA	Swan Coastal Plain north of Perth
flora survey (Keighery, G. 1996)	Database GIS*	CALM	Tuart (*Eucalyptus gomphocephala*) woodlands on the Swan Coastal Plain
flora survey, published and unpublished reports	text, lists	N/A	bushland areas on the Swan Coastal Plain

* plot location only

Directory Descriptors (Appendix 1, page 100,101)

Floristic community types are identified in Bushplan Sites in two ways:

(i) plots were located in the area of the Bushplan Site and the floristic community type was determined by analysis

(ii) the floristic community types were inferred from information on the floristics of the area and the area's geographic location. An asterisk indicates an inferred floristic community type.

Floristic community types could not be determined when the remaining vegetation was too disturbed to sample or not enough was known about the vegetation.

Units are grouped as: Supergroup 1 – Foothills/ Pinjarra Plain; Supergroup 2 – Seasonal Wetlands; Supergroup 3 – Uplands, centred on Bassendean Dunes and the Dandaragan Plateau; Supergroup 4 – Uplands centred on Spearwood Dunes and Quindalup Dunes.

4.4.3 WETLANDS

Introduction

The low relief and varied stratigraphy of the Swan Coastal Plain together with the rainfall and runoff from the Darling Plateau, and recharge and discharge of the underlying high ground water, has variably resulted in a complex mosaic of seasonal waterlogging and inundation which characterises Perth's wetlands (Semeniuk, CA 1987). Western Australia's wetlands have been defined as 'areas of seasonally, intermittently or permanently waterlogged soils or inundated land whether natural or otherwise, fresh or saline, e.g. waterlogged soils, ponds, billabongs, lakes, swamps, tidal flats, estuaries, rivers and their tributaries' (Wetland Advisory Committee 1977). This definition is directly comparable with the definition of wetlands used in the State Wetland Conservation Policy (Government of Western Australia 1997, see section 4.6.2) i.e. 'areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed more than six metres'.

Over a quarter of the Swan Coastal Plain land area between Wedge Island to Dunsborough is wetland. Wetlands are biologically some of the most productive and diverse of all areas on the Coastal Plain. They play a critical part in supporting and protecting the values of the estuarine and ground water systems and the life cycles and ecology of the Swan Coastal Plain fauna and flora. Approximately 17 per cent of the wetlands, 15 per cent of the rivers and 42 per cent of the creeks in the Wedge

Island to Mandurah area remain fully vegetated, with a substantial area of the resource partly vegetated. This complex and nationally unique wetland system has only recently been described in extent (Hill *et al.* 1996a&b) and is in its early days of being understood scientifically (Balla 1994).

Table 7: Wetland and Estuary definitions

7a: Wetland types (after Semeniuk, 1987, and Semeniuk and Semeniuk, 1996a&b)

WATER LONGEVITY	LANDFORM				
	BASIN	CHANNEL*	FLAT	SLOPE	HIGHLAND
Permanent inundation	lake*	river	-	-	-
Seasonal inundation	sumpland	creek	floodplain	-	-
Intermittent inundation	playa#	wadi#	barlkarra#	-	-
Seasonal waterlogging	dampland	trough#	palusplain	paluslope	palusmont#

Not used on Swan Coastal Plain in the Perth Metropolitan Region

* Artificial Channels and Artificial Lakes are man-made channels and lakes

7b: Estuaries (after A. Hill pers. comm.)

ESTUARY (waterbody)	that part of an estuary which is permanently or seasonally inundated
ESTUARY (peripheral)	that part of an estuary subject to seasonal waterlogging

Wetland Types

Background

To better describe wetland types in the Darling System Semeniuk, CA (1987) proposed a geomorphic approach to habitat classification based on basin shape and the nature or period of inundation. Twelve wetland types are now recognised from the application of this system: lake, sumpland, dampland, artificial lake, floodplain, palusplain, paluslope, river, creek, artificial channel, estuary waterbody and estuary periphery (Table 7). A detailed description of these wetland types across the Swan Coastal Plain from Wedge Island to Dunsborough has been published on maps and most recently in a comprehensive wetland atlas for the region (Hill *et al.* 1996b).

Information Source

Source	Form	Custodian	Coverage
basin and channel wetland (WRC 1996a)	GIS	WRC	Swan Coastal Plain
flora survey, published and unpublished reports	text, lists	N/A	bushland areas on the Swan Coastal Plain

Directory Descriptors (Appendix 1, page 102)

All wetland types as mapped by the Water and Rivers Commission (1996 GIS, 1997 GIS) that occur within the boundaries of the Bushplan Site are listed. When wetlands had been described from surveys but not mapped on the Water and Rivers Commission GIS they were allocated to a type, listed and annotated with the comment 'includes wetlands not previously described (survey reference)'.

Table 8: Natural Wetland Groups (Consanguineous Suites) (after Semeniuk, 1996). Map codes are in brackets.

Name & location	Geomorphic setting	Primary wetlands	Stratigraphy	Origin of wetlands
Dandaragan Plateau				
Red Gully suite (DP1) 9 km south of Moore River in Dandaragan Plateau	Dandaragan Plateau of gently undulating to flat surface with occasional broad gently sloping valleys alternating with incised creeks	Creeks & floodplains grading into sumplands	Quartz sand	Fluvial incision; surface runoff & depressions receiving groundwater discharge from slopes
Pinjarra Plain				
Keysbrook suite (P1) Alluvial fans along the foothills of the Darling Scarp occurring south of Forrestfield Lake & continuing as far south as Brunswick Junction	Alluvial fans & creeks of the Pinjarra Plain – gently undulating plain dissected by channels	Palusplains, floodplains & creeks	Clay overlying lateritic clay & sand	Sediment discharge to develop alluvial fans; groundwater seepage, & surface runoff from the plateau & ponding of precipitation
Ellen Brook suite (R3) Ellen Brook area	Pinjarra Plain	Creek, floodplain river	Clays & sandy clays overlying laterite & sandstones	Fluvial incision; sedimentation; surface runoff
Bassendean – Pinjarra transition OR Bassendean with fluvial features				
Mungala suite (B/P2) Perth Airport surrounds including Wright Lake	Transition between Bassendean Dunes & Pinjarra Plain. Underlying stratigraphy is a complex of sands, clays, calcrete & laterite. Wetlands lie along depressions at the distributary ends of the creeks or adjacent to intermittent disconnected drainage channels	Lakes, sumplands, floodplains & creeks	Variable: clays to clay overlying quartz sand to quartz sand overlying laterite or calcrete	Alluvial fan distributaries of creeks terminate in wetlands already present in Bassendean sandplain, bringing water & sediment
Muchea suite (B/P3) 1. Western margin of Whitfield Brook e.g. Six Mile Swamp 2. Western margin of Ellen Brook	Complex transition between Bassendean Dunes & Pinjarra Plain. Wetlands lie along the depressions at the base of Bassendean Dunes & at the headwaters of the tributaries of creeks	Sumplands & floodplains	Complex & variable pattern of quartz sand, clays, laterite & calcrete	Discharge of groundwater into basins, flats & creeks. Ponding of rainwater & groundwater occurs over impermeable sediments

Table 8 *(continued)*: Natural Wetland Groups (Consanguineous Suites) (after Semeniuk, 1996). Map codes are in brackets.

Name & location	Geomorphic setting	Primary wetlands	Stratigraphy	Origin of wetlands
Bennett Brook suite (B/P4) 1. Ballajura: In Bennett Brook area west of West Swan 2. Balannup: In Southern River area north of Forrestdale Lake 3. Yangedi: In Serpentine River area west of Serpentine township	Bassendean Dune – with microscale creeks	Sumplands creeks palusplains floodplains	Quartz sands, or clay overlying quartz sand	Depressions which intersect the water table. Precipitation is ponded by clay lenses in the sub-surface. Palusplains are situated between tributaries
Bassendean Dunes				
Lake Pinjar suite (B1) Lake Pinjar area	Bassendean Dunes with higher undulating dunes on the western margin of the wetland	Sumpland	Quartz sand sheet overlying clay sheet on Bassendean Sand	Coalesced Bassendean Dune wetlands; meteoric water & discharge water from Gnangara Mound ponded by clay bed
Gnangara suite (B2) East of Wanneroo includes Lake Gnangara & Lake Jandabup	Bassendean Dunes with slightly higher undulating dunes on western margin of this area. Wetlands enclosed by saddles or ridges	Lakes & sumplands & occasional damplands	Diatom mud peaty sand & clay overlying quartz sand. Hardpans (ferricreted quartz sand) at level of water table	Groundwater wetlands. Large lakes appear as coalesced smaller basins. Drainage is impeded by thin clay, diatom mud or ferricrete layers superimposed on, or within, the quartzose Bassendean sand
Jandakot suite (B3) 1. Nine Mile Swamp area 2. Spade Lake to Caladenia lake area 3. Bindiar area 4. Gnangara Pine Forest area 5. Jandakot area	Bassendean Dunes comprised of low dunes & depressions	Damplands & sumplands	Peat or peaty sand or humic sand overlying quartz sand	Groundwater surfacing or near surface in depressions to develop water table basins
Riverdale suite (B4) 1. West of Gingin, north & south of Gingin Brook 2. East Pinjar Lake area 3. Harvey River Flats area	Bassendean Dunes comprised of low, regularly undulating dunes	Sumplands	Clay, peat or peaty sand overlying quartz sand	Wetlands occur in regularly spaced depressions as parallel microscale interdunal swales to form linear, parallel chains; recharge by precipitation & groundwater rise, often maintained by ponding on a clay or peat bed

Table 8 *(continued)*: Natural Wetland Groups (Consanguineous Suites) (after Semeniuk, 1996). Map codes are in brackets.

Name & location	Geomorphic setting	Primary wetlands	Stratigraphy	Origin of wetlands
Spearwood Dunes				
Yanchep suite (S1) Between Yanchep to the north & Kingsley to the south in a linear belt about 5 km inland from the coast	Spearwood Dunes Unit – area of parallel, coastal dune ridges, up to 40-60 m above mean sea level, & associated segmented depressions	Lakes & sumplands	Thin layer of peat overlying grey to yellow sand	Wetlands occur in depressions between limestone ridges fed by discharge from limestone & groundwater table rise; basins are young karst features
Balcatta suite (S2) In a 5 x 10 km area north of the Swan River estuary about 3 km inland from the coast	Spearwood Dunes Unit/area of hills & depressions within the limestone dune ridges	Sumplands & lakes subsequent to clearing of vegetation e.g. Carine Swamp	Variable: peat overlying yellow sand, to peat & clay overlying thick yellow sand	Wetlands occur in depressions between hills; possibly old (mature) karst features
Coogee suite (S3) In a linear belt 1-2 km inland from the coast, east of Woodman Point	Spearwood Dunes Unit – inter dune ridge depression overlying limestone	Lakes & sumplands	Carbonate mud overlying limestone	Carbonate mud filled depressions now acting to pond meteoric water
Stakehill suite (S4) Linear belt extending from Wattleup to Mandurah	Spearwood Dunes Unit – ranging from ridges of limestone outcropping to ridges of yellow sand overlying limestone	Lakes & sumplands	Carbonate mud & peat over-lying yellow sand	Carbonate mud & peat filled depressions; probably originally karst depressions superimposed on palaeotopographic features
Spearwood – Bassendean Dunes Interface				
Bibra suite (SB1) 1. Linear belt extending south from Bidaminna to Caladenia Cave 2. Linear belt extending from Murdoch to Wellard, in a N/S orientation approximately 5-7 km east of the coast	Spearwood Dunes & Bassendean Dunes contact depression. Continuous high dune ridges to the west & a series of discontinuous hollows & hills with lower relief to the east.	Lakes & sumplands in a north-south oriented chain	Mud, peat, or peaty sand overlying Bassendean Sand	Contact depressions with groundwater impounded against Spearwood Dune ridge
Quindalup Dunes				
Cooloongup suite (Q1) Rockingham area Shoalwater Bay & Baldivis	Quindalup Dunes/ Spearwood Unit beachridge plain	Lakes	Carbonate mud overlying Becher sand or for Lake Richmond unfilled with sediment	Wetlands originated as barred oceanic basins as part of the prograding shoreline; now freshwater recharged
Becher suite (Q2) Between Safety Bay & Peelhurst, in the coastal dune area, locally at Preston	Quindalup Dunes – specifically the small scale plain of parallel beachridges	Sumplands & damplands	Humic sand or peat & thin carbonate mud overlying Safety Bay sand	Wetlands are a series of primary inter-ridge depressions which intersect or lie close to the water table in a prograding coastal beachridge plain

Table 8 *(continued)*: Natural Wetland Groups (Consanguineous Suites) (after Semeniuk, 1996). Map codes are in brackets.

Name & location	Geomorphic setting	Primary wetlands	Stratigraphy	Origin of wetlands
Peelhurst suite (Q3) Narrow strip, 3 km long along the coast south of Becher Point; locally along the west short of Lake Walyungup & in isolated areas such as Whitfords cusp	Quindalup Dunes – specifically area of semi-mobile dunes & blowout depressions	Sumplands & damplands	Safety Bay Sand overlain by (carbonate) muddy sand	Wetlands are basins deflated to the level of the water table by prevailing onshore winds
Estuaries				
Swan River Estuary suite (E2) Swan River area between Fremantle & Guildford	Traversing 3 dune units: Quindalup, Spearwood & Bassendean. Flooded basins extend north & south of Swan River channel along depressions between Spearwood Dune ridges & Bassendean Dunes.	Estuary	Mud & sand overlying quartz sand & limestone	Marine-inundated river valley which was receiving basin for Canning, Helena & Swan Rivers
Swan Coastal Plain Rivers				
Swan River suite (R2) Swan River, Helena River, Canning River, Serpentine River	Traversing the Swan Coastal Plain; incised channel alternates with braided shallow channel, terraces & large point bar deposits	River, floodplain	Alluvium of quartz sand & clay	Fluvial incision; sedimentation; surface runoff
Goegrup suite (R4) Serpentine River section north of Peel Inlet to Karnup	Contact depression between Spearwood Dunes Unit & Bassendean Dunes Unit – along which Serpentine River meanders	River, floodplains, palusplains & creeks	Quartz sand with iron indurated hardpans	Fluvial incision; sedimentation; river has been impounded & water flow reduced

Natural Wetland Groups (Consanguineous Suites)

Background

Forty-two natural wetland groups or consanguineous suites were described in the Perth to Bunbury region (northern boundary being the Moore River) after considering wetland similarity in response to factors of geomorphic setting, origin and water maintenance (Semeniuk CA 1987, Semeniuk CA 1996). These groupings provide a regional perspective on wetlands, assist in understanding the hydrologic maintenance requirements of the different wetland systems and provide assistance to assessments of the conservation value of wetlands (Hill *et al.* 1996a&b). This work has been used in the Water and Rivers Commission's regional assessment to ensure representation of wetland suite and type is adequately considered in the description of management categories. A systematic description of all wetlands by wetland suites and types has been published (Hill *et al.* 1996a&b).

The 21 consanguineous suites that occur within the Perth Metropolitan Region are listed alongside their characteristics in Table 8.

Information Source

Source	Form	Custodian	Coverage
mapped consanguineous suites (WRC 1996b)	GIS	WRC	Swan Coastal Plain north of Bunbury

Directory Descriptors (Appendix 1, page 102, 103)

All wetland suites as mapped on the Water and Rivers Commission GIS (1996 GIS) which intersect with bushland within the boundaries of the Bushplan Site are listed.

Suites are grouped according to landform elements, that is, Darling Plateau-Dandaragan Plateau interface, Dandaragan Plateau, Pinjarra Plain, Bassendean-Pinjarra transition or Bassendean with fluvial features, Bassendean Dunes, Spearwood-Bassendean interface, Spearwood Dunes, Quindalup Dunes, Swan Coastal Plain Rivers and Estuaries.

Wetland Management Objectives

Background

An assessment by the Water and Rivers Commission of the appropriate preliminary management category for 4,700 basin and flat wetlands in the Wedge Island to Mandurah area has been published in maps and reports (Hill and Del Marco 1996, Hill et al. 1996b). It is based on the existing recognition of wetland values at the international, national or regional level, the application of the Department of Environmental Protection's wetland evaluation method (EPA 1990) and the Commission's review of categories using 1993 assessments of wetland vegetation status/naturalness (Hill and Del Marco 1996, Hill *et al.* 1996b).

The management categories described by the Water and Rivers Commission are outlined below:

- Conservation wetlands: 'Wetlands recognised at the international, national or regional level, "High Conservation" and "Conservation" wetlands identified using Bulletin 374 (EPA 1990) assessment; wetlands 95–100% vegetated, sections of extensive wetlands' (Hill and Del Marco 1996 p 102). Conservation Category Wetlands are wetlands for which the appropriate management regime has the objective of preserving their natural attributes and functions.
- Resource Enhancement: 'Wetlands 10–94% vegetated and Bulletin 374 (EPA 1990) "Resource enhancement" and "Open Space" wetlands not identified above' (Hill and Del Marco 1996 p 102). Resource Enhancement Category Wetlands are wetlands for which the appropriate management objective should be restoration through maintenance and enhancement of natural attributes and functions.
- Multiple Use: 'Wetlands 0–9% vegetated, Bulletin 374 "Multiple Use" (EPA 1990) wetlands not identified above' (Hill and Del Marco 1996 p 102). Multiple Use Category Wetlands are wetlands most appropriately managed for their use and development in the context of water, town and environmental planning.

In the context of these definitions 'vegetated' refers to uncleared native vegetation which may be in any of the vegetation condition categories described in the section on Vegetation Condition (section 4.5.3). For the purposes of Perth's Bushplan channel wetlands that are 75% – 100% vegetated are given Conservation Category Wetland status (Hill and Del Marco 1996 p. 96).

Some of the most vulnerable Conservation Category Wetlands in the Perth Metropolitan Region were subject to boundary verification and field visits in January 1997 (Semeniuk, V & C Research Group 1997) to assist in selection of areas to be included in Perth's Bushplan (see Volume 1, Map 2, and Volume 2, Part C). These verified Conservation Category Wetlands may still include some wetland areas which are relatively degraded.

However, from the analysis, these include some of the best remaining examples of particular wetland suites and types (Semeniuk, V & C Research Group 1997), or on some single criterion (Hill and Del Marco 1996) are considered worthy of protection and rehabilitation in conservation reserves and through other complementary mechanisms.

While many channel wetlands have not been identified in Bushplan Sites, channels in the following categories are recognised as wetlands warranting protection, conservation and restoration (see Volume 1, Map 5). These categories are:

- rivers and creeks with existing specified regional significance
- principal channels for multiple-use corridors (or regional greenways)
- creeks that remain fully or partly vegetated.

These channel wetlands warrant protection and enhancement under existing and future State foreshore, catchment and environmental protection policies.

Information Source

Source	Form	Custodian	Coverage
basin and channel wetlands (WRC 1996a)	GIS	WRC	Perth Metropolitan Region
verified conservation category wetlands (Semeniuk, V&C Research Group 1997, WRC 1997)	reports, GIS	WRC	Perth Metropolitan Region
flora survey, published and unpublished reports	text, lists, vegetation maps	N/A	bushland areas on the Swan Coastal Plain

Directory Descriptors (Appendix 1, page 103)

All wetlands, as identified previously, are placed in management categories as described by Hill and Del Marco (1996). The area or length of each conservation category wetland is given. When wetlands had been described from survey work but not mapped by the Water and Rivers Commission (1996 GIS) they were allocated to a management category, listed and annotated with the comment 'includes wetlands not previously described (survey reference)'.

Categories are: Conservation, Resource Enhancement and Multiple Use.

Environmental Protection (Swan Coastal Plain Lakes) Policy

Background

The Environmental Protection (Swan Coastal Plain Lakes) Policy (referred to as the Swan Coastal Plain Lakes EPP) was gazetted in December 1992 (Government of Western Australia 1992c) to protect 'Swan Coastal Plain Lakes', a selection of permanently and seasonally inundated wetlands on the Swan Coastal Plain. Under the terms of this policy a 'lake' is 'a Swan Coastal Plain wetland with surface water of at least 1,000 square metres at the 1st December 1991 (the first day of summer)' (EPP lake).

All such EPP lakes are mapped on Department of Land Administration Miscellaneous Plan No. 1815. Wetlands identified in the Policy are protected from unauthorised filling, mining, effluent disposal and drainage.

Information Source

Source	Form	Custodian	Coverage
Department of Land Administration Miscellaneous Plan No. 1815 (DEP 1992b)	GIS	DEP	Swan Coastal Plain

Directory Descriptors (Appendix 1, page 103)

The following two categories were used in describing EPP lakes:

(i) 5ha, 10ha etc. — the area of each lake defined by the EPP within the Site

(ii) none identified — no area of EPP lake in the Site

Table 9: Definitions of the status of the threat to Ecological Communities (English and Blyth, 1997)

Category 1

Presumed Totally Destroyed

An ecological community which has been adequately searched for but for which no representative occurrences have been located. The community has been found to be totally destroyed or so extensively modified throughout its range that no occurrence of it is likely to recover its species composition and/or structure in the foreseeable future.

Category 2

Critically Endangered

An ecological community which has been adequately surveyed and found to have been subject to a major contraction in area and/or which was originally of limited distribution and is facing severe modification or destruction throughout its range in the immediate future, or is already severely degraded throughout its range but capable of being substantially restored or rehabilitated.

Category 3

Endangered

An ecological community which has been adequately surveyed and found to have been subject to a major contraction in area and/or was originally of limited distribution and is in danger of significant modification throughout its range or severe modification or destruction over most of its range in the near future.

Category 4

Vulnerable

An ecological community which has been adequately surveyed and found to be declining and/or has declined in distribution and/or condition and whose ultimate security has not been assured and/or a community which is still widespread but is believed likely to move into a category of higher threat in the near future if threatening processes continue or begin operating throughout its range.

Category 5

Data Deficient

An ecological community for which there is inadequate data to assign it to one of the above categories and/or which is not yet evaluated with respect to status of threat.

(Usually an ecological community with poorly known distribution or biology that is suspected to belong to any of the above categories. These ecological communities have a high priority for survey and/or research.)

Category 6

Lower Risk

A community which has been adequately surveyed and evaluated and available information suggests that it does not qualify for one of the above categories of threat.

Table 10: Threatened Ecological Communities on the Swan Coastal Plain in the Perth Metropolitan Region (after English and Blyth, 1997)

KEY	CR Critically Endangered EN Endangered VU Vulnerable *Floristic community type as identified in Gibson et al. 1994	
A. Floristic Community Types		
Supergroup 1 – Foothills/Pinjarra Plain		
2	Southern wet shrublands	EN
3a	*Eucalyptus calophylla – Kingia australis* woodlands on heavy soils	CR
3b	*Eucalyptus calophylla – Eucalyptus marginata* woodlands on sandy clay soils	VU
3c	*Eucalyptus calophylla – Xanthorrhoea preissii* woodlands and shrublands	CR
Supergroup 2 – Seasonal Wetlands		
7	Herb rich saline shrublands in clay pans	VU
8	Herb rich shrublands in clay pans	VU
9	Dense shrublands on clay flats	VU
10a	Shrublands on dry clay flats	EN
15	Forests and woodlands of deep seasonal wetlands	VU
18	Shrublands on calcareous silts	VU
*19	Sedgelands in Holocene dune swales	CR
Supergroup 3 – Uplands, centred on Bassendean Dunes and the Dandaragan Plateau		
20a	*Banksia attenuata* woodlands over species rich dense shrublands	EN
20b	Eastern *Banksia attenuata* and/or *Eucalyptus marginata* woodlands	EN
20c	Eastern shrublands and woodlands	CR
Supergroup 4 – Uplands centred on Spearwood and Quindalup Dunes		
Quindalup Dunes		
*30a	*Callitris preissii* and/or *Melaleuca lanceolata* forests and woodlands	VU
B: Restricted floristic community type mosaics		
Shrublands and woodlands on Muchea Limestones (Keighery, G), and Keighery 1995)		CR
C: Freshwater communities		
Communities of Tumulus Springs (Jasinska and Knott 1994, Ahmat 1993)		CR
Stromatalite-like microbialite community of coastal freshwater lakes (Lake Richmond, Moore 1993)		CR
Aquatic root mat community of caves of the Swan Coastal Plain (Jasinska 1997, Jasinska and Knott 1995)		CR

4.4.4 THREATENED ECOLOGICAL COMMUNITIES

Background

Over recent years the Department of Conservation and Land Management's Western Australian Threatened Species and Communities Unit (WATSCU), with financial help from Environment Australia, has developed a procedure for identifying 'threatened ecological communities' (English and Blyth 1997). Ecological communities are defined as 'naturally occurring biological assemblages that occur in a particular type of habitat'.

Information on the geographic extent of each ecological community and the threatening processes

that may be operating on the community is used to determine if an ecological community is 'threatened'. Threatened ecological communities are those that have been assessed and assigned to one of four categories related to the status of the threat to the community. The categories are 'Presumed Totally Destroyed', 'Critically Endangered', 'Endangered' or 'Vulnerable' (Table 9). Two further categories — 'Data Deficient' and 'Lower Risk' — are also distinguished. Ecological communities identified as 'data deficient' are usually communities with poorly known distributions which are suspected of belonging to one of the threatened categories. The 'lower risk' category describes communities that are well enough known and surveyed and not considered to be under threat.

On the Swan Coastal Plain a number of floristic studies (Gibson *et al.* 1994, Keighery, GJ, and Keighery 1995, DEP 1996) and freshwater organism studies (Ahmat 1993, Moore 1993, Jasinska and Knott 1994, 1995, Jasinska 1997) have delineated ecological communities in a form adequate for assessment. Twenty-four ecological communities defined by these studies have been assessed. One was considered 'data deficient' (floristic community type 14, Gibson et al. 1994) and 23 'threatened'. Nineteen of these communities occur within the Perth Metropolitan Region (Table 10).

CALM is working with government agencies and private land holders on whose lands these communities have been identified to protect and manage these threatened ecological communities.

Due to insufficient time the remaining ecological communities (floristic community types) identified by Gibson *et al.* (1994) have not been assessed. Also some of the additional floristic community types identified in the System 6 and Part System 1 Update Program (DEP 1996, Table 6) may be classified as 'threatened' once they are assessed. For example floristic community type S5 is only known from two bushland areas, one in the Perth Metropolitan Region and another in Bunbury.

Information Source

Source	Form	Custodian	Coverage
English and Blyth (1997); MfP & CALM (1996) (with additional locations from DEP 1996)	listed areas, point locations	MfP & CALM	N/A, determined in response to the identification of ecological communities by expert study

Directory Descriptors (Appendix 1, page 103)

The following categories are used in describing 'threatened' ecological communities:

- Not determined — applies to communities not referred to in English and Blyth (1997)
- Not assessed — applies to communities referred to in English and Blyth (1997) but yet to be assessed (generally considered not at risk)
- Critically Endangered, Endangered, Vulnerable — status of threat determined by English and Blyth (1997)

4.5 *SECTION 3: SPECIFIC SITE DETAIL*

4.5.1 INTRODUCTION

The information presented in *SECTION 3* essentially describes the area on the ground, that is, what it looks like. Specific information on the areas comes from survey data collected in the floristic surveys (databases used for/in Gibson *et al.* 1994, DEP 1996 and Griffin 1994), DEP survey records (DEP 1998), MfP survey (including Connell 1995, Mattiske Consulting Pty Ltd 1997), Western Australian Museum of Natural Science surveys, CALM's Bandicoot survey (Friend 1996 D) and published and unpublished reports. The level of detail varies, being dependent on the detail of survey on the particular area. Standard descriptions are used to indicate this level of detail.

4.5.2 LANDSCAPE FEATURES

Directory Descriptors (Appendix 1, page 103)

General landscape features as observed during survey are broadly described to give the general physical characteristics of the area. In general each term is self explanatory. The terms are:

- river — limestone cliff (Tamala Limestone)
- ocean — limestone cliff (Tamala Limestone)
- limestone ridge (Tamala Limestone)
- Muchea Limestone (limestone found on the eastern side of the Swan Coastal Plain)
- ironstone (locally formed ironstones found in the Pinjarra Plain)
- tall dune
- open water
- vegetated wetland (seasonally inundated or waterlogged)
- creek or streamline
- river
- estuary
- island
- vegetated uplands.

4.5.3 VEGETATION AND FLORA

Background

Information on the vegetation and flora of the bushland in each Bushplan Site has been grouped under a series of headings: Structural Units, Remnant Vegetation, Vegetation Condition, Total Flora and Significant Flora. This information has been collated from the surveys outlined in section 4.4.2 above and published and unpublished reports.

Information Source — see under Structural Units, Remnant Vegetation, Vegetation Condition, Total Flora and Significant Flora.

Directory Descriptors

Vegetation and flora information has been collated from CALM, DEP and MfP surveys and published and unpublished studies. For ease of reference these are listed at the beginning of 'Vegetation and Flora' and repeated as necessary under each of the other headings. The surveys and published and unpublished studies are categorised under the following headings:

- not known — area not visited, studies not known
- limited survey — area visited on a limited basis (generally once or twice); principal vegetation units described. (The majority of the survey work to locate floristic study plots falls into this category; all plots are listed by code and study source, see section 4.4.2 Floristic Community Types.)
- detailed survey — multiple visits, the entire area traversed, vegetation generally mapped, flora list prepared
- not field-surveyed (aerial photography interpretation only) — area not visited within the time of the project

Structural Units

Background

The basic patterning of the plant communities on the Plain is related to a series of broad vegetation formations (plant associations, assemblages or communities) described according to dominant

species and the structure and density of these dominants. Structural units are used at the regional and local level to map vegetation. For example Beard (1979a&b) maps vegetation on the Swan Coastal Plain (region) and Keighery, GJ, and Keighery (1993) maps individual areas (local) on the Plain. These broad units and associated dominant species are described below:

Open Forests and Woodlands dominated by a wide variety of trees, either individually or in various combinations. The major tree species are:

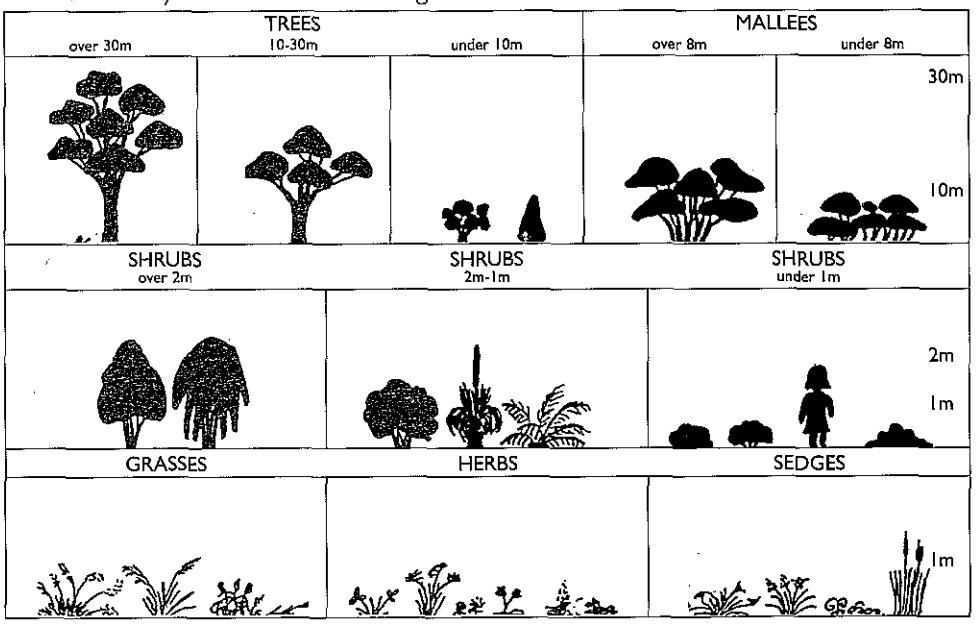
- Eucalypts — *Eucalyptus calophylla, E. wandoo, E. marginata, E. todtiana, E. rudis, E. decipiens, E. lanepoolei, E. haematoxylon* and *E. gomphocephala*
- Sheoaks — *Allocasuarina fraseriana* and *Casuarina obesa*
- Banksias — *Banksia attenuata, B. menziesii, B. prionotes, B. ilicifolia, B. grandis* and *B. littoralis*
- Melaleucas — *Melaleuca preissiana, M. rhaphiophylla* and *M. lanceolata*
- Rottnest Island Cypress — *Callitris preissii.*

Figure 3: Categories of vegetation information used to describe vegetation structure (Keighery, BJ, 1994a)

Each layer of vegetation in a plant community is described according to life form, height, cover and dominant species.

- **Life Form/Height**

Each layer in the community is described according to the divisions shown below.



- **Cover**

A measure of the plant cover in each layer is recorded. Plant cover (or crown cover) is the total area under an imaginary line bounding the extremities of all the plants in each layer described. To simplify the estimation of cover, cover 'classes' are used:

Cover Classes	2–10%	10–30%	30–70%	over 70%

Not all layers will be present in a site. Table 11 is used to name the vegetation structural classes from the information on the life form, height and cover.

- **Dominant Species**

The principal species in each layer are included in the description of the structural layers.

Shrublands

The dominant shrub species of these communities are too numerous to attempt to list, probably numbering close to 200. Examples are from the following genera: *Jacksonia, Viminaria, Daviesia, Leucopogon, Regelia, Banksia, Dryandra, Grevillea, Hakea, Petrophile, Stirlingia, Gompholobium, Calytrix, Verticordia, Pericalymma, Melaleuca, Hibbertia, Halosarcia, Sarcocornia, Xanthorrhoea, Kingia* and *Acacia* .

Herblands

Again the dominant herb species are too numerous to list. Examples are from the following genera: *Borya, Phlebocarya, Lomandra, Anigozanthos, Conostylis, Patersonia, Drosera* and *Stylidium.*

Sedgelands

Similarly the dominant sedge and rush species are too numerous to list. Examples are from the following genera: *Baumea, Gahnia, Evandra, Schoenus, Mesomelaena, Alexgeorgea, Cyathochaeta, Loxocarya, Leptocarpus, Restio* and *Juncus.*

Grasslands

Grasslands are not a very significant component of the flora of the Plain. Their greatest area of representation is on the Quindalup Dunes. Important genera are *Spinifex, Austrostipa, Austrodanthonia* and *Poa.*

The various combinations of these broad vegetation formations and the patterning of the hundreds of individual taxa found on the Perth Metropolitan Region portion of the Plain have resulted in the complex series of communities on the Plain. This structural diversity is significant as vegetation structure is an important aspect of landscape and has

Table 11: Vegetation Structural Classes (Keighery, BJ, 1994 (Adapted from Muir, 1977, and Aplin, 1979))

Life Form/ Height Class	Canopy Cover (percentage)			
	100 – 70%	70 – 30%	30 – 10%	10 – 2%
Trees over 30m Trees 10 – 30m Trees under 10m	Tall Closed Forest Closed Forest Low Closed Forest	Tall Open Forest Open Forest Low Open Forest	Tall Woodland Woodland Low Woodland	Tall Open Woodland Open Woodland Low Open Woodland
Tree Mallee Shrub Mallee	Closed Tree Mallee Closed Shrub Mallee	Tree Mallee Shrub Mallee	Open Tree Mallee Open Shrub Mallee	Very Open Tree Mallee Very Open Shrub Mallee
Shrubs over 2m Shrubs 1 – 2m Shrubs under 1m	Closed Tall Scrub Closed Heath Closed Low Heath	Tall Open Scrub Open Heath Open Low Heath	Tall Shrubland Shrubland Low Shrubland	Tall Open Shrubland Open Shrubland Low Open Shrubland
Grasses	Closed Grassland	Grassland	Open Grassland	Very Open Grassland
Herbs	Closed Herbland	Herbland	Open Herbland	Very Open Herbland
Sedges	Closed Sedgeland	Sedgeland	Open Sedgeland	Very Open Sedgeland

particular significance for fauna habitat. Mature plants of individual species, especially trees and tall shrubs, have significant biological and landscape values.

The diversity of vegetation structural units varies between the major landform elements. Structural diversity is greatest within the Spearwood Dunes and lowest within the Banksia Woodlands. This structural diversity is accentuated in the Spearwood Dunes as it combines with the greatest landscape diversity on the Plain.

In an individual bushland area the structural units are generally described in a number of categories related to the height class of each life form, the cover of each layer and the dominant species (Figure 3). The scale (regional or local) at which the vegetation is described and the subjective nature of cover determination can lead to some inconsistencies in descriptions of the same area.

Information Source

Source	Form	Custodian	Coverage
CALM flora survey 1991 – 1993 (Gibson *et al.* 1994)	database, GIS	CALM	individual bushland areas on the Swan Coastal Plain
DEP flora survey, 1994 – 1995 (DEP 1996)	database, GIS	DEP	individual bushland areas on the Swan Coastal Plain
DEP flora survey, 1994 – 1998 (DEP 1996, DEP 1998)	survey sheets	DEP	individual bushland areas on the Swan Coastal Plain
flora survey (Griffin 1994)	database, GIS	AgWA	individual bushland areas on the Swan Coastal Plain
flora survey (Keighery, GJ 1996)	database, GIS	CALM	individual bushland areas on the Swan Coastal Plain
flora survey (Mattiske Consulting Pty Ltd 1997)	text, lists	MfP	individual bushland areas on the Swan Coastal Plain
flora survey, published and unpublished reports	text, lists, vegetation maps	N/A	individual bushland areas on the Swan Coastal Plain
submissions to the System 6 and Part System 1 Update Program, various dates	text, lists	DEP	individual bushland areas on the Swan Coastal Plain

Directory Descriptors (Appendix 1, page 103)

Vegetation structural information has been collated from CALM, DEP and MfP surveys and published and unpublished studies. These are referenced at the beginning of the vegetation and flora section. Studies that include vegetation maps are indicated and referenced.

For uniformity a single vegetation structural code has been used (Table 11). When necessary, vegetation descriptions have been modified to conform with this code and/or several sources of structural information on the same area have been combined. The original descriptions can be found in the references quoted. In general, vegetation structural descriptions only refer to the dominant layer with the dominant species in this layer listed.

Scattered Native Plants

For Bushplan Sites in which there are areas of native vegetation that do not meet the definition of bushland (completely degraded, see Vegetation Condition below), an estimate of the area with some natural vegetation is made, if possible. When trees are present the type of woodland or forest is given. When insufficient detail of the Site is available this category is 'not assessed'.

Vegetation Condition

Background

Change is a feature of bushland. 'Individual plants grow, flower and shed seed. Plants age and die, to be replaced by others, either from seed or by vegetative growth. Changes in a plant community may be cyclic or directional. Broadly speaking, natural cycles in the plant community may be maintained by recurring events such as fire or flood. After these, species already in the habitat, perhaps as soil-stored seed, are recruited and the vegetation gradually regains its former structure. Depending on the sequence of events and weather conditions, slightly different combinations of species may be favoured, but the plant community is essentially self-maintaining. Directional change may be induced by habitat disturbance which alters soil and water properties, and allows recruitment of species not native to the habitat, in particular, exotic weeds. Such changes generally lead to bushland deterioration.' (Benson and Howell 1990).

Activities that adversely affect the self maintenance of bushlands are commonly called disturbance factors. Such factors include partial clearing, fragmentation, selective removal of species (for example timber cutting, wildflower picking, mowing), dieback, fire regime, 'enrichment plantings' (that is plantings of species not found in that plant community), weed invasion, animal impact (horses, foxes, rabbits, cats, dogs), soil movement (both removal and dumping), changes in water regimes (flooding, drainage and watering), rubbish dumping, mining (particularly that for roadworks), grazing (stock, overgrazing by native mammals), proliferation of tracks (fire breaks and walk trails), off-road vehicle use, use as service corridors (for electricity, gas, roads and water), fertiliser drift and pesticide or nutrient influx along waterways.

Not all of these factors have the same level of impact but, generally they are interrelated, the presence of one type of disturbance leading to further disturbance. The observed disturbance is most often the cumulative result of a series of compounding disturbance factors.

An assessment of disturbance, in relation to the ability of the bushland to self-maintain, has been used as the basis of defining condition ratings for plant communities. The three most widely used scales are given in Table 12 and the relationship between these scales indicated. Condition scales in the Perth Metropolitan Region used in Perth's Bushplan follow Keighery, BJ ((1994); also see Table 12, left-hand column). Two of these condition ratings were developed from Trudgen (1991). Such detailed condition ratings were designed to describe the condition of 100-square-metre plots (accurately located areas) or relevees (approximately located areas). In each case the condition rating is related to the vegetation structure, that is, the impact of disturbance on each of the layers and consequently on the ability of the community to regenerate.

In the actual assessment of vegetation condition in the field it is important to understand the basis of the condition ratings and the particular features of the individual plant communities being assessed. For example, woodlands of the Quindalup and Spearwood Dunes in pristine to excellent condition typically have areas of bare sand and Quindalup Dunes shrublands typically have a native grass layer. If either of these two features are absent or replaced by weeds the vegetation is degraded. Much of the confusion between condition ratings determined by different studies is related to inexperience with the variation in plant communities on the Plain and the subjective aspects of condition determination.

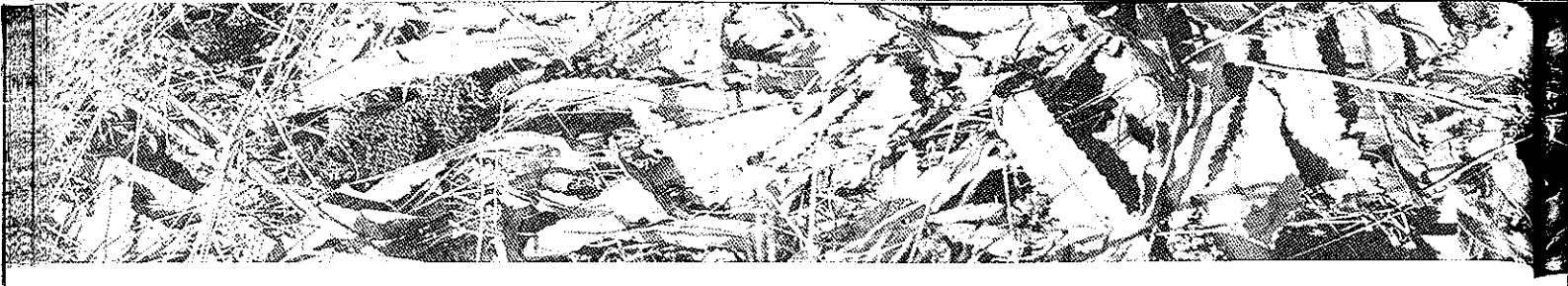


Table 12: Vegetation Condition Scales commonly used in the Perth Metropolitan Region

Condition scale used in *PERTH'S BUSHPLAN* DIRECTORY from Keighery B J (1994)	Condition scale used to derive Keighery B J (1994) and Connell (1995) after Trudgen (1991)	Condition scale used in PEP MAPPING after Connell (1995)
Pristine (1) Pristine or nearly so, no obvious signs of disturbance	**Excellent (E)** Pristine or nearly so, no obvious signs of damage caused by the activities of European man.	No equivalent unit
Excellent (2) Vegetation structure intact, disturbance affecting individual species and weeds are non-aggressive species.	**Very Good (VG)** Some relatively slight signs of damage caused by the activities of European man. For example, some signs of damage to tree trunks caused by repeated fires and the presence of some relatively non-aggressive weeds such as *Ursinia anthemoides* or *Briza* species, or occasional vehicle tracks.	**Very Good (vg)** Evidence of localised low level damage to otherwise healthy bush. Seedling recruitment and generally healthy population size (age/stage) structure apparent. Weed and grazing damage is confined (<20% of area). Some modification to vegetation structure due to changes in fire regimes may be apparent. Evidence of logging or fire wood collection may be found. High likelihood that vegetation structure and species richness can be maintained.
Very Good (3) Vegetation structure altered, obvious signs of disturbance. For example, disturbance to vegetation structure caused by repeated fires, the presence of some more aggressive weeds, dieback, logging and grazing.	**Good (G)** More obvious signs of damage caused by the activities of European man, including some obvious impact on the vegetation structure such as caused by low levels of grazing or by selective logging. Weeds as above, possibly plus some more aggressive ones.	**Good (g)** Evidence of localised high level damage to otherwise low level damaged bush. Recruitment is localised and the populations of some species may be senescent. Weed and grazing damage is apparent in 20-50% of the area. Modification to vegetation structure due to changes in fire regimes may be apparent. Localised gall and parasitic plant damage may be apparent. Evidence of logging or fire wood collection. Moderate likelihood that vegetation structure and species richness can be maintained.
Good (4) Vegetation structure significantly altered by very obvious signs of multiple disturbance. Retains basic vegetation structure or ability to regenerate it. For example, disturbance to vegetation structure caused by very frequent fires, the presence of some very aggressive weeds at high density, partial clearing, dieback and grazing	**Poor (P)** Still retains basic vegetation structure or ability to regenerate to it after very obvious impacts of activities of European man such as grazing or partial clearing (chaining) or very frequent fires. Weeds as above, probably plus some more aggressive ones such as Ehrharta species.	**Poor (p)** Widespread high level damage. Recruitment is disrupted and most woody species appear senescent. Weed and grazing damage may be apparent throughout >50% of the area. Modification to vegetation structure due to changes in fire regimes may be apparent. Locally some vertical strata are absent. Gall and mistletoe damage apparent. Evidence of logging or fire wood collection. Low likelihood that vegetation structure and species richness can be maintained or re-established.
Degraded (5) Basic vegetation structure severely impacted by disturbance. Scope for regeneration but not to a state approaching good condition without intensive management. For example, disturbance to vegetation structure caused by very frequent fires, the presence of very aggressive weeds, partial clearing, dieback and grazing.	**Very Poor (VP)** Severely impacted by grazing, fire, clearing, or a combination of these activities. Scope for some regeneration but not to a state approaching good condition without intensive management. Usually with a number of weed species including aggressive species.	**Very Poor (vp)** Widespread high level damage. Recruitment is disrupted and most species appear senescent. Weed and grazing damage apparent throughout the area. Modification to vegetation structure due to changes in fire regimes apparent. Widespread loss of vertical strata. Gall and mistletoe damage apparent. Evidence of logging or fire wood collection. Little to no likelihood that vegetation structure and species richness can be re-established.
Completely Degraded (6) The structure of the vegetation is no longer intact and the area is completely or almost completely without native species. These areas are often described as 'parkland cleared' with the flora comprising weed or crop species with isolated native trees or shrubs.	**Completely Degraded (D)** Areas that are completely or almost completely without native species in the structure of their vegetation i.e. areas that are cleared or 'parkland cleared' with their flora comprising weed or crop species with isolated native trees or shrubs.	Not used – does not apply to bushland.

Of particular interest when considering vegetation condition are the communities of the eastern side of the Plain. Heavy soils on the eastern side of the Swan Coastal Plain and other soils with a high percentage of clay are well known for their ability to maintain vegetation condition and biodiversity when reduced to small remnants (Keighery, BJ, and Trudgen 1992, Keighery, BJ 1996, Keighery, BJ *et al.* 1997, Mattiske Consulting Pty Ltd 1997). Examples of such remnants include that at the junction of Mundijong and Duckpond Roads (part Bushplan Site 360, approximately three hectares), private land on Page Road (Bushplan Site 78, approximately one hectare), Lambert Lane Bushland (Bushplan Site 264, approximately four hectares), Lambkin Reserve (part Bushplan Site 375, approximately one hectare) and the smaller remnants in Hartfield Park (Bushplan Site 320). This ability to maintain condition is also apparent in the linear remnants along Mundijong Road (Bushplan Site 360). The ability of such remnants to resist weed invasion appears to be related to a combination of all or some of the following factors: the density of the cover of the plant communities, seasonal inundation and the dry impenetrable nature of clay-based soils in summer.

In most vegetation condition mapping, ranges (Trudgen 1991, Keighery, BJ, and Trudgen 1992) or broader units (Kaeshagen 1994, Keighery, BJ 1996c) are generally used, as most bushland areas are a mosaic of conditions and broader units are more applicable.

Information Source

Source	Form	Custodian	Coverage
CALM flora survey 1991 – 1993, (Gibson *et al.* 1994)	database, GIS	CALM	individual bushland areas on the Swan Coastal Plain
DEP flora survey 1994 – 1995 (DEP 1996)	database, GIS	DEP	individual bushland areas on the Swan Coastal Plain
DEP flora survey, 1994 – 1998 (DEP 1996, DEP 1998)	survey sheets	DEP	individual bushland areas on the Swan Coastal Plain
flora survey (Griffin 1994)	database, GIS	AgWA	individual bushland areas on the Swan Coastal Plain
Connell (1995) as digitised by MfP (1996)	GIS	MfP	individual bushland areas on the Swan Coastal Plain
flora survey (Mattiske Consulting Pty Ltd 1997)	text, lists	MfP	individual bushland areas on the Swan Coastal Plain
flora survey, published and unpublished reports	text, lists, vegetation condition maps	N/A	individual bushland areas on the Swan Coastal Plain
submissions to the System 6 and Part System 1 Update Program, various dates	text, lists	DEP	individual bushland areas on the Swan Coastal Plain

Directory Descriptors (Appendix 1, page 103)

Condition scales follow Keighery, BJ (1994) as defined in Table 12, left-hand column. Wherever possible vegetation condition is given as an estimate of the percentage of the bushland area in a range of conditions (Table 12) selected from two categories, for example: '>75% Excellent to Very Good with <25% Good to Degraded'. In many bushland areas there are pockets of completely degraded vegetation and these are referred to as 'areas of severe localised disturbance'.

At times there was not sufficient information available from which to determine a range and a single condition is given.

Total Flora

Background

The flora of the Perth Region (Marchant *et al.* 1987) which covers much of the Swan Coastal Plain (and some of the Darling Plateau) identifies approximately 1,500 vascular plant taxa (species, subspecies and varieties) on the Plain. A total of 1,485 vascular plant taxa were identified by Gibson *et al.* (1994) in the 509 plots and in adjacent areas. Around nine per cent of these were not described and were additional to those described in the flora of the Perth Region. The System 6 and Part System 1 Update Program has identified around 200 additional taxa in the update area (DEP 1996).

Within the Swan Coastal Plain portion of the Perth Metropolitan Region over 1,200 native taxa have been identified from the floristic study plots, bushland area records and WA Herbarium records (Appendix 6). This is not a complete list as WA Herbarium records are yet to be fully interrogated.

Species diversity on the Plain is generally high. Detailed vegetation studies have established that the diversity of flora on the Plain is considerably higher than originally estimated. Fox *et al.* (1980) recorded approximately 250 taxa for Yalgorup National Park, yet recent survey recorded in excess of 600 taxa for the Park (Keighery, GJ 1996). Other areas have demonstrated exceptional levels of species diversity, 19 hectares of the nationally significant Brixton Street Wetlands having over 300 taxa (Keighery, BJ, and Keighery 1995) and the larger area of the Wetlands (Bushplan Site 387) containing in excess of 500 taxa (Keighery, GJ 1993).

There is now a considerable number of studies detailing the flora of individual bushland areas (see references for each Bushplan Site). In addition, a study surveying and collating flora lists for national parks and nature reserves on the Plain is currently under way (Keighery, GJ 1996). When completed, this study will consider the conservation status of species on the Plain, from the widespread and common species to the rare and restricted.

Direct comparisons of species diversity between bushland areas are not meaningful as species diversity in a given area on the Plain relates to habitat diversity which in turn is related to geomorphology, inundation and floristics. As a consequence a comparison of the average species diversity per plot (less taxa found in only one plot) for each floristic community type can give an indication of the patterning of species diversity on the Plain (Table 6). With the singles excluded, diversity ranges from 66.2 taxa to 8.6 taxa per 10-metre x 10-metre plot. The highest diversity is found in the woodlands of the Bassendean Dunes and the eastern side of the Plain (Foothills and Pinjarra Plain). Within the seasonal wetland communities the highest diversity is associated with the wetlands of the eastern side of the Plain.

Information Source

Source	Form	Custodian	Coverage
CALM flora survey 1991 – 1993 (Gibson *et al.* 1994)	database, GIS	CALM	individual bushland areas on the Swan Coastal Plain
DEP flora survey, 1994 – 1995 (DEP 1996)	database, GIS	DEP	individual bushland areas on the Swan Coastal Plain
DEP flora survey, 1994 – 1998 (DEP 1996, DEP 1998)	survey sheets	DEP	individual bushland areas on the Swan Coastal Plain
flora survey (Griffin 1994)	database	AgWA	individual bushland areas on the Swan Coastal Plain
flora survey (Keighery, GJ 1996)	database	CALM	individual bushland areas on the Swan Coastal Plain
flora survey, published and unpublished reports	text, lists	N/A	individual bushland areas on the Swan Coastal Plain
submissions to the System 6 and Part System 1 Update Program, various dates	text, lists	DEP	individual bushland areas on the Swan Coastal Plain

Directory Descriptors (Appendix 1, page 103)

A measure of the native vascular plant flora has been collated from survey work undertaken specifically for Perth's Bushplan by DEP and from published and unpublished studies. Survey information additional to the regional surveys are referenced in each case. The sources are categorised according to the level of detail of survey to give an indication of the percentage of the flora the survey recorded. Categories were:

- not known — area not visited, studies not known to exist
- plot-generated list only — a list extracted from amalgamated floristic study plots
- estimate % — quoted as percentage of the expected flora. The following ranges were used in most cases: >50%, >75% and >90% expected flora.
- estimate — estimate of expected total flora based on knowledge of plant communities in the Site

Significant Flora

Background

One hundred and seventy nine vascular plant taxa (species, subspecies or varieties) recorded on the Swan Coastal Plain are of particular interest as they are rare, poorly known, restricted in distribution or have some other distinctive feature. The categories of significance considered relevant in assessing bushland areas for regional conservation value are detailed below.

DECLARED RARE AND PRIORITY TAXA

The Department of Conservation and Land Management has statutory responsibility for flora conservation and particular responsibility for threatened flora. Section 23F of the *Wildlife Conservation Act 1950* prohibits the 'taking' of Declared Rare Flora (generally referred to as threatened flora) by any person on any land throughout the State without the consent in writing of the Minister for the Environment. Under the terms of the Act, 'taking' includes direct injury or destruction by human hand or machine and such activities as allowing stock to graze on the flora, introducing pathogens that attack it, altering water tables such that the flora is deprived of adequate soil moisture or is inundated, allowing air pollutants to harm foliage etc. A breach of this provision may lead to a fine of up to $10,000. The flora provisions of the Act are binding on the Crown. The 'Schedule of Declared Rare Flora' is reviewed annually and published in the government gazette. The most recent gazettal was 14 July 1998.

A number of criteria are used to identify Declared Rare Flora. These are related to the taxon being well defined and readily identifiable and the extent to which the taxon's distribution in the wild has been recently determined by competent botanists. The status of a threatened plant in cultivation has no bearing on the matter. The legislation only refers to the status of the plant in the wild.

Declared Rare Flora may be extant or presumed extinct (after CALM 1997 and Atkins 1998):

'Declared Rare Flora — Extant Taxa (R): *Taxa which* have been adequately searched for and are deemed to be in the wild either rare, in danger of extinction, or otherwise in need of special protection, and have been declared under section 23F of the *Wildlife Conservation Act 1950* to be "rare flora".

'Declared Rare Flora — Presumed Extinct Taxa (X): Taxa which have not been collected, or otherwise verified, over the past 50 years despite thorough searching, or of which all known wild populations have been destroyed more recently, and have been declared under section 23F of the *Wildlife Conservation Act 1950* to be "rare flora".'

A 'Declared Rare Flora and Priority Flora List' is published each year by CALM (Atkins 1998). Priority Flora are taxa that are under consideration for declaration as 'rare flora' but are in need of further survey or continued monitoring. The list recognises four categories of Priority Flora:

'Priority One — Poorly Known Taxa (1): Taxa which are known from one or a few (generally < 5) populations which are under threat, either due to small population size, or being on lands under immediate threat, e.g. road verges, urban areas, farmland, active mineral leases, etc., or the plants are under threat, e.g. from disease, grazing by feral animals, etc. May include taxa with threatened populations on protected lands. Such taxa are under consideration for declaration as "rare flora", but are in urgent need of further survey.

'Priority Two — Poorly Known Taxa (2): Taxa which are known from one or a few (generally < 5) populations, at least some of which are not believed to be under immediate threat (i.e. not currently endangered). Such taxa are under consideration for declaration as "rare flora", but are in urgent need of further survey.

'Priority Three — Poorly Known Taxa (3): Taxa which are known from several populations, and the taxa are not believed to be under immediate threat (i.e. not currently endangered). Such taxa are under consideration for declaration as "rare flora", but are in urgent need of further survey.

'Priority Four — Rare Taxa (4): Taxa which are considered to have been adequately surveyed and which, whilst being rare (in Australia), are not currently threatened by any identifiable factors. These taxa require monitoring every 5–10 years.'

The priority list is also reviewed annually and distributed within CALM and to other government agencies, groups and individuals. CALM Wildlife Branch is responsible for the preparation of the list and the administration of the statutory requirements of the Act with respect to Declared Rare Flora. As this list changes annually any reference to taxa on the 'Declared Rare Flora and Priority Flora List' should be referenced.

Twenty-one Declared Rare Flora taxa are presently gazetted and 74 Priority Flora taxa are recorded for the Swan Coastal Plain in the Perth Metropolitan Region (Table 13, after Atkins 1998).

ENDEMIC TAXA

When a taxon is confined to a specific geographic area it is considered to be endemic to that area.

Forty-six taxa from Table 13 appear to be endemic to the Swan Coastal Plain and of these nine appear to be endemic to the Perth Metropolitan Region section of the Plain.

Most of the endemics are restricted to the eastern side of the coastal plain (22 taxa, Table 13) while another smaller group (three taxa) are confined to the outcropping Tamala Limestone (Keighery, GJ 1990, Griffin 1993).

There are also several forms of species recognised on the Plain which are significant local variants. Many of these do not have taxonomic recognition but recent work is distinguishing some of these taxonomically. For example *Diplolaena huegelii* now has two subspecies, one within the Spearwood Dunes (on the Tamala Limestones) and another on the Scarp (GJ Keighery *pers. comm.).*

GEOGRAPHIC VARIATION

Plants occur over a geographic area in a series of populations. An understanding of the patterning of variation within a species is of significance when designing a reserve system as sufficient representations of each species are required from different areas to ensure that the variation within the species is encompassed within the reserve system. Particular attention should be given to:

- distinctive local forms that have not been recognised taxonomically (not a species, subspecies or varieties)
- populations that are outside the main geographic range i.e. disjunct populations
- populations at the ends of the plant's geographic range (on the Swan Coastal Plain this being north or south)
- populations that represent a significant number of the known individuals of the taxon in the region and/or a population in good condition (that is, a mixture of different-aged individuals — mature adults to seedlings).

Gibson *et al.* 1994 found that 77 taxa appeared to have their southern range end and 48 taxa to have their northern range end in their study area (see Map 1). Within the Swan Coastal Plain portion of the Perth Metropolitan Region 16 taxa appear to be at their range end (Table 13).

Table 13: Significant Flora of the Perth Metropolitan Region

Key

Column 1 Taxon

Names follow Gibson *et al.* (1994) and Atkins (1998) unless indicated otherwise. Taxa yet to be named have an attached reference collection number from the relevant collector. An 'ms' after the name indicates that this is a manuscript name which is yet to be published.

Column 2 Conservation Status (Atkins 1998)

R = Declared Rare Flora
1 = Priority 1: Poorly Known Taxa
2 = Priority 2: Poorly Known Taxa
3 = Priority 3: Poorly Known Taxa
4 = Priority 4: Rare Taxa

Column 3

Regional ecological preferences

e = taxa endemic to the Swan Coastal Plain
E = taxa endemic to the Swan Coastal Plain in the Perth Metropolitan Region

Geographical Variation

r = populations at the northern or southern limit of their known geographic range
d = populations disjunct from their known geographic range
p = considered to be poorly reserved (applies to all Declared Rare Flora and Priority taxa)
s = significant populations (applies to all Declared Rare Flora and Priority taxa)
X = considered lost in the Perth Metropolitan Region

Taxon	DRF/ Priority Code	Significance Code
Acacia anomala	R	p, s
Acacia alata var. *tetrantha*		s
Acacia benthamii	2	p, s, E
Acacia lasiocarpa var. *bracteolata* (long peduncle form)	1	p, s, e
Acacia littorea		d
Actinodium cunninghamii		X
Actinostrobus acuminatus		p, d
Adenanthos cygnorum subsp. *chamaephyton*	3	p, s
Allocasuarina lehmanniana		s
Alyogyne huegelii var. *glabrata*		s
Amperea protensa	2	p, s
Andersonia gracilis	R	p, s
Angianthus micropodioides	3	p, s
Anthotium junciforme	4	p, s
Aotus cordifolia	3	p, s
Aponogeton hexatepalus	4	p, s, e
Aristida ramosa	1	p, s, d
Asteridea gracilis	1	p, s, d
Astroloma macrocalyx		s, p
Astroloma microcalyx		s
Banksia micrantha	3	p, s, d
Baeckea sp. Chittering (R. Cranfield 1983)	1	p, s
Baeckea tenuifolia	3	p, s, d
Blancoa canescens		d, p
Boronia crenulata var. *gracilis*		e
Boronia capitata var. *gracilis*		e
Boronia purdieana		r
Burchardia bairdii		r

Table 13 *(continued)*: Significant Flora of the Perth Metropolitan Region

Taxon	DRF/ Priority Code	Significance Code
Beyeria cygnorum	2	p, s
Byblis gigantea		d, p, r
Caesia micrantha (Large swamp form, BJK & NG 094)		e
Caladenia huegelii	R	p, s
Calandrinia sp. Kenwick (aff. *composita*, GJK 10905)	1	p, s
Callitris preissii		s, E
Calothamnus graniticus subsp. *leptophyllus*	4	p, s
Calothamnus rupestris	4	p, s
Carpobrotus modestus		s
Calytrix breviseta subsp. *breviseta*	R	p, s, E
Centrolepis caespitosa	R	p, s
Chamaescilla sp. Ellen Brook (GJK 12501) (= aff. spiralis)	3	s, e
Chamelaucium uncinatum		r
Comesperma rhadinocarpum	2	p, s, d
Conospermum huegelii		s
Conospermum triplinervium		s, p
Conospermum undulatum	R	p, s, E
Conostephium minus	4	p, s
Conostylis bracteata	3	p, e, s, r
Conostylis aculeata subsp. *cygnorum*		e
Conostylis pauciflora subsp. *pauciflora*	4	p, s, e
Conostylis pauciflora subsp. *euryrhipis*	3	p, s
Craspedia sp. (JPT 277)		s
Cyathochaeta teretifolia	3	p, s
Darwinia sp. 'Muchea' (BJK 2006)		s, p
Dasypogon obliquifolius		d
Dillwynia dillwynioides	3	p, s, e
Diplolaena angustifolium		p
Diuris micrantha	R	p, s
Diuris purdiei	R	p, s, e
Dodonaea hackettiana	4	p, s, e
Drakaea elastica	R	p, s, e
Drakaea micrantha	R	p, s
Drosera bulbigena		e
Drosera gigantea subsp. *geniculata*		s, e
Drosera macrantha (Swan coastal plain form, BJK & NG 228)		e
Drosera occidentalis subsp. *occidentalis*	4	p, s
Dryandra kippistiana		d, r
Dryandra mimica	R	p, s
Eleocharis keigheryi (sp. Kenwick GJK 5180)	R	p, s
Epiblema grandiflorum var. *cyanea* ms	R	p, s
Eremaea asterocarpa subsp. *brachyclada*	1	p, s, e
Eremaea fimbriata		r
Eremaea purpurea		d, p
Eryngium pinnatifidum subsp. *palustre* ms	2	p, s, e
Eryngium subdecumbens ms	1	p, s, e
Eucalyptus argutifolia	R	p, s
Eucalyptus foecunda		p
Eucalyptus lane-poolei		p
Eucalyptus mundijongensis (hybrid)	1	p, s
Eucalyptus petrensis		p, s
Evandra pauciflora		r

Table 13 *(continued)*: Significant Flora of the Perth Metropolitan Region

Taxon	DRF/ Priority Code	Significance Code
Glischrocaryon aureum		p
Gnephosis angianthoides		d, s
Grevillea althoferorum	R	p, s, d
Grevillea curviloba subsp. *curviloba*	R	p, s, e
Grevillea evanescens	1	p, s, e
Grevillea obtusifolia		e, s
Grevillea thelemanniana	4	p, s, E
Haemodorum brevisepalum		p
Haemodorum loratum	3	p, s, d
Hakea conchifolia		s
Hakea myrtoides	3	p, s
Hakea sp. Walyunga (L. Pen sn) (aff. *lasiantha*)	2	p, s, r
Haloragis aculeolata	2	p, s, e
Haloragis cordiger		s
Haloragis tenuifolia	1	p, s
Hensmania turbinata		r
Hibbertia spicata subsp. *leptotheca*	3	p, s, E
Hydatella dioica	R	p, s, e
Hydrocotyle lemnoides	4	p, s
Isopogon asper		s
Isopogon drummondii	3	p, s, d
Jacksonia gracilis (previously aff. *sericea* or swamp form)		e
Jacksonia sericea	3	p, s, E
Johnsonia aff. *pubescens* (GJK 5249)		s
Kennedia coccinea		s
Kunzea littoricola ms		e
Lambertia multiflora var. *darlingensis*	3	p, s
Lasiopetalum membranaceum	2	p, s
Laxmannia grandiflora		d
Lechenaultia linarioides		p
Lepidium pseudohyssopifolium	1	p, s, d
Lepidium pseudotasmanicum	4	p, s
Lepidium puberulum	4	p, s
Lepidosperma rostratum	R	p, s, E
Leptocarpus aff. *crebriculmis*		s
Leptocarpus sp. Forrestdale Lake		s, e
Lepyrodia heleocharoides	3	p, s
Leucopogon kingianus		s
Leucopogon oliganthus		s
Lomandra spartea		r
Lysinema elegans		p, s, e
Macarthuria apetala		s
Macarthuria keigheryi	R	p, s, d
Melaleuca cardiophylla		r
Melaleuca bracteosa		d, p
Melaleuca lanceolata		d, s
Melaleuca sp. Yanchep (GJK 11242)	2	e
Myriocephalus appendiculatus	3	p, s
Myriocephalus helichrysoides		e
Myriophyllum echinatum	3	X, e
Nemcia diiatata		s
Olax scalariformis	3	p, s, d

Table 13 *(continued)*: Significant Flora of the Perth Metropolitan Region		
Taxon	DRF/ Priority Code	Significance Code
Patersonia babianoides		s
Parsonsia diaphanophleba	4	p, s
Picris compacta	1	p, s
Pimelea calcicola		s
Pimelea imbricata var. *major*		s
Pithocarpa pulchella var. *pulchella*		r
Pityrodia bartlingii		r, d
Platysace juncea		p
Platysace ramosissima	3	p, s
Pterostylis frenchii ms		e, r , s , p
Restio stenostachyus		e
Rhodanthe pyrethrum	3	p, s, e
Sarcozona bicarinata (= *Carpobrotus* sp. Hepburn)	3	p, s, e
Schoenus aff. *tenellus* (BJK & NG 110)		s
Schoenus benthamii	3	p, s
Schoenus capillifolius	2	p, s
Schoenus latitans		r, p
Schoenus pennisetis	1	p, s
Schoenus sp. Bullsbrook (JJ Alford 915)	2	p, s
Schoenus sp. Waroona (GJ Keighery 12235)	3	p, s, e
Stachystemon axillaris	4	p, s
Stenanthemum humile		d
Stylidium crossocephalum		r
Stylidium longitubum	3	p, s, e
Stylidium maritimum	3	p, s, e
Stylidium mimeticum	3	p, s
Stylidium roseo – alatum		s, p
Stylidium utricularioides		e
Synaphea acutiloba	3	p, s, e
Synaphea pinnata	3	p, s
Tetraria australiensis	R	p, s, e
Thysanotus glaucus	4	p, s
Trachymene coerulea		s
Trichocline sp. Treeton (BJK and NG 564)	2	s, p
Trichocline spathulata		s
Tripterococcus paniculatus (sp. Cannington, A.S. George 16201)	1	p, s, e
Veronica aff. *calycina* (BJK & NG 235)		s, p
Verticordia lindleyi subsp. *lindleyi*	4	p, s
Verticordia nitens		s
Verticordia plumosa var. *pleiobotrya*	R	p, s, E
Verticordia serrata subsp. *linearis*	3	p, s
Villarsia submersa	4	p, s
Villarsia violifolia		p, s
Wilsonia humilis		p
Xanthorrhoea acanthostachya		s
Xanthorrhoea drummondii		s

Information Source

Source	Form	Custodian	Coverage
CALM DRF/Priority Flora database (CALM 1998)	GIS	CALM	Perth Metropolitan Region
CALM DRF/Priority Flora list (Atkins 1998)	list	CALM	WA
CALM flora survey 1991 – 1993 (Gibson *et al.* 1994)	database, GIS	CALM	Swan Coastal Plain
DEP flora survey, 1994 and 1995 (DEP 1996)	database, GIS	DEP	Swan Coastal Plain
flora survey (Griffin 1994)	database, GIS	AgWA	Swan Coastal Plain north of Perth
flora survey (Keighery, GJ 1996)	database, GIS	CALM	*Eucalyptus gomphocephala* (Tuart) woodlands on the Swan Coastal Plain
published and unpublished reports	text, lists	N/A	bushland areas on the Swan Coastal Plain

Directory Descriptors (Appendix 1, page 103)

Significant flora known to occur in each area are listed by name. These names are annotated to indicate Declared Rare Flora (R), Priority Flora (numbers 1, 2, 3 or 4), range ends and significant disjunctions. Sources other than CALM database and regional surveys are referenced individually.

4.5.4 FAUNA

Background

Most of the native fauna around Perth is dependent on remnants of the bushland that once covered the Swan Coastal Plain and adjacent Darling Scarp and Plateau. Since the mid-1970s there has been a growing interest in documenting and evaluating the fauna that still persists on the Swan Coastal Plain around Perth. However, only over the last decade have there been any systematic surveys of the fauna of the area. The Western Australia Museum of Natural Science conducted a study in 1978 to document the vertebrate and aquatic fauna of the Swan Coastal Plain between the Swan and Moore Rivers and to evaluate the impact of the first 150 years of European settlement on the indigenous fauna. This study concluded that the impact of settlement had been most pronounced on the mammalian fauna, but that numerous bird species had also been affected with several becoming locally extinct. Reptiles had been least affected by the changes induced by settlement (How 1978).

The persistence of urban bushland ecosystems is based on the intricate interaction of abiotic factors with the composite floral and faunal assemblages. There is little information on the entire suite of faunal species of bushland remnants, their spatial requirements or their responses to the effects of fragmentation and its associated perturbations, such as fire, weeds and predators. Recent research on reptiles has shown that assemblages are closely tied to landform type and not directly related to the floristics of the bushland remnant, and that remnants as small as four hectares are important in maintaining vertebrate faunal assemblages in inner urban regions. Many invertebrate groups are represented by unique or rare species in the vicinity of Perth, a fact that is not surprising given the geological history of the region and the unique flora with which the fauna has co-evolved. Such findings illustrate the need for the entire biota of remnants to be considered when identifying the significance of bushland areas and their conservation status.

Significant Fauna

Under the *Wildlife Conservation Act 1950* the Minister for the Environment may declare species of fauna to be 'Specially Protected' if they are likely to become extinct, or are rare, or are otherwise in need of special protection. These species are considered threatened fauna and receive special consideration in management by CALM. This listing includes species that are presumed to be extinct (so that they receive the highest protection in case they are rediscovered, such as happened when Gilbert's Potoroo was recently rediscovered near Albany) as well as species that require special protection for other reasons, such as the possible effect of excessive harvesting.

Threatened fauna are listed in the *Wildlife Conservation (Specially Protected Fauna) Notice*, last updated in July 1998. Those species of fauna declared Specially Protected are placed in four schedules under the Notice:

Schedule 1 — being fauna that is rare or likely to become extinct;

Schedule 2 — being fauna that is presumed to be extinct;

Schedule 3 — being birds that are subject to an agreement between the governments of Australia and Japan relating to the protection of migratory birds and birds in danger of extinction;

Schedule 4 — being fauna that is in need of special protection otherwise than for the reasons mentioned under Schedules 1, 2 and 3.

Of the 116 Specially Protected fauna taxa in Schedule 1, eleven have recently been recorded from the Swan Coastal Plain portion of the Perth Metropolitan Region (Tables 14 and 15). Some of the birds, mammals and reptiles that are now locally extinct on the Swan Coastal Plain around Perth are included in the Schedule 1 fauna list.

As with poorly known flora species, CALM also maintains a supplementary or priority list of fauna taxa (CALM 1998). There are four categories of priority fauna, these being:

'Priority One (P1)
Taxa with few, poorly known populations on threatened lands. Taxa which are known from few specimens or sight records from one or a few localities on lands not managed for conservation, e.g. agricultural or pastoral lands, urban areas, active mineral leases. These taxa need urgent survey and evaluation.

'Priority Two (P2)
Taxa with few, poorly known populations on conservation lands. Taxa which are known from few specimens or sight records from one or a few localities on lands not under immediate threat of habitat destruction or degradation, e.g. national parks, conservation parks, nature reserves, State forest, vacant Crown land, water reserves, etc. The taxa need urgent survey and evaluation of conservation status before consideration can be given to declaration as threatened fauna.

'Priority Three (P3)
Taxa with several, poorly known populations, some on conservation lands. Taxa which are known from few specimens or sight records from several localities, some of which are on lands not under immediate threat of habitat destruction or degradation. These taxa need urgent survey and evaluation of conservation status before consideration can be given to declaration as threatened flora.

'Priority Four (P4)
Taxa in need of monitoring. Taxa which are considered to have been adequately surveyed, or for which sufficient knowledge is available, and which are considered not currently threatened or in need of special protection, but could be if present circumstances change. These taxa are usually represented on conservation lands.'

There are 18 taxa of Priority Fauna recently recorded for the Swan Coastal Plain portion of the Perth Metropolitan Region (Tables 14 and 15).

Other significant fauna identified in the Bushplan Site descriptions are those birds that are habitat specialists with a reduced distribution on the Swan Coastal Plain or wide-ranging species with reduced populations on the Swan Coastal Plain; those mammals that have few populations on the Swan Coastal Plain; and those reptile species that have reduced ranges or few recent records on the Swan Coastal Plain.

Faunal Groups

Birds

Storr and Johnstone (1988) listed 311 species of birds recorded from the Swan Coastal Plain and adjacent seas. Excluding seabirds and trans-equatorial migrants, 140 species are, or were, resident in or regular visitors to the Perth area from other parts of Western Australia (Appendix 7). These 140 species comprise 94 non-passerine and 71 passerine species. Additionally a further 34 non-passerine species annually migrate to the Swan Coastal Plain from the northern hemisphere while two non-passerine species are occasional visitors from the northern hemisphere. Ten non-passerine species have also colonised the Swan Coastal Plain from other parts of Western Australia. Eight non-passerine and two passerine species have been introduced into the area from either overseas or from other parts of Australia.

About 40 per cent of the non-passerine species have decreased in number since European settlement. Some of the waterfowl species and most of the occupants of the lake and swamp edges have suffered serious reductions as these habitats have been changed or cleared. Ducks such as the Freckled Duck, the Australasian Shoveler and Hardhead, the Little, Black and Australasian Bitterns, and the Dusky Moorhen have declined seriously. Birds of prey including the Square-tailed Kite, Whistling Kite, Brown Goshawk and Collared Sparrowhawk, and habitat-specialist species like the Painted Button-quail and Brush Bronzewing have declined with habitat removal.

Nearly half of the 71 naturally occurring passerine bird species have decreased in abundance since European settlement with nearly all of the insectivorous and nectarivorous species declining as a direct result of the clearing of the natural vegetation. Some of them, such as the Scarlet, Hooded and White-breasted Robins, the Golden Whistler, the Grey Shrike-thrush, the Weebill, Broad-tailed, Yellow-rumped and Western Thornbills, the

Table 14: Threatened Fauna in the Swan Coastal Plain Portion of the Perth Metropolitan Region (excluding birds which are listed in Table 15)

Key

Column 1	Scientific Name
Column 2	Common Name
Column 3	Conservation Status

Refers to the *Wildlife Conservation (Specially Protected Fauna) Notice 1998* where:

R1 = Specially Protected Fauna – Schedule 1
R4 = Specially Protected Fauna – Schedule 4
and the CALM Priority Fauna List (1998) where:
P1 = Priority 1 Fauna
P2 = Priority 2 Fauna
P3 = Priority 3 Fauna
P4 = Priority 4 Fauna

Scientific Name	Common Name	Conservation Status
MAMMALS (excluding marine)		
Dasyurus geoffroii	Chuditch or Western Quoll	R1
Isoodon obesulus fusciventer	Quenda or Southern Brown Bandicoot	P4
Phascogale tapoatafa	Brush-tailed Phascogale	P3
Macropus eugenii derbianus	Tammar Wallaby	P4
Macropus irma	Western Brush Wallaby	P4
Hydromys chrysogaster	Water Rat	P4
REPTILES		
Pseudemydura umbrina	Western Swamp Tortoise	R1
Morelia spilota imbricata	Carpet Python	R4
FISH		
Galaxiella nigrostriata	Black-stripe Minnow	P3
MOLLUSCS (freshwater)		
Westralunio carteri		P4
NATIVE BEES		
Leioproctus bilobatus		P2
Leioproctus contrarius		R1
Leioproctus douglasiellus		R1
Neopasiphe simplicior		R1
Hyaleus globuliferus		P3
CRICKETS		
Austrosaga spinifer		P3
MOTHS		
Synemon gratiosa	Graceful Sunmoth	R1
SPRINGTAILS		
Australotomurus sp. nov. (SAM #122621)	Guildford Springtail	R1
AMPHIPOD		
Undescribed *Crangonyctid* sp. (WAM #642–97)	Crystal Cave Crangonyctid	R1

Table 15: Significant Birds of the Swan Coastal Plain Portion of the Perth Metropolitan Region

Key

Column 1 Scientific Name Names follow Christides & Bowles, 1994
Column 2 Common Name
Column 3 Significant Bird Species (after Volume 2, section 4.5.4)

1 = species listed under the Wildlife Conservation Act 1950.
2 = species listed on the JAMBA/CAMBA agreements.
3 = habitat specialists with a reduced distribution on the Swan Coastal Plain.
4 = wide-ranging species with reduced populations on the Swan Coastal Plain.

Column 4 Conservation Status
after the *Wildlife Conservation (Specially Protected Fauna) Notice, 1998,* where:

R1 = Specially Protected Fauna – Schedule 1
R4 = Specially Protected Fauna – Schedule 4
and the CALM Priority Fauna List (1998) where:
P1 = Priority 1 Fauna
P2 = Priority 2 Fauna
P3 = Priority 3 Fauna
P4 = Priority 4 Fauna

Scientific Name	Common Name	Significant Bird Species	Conservation Status
Order STRUTHIONIFORMES			
Family CASUARIIDAE			
Dromais novaehollandiae	Emu	4	
Order ANSERIFORMES			
Family ANATIDAE			
Stictonetta naevosa	Freckled Duck	4	P4
Oxyura australis	Blue-billed Duck	3	
Biziura lobata	Musk Duck	3	
Anas rhynchotis	Australasian Shoveler	3	
Malacorhynchus membranaceus	Pink-eared Duck	3	
Aythya australis	Hardhead	3	
Order CICONIIFORMES			
Family ARDEIDAE			
Nycticorax caledonicus	Rufous Night Heron	4	
Ixobrychus minutus	Little Bittern	4	P4
Ixobrychus flavicollis	Black Bittern	4	P2
Botaurus poiciloptilus	Australasian Bittern	1, 4	R1
Order FALCONIFORMES			
Family ACCIPITRIDAE			
Lophoictinia isura	Square-tailed Kite	4	P4
Haliastur sphenurus	Whistling Kite	4	
Accipiter fasciatus	Brown Goshawk	4	
Accipiter cirrocephalus	Collared Sparrowhawk	4	
Aquila morphnoides	Little Eagle	4	
Aquila audax	Wedge-tailed Eagle	4	
Family FALCONIDAE			
Falco berigora	Brown Falcon	4	
Falco peregrinus	Peregrine Falcon	1, 4	R4
Order GRUIFORMES			
Family RALLIDAE			
Gallinula tenebrosa	Dusky Moorhen	3	
Family OTIDIDAE			
Otis australis	Australian Bustard	4	
Order TURNICIFORMES			
Family TURNICIDAE			
Turnix varia	Painted Button-quail	4	

Table 15 *(continued)*: Significant Birds of the Swan Coastal Plain Portion of the Perth Metropolitan Region

Scientific Name	Common Name	Significant Bird Species	Conservation Status
Order CHARADRIIFORMES			
Family SCOLOPACIDAE			
Limosa limosa	Black-tailed Godwit	2	
Limosa lapponica	Bar-tailed Godwit	2	
Numenius minutus	Little Curlew	2	
Numenius phaeopus	Whimbrel	2	
Numenius madagascariensis	Eastern Curlew	2	P4
Tringa totanus	Common Redshank	2	
Tringa stagnatilis	Marsh Sandpiper	2	
Tringa nebularia	Common Greenshank	2	
Tringa glareola	Wood Sandpiper	2	
Tringa terek	Terek Sandpiper	2	
Tringa hypoleucos	Common Sandpiper	2	
Tringa brevipes	Grey-tailed Tattler	2	
Arenaria interpres	Ruddy Turnstone	2	
Calidris canutus	Red Knot	2	
Calidris tenuirostris	Great Knot	2	
Calidris alba	Sanderling	2	
Calidris ruficollis	Red-necked Stint	2	
Calidris minuta	Little Stint	2	
Calidris subminuta	Long-toed Stint	2	
Calidris fuscicollis	White-rumped Sandpiper	2	
Calidris melanotos	Pectoral Sandpiper	2	
Calidris acuminata	Sharp-tailed Sandpiper	2	
Calidris ferruginea	Curlew Sandpiper	2	
Limicola falcinellus	Broad-billed Sandpiper	2	
Philomachus pugnax	Ruff	2	
Family BURHINIDAE			
Burhinus grallarius	Bush Stone-curlew	locally extinct	P4
Family ROSTRATULIDAE			
Rostratula benghalensis	Painted Snipe	4	P3
Family CHARADRIIDAE			
Pluvialis fulva	Pacific Golden Plover	2	
Charadrius dubius	Little Ringed Plover	2	
Charadrius bicinctus	Double-banded Plover	2	
Charadrius mongolus	Lesser Sand Plover	2	
Charadrius leschenaultii	Greater Sand Plover	2	
Charadrius rubricollis	Hooded Plover		P4
Charadrius veredus	Oriental Plover	2	
Erythrogonys cinctus	Red-kneed Dotterel	2	
Order COLUMBIFORMES			
Family COLUMBIDAE			
Phaps chalcoptera	Common Bronzewing	3	
Phaps elegans	Brush Bronzewing	3	
Order PSITTACIFORMES			
Family CACATUIDAE			
Cacatua pastinator pastinator	Western Long-billed Corella	1, locally extinct	R1
Calyptorhynchus banksii	Red-tailed Black Cockatoo	4	P4
Calyptorhynchus banksii naso	Forest Red-tailed Black Cockatoo	locally extinct	P4
Calyptorhynchus latirostris	Carnaby's Cockatoo	1, 4	R1
Calyptorhynchus baudinii	Baudin's Cockatoo	1, 4	R1
Family PSITTACIDAE			
Platycercus icterotis	Western Rosella	4	
Neophema petrophila	Rock Parrot	3	

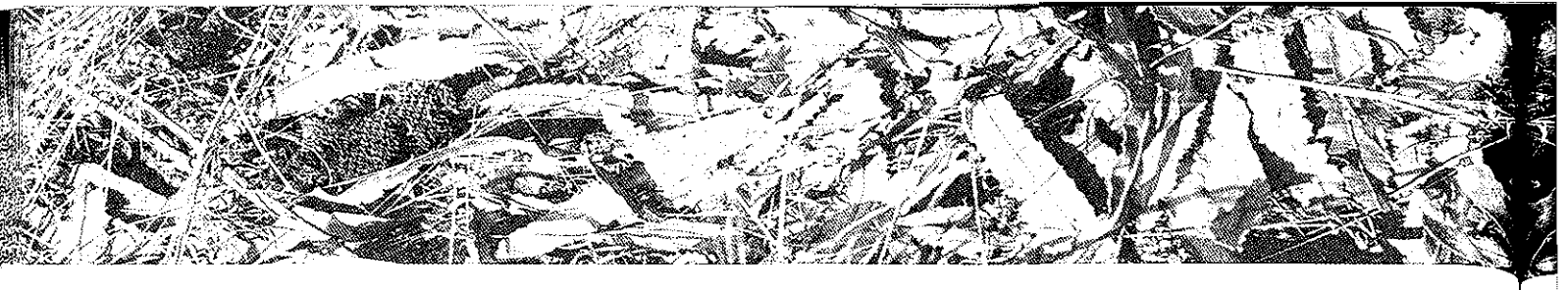


Table 15 *(continued)*: Significant Birds of the Swan Coastal Plain Portion of the Perth Metropolitan Region

Scientific Name	Common Name	Significant Bird Species	Conservation Status
Order STRIGIFORMES			
Family STRIGIDAE			
Ninox connivens connivens	Barking Owl (south-west population)		locally extinct P2
Order PASSERIFORMES			
Family CLIMACTERIDAE			
Climacteris rufa	Rufous Treecreeper	3	
Family MALURIDAE			
Malurus elegans (Gingin population)	Red-winged Fairy-wren	locally extinct	P1
Malurus splendens	Splendid Fairy-wren	3	
Malurus lamberti	Variegated Fairy-wren	3	
Malurus leucopterus	White-winged Fairy-wren	3	
Stipiturus malachurus	Southern Emu-wren	3	
Family ACANTHIZIDAE			
Sericornis frontalis	White-browed Scrubwren	3	
Smicrornis brevirostris	Weebill	3	
Acanthiza apicalis	Broad-tailed Thornbill	3	
Acanthiza inornata	Western Thornbill	3	
Acanthiza chrysorrhoa	Yellow-rumped Thornbill	3	
Family MELIPHAGIDAE			
Melithreptus chloropsis	Western White-naped Honeyeater	4	
Phylidonyris novaehollandiae	New Holland Honeyeater	4	
Phylidonyris nigra	White-cheeked Honeyeater	4	
Phylidonyris melanops	Tawny-crowned Honeyeater	4	
Lichenostomus ornatus	Yellow-plumed Honeyeater	3	
Anthochaera chrysoptera	Little Wattlebird	4	
Manorina flavigula	Yellow-throated Miner	4	
Family PETROICIDAE			
Petroica multicolor	Scarlet Robin	3	
Petroica cucullata	Hooded Robin	3	
Eopsaltria australis	Yellow Robin	3	
Eopsaltria georgiana	White-breasted Robin	3	
Family CINCLOSOMATIDAE			
Psophodes nigrogularis	Western Whipbird	locally extinct	R1
Family NEOSITTIDAE			
Daphoenositta chrysoptera	Varied Sittella	3	
Family PACHYCEPHALIDAE			
Falcunculus frontatus leucogaster	Crested Shrike-tit	locally extinct	P4
Pachycephala pectoralis	Golden Whistler	3	
Colluricincla harmonica	Grey Shrike-thrush	3	
Family DICRURIDAE			
Myiagra inquieta	Restless Flycatcher	3	
Family ARTAMIDAE			
Artamus cinereus	Black-faced Woodswallow	4	
Artamus cyanopterus	Dusky Woodswallow	4	
Family CRACTICIDAE			
Strepera versicolor	Grey Currawong	4	

White-browed Scrubwren, Splendid, Variegated and White-winged Fairy-wrens, the Varied Sittella, the Rufous Treecreeper, Tawny-crowned, White-naped, New Holland and White-cheeked Honeyeaters, Black-faced and Dusky Woodswallows, and the Grey Currawong are now absent from most of that part of the Swan Coastal Plain previously occupied by them, although most still occur in the Darling Scarp or Darling Plateau. Some of these, including the Western Thornbill and Splendid Fairy-wren, are surviving on urban remnants only recently isolated and may not persist long-term. In addition, the Yellow Robin, Restless Flycatcher, Southern Emu-wren, Red-eared Firetail and Brown-headed Honeyeater no longer occur in the Swan Coastal Plain portion of the Perth Metropolitan Region.

Three non-passerine species, the Bush Stone-curlew, Western Long-billed Corella and Barking Owl, and three passerine species, the Red-winged Fairy-wren, Western Whipbird and Crested Shrike-tit, are now extinct in the area (Table 15).

Four categories of birds representing species of conservation significance on the Swan Coastal Plain are shown in Table 15. This list includes species listed as threatened under the *Wildlife Conservation Act 1950* and species listed under the Japan-Australia and China-Australia Migratory Bird Agreements (JAMBA and CAMBA, see section 4.6.5), as well as species which have undergone status reductions on the Swan Coastal Plain.

Mammals

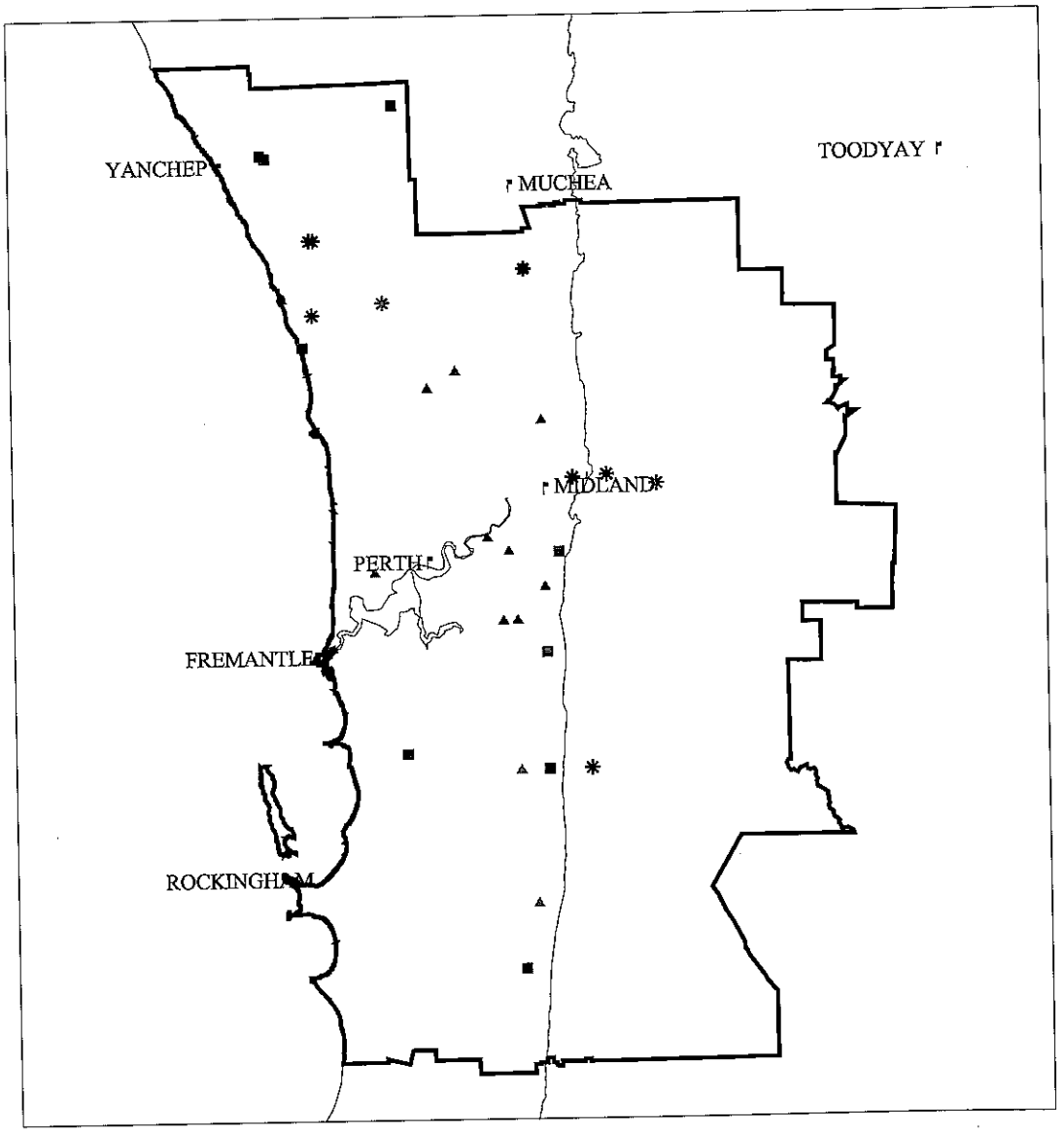
Prior to European settlement, 33 species of native mammals were known from the Swan Coastal Plain around Perth (Appendix 7) with the possibility that a few additional species may have occurred there (How and Dell 1993). An extensive survey in 1978 and subsequent work on the Swan Coastal Plain confirmed the presence of 18 native species (Grey Kangaroo, Western Brush Wallaby, Brushtail Possum, Western Pygmy Possum, Honey Possum, Mardo, Wambenger, Quenda (Southern Brown Bandicoot), Bush Rat, Water Rat, Ash-grey Mouse, Gould's, Greater and Lesser Long-eared Bats, Southern Forest Bat, Gould's Wattled Bat, White-striped Freetail-bat and Echidna) with the possibility that another two (Chuditch and Chocolate Bat) may still be extant, as they are known from the nearby Darling Scarp and Plateau. An additional species, the Western False Pipistrelle, has recently been recorded on the Swan Coastal Plain near Perth (Hosken and O'Shea 1994).

The status of many of these species of mammals has declined further in the last 20 years. There has been no systematic survey of bats, so consequently there is no new information on the status of this group. Recent surveys of urban bushland remnants indicate that of the native mammals, only the Western Grey Kangaroo, Brushtail Possum and Quenda (Southern Brown Bandicoot) survive on several bushland remnants while the Western Brush Wallaby, Honey Possum, Wambenger and Western Pygmy Possum still occur on a select few. The two macropods only persist in larger remnants that have been recently isolated from extensive tracts of native bushland peripheral to urban areas. The Water Rat, Bush Rat and Mardo all prefer dense vegetation associated with swamps, lakes and waterways, and all have declined markedly around Perth, only persisting in small populations in surrounding areas. The Ash-grey Mouse occurs in the heaths north of Mullaloo where they occupy long-unburnt habitats but may also be found at Whiteman and Melaleuca Parks. The historical distribution of the Honey Possum *(Tarsipes rostratus,* Map 4), Wambenger *(Phascogale tapoatafa,* Map 5), and Ash-grey Mouse (Pseudomys albocinereus, Map 6) indicates the decline of these species on the Swan Coastal Plain.

The Department of Conservation and Land Management recently carried out a study of Bandicoot (Quenda) in the Perth Metropolitan Region which included widespread media coverage encouraging the public to report sightings (Friend 1996 database). The survey commenced in March 1993 and included sightings and specimens from 1991 until 1996. This survey resulted in many records of Quenda, particularly south of the Swan River (Map 7), although many of the records were in areas which had no protection from clearing or development.

Map 4: Western Australian Museum of Natural Science specimen records showing the distribution and abundance of the Honey Possum (*Tarsipes rostratus*) over time

Department of Environmental Protection



Specimen records for the Honey Possum (Western Australian Museum of Natural Science 1996):-

- ✱ from 1981 to present
- ■ from 1941 to 1980
- ▲ pre 1940

Perth Metropolitan Area (MfP 1997b)

Swan Coastal Plain Boundary (CALM & ANCA 1996)

Locations (AUSLIG 1996)

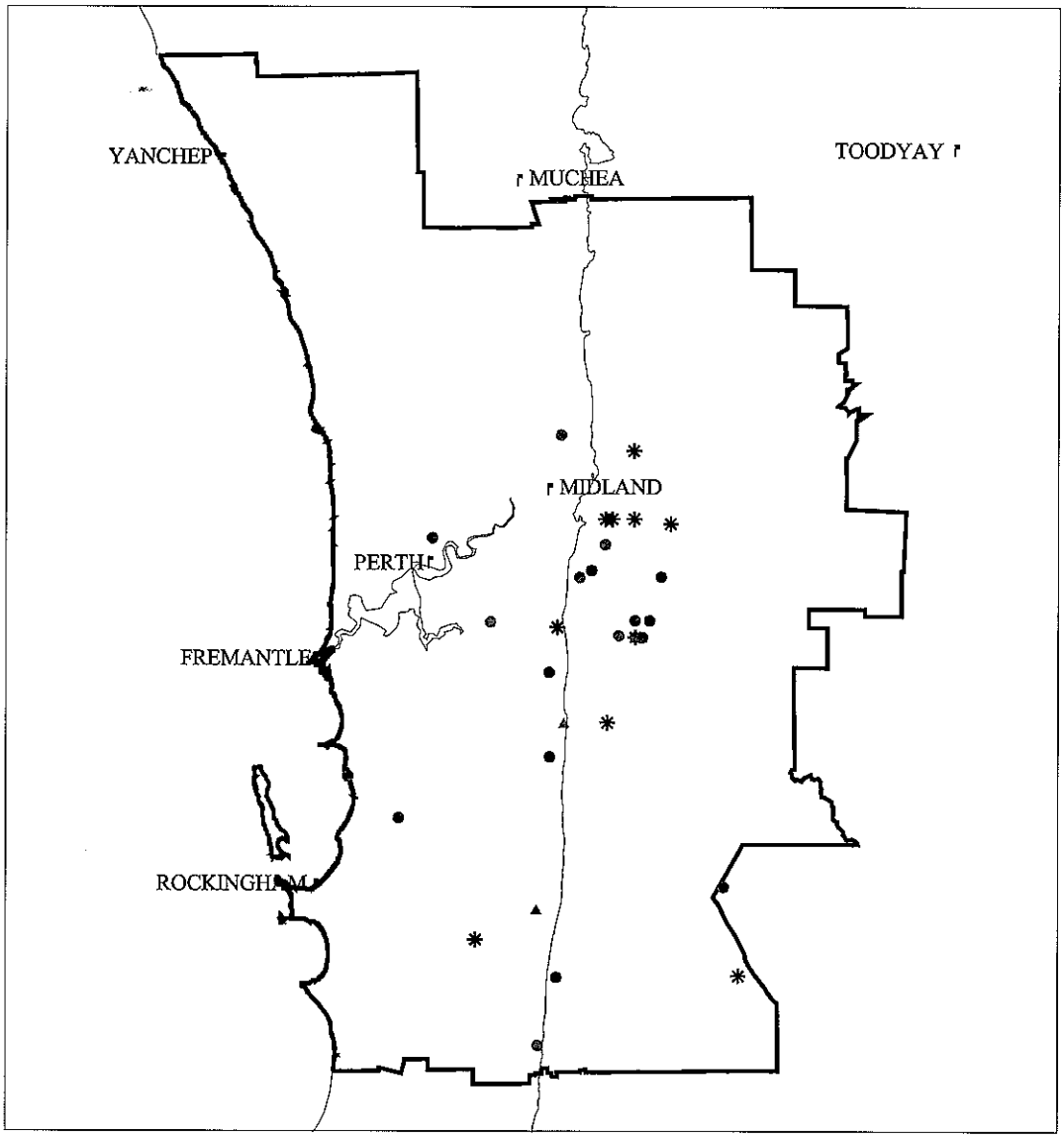
N

5 0 5 10 Kilometres

This map has been produced using various data from other agencies. No responsibility is accepted for any error or omission.

Map 5: Western Australian Museum of Natural Science specimen records showing the distribution and abundance of the Wambenger (*Phascogale tapoatafa*) over time

Department of Environmental Protection



Specimen records for the Wambenger (Western Australian Museum of Natural Science 1996):-

- ✱ from 1981 to present
- ■ from 1941 to 1980
- ▲ pre 1940

Perth Metropolitan Area (MfP 1997b)

Swan Coastal Plain Boundary (CALM & ANCA 1996)

Locations (AUSLIG 1996)

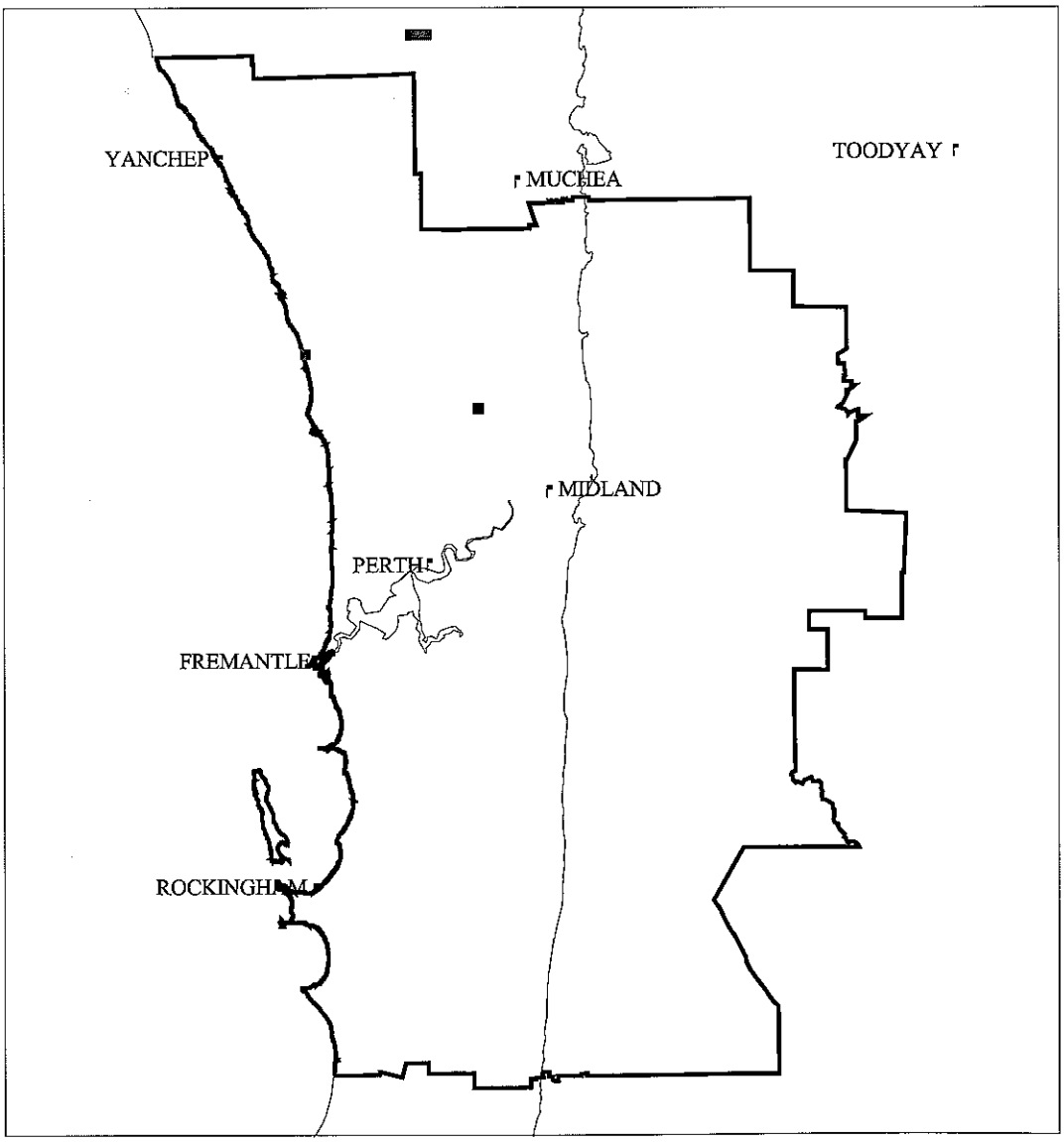
N

5 0 5 10 Kilometres

This map has been produced using various data from other agencies. No responsibility is accepted for any error or omission.

Map 6: Western Australian Museum of Natural Science specimen records showing the distribution and abundance of the Ash Grey Mouse (*Pseudomys albocinereus*) over time

Department of Environmental Protection



Specimen records for the Ash Grey Mouse (Western Australian Museum of Natural Science 1996):-

- ✱ from 1981 to present
- ■ from 1941 to 1980
- ▲ pre 1940

Perth Metropolitan Area (MfP 1997b)

Swan Coastal Plain Boundary (CALM & ANCA 1996)

Locations (AUSLIG 1996)

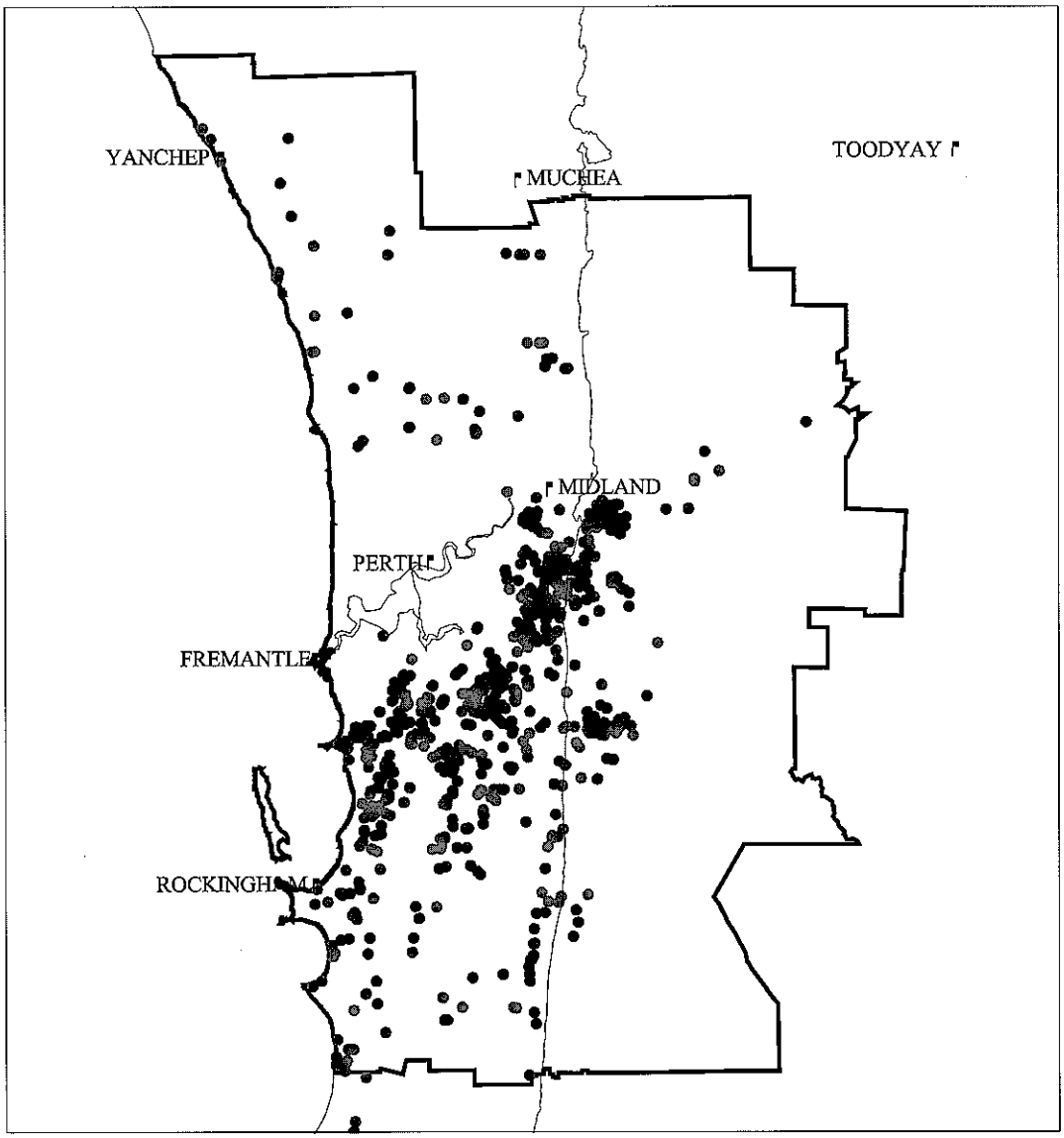
N

5 0 5 10 Kilometres

This map has been produced using various data from other agencies. No responsibility is accepted for any error or omission.

Map 7: Sightings of Quenda (*Isoodon obesulus*) reported by the public during CALM's Bandicoot Survey 1991-1996

Department of Environmental Protection



This map has been produced using various data from other agencies. No responsibility is accepted for any error or omission.

Reptiles

The reptile fauna of the Swan Coastal Plain around Perth consists of 64 species (How and Dell 1993) in nine families and is one of the richest recorded for any major urban area anywhere in the world (Appendix 7). The juxtaposition of diverse landform units and the varied habitats they contain is, in large part, the explanation for this rich assemblage.

The detailed documentation and survey of the herpetofauna of the northern Swan Coastal Plain by the Western Australian Museum highlighted the richness of the reptile fauna and acknowledged the lack of historical data. In the last 10 years there has been a proliferation of studies on the herpetofauna of the Perth area by government, amateur and consultancy groups such that a much more detailed knowledge of the pattern of distribution is now available (How and Dell 1994). Reptile diversity decreases from 52 species on the western near-coastal dunes to 35 species on the Darling Plateau in the east (How and Dell 1993). Most species, however, have declined in both local distribution and abundance and usually persist only on the remaining remnants of bushland.

Australia's most threatened vertebrate species, the Western Swamp Tortoise *(Pseudemydura umbrina)* is endemic to the Perth Metropolitan Region, being restricted to two localities on the Swan Coastal Plain. Several other species are scarce or rare in the area, including the skinks *Lerista christinae* and *L. lineata*, and have relatively localised distributions. *Lerista lineata* is virtually confined to the Perth Metropolitan Region. Others such as the gecko *Heteronotia binoei*, legless lizard *(Aclys concinna)* and snakes *Notechis coronatus, Rhinoplocephalus gouldii* and *Pseudonaja modesta* are uncommon in the Perth area but more abundant elsewhere. The latter species and *Morelia stimsoni* are now locally extinct. Species most severely affected by urban development are the larger predators in the genera *Varanus* (monitors) and *Morelia* (pythons). These species prey on a large variety of native mammals, reptiles and frogs that have become far less numerous, so that species in these genera are now confined to a few larger remnant bushlands. The skink *Egernia luctuosa* has declined dramatically due to the draining and reduction of wetland habitats. The Dugite *(Pseudonaja affinis)*, however, has been decidedly advantaged since European settlement and has become relatively common in urban bushland remnants and areas marginal to the metropolitan region. Only two species, the Marbled Gecko *(Phyllodactylus marmoratus)* and the Fence Skink *(Cryptoblepharus plagiocephalus)*, occur in inner city areas although the skink *Hemiergis quadrilineata* is frequently found in urban gardens.

Amphibians

Thirteen species of amphibians, representing two families and nine genera (How and Dell 1993) are known from the Swan Coastal Plain near Perth (Appendix 7). Frogs reach their greatest diversity and abundance in areas where swamps, lakes or streams are more prominent on the eastern side of the Plain (Foothills and Pinjarra Plain) (How and Dell 1993). Fewer species occur on the Quindalup and Spearwood Dunes, where deep sands support fewer ephemeral wetlands.

There are no historical data on the changes in abundance or distribution of amphibians since settlement. However, the draining of wetlands and large-scale replacement of natural ecosystems with agricultural ones would have markedly reduced the habitat available for most species. In the future, pollutants that find their way into aquatic systems will also cause marked population declines. Responses to fire by frogs on the Swan Coastal Plain were documented by Bamford (1992) who concluded that *Heleioporus eyrei* was not greatly affected by fire, but that *Limnodynastes dorsalis* and *Myobatrachus gouldii* were more abundant in long-unburnt areas. Most other species do not occur outside the vicinity of wetlands.

Invertebrates

Invertebrates constitute a major and essential component of every landform, but due to their vast number, remain little studied. This is true of the Swan Coastal Plain, where a recent survey by the Western Australian Museum of Natural Science at a variety of sites in different landforms (How *et al.* 1996, Harvey *et al.* 1997) uncovered a startlingly diverse ground

fauna. This study concentrated on several arachnid and myriapod groups, as well as cockroaches and some parasitic wasps. Numerous species and genera were recorded from the Swan Coastal Plain for the first time, and many undescribed species were collected. Some groups exhibited no correlations with landform or floristic variables, while others showed significant spatial patterning consistent with being long isolated on the north-south oriented dune system which formed during periods of sea-level reductions during the Pleistocene.

No data are available to indicate whether any of these invertebrate assemblages have been significantly reduced since European settlement, although observations on individual species, such as the trapdoor spider *(Idiosoma sigillatum)*, indicate that original ranges are diminishing rapidly due to habitat clearance (Main 1990).

Six invertebrate species found in the Perth Metropolitan Region are listed under Schedule 1 of the *Wildlife Conservation (Specially Protected Fauna) Notice 1998* as 'fauna that is rare or likely to become extinct' (Table 14). Four other invertebrate species have been listed as 'Priority' species.

Information Source

Source	Form	Custodian	Coverage
CALM Scheduled/Priority Fauna List (CALM 1998)	list	CALM	WA
Western Australian Museum of Natural Science collections and database (Western Australian Museum of Natural Science 1996)	database, GIS	Western Australian Museum of Natural Science	individual bushland areas on the Swan Coastal Plain
CALM Bandicoot database, (Friend 1996)	database, GIS	CALM	individual bushland areas on the Swan Coastal Plain
RAOU (Birds Australia) Bird database (RAOU 1996)	database	RAOU	individual bushland areas on the Swan Coastal Plain
published and unpublished reports	text, lists	N/A	individual bushland areas on the Swan Coastal Plain
submissions to the System 6 and Part System 1 Update Program	text, lists	N/A	individual bushland areas on the Swan Coastal Plain

Directory Descriptors (Appendix 1, page 103)

Information on the fauna of particular Bushplan Sites has been collated from Museum of Natural Science fauna surveys, Quenda sightings by the public reported to CALM's Bandicoot Database (Friend 1996 D), bird survey data collected by the RAOU (RAOU 1995 D) and published and unpublished studies. These studies are referenced in each instance.

The sources are categorised to indicate the scope of the survey — that is, the faunal groups surveyed, the comprehensiveness of the survey and the significance of the particular species recorded for the Site. As survey techniques and best time of survey varies between faunal group the comprehensiveness is related to the group surveyed.

(continued)

Directory Descriptors (continued)

The categories are:

Survey Information

- no known information — compilers of the Directory were not aware of any information on the Bushplan Site
- scope of survey — birds, mammals, reptiles, amphibians and/or invertebrates

Comprehensiveness of survey

- single visit — sight records from one visit
- multiple visit — repeated visits, may involve sight records and trapping over several days in one or several years
- structured survey — longer-term study involving multiple visits and permanent traplines; generally involves collection of data on birds, mammals, reptiles, amphibians and/or invertebrates all seasons

Significant species

- birds — refers to species of conservation significance (Table 15). Four categories:
  1 species listed under the *Wildlife Conservation Act 1950*
  2 species listed on the JAMBA/CAMBA agreements
  3 habitat specialists with a reduced distribution on the Swan Coastal Plain
  4 wide-ranging species with reduced populations on the Swan Coastal Plain
- mammals — species that are listed as threatened under the Wildlife Conservation Act 1950 or those that have few populations on the Swan Coastal Plain
- reptiles and amphibians — species that have reduced ranges or few recent records on the Swan Coastal Plain
- invertebrates — species listed as 'Specially Protected' or 'Priority' fauna are described where locations are known. Most records are allocated to a suburb and not a specific bushland area and so are not included in the Bushplan Site Descriptions

4.5.5 LINKAGE

Background

The natural processes occurring in ecosystems are complex and poorly understood, though it is generally accepted that large consolidated areas are the best options for viable conservation areas. Within the Perth Metropolitan Region there are few large areas available for conservation, many of the Bushplan Sites are relatively small in size (less than 100 hectares) and isolated from other conservation areas. Issues of particular concern in fragmented ecosystems are:

- the requirement of vertebrates, such as some bird and mammal species and many invertebrates, of a large area for their home range and hence their survival
- the movement of animals is essential in maintaining genetic diversity in plant communities by moving pollen from one remnant to another
- that populations of plants and animals are effectively isolated from other populations leaving populations susceptible to local extinction
- the loss of genetic diversity through inbreeding.

As a consequence the consideration of the surrounding land uses and connectivity between Bushplan Sites is important in the selection of conservation areas and the design of a conservation

area network. Some Bushplan Sites are of particular significance as they provide corridors through otherwise highly cleared lands and provide linkages of regional significance.

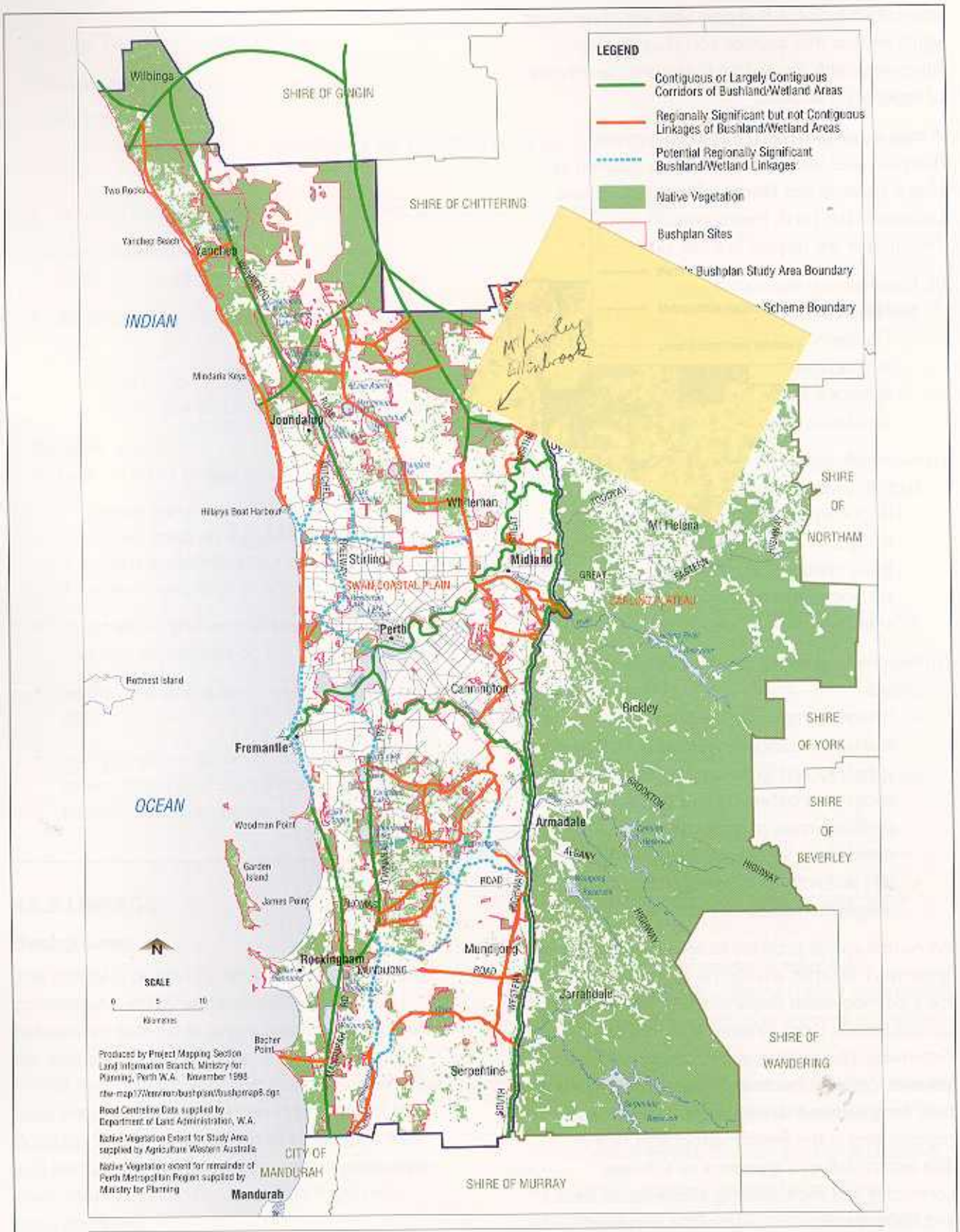
A map showing the major linkages between Bushplan Sites was developed and is included as Map 8 (Existing and Potential Bushland/Wetland Linkages in the Perth Metropolitan Region). The linkages are defined in three categories:

(i) Regionally significant contiguous bushland/wetland linkage
   - Contiguous or largely contiguous corridors of bushland/wetland areas, being regionally significant links that are continuous or largely continuous bushland or wetland areas.

(ii) Regionally significant fragmented bushland/wetland linkage
   - Regionally significant but not contiguous linkages of bushland/wetland areas being those regionally significant links that as stated are not continuous bushland or wetland areas.

(iii) Regionally significant potential bushland/wetland linkage
   - Potentially regionally significant bushland/wetland linkages being those regional scale links that follow existing features or bridge gaps between existing regionally significant areas of bushland/ wetland. As stated, these linkages could potentially form links and with some management and/or revegetation could be restored.

An Australia-wide program to recognise linkages or 'greenways' in urban environments was initiated by the Commonwealth Department of Transport. As a consequence a Draft Strategic Plan for Perth's Greenways (Tingay, Alan and Associates 1997, see Volume 1, Map 6) has been produced to provide a basis for greenways development at a local and regional level in the Perth Metropolitan Region. The report defines a greenway as 'a linkage connecting and encompassing conservation areas and landscape features'. Each of the proposed greenways is numbered.



Ecological Linkages and Corridors of the Perth Metropolitan Region

Map 8

Information Source

Source	Form	Custodian	Coverage
1997 native vegetation maps, (AgWA 1998) (see Volume 1, Map 2)	GIS	AgWA	Swan Coastal Plain portion of the Perth Metropolitan Region
1998 PanAirama (aerial photography) DOLA 1998d	CD ROM	DOLA	South West
Draft Strategic Plan for Perth's Greenways, report (Tingay, Alan & Associates 1997)	map	N/A	Perth Metropolitan Region
channel wetlands (water courses), (WRC 1996a GIS)	GIS	WRC	Swan Coastal Plain

Directory Descriptors (Appendix 1, page 103)

The following standard descriptions are used to describe each Bushplan Site in relation to the surrounding area:

- no adjacent bushland
- bushland canopy creekline linkage to north, south, east, west (Bushplan Site number(s))
- part of proposed Greenway 'Greenway number(s)' e.g. 37 (Tingay, Alan & Associates 1997)
- part of regionally significant contiguous or regionally significant fragmented or regionally significant potential bushland/wetland linkage (see Map 8).

4.5.6 OTHER SPECIAL ATTRIBUTES

Background

In many cases some section of, or all of, a Bushplan Site has been recognised as having significance at a regional level by previous studies or identification processes. When known and accessible these are listed in this Section. Examples of such studies/processes are:

- Regional and local government studies such as Payne (1993a&b), Keighery, BJ, and Trudgen (1992), Griffin (1993), Griffin (1994), Gibson *et al.* (1994), Trudgen and Keighery (1995) etc.
- Classification by the National Trust of natural areas or landscapes that meet a series of heritage values. Classified Landscapes are entered onto the Register of the National Trust of Western Australia (National Trust of Australia (WA) 1998)
- Natural Areas identified by the interim 'Environmental and Landscape Audits' prepared for the Department of Planning and Urban Development (Semeniuk, V&C Research Group from 1991 to 1994)
- 'Threatened or Poorly Reserved Plant Communities' identified by the Environmental Protection Authority (1994 GIS). This series of bushland areas on the Swan Coastal Plain was considered to be in need of interim protection under the System 6 and part System 1 Update Program. The majority of these areas are on the eastern side of the Swan Coastal Plain, with several from the west of the Plain. Studies by Keighery, BJ, and Trudgen (1992) and Gibson *et al.* (1994) were used to identify these areas.

Information Source

Source	Form	Custodian	Coverage
National Trust Classified Landscapes (National Trust of Australia (WA) 1998)	list	National Trust of Australia (WA)	WA
published and unpublished reports	text	N/A	individual bushland areas on the Swan Coastal Plain
Threatened or Poorly Reserved Plant Communities, Environmental Protection Authority (1994)	GIS	DEP	individual bushland areas on the Swan Coastal Plain

Directory Descriptors (Appendix 1, page 103)

The special attribute is briefly described and referenced.

4.6 *SECTION 4: INTERNATIONAL AND NATIONAL SIGNIFICANCE*

4.6.1 INTRODUCTION

There are a series of national and international listings of important natural areas within the Perth Metropolitan Region. In each case a set of criteria, related to the natural value, is used to assess the significance of an area. While these listings confer added significance on an area it should not be inferred that areas not listed have a lesser value. Western Australia generally has poorly known and documented flora and fauna and the selection of areas has not been based on systematic survey. As a consequence none of the 'listings' should be seen as definitive.

4.6.2 WETLANDS OF INTERNATIONAL IMPORTANCE (RAMSAR WETLANDS)

Background

The Convention on Wetlands of International Importance Especially as Waterfowl Habitat, known as the Ramsar Convention after the Iranian town of Ramsar where it was adopted in 1971, provides a framework for international cooperation in the conservation and wise use of wetlands (UNESCO 1971). In 1998 105 nations or Contracting Parties were party to the Ramsar Convention (Environment Australia 1998 database). Each Contracting Party is required to nominate at least one Wetland of International Importance (Ramsar site). At least one of three criteria (Table 16) must be met for the nomination to be successful. Once listed as a Wetland of International Importance the Contracting Party undertakes to maintain its ecological character in perpetuity. One of the nine Ramsar sites in WA (Forrestdale and Thomsons Lakes) is in the Perth Metropolitan Region (Environment Australia 1998).

Under the 'Ramsar' Convention wetlands are defined as 'areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed more than six metres'. This definition is also used in the State Wetland Conservation Policy (Government of Western Australia 1997).

Information Source

Source	Form	Custodian	Coverage
Environment Australia (1998)	database	Environment Australia	international

Directory Descriptors (Appendix 1, page 103)

Ramsar sites are listed.

Table 16: Criteria for Identifying Wetlands of International Importance

The Ramsar Convention

A wetland is identified as being of international importance if it meets at least one of the criteria set out below:

1. *Criteria for representative or unique wetlands*

A wetland should be considered internationally important if:

(a) it is a particularly good representative example of a natural, or near-natural, wetland, characteristic of the appropriate biogeographical region; or

(b) it is a particularly good representative example of a natural, or near-natural, wetland common to more than one biogeographical region; or

(c) it is a particularly good representative example of a wetland which plays a substantial hydrological, biological or ecological role in the natural functioning of a major river basin or coastal system, especially where it is located in a trans-border position; or

(d) it is an example of a specific type of wetland, rare or unusual in the appropriate biogeographical region.

2. *Criteria based on plants and animals*

A wetland should be considered internationally important if:

(a) it supports an appreciable assemblage of rare, vulnerable or endangered species or subspecies of plant or animals, or an appreciable number of individuals of any one or more of these species; or

(b) it is of special value for maintaining the genetic and ecological diversity of a region because of the quality and peculiarities of its flora and fauna; or

(c) it is of special value as the habitat of plants or animals at a critical stage of their biological cycle; or

(d) it is of special value for one or more endemic plant or animals species or communities.

3. *Specific criteria based on waterfowl*

A wetland should be considered internationally important if:

(a) it regularly supports 20,000 waterfowl; or

(b) it regularly supports substantial numbers of individuals from particular groups of waterfowl, indicative of wetland values, productivity or diversity; or

(c) where data on populations is available, it regularly supports 1% of the individuals in a population of one species or subspecies of waterfowl.

4.6.3 DIRECTORY OF IMPORTANT WETLANDS IN AUSTRALIA

Background

The Directory of Important Wetlands in Australia (ANCA 1994, 1996) provides the most complete compilation available at present of Australia's nationally important wetlands. The Directory is the result of cooperative work between Federal, State and Territory nature conservation agencies and was compiled to assist in the conservation and wise management of wetlands.

Wetlands are essentially defined according to the definition established by the Ramsar Convention (see section 4.6.2 above).

Six criteria are used to identify wetlands for inclusion in the Directory of Important Wetlands in Australia (ANCA 1996). The Convention states:

'A wetland may be considered nationally important if it meets at least one of the following criteria:

1. It is a good example of a wetland type occurring within a Biogeographic Region in Australia.
2. It is a wetland which plays an important ecological or hydrological role in the natural functioning of a major wetland system/complex.
3. It is a wetland which is important as the habitat for animal taxa at a vulnerable stage in their life cycles, or provides a refuge when adverse conditions such as drought, prevail.
4. The wetland supports 1% or more of the national population of any plant or animal taxa.
5. The wetland supports native plant or animal taxa or communities which are considered endangered or vulnerable at the national level.
6. The wetland is of outstanding historical or cultural significance.'

These criteria were established for the first edition of the Directory of Important Wetlands in Australia (ANCA 1994) and revised by the Australian and New Zealand Environment and Conservation Council Wetlands Network in 1994.

The Directory of Important Wetlands in Australia gives '110 site accounts' in WA which cover several hundred discrete wetlands. Thirteen of these accounts refer to wetlands on the Swan Coastal Plain in the Perth Metropolitan Region. These are: Becher Point Wetlands (part included in Bushplan Site 377), Booragoon Lake (Bushplan Site 337), Brixton Street Swamps (part Bushplan Site 387), Ellen Brook Swamps System (Bushplan Sites 301, 400), Forrestdale Lake (Bushplan Site 345), Gibbs Road Swamp System (Bushplan Site 344), Herdsman Lake (Bushplan Site 281), Joondalup Lake (Bushplan Site 299), Loch McNess System (Bushplan Site 288), Perth Airport Woodland Swamps (Bushplan Site 386), Spectacles Swamp (Bushplan Site 269), Swan-Canning Estuary (for example Bushplan Sites 214, 224, 225, 313, 314, 333, 338 and 402) and Thomsons Lake (Bushplan Site 391).

This listing for WA is not definitive (Lane *et al.* 1996) as there has been no systematic survey of wetlands or wetland values across the State.

Information Source

Source	Form	Coverage
Directory of Important Wetlands in Australia (ANCA 1996)	text, maps	Australia (see comments in Background)

Directory Descriptors (Appendix 1, page 103)

All Bushplan Sites included in the Directory of Important Wetlands in Australia are indicated.

4.6.4 REGISTER OF THE NATIONAL ESTATE

Background (Australian Heritage Commission 1994)

The Commission was established by the Commonwealth Government in 1975 with the aim of helping Australians identify and appreciate the National Estate and promote its conservation. Aboriginal and Torres Strait Islander places, natural environment places and historical places are all considered part of the National Estate.

The Heritage Commission is a Commonwealth Government statutory authority and its main responsibilities are to:

- advise the Commonwealth Minister for Environment and the Government on national estate and conservation issues
- compile an inventory of national estate places throughout Australia — the Register of the National Estate
- coordinate the National Estate Grants Program and administer the program's national component
- encourage community appreciation of and concern for the National Estate through information, education and training.

The main task of the Commission is to compile the Register of the National Estate. Over 12,000 natural and cultural places throughout Australia, including 1,858 natural places, are listed on the Register (Australian Heritage Commission 1998 D). Anyone can nominate a place for registration. All places entered on the Register are assessed against the published criteria used to identify national estate values (Table 17).

Areas proposed for listing are published in the Commonwealth of Australia Gazette and in public notices in the press. The place is then on the 'Interim List'. Any person may object to or comment on the interim listing of the place on the Register. Usually objections must be made within three months of the publication of the notice. Objections must relate to the criteria under which the place was proposed for listing and are assessed by an independent expert panel. The final decision on national estate significance is made by the Commission.

Over 40 natural places in the Perth Metropolitan Region are listed on the Register. While places are being increasingly assessed on a thematic or regional basis, both within WA and throughout Australia, listing on the Swan Coastal Plain has not been based on systematic survey and is far from complete.

The Register alerts governments, planners, decision makers, researchers and the community to the heritage values of these places, so they can take action to conserve them. Listing does not directly affect the way in which owners manage places. Thus it confers a moral rather than legal obligation on the owners. The Commission does not own or manage any national estate places and does not have entry rights to places in the Register. The Commonwealth Government is the only body whose actions are formally constrained as a result of listing on the Register.

Information Source

Source	Form	Custodian	Coverage
AHC (1998)	database (list of natural places)	AHC	Australia (see comments in Background)

Directory Descriptors (Appendix 1, page 103)

Three categories of recognition by the Commission are given:

- Listed on the Register of the National Estate
- Interim List of the Register of the National Estate
- Indicative Place of the Register of the National Estate (i.e. a place thought to have national estate values)

Table 17: Criteria for the Register of the National Estate (Australian Heritage Commission 1990)

Without limiting the generality of sub-section (1) of the Australian Heritage Commission Act, a place that is a component of the natural or cultural environment of Australia is to be taken to be a place included in the national estate if it has significance or other special value for future generations as well as for the present community because of:

Criterion A: Its importance in the course, or pattern, of Australia's natural or cultural history.

A.1 Importance in the evolution of Australian flora, fauna, landscapes or climate.

A.2 Importance in maintaining existing processes or national systems at the regional or national scale.

A.3 Importance in exhibiting unusual richness or diversity of flora, fauna, landscapes or cultural features.

A.4 Importance for association with events, development or cultural phases which have had a significant role in the human occupation and evolution of the nation, State, region or community.

Criterion B: Its possession of uncommon, rare or endangered aspects of Australia's natural or cultural history.

B.1 Importance for rare, endangered or uncommon flora, fauna, communities, ecosystems, natural landscapes or phenomena, or as a wilderness.

B.2 Importance in demonstrating a distinctive way of life, custom, process, land-use, function or design no longer practised, in danger of being lost, or of exceptional interest.

Criterion C: Its potential to yield information that will contribute to an understanding of Australia's natural or cultural history.

C.1 Importance for information contributing to a wider understanding of Australian natural history, by virtue of its use as a research site, teaching site, type locality, reference or benchmark site.

C.2 Importance for information contributing to a wider understanding of the history of human occupation of Australia.

Criterion D: Its importance in demonstrating the principal characteristics of: (I) A class of Australia's natural or cultural places; or (II) A class of Australia's natural or cultural environments.

D.1 Importance in demonstrating the principal characteristics of the range of landscapes, environments or ecosystems, the attributes of which identify them as being characteristic of their class.

D.2 Importance in demonstrating the principal characteristics of the range of human activities in the Australian environment (including way of life, custom, process, land-use, function, design or technique).

Criterion E: Its importance in exhibiting particular aesthetic characteristics valued by a community or cultural group.

E.1 Importance for a community for aesthetic characteristics held in high esteem or otherwise valued by the community.

Criterion F: Its importance in demonstrating a high degree of creative or technical achievement of a particular period.

F.1 Importance for its technical, creative, design or artistic excellence, innovation or achievement.

Criterion G: Its strong or special associations with a particular community or cultural group for social, cultural or spiritual reasons.

G.1 Importance as a place highly valued by a community for reasons of religious, spiritual, symbolic, cultural, educational, or social associations.

Criterion H: Its special association with the life or works of a person, or group of persons, of importance in Australia's natural or cultural history.

H.1 Importance for close associations with individuals whose activities have been significant within the history of the nation, State or region.

4.6.5 MIGRATORY BIRD AGREEMENTS (JAMBA AND CAMBA)

Background

Some of the Bushplan Sites are visited by birds which migrate between the northern and southern hemispheres each year. Conservation of these birds is supported by two international agreements covering these birds and their habitats (ANCA 1996). These agreements are between the Government of Australia and the Governments of Japan and the People's Republic of China, the former being the Japan-Australia Migratory Bird Agreement (JAMBA, signed on 6 February 1974) and the latter the China-Australia Migratory Bird Agreement (CAMBA, signed on 20 October 1986). The bird species subject to these agreements are listed in Table 15. Some of the species included under JAMBA/CAMBA are also recognised under the *Western* Australian *Wildlife Conservation Act 1950* as Specially Protected Fauna.

Information Source

Source	Form	Coverage
Agreements	listed individual bird species	China – Japan – Australia

Directory Descriptors (Appendix 1, page 103)

Bushplan Sites are noted as being a 'location for JAMBA/CAMBA species'. (Detail of the species is contained in the 'Fauna' section.)

4.7 *SECTION 5: SELECTION CRITERIA AND RECOMMENDATIONS*

4.7.1 CRITERIA

Background

The selection criteria have been developed to meet objectives established in the State Urban Bushland Strategy (Government of Western Australia 1995a); the Wetlands Conservation Policy (Government of Western Australia 1997) and the National Strategy for the Conservation of Australia's Biological Diversity (Commonwealth of Australia 1996).

A key commitment in the Urban Bushland Strategy is to protect :

'at least 10 per cent, in accordance with guidelines set by the IUCN (International Union for Conservation, now known as the World Conservation Organisation), or 400ha, whichever is the largest, of each complex in at least five separate areas' (see Volume 1, section 2.2).

A primary objective of the National Strategy is to:

'Establish and manage a comprehensive, adequate and representative system of protected areas covering Australia's biological diversity.'

'Comprehensive', 'adequate' and 'representative' are terms defined in the National Strategy as follows:

- comprehensiveness — the degree to which the full range of ecological communities and their biological diversity are incorporated within reserves
- adequacy — the ability of the reserve to maintain the ecological viability and integrity of populations, species, and communities. (The interactions between reserves and surrounding areas should be taken into account in determining the reserve's ability to meet ecological viability and integrity criteria. Complementary management of the adjacent areas can play a significant role. In some instances, however, the ecological viability of the protected area itself will be paramount.)
- representativeness — the extent to which areas selected for inclusion in the national reserves system are capable of reflecting the known biological diversity and ecological patterns and processes of the ecological community or ecosystem concerned.

Perth's Bushplan aims, within the limits of the natural areas available, to identify a comprehensive, adequate and representative system of reserved and protected areas in the Perth Metropolitan Region portion of the Swan Coastal Plain, and represents the primary means of achieving these objectives in the Perth area.

The selection criteria for *Perth's Bushplan* were developed with input from a workshop (established for the System 6 and Part System 1 Update Program) attended by conservation scientists, consultants, representatives of a range of key government agencies and the community. These draft recommendations were reviewed through a broadly based Technical Working Group and the Steering Committee established for the System 6 and Part System 1 Update Program (Department of Environmental Protection), and the Urban Bushland Advisory Group (advisory group to the Western Australian Planning Commission).

Representation of Ecological Communities

Ecological communities, rather than species, are used as the main unit on which the selection/representation of biological diversity has been made in *Perth's Bushplan,* as this is the level at which:

- the most comprehensive regional plot– and map-based information on the biological diversity of the Swan Coastal Plain is available
- both the National Strategy and Urban Bushland Strategy focus.

Each of the criteria is presented and discussed below.

REPRESENTATION OF ECOLOGICAL COMMUNITIES

A number of areas selected to represent the range of ecological communities and the places in which these communities merge

Scope

Regional representation will be primarily based upon the target of achieving:

- comprehensive and adequate representation of each floristic community type within each vegetation complex (in uplands and vegetated wetlands).
- comprehensive and adequate representation of each natural wetland group and wetland types within each group.

Inclusion guidelines

- Areas which are good examples of each floristic community type, selected to be representative of the vegetation of a geomorphic unit.
- Areas contributing to at least 10 per cent or 400 hectares of each vegetation complex, whichever is the larger, in at least five separate areas.
- Best available examples of each natural wetland group and wetland types within each group.
- Areas identified as being of national or international significance through treaty/convention/policy.

Exclusion guidelines

- Vegetation which does not satisfy the definition of bushland (unless it is the best example of its type with particular reference to fauna habitat).
- Areas which are not best available examples of particular ecological communities (floristic community type/vegetation complexes/threatened ecological communities) because there are more appropriate (bigger, better condition, richer/more diverse) sites elsewhere.

Diversity

Diversity is an important supporting criterion, usually used in conjunction with representativeness. Within the primary objective of maximising representation, selections of Bushplan Sites are made to choose sites supporting a diversity of plant communities from the aspects of both structural and floristic diversity.

DIVERSITY

Areas with a high diversity of flora and/or fauna species or communities in close association

Scope

The conservation of important areas by virtue of their richness, diversity or complexity for their physical or biological attributes at the community, species or genetic level. This will be primarily based on areas supporting:

- a wide variety of flora and/or fauna species.
- unusual concentrations of subspecies or varieties occurring together.
- wide representation of floristic community types in close proximity.
- species-rich examples of communities of their type.
- a wide variety of plant associations, assemblages or communities.

This criterion will commonly support other criteria for selection of representative areas.

Inclusion guidelines

- Areas with high flora diversity at the community, species or genetic level.
- Areas with a high diversity of plant associations, assemblages or communities relative to the area.
- Areas with a high diversity of faunal assemblages.

Exclusion guidelines

- Floristic community types which are replicated in many areas.
- Areas with low to moderate diversity at the community, species or generic level.

Rarity

Rarity is considered at a community and individual species perspective. Selection of Threatened Ecological Communities (after English and Blyth 1997, see section 4.4.4) is a priority, related to this criterion and the representativeness criterion.

Protecting rare or restricted taxa of flora and fauna (may be species, subspecies or varieties) is achieved through the preferential selection of representative examples of communities that are known to support populations of these species.

RARITY

Areas containing rare or threatened communities or species, or species of restricted distribution

Scope

This criterion applies to aspects of the environment which are rare or relatively rare, and can encompass any environmental, biological or ecological feature or phenomenon which can be regarded as outstanding because it is one of the few of its type.

Inclusion guidelines

- Threatened ecological communities.
- Habitat of rare, uncommon or restricted flora and/or fauna species and/or species outside of or at the limit of their range.
- Areas supporting rare, uncommon or restricted communities and/or communities outside of or at the limit of their normal range.

Exclusion guidelines

- Habitats of species or communities whose significance (as described above) is not established.
- Areas, which if supporting outlying species or communities, are replicated by better examples elsewhere.

Maintaining Ecological Processes or Natural Systems

The selection of areas for their role in 'maintaining ecological processes or natural systems' relates to the 'adequacy' objective of the National Strategy (Commonwealth of Australia 1996). This is the most difficult of the national criteria to fully achieve in the Perth Metropolitan Region, given the extent of clearing and the fragmented nature of much of the remaining bushland.

The protection of remaining large areas of bushland, particularly those providing representation of two or more vegetation complexes, or a range of floristic community types, is an important component of this selection criterion. These larger areas represent core Bushplan Sites with the best opportunity for maintenance of a more complete range of ecological function. For the same reasons, the identification, protection and enhancement of remaining linkages or corridors of bushland through the metropolitan area is considered an important component of providing for the on-going viability (adequacy) of the protected areas.

Several of the wetlands in the metropolitan area are of international importance for the protection of migratory waterbirds, serving to maintain ecological systems that extend beyond Australia.

It is notable that small bushland areas on the eastern side of the plain have demonstrated an ability to maintain good condition after many years of isolation in an agricultural environment, provided they are not subject to gross disturbance (see 4.5.3 Vegetation Condition).

MAINTAINING ECOLOGICAL PROCESSES OR NATURAL SYSTEMS

Maintenance of ecological processes or natural systems at a regional or national scale

Scope

This criterion applies to areas which are important in the maintenance of existing processes or natural systems.

This criterion would normally be used in conjunction with other criteria for the selection of representative areas.

Inclusion guidelines

- Large areas in natural condition with natural processes intact or largely so.
- Fauna habitats providing specific requirements for feeding/breeding/nursery functions.
- Substantive wildlife corridors connecting bushland areas.
- Habitat for significant populations of migratory birds.

Exclusion guidelines

- Areas which are replicated by other areas supporting significant populations or in better condition.
- Areas not recognised as being of national or international significance for migratory birds.

Scientific or Evolutionary Importance

This criterion is intended to address areas supporting restricted specialist communities, for example, the Lake Richmond thrombolites, or areas of scientific and evolutionary significance, such as study areas for regional studies and the Minim Cove foreshore fossil site on the Swan River.

SCIENTIFIC OR EVOLUTIONARY IMPORTANCE

Areas containing evidence of evolutionary processes either as fossilised material or as relict species and areas containing unusual or important geomorphological or geological sites; Areas of recognised scientific and education interest as reference sites or as examples of the important environmental processes at work

Scope

This criterion applies generally to areas which contain evidence of past ecological or biological processes, and important geomorphological or geological sites and to areas which have recognised value as research sites, type localities or to sites having reference or benchmark value.

This criterion will usually support other criteria for selection of representative areas.

Inclusion guidelines

- Areas with remains of flora and fauna now extinct (fossil sites).
- Areas with primitive or relict flora or fauna surviving from earlier times.
- Areas with fossil or other records of identifiable past climates or environments.
- Long-term scientific/educational monitoring sites or study areas.

Exclusion guidelines

- Areas in which the evidence of past processes is not clearly established.
- Areas which are replicated by places with clearer evidence of the above or in better condition.
- Areas not identified as important geomorphological sites.
- Areas not identified as important geological sites.

General Criteria for Protection of Wetland, Streamline and Estuarine Fringing Vegetation and Coastal Vegetation

Wetlands are recognised as an important feature of the Swan Coastal Plain where they are a focus of biological diversity and a key component for the maintenance of ecological functions associated with the hydrological cycle.

Conservation category wetlands (Hill *et al.* 1996a&b) are often core areas in Bushplan Sites and their inclusion in Sites makes a significant contribution to the protection of the diversity, representation and function of important examples of the remaining wetlands on the Swan Coastal Plain.

River foreshores and coastal vegetation are also widely recognised as important, not only for conservation of biological diversity and the opportunities for linkage that they present, but also for maintenance of the stability of these environments and their protection as key areas of public open space and landscape diversity.

GENERAL CRITERIA FOR PROTECTION OF WETLAND, STREAMLINE, AND ESTUARINE FRINGING VEGETATION AND COASTAL VEGETATION

Conservation category wetland areas including fringing vegetation and associated upland vegetation; Coastal vegetation within the accepted coastal management zone

Scope

This criterion applies to wetlands in good condition, their fringing vegetation and adjacent upland vegetation and to coastal vegetation within the accepted coastal management zone.

Inclusion Guidelines

- Conservation category wetlands associated with regionally significant bushland, their fringing vegetation and associated upland vegetation.
- Coastal vegetation within the accepted coastal management zone.

Exclusion Guidelines

- Conservation category wetlands not associated with regionally significant bushland (to be dealt with by other State policy mechanisms).
- Channel wetlands not supporting regionally significant bushland.
- Resource enhancement category wetlands and degraded conservation category wetlands.
- Other wetlands with vegetation removed or severely altered, such as multiple-use management category wetlands.
- Cleared or developed coastlines and estuarine fringes.

Criteria Not Relevant to Determination of Regional Significance, but which may be Applied When Evaluating Areas Having Similar Values

Many of the natural areas identified in Perth's Bushplan have additional values related to their cultural significance. While these have not been researched in a comprehensive manner for Perth's Bushplan such values have been taken into account in the evaluation of natural areas having similar values.

CRITERIA NOT RELEVANT TO DETERMINATION OF REGIONAL SIGNIFICANCE, BUT WHICH MAY BE APPLIED WHEN EVALUATING AREAS HAVING SIMILAR VALUES

Attributes which when taken alone do not establish regional significance, but which can add to the value of bushland and enhance its contribution to Perth's Bushplan

- The area is a regional recreation resource.
- The area is of historic significance or contains significant sites (post-European settlement).
- The area contains a site or sites of significance for Aboriginal people.
- The area has social value to a community group.
- The area has aesthetic value as a notable landscape feature or viewpoint.

Information Source

All information sources referred to in the report as outlined in sections 4.4, 4.5 and 4.6.

Directory Descriptors (Appendix 1, page 104)

The criteria met are listed as follows:

- Representation of ecological communities
- Diversity
- Rarity
- Maintaining ecological processes or natural systems
- Scientific or evolutionary importance
- General criteria for the protection of wetland, streamline and estuarine fringing vegetation and coastal vegetation
- Criteria not relevant to determination of regional significance, but which may be applied when evaluating areas having similar values.

4.7.2 OPPORTUNITIES AND/OR CONSTRAINTS

Background

Attributes can be identified that support (opportunities) or diminish (constraints) the degree to which the bushland within each Bushplan Site is currently protected or able to be protected. These opportunities and constraints are discussed below. Information on many of these attributes is contained in *SECTIONS 1–4* of the Bushplan Site Descriptions.

Opportunities

Opportunities arise from various forms of land tenure that provide some existing measure of protection. The principal means of protecting natural areas is reservation under the Metropolitan Region Scheme (Parks and Recreation Reservation) and/or the *Land Administration Act 1997* (see Volume 1, section 2.5).

A diverse suite of other mechanisms provides a level of protection to features or species of recognised conservation or heritage importance. The most effective of these opportunities are listed below. A brief description of those opportunities not described previously follows this listing.

- Declared Rare Flora and Fauna (see sections 4.5.3 and 4.5.4)
- Conservation Category Wetlands (see section 4.4.3)
- Environmental Conditions
- Environmental Protection Policies
- Statement of Planning Policies
- Planning Control Areas
- Clearing controls

Environmental Conditions (Ministerial Conditions)

Environmental conditions can be set under Part IV of the Environmental Protection Act 1986. Part IV of the Act allows the EPA to assess proposals and schemes and impose environmental conditions to which the proposal or scheme should be subject. The conditions are set by the Minister for the Environment. An example of the setting of such conditions is outlined below under Peel Inlet-Harvey Estuary Environmental Protection Policy.

Environmental conditions can be imposed on proposals and schemes requiring that specific areas of bushland should be appropriately protected and managed. These are not included in the Bushplan Site descriptions but should be taken into account in implementation.

Environmental Protection Policies

An Environmental Protection Policy (EPP) is prepared under Part III of the Environmental Protection Act 1986 and has 'the force of law as though it had been enacted as part of this Act', on and from the day on which the policy is published in the Government Gazette.

An EPP establishes:

- the boundaries of the area and the portion of the environment to which the policy applies;
- the basis on which the environment in this area is to be protected, or pollution is to be prevented, controlled or abated.

In addition, an EPP may also:

- specify the environmental quality objectives to be achieved and maintained under the policy;
- set out the indicators, parameters or criteria to be used for measuring environmental quality in the policy area;
- relate to any activity directed towards the protection of the environment, including the discharge of waste;
- create offences and penalty provisions;
- establish a program for the protection of the environmental values within the policy area and may specify, among other things, measures designed to:
  (i) minimise the possibility of pollution;
  (ii) protect the environment;
  (iii) achieve and maintain the environmental values to be protected.

There are a number of Environmental Protection Policies which protect portions of the Swan Coastal Plain in the Perth Metropolitan Region. Those of particular relevance to Perth's Bushplan are outlined below:

Peel Inlet-Harvey Estuary Environmental Protection Policy (Government of Western Australia 1992a)

Stage 1 of an Environmental Review and Management Plan (ERMP) for the eutrophic Peel Inlet and Harvey Estuary was published in 1985 (Peel-Harvey Study Group 1985), with Stage 2 of the ERMP being subsequently published in 1988 (Kinhill 1988).

The EPA undertook an assessment of both Stage 1 and Stage 2 of the ERMP (EPA 1985 and EPA 1988), the result of which was the imposition of legally binding conditions by the Minister for the Environment. These Environmental Conditions include a moratorium on land clearing and drainage within the Swan Coastal Plain portion of the catchment of the estuary.

The Environmental Conditions had the effect of requiring the proponents of the management plan (being the Ministers for Transport, Agriculture and Waterways) to exercise control on clearing and drainage in the catchment for the purpose of controlling nutrient inputs to the waterway.

In 1992 the Department of Planning and Urban Development prepared the Statement of Planning Policy No. 2 (The Peel-Harvey Coastal Plain Catchment) to give effect to both land use controls identified within the management strategy and environmental conditions of approval (Government of Western Australia 1992b). The Statement of Planning Policy (SPP) was prepared 'to ensure that land use changes within the Peel-Harvey Estuarine System likely to cause environmental damage to the estuary are brought under planning control and prevented'.

The Environmental Protection (Peel Inlet-Harvey Estuary) Policy was proclaimed on 11 December 1992 primarily for the purpose of establishing water quality targets for the estuary and, by reference to it, to give statutory effect to the Statement of Planning Policy No. 2 by requiring implementation of the SPP by local authorities.

Swan Coastal Plain Lakes Environmental Protection Policy (Government of Western Australia 1992c, see section 4.3.3)

The Swan Coastal Plain Lakes EPP protects lakes, identified under the policy, from draining, filling and (the discharge of) pollution.

Significantly the EPA is required under section 36 of the *Environmental Protection Act 1986* to review and prepare a new draft policy by 18 December 1999. This review may provide an opportunity to extend the EPP such that regionally significant wetlands and bushland associated with these habitats are afforded statutory protection.

Gnangara Mound Crown Land Environmental Protection Policy (Government of Western Australia 1992d)

The Gnangara Mound Crown Land EPP was gazetted on 24 December 1992 with the objective of protecting:

(i) the level and quality of groundwater; and

(ii) native vegetation and wetlands associated with Crown Land on the Mound.

The policy includes provisions which control unauthorised activities which may destroy or degrade native vegetation or wetlands located on Crown Land on the Mound. A person who contravenes these requirements commits an offence and is subject to penalty provisions under the *Environmental Protection Act 1986.*

Swan and Canning Rivers Environmental Protection Policy (Government of Western Australia 1998b)

The Swan and Canning Rivers EPP was gazetted on 10 July 1998 and declares the beneficial uses of the rivers to be protected and establishes a program of protection. The uses declared to be protected include the maintenance of the natural ecosystem, aesthetic and landscape amenity, recreation, fishing, navigation and port facilities.

In seeking to protect the beneficial uses of the rivers the EPP also identifies important values and functions of native fringing vegetation to be protected. These include when native fringing vegetation:

- is of value for bank and shoreline stabilisation, erosion control and the filtration and attenuation of the discharge of pollutants;
- is remnant vegetation, is in unusually good condition or has integrity as a sample of its type;
- is a disjunct population of a native species, is at

the limit of its geographical range or is inadequately represented in reserves;

- has connective importance as, or part of, a corridor of native vegetation or migratory route;
- is situated in an area that has high biological diversity; and
- is regionally significant remnant vegetation identified for conservation by the Department of Environmental Protection.

This last consideration was made in direct relation to regionally significant vegetation as identified in Perth's Bushplan.

The EPP also requires that the EPA prepare and submit to the Minister for the Environment a catchment-wide Comprehensive Management Plan (CMP) by December 1999. The CMP is required to delineate the beneficial uses and critical areas that are to be protected and to stipulate the roles and responsibilities of key decision-making bodies.

Western Swamp Tortoise Draft Environmental Protection Policy (EPA 1998)
The Western Swamp Tortoise is considered to be one of the world's rarest reptiles with, at one time, less than 40 individuals left in the wild. There is concern in the community that the animal will become extinct if immediate action is not taken to increase the size of the population and to protect its habitat. A draft EPP released in 1994 aimed to help protect the only remaining habitat for the tortoise at Twin Swamps (part Bushplan Site 400) and Ellen Brook (part Bushplan Site 301) Nature Reserves. Much of the affected land within the policy boundaries is in private ownership. The EPA sought further public comment on a refined draft towards the middle of 1998 prior to finalising the policy.

State Groundwater Draft Environmental Protection Policy (EPA1997)
The State Groundwater Draft Environmental Protection Policy was released for public comment in December 1997 and provides a state-wide framework for protecting the environmental values of important groundwater systems. Under the EPP, regulations may be prepared to protect drinking water supplies, groundwater-dependant ecosystems and recreational activities associated with groundwater.

Groundwater-dependent ecosystems include caves, wetlands and phraetophytic (groundwater-dependent) vegetation. Water allocation strategies and water resource management plans are required to complement the environmental objectives of the policy. The State Groundwater EPP has been drafted to provide for the Gnangara Mound Crown Land EPP, Gnangara Mound Private Land Draft EPP and Jandakot Mound Groundwater Draft EPP. Accordingly, it is anticipated that these EPPs will be repealed once the State Groundwater EPP is proclaimed.

Reference to the State Groundwater Draft Environment Protection Policy is not included in the relevant Bushplan Site descriptions but the provision of water for the environment, in particular, is fundamental to the maintenance of the bushland within the Bushplan Sites, particularly where the bushland may otherwise be subject to degradation from groundwater drawdown or over-abstraction.

Statements of Planning Policy

Statements of Planning Policy (SPP) are prepared under the provisions of Section 5AA of the *Town Planning and Development Act 1928* by the Western Australian Planning Commission. Statements of Planning Policy must receive approval from the Minister for Planning and the Governor and are published in the *Government Gazette*.

Statements of Planning Policy are concerned with broad planning policies to co-ordinate planning and can be made for particular classes of development or matters which relate to a specific region or area of the State.

There are a number of SPPs that provide direction for local authorities when considering portions of the Swan Coastal Plain in the Perth Metropolitan Region. Development in these areas is guided in specific ways by the particular requirements of the SPP and provides additional opportunities for conservation. These SPPs are:

Peel-Harvey Coastal Plain Catchment Statement of Planning Policy No. 2 (Government of Western Australia 1992a)

This policy is intended to control landuses which are likely to result in pollution of surface and groundwater. A number of the specific objectives of this policy are compatible with the objective of protecting and conserving bushland. These objectives are:

- to increase high water-using vegetation cover within the Peel-Harvey Coastal Plain Catchment;
- to ensure that changes to landuse within the catchment to the Peel Harvey Estuarine system are controlled so as to avoid and minimise environmental damage.

Gnangara Mound Crown Land Statement of Planning Policy No. 3. (Government of Western Australia 1995b)
The main purpose of the policy is to prevent development which could prejudice the long-term use of groundwater. Acceptable landuses are those which are compatible with the sustainable use of the groundwater resource and the retention of the environmental values associated with that resource. An objective of the policy is to protect wetlands and natural vegetation which is compatible with the objective of protecting and conserving bushland.

Jandakot Groundwater Protection Policy Statement of Planning Policy No. 6. (Government of Western Australia 1998a)
The main purpose of this policy is to ensure that development over the Jandakot public groundwater supply mound is compatible with the long-term use of the groundwater for human consumption. The Policy is to ensure that landuse changes within the policy area that are likely to cause detrimental effects to the groundwater are brought under planning control and prevented or managed.

Reference to SPPs may not be included in the relevant Bushplan Site descriptions but the presence of these should be taken into account in implementation.

Planning Control Areas

Planning Control Areas (PCAs) are prepared under the provisions of Section 35C of the *Metropolitan Region Town Planning Scheme Act 1959*. A Planning Control Area may be declared when the Western Australian Planning Commission considers that land situated within the Perth Metropolitan Region may be required for a range of purposes as specified in the Act, including Parks and Recreation.

Proposals for development within a Planning Control Area must be referred to the WAPC for determination. References to the PCAs may not be included in the relevant Bushplan Site descriptions but the presence of these should be taken into account in implementation.

Clearing Controls

Under Regulation 4 of the Soil and Land Conservation Regulations 1992 the owner or occupier of any land in the State is required to lodge a Notice of Intention to Clear Land where it is intended to clear more than one hectare and where that clearing will result in a change in land use.

The Commissioner may then, using the soil conservation notice provisions of the *Soil and Land Conservation Act 1945*, direct the landholder to refrain from clearing any land specified in the notice, or the landholder may enter into an agreement to reserve or agree to protect and manage under a conservation covenant any of the vegetation the Commissioner would not allow to be cleared. The Commissioner's concern extends only to any clearing which may result in land degradation.

The Memorandum of Understanding (Commissioner of Soil and Land Conservation 1997) on land clearing provides a process for coordinating the assessment of clearing proposals by other key agencies (the Department of Environmental Protection, the Department of Conservation and Land Management, the Water and Rivers Commission) in cases where other natural resource values, such as biodiversity or water resources may be threatened by the clearing. In cases where other statutes do not provide protection (such as habitat) the process may lead to formal assessment by the Environmental Protection Authority.

The MOU covers clearing for agricultural purposes on rural-zoned land, including such land in the metropolitan region. Clearing for urban development is presumed by the Commissioner to have had the necessary assessment for controls placed on land degradation during the processes of rezoning.

Constraints

In an area as intensively developed as the Perth Metropolitan Region most areas identified for conservation will have some constraining factors. Factors such as zoning for intensive land uses, specific requirements for purposes such as the regional road network, and mineral or basic raw material resources (and tenements) are recognised as constraints.

In selecting areas for the conservation of a comprehensive and representative system of protected areas, the first emphasis has been placed on using the available information sources. These have been used to achieve the objectives established through the Urban Bushland Strategy and the National Strategy for the Conservation of Australia's Biological Diversity. Within this objective however selection has taken constraining factors into consideration (see Volume 1, sections 2.3, 2.4 and 2.5), attempting to seek the least constrained site, where equivalent areas exist.

Information Source

Opportunities

Source	Form	Custodian	Coverage
DRF flora (see section 4.5.3)	GIS, lists	CALM	Perth Metropolitan Region, WA
Scheduled Fauna (see section 4.5.4)	lists	CALM	WA
Conservation category wetlands (WRC 1996c)	GIS	WRC	Swan Coastal Plain north of Bunbury
MRS Parks and Recreation Reservation (MfP 1998a)	GIS	MfP	Perth Metropolitan Region
TPS Parks and Recreation Zone (MfP 1998b)	GIS	MfP	Perth Metropolitan Region
DOLA reserve cadastre (DOLA 1998a)	GIS	DOLA	WA
Peel Inlet-Harvey Estuary EPP (DEP 1992a)	GIS	DEP	Peel Inlet-Harvey Estuary catchment
Swan Coastal Plain Lakes EPP (DEP 1992b)	GIS	DEP	Swan Coastal Plain
Gnangara Mound Crown Land EPP (DEP 1995a)	GIS	DEP	Gnangara Mound Crown Land
Swan and Canning Rivers EPP (DEP 1997)	GIS	DEP	Swan and Canning Rivers
Western Swamp Tortoise Draft EPP (DEP 1998)	GIS	DEP	Western Swamp Tortoise habitat and catchment

Constraints

Source	Form	Custodian	Coverage
DOLA cadastre ownership and easements (DOLA 1998a)	GIS	DOLA	WA
MRD regional road requirements			
MRS Urban/Urban deferred and Industrial zones (MfP 1998a)	GIS	MfP	Perth Metropolitan Region
Basic Raw Materials Core areas (MfP 1997a)	GIS	DOME	WA
Mineral Lease	maps	DOME/MfP	Perth Metropolitan Region

Directory Descriptors (Appendix 1, page 104)

Opportunities: Bushplan Site/part Bushplan Site

- subject to
  (named) EPP/SPP
  Environmental Conditions
- location of
  Declared Rare Flora (and) Scheduled Fauna
  conservation category wetland(s)
- MRS P&R Reservation and/or TPS Parks and Recreation Zoning, Crown Reserve

Constraints: Bushplan Site/part Bushplan Site

- Private land
- MRS Urban/Urban Deferred Zoning
- MRS Industrial Zoning
- MRD regional road requirements
- Basic Raw Materials Core areas/ Mineral Resource Area
- Mineral Lease

4.7.3 SPECIFIC SITE RECOMMENDATIONS

Background

Perth's Bushplan places a significant focus on the development of a range of measures to facilitate off-reserve conservation to complement the traditional means of achieving conservation through reservation. These measures potentially provide a number of alternative means of conserving individual Bushplan Sites, which may involve the application of two or more mechanisms in combination.

Bushplan Site specific recommendations are restricted to a limited set of options framed to reflect the circumstances of the Bushplan Site. Five broad categories (or types) of recommendation are recognised.

The specific Bushplan Site recommendations used in the Directory are applied as follows:

Category 1 • Private land where reservation under the Metropolitan Region Scheme for Parks and Recreation, purchase and reservation under the *Land Administration Act 1997* is proposed or in progress. Two variations exist:

Recommendation 1a
The Bushplan Site be reserved for Parks and Recreation in the Metropolitan Region Scheme and be purchased for [either] **National Park, Conservation Park, Nature Reserve** [or] **Regional Park.**
(This recommendation is adopted where there is a clear intention supported by CALM for the Bushplan Site to be purchased and reserved as part of the formal conservation reserve system. Note: where a Bushplan Site has already been Reserved for Parks and Recreation and/or purchased the recommendation is shortened by deleting these components.)

Recommendation 1b
The Bushplan Site be reserved for Parks and Recreation in the Metropolitan Region Scheme, purchased and added to [named] **National Park, Conservation Park, Nature Reserve** [or] **Regional Park.**
(This recommendation applies to areas that adjoin an existing CALM-managed conservation reserve and is adopted where there is a clear intention supported by CALM for the Bushplan Site to be purchased and included in the adjacent conservation reserve. Note: where a Bushplan Site

has already been Reserved for Parks and Recreation and/or purchased the recommendation is shortened by deleting these components.)

Category 2 • Private and/or Crown land where the most suitable means of achieving conservation protection and management, generally through mechanisms complementary to the formal CALM conservation reserve system, will be determined in consultation/negotiation with the land owner/s. There are two broad approaches within this category:

Recommendation 2a

The conservation values of the Bushplan Site be protected through one or more of a range of complementary mechanisms to encourage and secure conservation management on private lands. The specific approach to be determined in consultation/negotiation with the land owner(s), but will generally include conservation covenants/management agreements.

(This recommendation applies to the majority of Bushplan Sites in this category. The expectation is that the conservation intention of these recommendations will be fully met, though some limited conservation-compatible development may be permitted (such as a house and building envelope). Purchase is an option if the current owners are opposed to conservation, in which case the land will generally be covenanted and resold to owners interested in retaining the land for conservation.)

Recommendation 2b

As much as possible of the conservation values of the Bushplan Site be protected and managed for conservation. The area to be protected, and means of protection to be determined through a process of negotiation with the land owner(s), but will primarily involve mechanisms available in planning legislation.

(This recommendation applies to certain designated Bushplan Sites which are acknowledged to be highly constrained by current zoning and/or development approvals and the expectation is that only a portion of the area will be retained for conservation.)

Category 3 • Private or Crown reserve land where the current owner/reserve management body is known to be managing and intends managing the Bushplan Site for conservation. Two (Private and Crown reserve) variations exist:

Recommendation 3a

The private ownership and management intent of the Bushplan Site is endorsed. Appropriate mechanisms to support and reinforce existing management for conservation and provide long-term security be applied in consultation with the land owner(s).

(This recommendation is applied to private land where there is a clear understanding that the land owner has been and intends to continue to manage the area for conservation purposes, and this is considered to be the most appropriate means of conserving the Bushplan Site.)

Recommendation 3b

The existing care, control and management intent of the reserve is endorsed. Long-term security and support for conservation management of the Bushplan Site be enhanced by: amending the purpose of the reserve to include conservation; and applying appropriate mechanisms in consultation with the reserve management body.

(This recommendation applies to non-CALM-managed bushland currently managed for purposes consistent with conservation and is intended to reinforce conservation as a primary purpose and improve long-term security and support for conservation management within the existing management arrangements.)

Category 4 • Endorsement of existing reservation.

Recommendation 4

The existing purpose, care, control and management of Reserve (Number) **is endorsed.**

(This recommendation applies to Bushplan Sites that are already securely conserved and managed as part of the existing formal conservation reserve system, e.g. Yanchep National Park, or other secure areas such as Kings Park.)

Category 5 • Private and/or Crown land where the best means of achieving conservation management is to be further considered in the public comment period.

> **Recommendation 5**
> **The most appropriate mechanism for the protection of this Bushplan Site be considered through the public comment period in consultation with the land owner(s).**
> *(This recommendation is designed to allow for further detailed consideration of the most appropriate means of achieving the conservation objectives through reservation and/or complementary mechanisms in liaison with the land owner(s)).*

The selection of the most appropriate mechanism/s for each Bushplan Site is influenced by the characteristics of the Bushplan Site, including its size, shape, conservation values, position relative to existing conservation areas, zoning and associated constraints and the desires of the owner(s).

The Bushplan Site boundaries have been determined on the basis of the best information available. Some define bushland areas only; others include a management boundary beyond the bushland of specific conservation value. The final boundary of the protected areas will involve consideration of:

- individual area ground-truthing of bushland boundaries
- management design criteria such as
  - reducing the bushland edge-to-area ratio
  - establishing a foreshore reserve of management buffer area
  - connectivity with other Bushplan Sites and natural areas
  - cadastral boundaries

Information Source

Combination of all previous sources.

Directory Descriptors (Appendix 1, page 104)

The appropriate recommendation is selected from the following:

Recommendation 1a
The Bushplan Site be reserved for Parks and Recreation in the Metropolitan Region Scheme and be purchased for [either] National Park, Conservation Park, Nature Reserve [or] Regional Park.

Recommendation 1b
The Bushplan Site be reserved for Parks and Recreation in the Metropolitan Region Scheme, purchased and added to [named] National Park, Conservation Park, Nature Reserve [or] Regional Park.

Recommendation 2a
The conservation values of the Bushplan Site be protected through one or more of a range of complementary mechanisms to encourage and secure conservation management on private lands. The specific approach to be determined in consultation/negotiation with the land owner(s), but will generally include conservation covenants/management agreements.

Recommendation 2b
As much as possible of the conservation values of the Bushplan Site be protected and managed for conservation. The area to be protected and means of protection to be determined through a process of negotiation with the land owner(s), but will primarily involve mechanisms available in planning legislation.

(Continued)

Directory Descriptors (Appendix 1, page 7) (continued)

Recommendation 3a

The private ownership and management intent of the Bushplan Site is endorsed. Appropriate mechanisms to support and reinforce existing management for conservation and provide long-term security be applied in consultation with the land owner(s).

Recommendation 3b

The existing care, control and management intent of the reserve is endorsed. Long-term security and support for conservation management of the Bushplan Site be enhanced by: amending the purpose of the reserve to include conservation; and applying appropriate mechanisms in consultation with the reserve management body.

Recommendation 4

The existing purpose, care, control and management of Reserve (number) is endorsed.

Recommendation 5

The most appropriate mechanism for the protection of this Bushplan Site be considered through the public comment period in consultation with the land owner(s).

5. References

Perth's Bushplan uses a variety of information sources such as geographic information systems, databases, aerial photography, Acts, unpublished reports and published reports. For ease of access to all of these original sources each is listed in the References. References authored by a government department are listed under the acronym for that department.

The References are divided into two sections

- *Geographic Information Systems (GIS), Databases (D) and Photographs (P)*
  Database references are annotated with a 'D', geographic information system references are annotated with 'GIS' and aerial photographs with a 'P'.
- *Reports – Published and Unpublished*

Geographic Information Systems (GIS), Databases (D) and Photographs (P)

AgWA 1998 GIS *Native Vegetation Mapping of the Perth Metropolitan Region.* Spatial Resource Unit, Agriculture Western Australia, South Perth, Western Australia.

Agriculture Western Australia – refer to AgWA

AHC 1998 D *Register of the National Estate Database.* Australian Heritage Commission, Canberra, Australian Capital Territory.

Australian Heritage Commission – refer to AHC

CALM 1998 GIS *Declared Rare and Priority Flora in the Perth Metropolitan Region.* Department of Conservation and Land Management, Como, Western Australia.

CALM and ANCA 1996 Interim Biogeographic Regionalisation for Australia. Environment Australia, Department of Environment Sport and Territories, Canberra, Australian Capital Territory.

DCE 1990 GIS *Vegetation of the Darling System* after Heddle EM, Loneragan OW & Havel JJ 1980. IN: DCE 1980 *Atlas of Natural Resources, Darling System, Western Australia.* Department of Conservation and Environment, Perth, Western Australia;. Ministry for Planning, Perth, Western Australia.

DEP 1992a GIS *Peel Inlet – Harvey Estuary Policy Area* after Government of Western Australia 1992a. Western Australian Government Gazette, 11 December, 1992, pp5969-75.

DEP 1992b GIS *Swan Coastal Plain Lakes Policy Area – legally defined areas with at least 2000m² of surface water as at 1 December 1991* after Government of Western Australia 1992c. Western Australian Government Gazette, 18 December, 1992, pp100-02.

DEP 1995a GIS *Gnangara Mound Crown Land Policy Area* after Government of Western Australia 1992d. Western Australian Government Gazette, 24 December, 1992, pp6287-93.

DEP 1996 D *System 6 and Part System 1 Update Programme.* Unpublished bushland plot and area records. Department of Environmental Protection, Perth, Western Australia.

DEP 1995b GIS *System 6 Recommendation Areas.* Department of Conservation and Environment, Perth, Western Australia.

DEP 1997 GIS *Swan and Canning Rivers Policy Area* after Government of Western Australia 1998. Western Australian Government Gazette, 10 July, 1998, pp3679-96.

DEP 1998 GIS Western Swamp Tortoise Habitat Draft Policy Area after EPA 1998. Environmental Protection Authority, Perth, Western Australia.

Department of Conservation and Environment – refer to DCE.

Department of Conservation and Land Management – refer to CALM.

Department of Environmental Protection – refer to DEP.

Department of Land Administration – refer to DOLA.

DOLA 1996 P *Black and White Orthophotographs of the Perth Metropolitan Region.* Department of Land Administration, Midland, Western Australia.

DOLA 1997 GIS *Digital Colour Orthophotographs of the Perth Metropolitan Region.* Department of Land Administration, Midland, Western Australia.

DOLA 1998a GIS *Cadastre.* Department of Land Administration, Midland, Western Australia.

DOLA 1998b GIS *Local Government Authorities.* Department of Land Administration, Midland, Western Australia.

DOLA 1998c GIS *Suburbs.* Department of Land Administration, Midland, Western Australia.

DOLA 1998d P *PanAirama.* Department of Land Administration, Midland, Western Australia.

Environment Australia 1998 D *Wetlands listed under the RAMSAR Convention.* Wetlands Unit, Environment Australia, Department of Environment Sport and Territories, Canberra, Australian Capital Territory.

Environmental Protection Authority – refer to EPA

EPA 1994 GIS *Threatened or Poorly Reserved Plant Communities Requiring Interim Protection.* Environmental Protection Authority, Perth, Western Australia.

Friend A 1996 D CALM *Bandicoot Survey 1991-1996.* Database of Bandicoot sitings reported by the public. Department of Conservation and Land Management, Como, Western Australia.

Geological Survey of WA 1989 GIS *Perth Metropolitan Region Environmental Geology Series.*

Gibson N, Keighery BJ, Keighery GJ, Burbidge AH and Lyons MN 1994 D *Plot records used in 'A Floristic Survey of the Southern Swan Coastal Plain'.* Unpublished Report for the Australian Heritage Commission prepared by the Department of Conservation and Land Management and the Conservation Council of WA, Perth, Western Australia.

Griffin EA 1994 D *Plot records used in 'Floristic Survey of Northern Sandplains between Perth and Geraldton.'* Unpublished Report to the Heritage Council of Western Australia for the Australian Heritage Commission, Canberra, Australian Capital Territory.

Keighery GJ 1996 D *Plot records from Tuart dominated communities.*

McArthur WM 1998 GIS *Change in Species and Structure in the Major Plant Communities of Garden Island, WA 1990-1996.* HMAS STIRLING Environmental Working Paper No. 11. Prepared for the Chairman, Garden Island Advisory Committee, HMAS STIRLING.

MfP 1996 GIS *Bushland Mapping of the Perth Metropolitan Region.* Ministry for Planning, Perth, Western Australia.

MfP 1997a GIS *Basic Raw Material Resource Areas and Priority.* Department of Minerals and Energy.

MfP 1997b GIS *Extent of Metropolitan Region Scheme.* Ministry for Planning, Perth, Western Australia.

MfP 1998a GIS *Metropolitan Region Scheme Zonings.* Western Australian Planning Commission.

MfP 1998b GIS *Town Planning Scheme Zonings.* Local Government Authorities.

MfP and CALM 1996 GIS *Point locations of Threatened Ecological Communities* after English & Blyth 1997. Department of Conservation and Land Management, Como, Western Australia.

Ministry for Planning – refer to MfP

National Trust of Australia (WA) 1998 D *Listing for Landscape and Cultural Environment.* National Trust of Australia (WA), West Perth, Western Australia.

RAOU 1996 D *Database of Western Australian Birds Project (RAOU Tracking Database).*

Royal Australasian Ornithologists' Union – refer to RAOU (now Birds Australia)

Water and Rivers Commission – refer to WRC

Western Australian Museum of Natural Science 1996 D *Specimen records of Ash Grey Mouse, Wambenger and Honey Possum* from Western Australian Museum of Natural Science Mammals Database.

Wildflower Society of WA (Inc.) Murdoch Branch 1995 D *Flora of Wireless Hill.* Database print out, unpublished.

WRC 1996a GIS *Basin and Channel Wetlands* after Hill *et al.* 1996b. Water & Rivers Commission, Perth, Western Australia.

WRC 1996b GIS *Consanguineous Suites* after Hill *et al.* 1996b. Water & Rivers Commission, Perth, Western Australia.

WRC 1996c GIS *Conservation Category Wetlands* after Hill *et al.* 1996b. Water & Rivers Commission, Perth, Western Australia.

WRC 1997 GIS *Verified Conservation Category Wetlands* after Semeniuk, V&C Research Group 1997. Water & Rivers Commission, Perth, Western Australia.

Reports - Published and Unpublished

AHC 1990 *Criteria for the Register of the National Estate.* Australian Heritage Commission, Canberra, Australian Capital Territory. April 1990

AHC 1994 *The Australian Heritage Commission.* Information pamphlet. Australian Heritage Commission, Canberra, Australian Capital Territory.

Ahmat AJ 1993 *The biology of eight non-thermal springs along the Ellen Brook valley.* Honours Thesis. Zoology Department, University of Western Australia, Nedlands, Western Australia.

Alan Tingay & Associates – refer to Tingay, Alan & Associates

ANCA 1994 *A Directory of Important Wetlands in Australia.* ANCA, Canberra, Australian Capital Territory.

ANCA 1996 *A Directory of Important Wetlands in Australia* (Second Edition). ANCA, Canberra, Australian Capital Territory.

Aplin TEH 1979 The Flora. IN: BJ O'Brien (Ed.) *Environment and Science.* University of Western Australia Press, Nedlands, Western Australia.

Atkins K 1998 *Declared Rare and Priority Flora List for Western Australia.* Department of Conservation and Land Management, Como, Western Australia.

Australian Heritage Commission – refer to AHC

Australian Nature Conservation Agency – refer to ANCA

Balla SA 1994 *Wetlands of the Swan Coastal Plain. Volume 1: Their nature and management.* Water Authority of Western Australia and Department of Environmental Protection, Perth, Western Australia.

Bamford MJ 1992 The impact of fire and increasing time after fire upon *Heleioporus eyrei, Limnodynastes dorsalis* and *Myobatrachus gouldii* (Anura: Leptodactylidae) in Banksia Woodland near Perth, Western Australia. *Wildlife Research 19:* 169-178.

Beard JS 1979a *Vegetation Survey of Western Australia. The Vegetation of the Perth Area, Western Australia. 1 : 250 000 Series.* Vegmap Publications, Applecross, Western Australia.

Beard JS 1979b *Vegetation Survey of Western Australia. The Vegetation of the Pinjarra Area, Western Australia. 1 : 250 000 Series.* Vegmap Publications, Applecross, Western Australia.

Beeston G, Mlodawski G, True D and Sanders A 1995 Remnant vegetation inventory in the southern agricultural areas of Western Australia. Resource Management Technical Report No 149. Regional Operations Division, Department of Agriculture, South Perth, Western Australia.

CALM 1997 **Annual Report 1996-97.** Department of Conservation and Land Management, Como, Western Australia.

CALM 1998 *Threatened and Priority Fauna List for Western Australia.* Unpublished report to the Department of Conservation and Land Management, Como, Western Australia.

Christides L and Bowles WE 1994. *The taxonomy and species of birds of Australia and its territories.* RAOU Monograph 2.

Churchward HM and McArthur WM 1980 Landforms and Soils of the Darling System. IN: *Atlas of Natural Resources, Darling System, Western Australia.* Department of Conservation and Environment, Western Australia.

Commissioner of Soil and Land Conservation 1997 Memorandum of Understanding between the Commissioner of Soil and Land Conservation, Environmental Protection Authority, Department of Environmental Protection, Agriculture Western Australia, Department of Conservation and Land Management, Water and Rivers Commission for the Protection of Remnant Vegetation on Private Land in the Agricultural Region of Western Australia. Department of Agriculture, Western Australia.

Commonwealth of Australia *1996 The National Strategy for Conservation of Australia's Biological Diversity.* AGPS, Canberra, Australian Capital Territory.

Connell S 1995 *Perth Environment Project – Remnant Vegetation Inventory and Assessment.* Unpublished report to the Australian Heritage Commission (National Estate Grants Programme) and the Ministry for Planning, Perth, Western Australia.

DCE 1983 *Conservation Reserves for Western Australia. The Darling System – System 6. Parts 1 and 2. Report 13.* Department of Conservation and Environment, Perth, Western Australia.

DEP 1996 *System 6 and Part System 1 Update Programme.* Unpublished bushland plot and area records and analysis.

DEP 1998 *System 6 and Part 1 Update Programme.* Unpublished bushland area records.

Department of Conservation and Environment – refer to DCE

Department of Conservation and Land Management – refer to CALM

Department of Environmental Protection – refer to DEP

Department of Planning and Urban Development – refer to DPUD

Dixon J, Connell S, Bailey J and Keenan C 1994 The Perth Environmental Project and an inventory of Perth's remnant native vegetation. IN: *A Vision for a Greener City,* the Proceedings of the 1994 National Greening Australia Conference, Perth, Western Australia.

English VJ and Blyth J 1997 *Identifying and Conserving Threatened Ecological Communities in the South West Botanical Province.* Project Number N702, Final Report to Environment Australia. Department of Conservation and Land Management, Como, Western Australia.

Environmental Protection Authority – refer to EPA

EPA 1985 *Peel Inlet and Harvey Estuary Management Strategy, Report and Recommendations by the Environmental Protection Authority – Assessment Report of Stage 1 ERMP* (Bulletin 243). Department of Conservation and Environment, Perth, Western Australia.

EPA 1988 *Peel Inlet and Harvey Estuary Management Strategy, Environmental Review and Management Programme Stage 2 – Report and Recommendations of the Environmental Protection Authority, Parts I and II* (Bulletin 363). Environmental Protection Authority, Perth, Western Australia.

EPA 1990 *A Guide to wetland management in Perth* (Bulletin 374). Environmental Protection Authority, Perth, Western Australia.

EPA 1997 *Draft Environmental Protection (State Groundwater) Policy 1997.* Environmental Protection Authority, Perth, Western Australia.

EPA 1998 *Second Draft Environmental Protection (Western Swamp Tortoise Habitat) Policy 1998.* Environmental Protection Authority, Perth, Western Australia.

Fox JED, Downes S and Maslin BR 1980 The vascular plants of Yalgorup National Park. *WA Herbarium Research Notes* 3: 1-18.

Gibson N, Keighery BJ, Keighery GJ, Burbidge AH and Lyons MN 1994 *A Floristic Survey of the Southern Swan Coastal Plain.* Unpublished Report for the Australian Heritage Commission prepared by Department of Conservation and Land Management and the Conservation Council of Western Australia (Inc).

Government of Western Australia 1992a *Environmental Protection (Peel Inlet – Harvey Estuary) Policy 1992.* Western Australian Government Gazette, 11 December, 1992, pp 5969-5975.

Government of Western Australia 1992b *Statement of Planning Policy No. 2 – The Peel-Harvey Coastal Pain Catchment.* Western Australian Government Gazette, 21 February, 1992, pp 945 – 55.

Government of Western Australia 1992c *Environmental Protection (Swan Coastal Plain Lakes) Policy 1992.* Western Australian Government Gazette, 18 December, 1992, pp 100-02.

Government of Western Australia 1992d *Environmental Protection (Gnangara Mound Crown Land) Policy 1992.* Western Australian Government Gazette, 24 December, 1992, pp 6287-93.

Government of Western Australia 1995a *Urban Bushland Strategy.* Ministry for Planning, Perth Western Australia.

Government of Western Australia 1995b *Statement of Planning Policy No. 3* – Gnangara Mound Crown Land. Western Australian Government Gazette, 8 September, 1995, pp 4245 – 4249.

Government of Western Australia 1997 *Wetlands Conservation Policy for Western Australia.*

Government of Western Australia 1998a *Statement of Planning Policy No. 6* – Jandakot Groundwater Protection Policy. Western Australian Government Gazette, 12 June, 1998, pp 3209 – 32.

Government of Western Australia 1998b *Environmental Protection (Swan and Canning Rivers) Policy 1998.* Western Australian Government Gazette, 10 July, 1998, pp 3679-96.

Gozzard JR 1982a *Yanchep Sheet 2034 IV, Environmental Geology Series.* Geological Survey of Western Australia, Department of Minerals and Energy, Perth, Western Australia.

Gozzard JR 1982b *Muchea Sheet 2034 I and part Sheet 2134 IV, Environmental Geology Series.* Geological Survey of Western Australia, Department of Minerals and Energy, Perth, Western Australia.

Gozzard JR 1983a *Fremantle Part Sheet 2033 I and 2033 IV, Environmental Geology Series.* Geological Survey of Western Australia, Department of Minerals and Energy, Perth, Western Australia.

Gozzard JR 1983b *Rockingham Sheet 2033 II and 2033 III, Environmental Geology Series. Geological Survey of Western Australia,* Department of Minerals and Energy, Perth, Western Australia.

Gozzard JR 1986 *Perth Sheet 2034 II and part Sheets 2034 II and 2134 III, Environmental Geology Series.* Geological Survey of Western Australia, Department of Minerals and Energy, Perth, Western Australia.

Griffin EA 1993 *Flora of the Quindalup Dunes between the Swan and Irwin Rivers, Western Australia.* Unpublished Report to the Coastal Planning Branch, Department of Planning and Urban Development and the Heritage Council of WA, East Perth, Western Australia.

Griffin EA 1994 *Floristic Survey of Northern Sandplains between Perth and Geraldton.* Unpublished Report to the Heritage Council of WA for the Australian Heritage Commission, Canberra, Australian Capital Territory.

Harvey MS, Dell J, How RA and Waldock JM 1997 *Ground Fauna of Bushland Remnants on the Ridge Hill Shelf and Pinjarra Plain Landforms, Perth.* Unpublished Report to the Australian Heritage Commission, Canberra, Australian Capital Territory.

Havel JJ 1968 *The potential of the northern Swan Coastal Plain for Pinus pinaster Ait. Plantations.* Bulletin 76, Forests Department of Western Australia.

Heddle EM, Loneragan OW and Havel JJ 1980 Vegetation of the Darling System. IN: DCE 1980 *Atlas of Natural Resources, Darling System, Western Australia.* Department of Conservation and Environment, Perth, Western Australia.

Hill AL and Del Marco A 1996 Wetland evaluation. *IN: Hill et al. 1996a Wetlands of the Swan Coastal Plain. Volume 1: Wetland mapping, classification and evaluation, Main Report.* Prepared for the Water and Rivers Commission and the Department of Environmental Protection, Western Australia.

Hill AL, Semeniuk CA, Semeniuk V and Del Marco A 1996a *Wetlands of the Swan Coastal Plain. Volume 1: Wetland Mapping, Classification and Evaluation – Main Report.* Prepared for the Water and Rivers Commission and the Department of Environmental Protection, Western Australia.

Hill AL, Semeniuk CA, Semeniuk V and Del Marco A 1996b *Wetlands of the Swan Coastal Plain. Volume 2: Wetland Mapping Classification and Evaluation – Wetland Atlas.* Prepared for the Water and Rivers Commission and the Department of Environmental Protection, Western Australia.

Hosken DJ and O'Shea JE 1994 Falsistrellus mackenziei at Jandakot. *Western Australian Naturalist* 19: 351.

How RA (Ed) 1978 *Faunal studies of the Northern Swan Coastal Plain: A consideration of Past and Future Changes* Western Australian Museum. Unpublished report for the Department of Conservation and Environment, Perth, Western Australia.

How RA and Dell J 1993 Vertebrate fauna of the Perth metropolitan region: consequences of a modified environment. IN: Hipkins M (ed.) **Urban Bush Management** (pp 28-47). Australian Institute of Urban Studies, Perth, Western Australia.

How RA and Dell J 1994 The zoogeographic significance of urban bushland remnants to reptiles in the Perth region, Western Australia. *Pacific Conservation Biologist* 1:132-140.

How RA, Harvey MS, Dell J and Waldock JM 1996 *Ground Fauna of Urban Bushland Remnants in Perth.* Report to the Australian Heritage Commission, Canberra, Australian Capital Territory.

Jasinska EJJ 1997 *Aquatic root fauna in caves of southwestern Australia: origins and ecology.* PhD Thesis submitted to Zoology Department, University of Western Australia, Nedlands, Western Australia.

Jasinska E and Knott B 1994 *Aquatic fauna in the Gnangara Mound discharge areas of the Ellen Brook catchment, Western Australia.* Unpublished report for the Zoology Department, University of Western Australia for the Water Authority of Western Australia, Leederville, Western Australia.

Jasinska E and Knott B 1995 Water Requirements of Cave Dwelling in the Yanchep Area. Section 46, Appendix 3, pp 113–119 IN: *Review of Proposed Changes to Environmental Water Conditions Gnangara Mound Groundwater Resources.* Water Authority of Western Australia, Leederville, Western Australia.

Jordan JE 1986a *Armadale Sheet part of Sheets 2033 I and 2133 IV. Environmental Geology Series.* Geological Survey of Western Australia, Department of Minerals and Energy, Perth, Western Australia.

Jordan JE 1986b *Serpentine Sheet part of Sheets 2033 II and 2133 III. Environmental Geology Series.* Geological Survey of Western Australia, Department of Minerals and Energy, Perth, Western Australia.

Keighery BJ 1994 *Bushland Plant Survey. A Guide to Plant Community Survey for the Community.* Wildflower Society of WA (Inc), Nedlands, Western Australia.

Keighery BJ and Gray M 1993 Towards an Urban Bushland Policy for the National Trust (WA). A Discussion Paper. IN: National Trust of Australia (WA) *Urban Bushland Policy.* National

Trust of Australia (WA), Wildflower Society of Western Australia (Inc) and The Tree Society (Inc), Perth, Western Australia.

Keighery BJ and Keighery GJ 1995 Flora. IN: Keighery BJ (ed.) 1995 *Knowing and Managing the Brixton Street Wetlands.* Unpublished report for the Friends of Brixton Street and the Perth Branch of the Wildflower Society of WA (Inc), Nedlands, Western Australia.

Keighery BJ, Keighery GJ and Gibson N 1997 Part XI: Floristics of the Mundijong Bushland. IN: Keighery BJ, Keighery GJ & Gibson N 1997a *Floristics of Reserves and Bushland Areas of the Perth Region (System 6). Parts XI-XV.* Wildflower Society of Western Australia (Inc), Nedlands, Western Australia.

Keighery BJ and Trudgen ME 1992 *The Remnant Vegetation of the Eastern Side of the Swan Coastal Plain.* Unpublished report to the Department of Conservation and Land Management for the National Estate Grants Program.

Keighery GJ 1990 *Coastal Limestone Endemics.* Unpublished report for the Department of Conservation and Land Management, Perth, Western Australia.

Keighery GJ 1993 *Species list for Brixton Street Wetlands and Yule Brook Reserve.* An unpublished list for the Department of Conservation and Land Management, Perth, Western Australia IN: Gray M 1993 *Evaluation of the National Estate value of remnant bushland on the Swan Coastal Plain between Moore River and Mandurah. Brixton Street Wetlands and adjacent bushland including System 6 areas M69.* Unpublished report to the Wildflower Society of WA (Inc) for the Australian Heritage Commission, Canberra, Australian Capital Territory.

Keighery GJ 1996 *Progress Report: Conservation Status of Vascular Flora of the Southern Swan Coastal Plain.* Unpublished Report to the Australian Nature Conservation Agency, Canberra, Australian Capital Territory.

Keighery GJ and Keighery BJ 1993 Floristics of Three Bushland Areas of the Eastern Side of the Swan Coastal Plain (Part V Floristics of Talbot Road Bushland, Part VI Floristics of Brickwood Bushland and Part VII Floristics of Cardup Nature Reserve). Part V-VII. IN: Keighery GJ & Keighery BJ 1993 *Floristics of Reserves and Bushland Areas of the Perth Region (System 6). Parts V-IX.* Wildflower Society of WA (Inc), Nedlands, Western Australia.

Keighery GJ and Keighery BJ 1995 *Muchea Limestones – Floristics.* Unpublished report to Australian Nature Conservation Agency National Reserves Network and the Department of Conservation and Land Management, Como, Western Australia.

Kinhill Engineers Pty Ltd 1988 Peel Inlet and Harvey Estuary Management Strategy, Environmental Review and Management Programme – Stage 2. Report to the Departments of Agriculture and Marine and Harbours, Perth, Western Australia.

Lane J, Janesch R and Lynch R 1996 Western Australia. IN: Australian Nature Conservation Agency *A Directory of Important Wetlands in Australia (Second Edition).* ANCA, Canberra, Australian Capital Territory.

Main BY 1990 Restoration of biological scenarios: the role of museum collections. *Proceedings of the Ecological Society of Australia* 16: 397-409.

Marchant NG, Wheeler JR, Rye BL, Bennett EM, Lander NS and Macfarlane TD 1987 *Flora of the Perth Region: Parts One and Two.* Western Australian Herbarium, Department of Agriculture, Perth, Western Australia.

Mattiske Consulting Pty Ltd 1997 *Assessment of Bushland Patches in the Perth Metropolitan Region.* Unpublished report for the Ministry for Planning, Perth, Western Australia.

McArthur WM and Bettenay E 1960 *The development and distribution of soils on the Swan Coastal Plain, Western Australia.* CSIRO Soil Publication No 16.

Moore LS 1993 *The Modern Thrombolites of Lake Clifton, Southwestern Australia.* Unpublished PhD Thesis, University of Western Australia, Nedlands, Western Australia.

Muir BG 1977 Biological Survey of the Western Australian Wheatbelt. Part II: Vegetation and habitat of Bendering Reserve. *Records of the Western Australian Museum,* Supplement No 3.

National Trust of Australia (WA) 1993 *Urban Bushland Policy.* National Trust of Australia (WA), Wildflower Society of Western Australia (Inc) and The Tree Society (Inc), Perth, Western Australia.

Payne J 1993a *Wetlands in the City of Armadale.* Report to the Water Authority of Western Australia and the Environmental Protection Authority, Perth, Western Australia.

Payne J 1993b *Wetlands in the City of Gosnells.* Report to the Water Authority of Western Australia and the Environmental Protection Authority, Perth, Western Australia.

Peel-Harvey Study Group 1985 Peel Inlet and Harvey Estuary Management Strategy, Environmental Review and Management Programme Stage 1. Report to the Department of Conservation and Land Management, Como, Western Australia.

Pen LJ 1983 *Peripheral Vegetation of the Swan and Canning Estuaries 1981.* Bulletin 113. Department of Conservation and Environment and the Swan River Management Authority, Perth, Western Australia.

Pen LJ 1993 *Fringing vegetation of the Canning, Southern and Wungong Rivers.* Report No 7. Swan River Trust, Perth, Western Australia.

Playford PE, Cockbain AE and Low GH 1976 Geology of the Perth Basin Western Australia. *Geological Survey of Western Australia Bulletin* 124: 1–310.

RAMSAR – refer to Environment Australia 1998 D; also UNESCO

Semeniuk CA 1987 Wetlands of the Darling System – consanguineous wetlands and their distribution in the Darling System, South Western Australia. *Journal of the Royal Society of Western Australia* 70:69-87.

Semeniuk CA 1996 Natural Wetland groups in the Perth to Bunbury Region. IN: Hill *et al. 1996a Wetlands of the Swan Coastal Plain. Volume 1: Wetland mapping, classification and evaluation, Main Report.* Prepared for the Water and Rivers Commission and the Department of Environmental Protection, Western Australia.

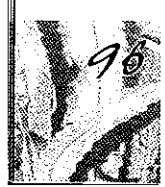
Semeniuk CA and Semeniuk V 1996a The geomorphic classification of Wetlands. IN: Hill *et al.* 1996a *Wetlands of the Swan Coastal Plain. Volume 1: Wetland mapping, classification and evaluation, Main Report.* Prepared for the Water and Rivers Commission and the Department of Environmental Protection, Western Australia.

Semeniuk CA and Semeniuk V 1996b Geomorphic wetland mapping and classification in the Perth to Bunbury region. IN: Hill *et al.* 1996a *Wetlands of the Swan Coastal Plain. Volume 1: Wetland mapping, classification and evaluation, Main Report.* Prepared for the Water and Rivers Commission and the Department of Environmental Protection, Western Australia.

Semeniuk, V&C Research Group 1991a *Environmental and Landscape Audit of the Southwest, Northwest, and Northeast Corridors Perth Metropolitan Region. Stage 1 Interim Report: The Northwest Corridor Study.* Unpublished report for the Department of Planning and Urban Development (available for viewing at the Ministry for Planning Library), Perth, Western Australia.

Semeniuk, V&C Research Group 1991b *Environmental and Landscape Audit of the Southwest, Northwest, and Northeast Corridors Perth Metropolitan Region. Stage 2 Interim Report: The Southwest Corridor Study.* Unpublished report for the Department of Planning and Urban Development (available for viewing at the Ministry for Planning Library), Perth, Western Australia.

Semeniuk, V&C Research Group 1991c *Environmental and Landscape Audit of the Southwest, Northwest, and Northeast Corridors*



Perth Metropolitan Region. Stage 3 Interim Report: The Foothills Corridor Study. Unpublished report for the Department of Planning and Urban Development (available for viewing at the Ministry for Planning Library), Perth, Western Australia.

Semeniuk, V&C Research Group 1992 *Environmental and Landscape Audit of the Southwest, Northeast, and Northeast Corridors Perth Metropolitan Region. Stage 4 Interim Report: The Northeast Corridor Study.* Unpublished report for the Department of Planning and Urban Development (available for viewing at the Ministry for Planning Library), Perth, Western Australia.

Semeniuk, V&C Research Group 1993 *Environmental and Landscape Audit of the Southwest, Northeast, and Northeast Corridors Perth Metropolitan Region. Stage 5 Interim Report: The Southeast Corridor Study.* Unpublished report for the Department of Planning and Urban Development (available for viewing at the Ministry for Planning Library), Perth, Western Australia.

Semeniuk, V&C Research Group 1997 *Verification of the Conservation Category Wetlands in the Perth Metropolitan Region.* Unpublished report to the Water and Rivers Commission, Perth, Western Australia.

Siemon N, Davis G, Hubbard, P and Duckworth A 1993 *Fringing Vegetation of the Serpentine River in the Shire of Serpentine-Jarrahdale and City of Rockingham.* Report (No. 38) to the Peel Inlet Management Authority. Waterways Commission, Perth, Western Australia.

Smurthwaite AJ 1986a *Mundaring Sheet part Sheet 2133 II and 2134 III, Environmental Geology Series.* Geological Survey of Western Australia, Department of Minerals and Energy, Perth, Western Australia.

Smurthwaite AJ 1986b *Gleneagle Sheet part Sheet 2134 II and 2133 III, Environmental Geology Series.* Geological Survey of Western Australia, Department of Minerals and Energy, Perth, Western Australia.

Storr GM and Johnstone RE 1988 Birds of the Swan Coastal Plain. *Recordings of the Western Australian Museum Supplement 28.*

Tingay, Alan & Associates 1997 *A Strategic Plan for Perth's Greenways – Draft.* Prepared for Environment Australia, Ministry for Planning, Department of Conservation and Land Management, Western Australia Municipal Association, Department of Environmental Protection, Water and Rivers Commission, Main Roads WA, Swan Catchment Centre, Conservation Council, Greening WA and Australian Trust for Conservation Volunteers.

Trudgen ME 1991 Vegetation Condition Scale. IN: National Trust (WA) 1993 *Urban Bushland Policy.* National Trust of Australia (WA), Wildflower Society of Western Australia (Inc) and The Tree Society (Inc), Perth, Western Australia.

Trudgen ME 1996 *An assessment of the conservation values of the remnant vegetation in the City of Wanneroo with recommendations for appropriate reserves for the City.* Unpublished report for the City of Wanneroo, Western Australia.

Trudgen ME and Keighery BJ 1995 *A Survey of the Remnant Vegetation of the City of Gosnells west of the Darling Scarp.* Unpublished report prepared for the City of Gosnells, Western Australia.

UNESCO 1971 *Article 1, part 1, Convention on Wetlands of International Importance especially as Waterfowl Habitat.* Published in Australia, 1976, for the Department of Foreign Affairs, Australian Government Publishing Service, Treaty Series 1975, No 48.

United Nations Environment and Science Conservation Organisation – refer to UNESCO

Van Gool D 1994 *Preliminary Vegetation and Land Use Mapping in the Peel-Harvey Catchment Area.* Peel-Harvey Catchment Support Group and Department of Agriculture, Perth, Western Australia.

Wetland Advisory Committee 1977 *The Status of Wetland Reserves in System Six.* Report of the Wetlands Advisory Committee to the Environmental Protection Authority, Perth, Western Australia.

Bushplan Site Description Basic Format

NAME

Boundary Definition: protected area boundary management boundary management/bushland boundary bushland boundary bushland group boundary conservation wetland boundary vegetation complex boundary

SECTION 1: CADASTRAL INFORMATION

Bushplan Site no.

Map no.

Map sheet series ref. no.

System 6 (1983): All System area bushland, total area described Part System area bushland, only bushland described Area of bushland goes beyond System area boundaries, all bushland described Part System area bushland and part scattered native plants (canopy), all vegetation described

Other Names

Area (ha):

Local Authorities (Suburb)

Zoning

MRS:

TPS:

Ownership Categories

Lot/Reserve numbers (Purpose), Street name

SECTION 2: REGIONAL INFORMATION

LANDFORMS AND SOILS

Darling Plateau (Darling Range)/Darling Scarp
Laterite
Even-grained Granite

Dandaragan Plateau/Gingin Scarp
Colluvial Sand
Laterite
Leederville Formation
Osborne Formation

Foothills
Colluvial Deposits
Colluvial Sand
Yoganup Formation
Ridge Hill Sandstone
Armadale Shale

Pinjarra Plain
Guildford Formation
Alluvial/Colluvial Deposit
Muchea Limestone

Bassendean Dunes
Bassendean Sands

Bassendean Dunes/Pinjarra Plain
Bassendean Sands over Guildford Formation

Spearwood Dunes
Sands derived from Tamala Limestone
Tamala Limestone

Quindalup Dunes (Holocene Dunes)
Safety Bay Sands

Wetlands (within the Quindalup Spearwood Bassendean Dunes Pinjarra Plain)
Holocene Swamp Deposits

Lagoonal and Estuarine Deposits (within the Quindalup Spearwood Bassendean Dunes Pinjarra Plain)
Lagoonal and Estuarine Deposits (Vasse)
Lagoonal Deposits in Bassendean Dunes

VEGETATION AND FLORA

Vegetation Complexes

Plateaus
Mogumber Complex – South (Dandaragan Plateau)

Scarps
Reagan Complex (Gingin Scarp, Dandaragan Plateau)

Foothills
Coonambidgee Complex (Dandaragan Plateau)
Forrestfield Complex (Ridge Hill Shelf, Darling Plateau)

Pinjarra Plain
Guildford Complex
Swan Complex
Dardanup Complex
Serpentine River Complex
Beermullah Complex
Yanga Complex

Bassendean Dunes
Bassendean Complex – North
Bassendean Complex – Central and South
Bassendean Complex – North Transition
Bassendean Complex – Central and South Transition

Combinations of Bassendean Dunes/Pinjarra Plain/Spearwood Dunes
Southern River Complex
Cannington Complex

Spearwood Dunes
Karrakatta Complex – North
Karrakatta Complex – North Transition
Karrakatta Complex – Central and South
Cottesloe Complex – North
Cottesloe Complex – Central and South

Quindalup Dunes
Quindalup Complex

Wetlands
Herdsman Complex
Pinjar Complex

Marine (lagoonal and estuarine) Deposits
Yoongarillup Complex
Vasse Complex

Floristic Community Types: *not sampled, types inferred, not sampled insufficient vegetation, not sampled, types not inferred

Supergroup 1 – Foothills/Pinjarra Plain

1a *Eucalyptus haematoxylon* – E. marginata woodlands on Whicher foothills
1b Southern *Eucalyptus calophylla* woodlands on heavy soils
2 Southern wet shrublands
3a *Eucalyptus calophylla – Kingia australis* woodlands on heavy soils
3b *Eucalyptus calophylla – E. marginata* woodlands on sandy clay soils
3c *Eucalyptus calophylla – Xanthorrhoea preissii* woodlands and shrublands
S8 *Eucalyptus wandoo* woodlands (Scarp)

Supergroup 2 – Seasonal Wetlands

4 *Melaleuca preissiana* damplands
5 Mixed shrub damplands
6 Weed dominated wetlands on heavy soils
7 Herb rich saline shrublands in clay pans
8 Herb rich shrublands in clay pans
9 Dense shrublands on clay flats
10a Shrublands on dry clay flats
10b Shrublands on southern ironstones
11 Wet forests and woodlands
12 *Melaleuca teretifolia and/or Astartea aff. fascicularis* shrublands
13 Deeper wetlands on heavy soils
14 Deeper wetlands on sandy soils
15 Forests and woodlands of deep seasonal wetlands
16 Highly saline seasonal wetlands
17 *Melaleuca rhaphiophylla – Gahnia trifida* seasonal wetlands
18 Shrublands on calcareous silts
19a Sedgelands in Holocene dune swales
19b Woodlands over sedgelands in Holocene dune swales
S1 *Astartea* aff. *fascicularis – Melaleuca* species dense shrublands
S2 Northern *Pericalymma ellipticum* dense low shrublands

S3 Wet sedgelands on sandy clays
S4 *Regelia ciliata* Dandaragan Plateau wetlands
S5 *Acacia saligna* wetlands
S6 Northern dense low shrublands
S7 Northern woodlands to forests over tall sedgelands alongside permanent wetlands
S17 *Eucalyptus rudis – Agonis linearifolia* wetlands in Bassendean Dunes
S19 Dense tall shrublands
S20 Northern shrublands on sandy clays

Supergroup 3 – Uplands centred on Bassendean Dunes and Dandaragan Plateau

20a *Banksia attenuata* woodlands over species rich dense shrublands
20b Eastern *Banksia attenuata* and/or *Eucalyptus marginata* woodlands
20c Eastern shrublands and woodlands
20d Dandaragan Plateau shrublands and woodlands
21a Central *Banksia attenuata – Eucalyptus marginata* woodlands
21b Southern *Banksia attenuata* woodlands
21c Low lying *Banksia attenuata* woodlands or shrublands
22 *Banksia ilicifolia* woodlands
23a Central *Banksia attenuata – B. menziesii* woodlands
23b Northern *Banksia attenuata – B. menziesii* woodlands
23c North-eastern *Banksia attenuata – B. menziesii* woodlands
S9 *Banksia attenuata* woodlands over dense low shrublands
S10 *Calothamnus sanguineus* dense low shrublands on sandy laterites
S16 Mixed dense shrublands on yellow brown sands
S18 *Eucalyptus marginata – E. calophylla* woodlands on laterites

Supergroup 4 – Uplands centred on Spearwood and Quindalup Dunes

24 Northern Spearwood shrublands and woodlands
25 Southern *Eucalyptus gomphocephala – Agonis flexuosa* woodlands
26a *Melaleuca huegelii – M. acerosa* shrublands of limestone ridges
26b Woodlands and mallees on limestone
27 Species poor mallees and shrublands on limestone
28 Spearwood *Banksia attenuata* or *B. attenuata – Eucalyptus* woodlands
29a Coastal shrublands on shallow sands
29b *Acacia* shrublands on taller dunes
30a2 *Callitris preissii* and/or *Melaleuca lanceolata* forests and woodlands
30b Quindalup *Eucalyptus gomphocephala* and/or *Agonis flexuosa* woodlands
30c2 Woodlands and shrublands on Holocene dunes (re-allocated from 30c)
S11 Northern *Acacia rostellifera – Melaleuca acerosa* shrublands
S12 Rottnest Island *Melaleuca lanceolata* and/or *Callitris preissii* forests and woodlands
S13 Northern *Olearia axillaris – Scaevola crassifolia* shrublands
S14 *Spinifex longifolius* grassland and low shrubland

WETLANDS

No wetlands mapped

Wetland Types: lake, sumpland, dampland, artificial lake, floodplain, palusplain, paluslope, river, creek, artificial channel, estuary (waterbody), estuary (peripheral), includes wetlands not previously described (survey reference)

Natural Wetland Groups (undefined areas included in boundary)

Darling Plateau
Walyunga (D.1)
Little Dardanup (D.2)
Nalyerin (D.4)
Brockman (D.6)

Dandaragan Plateau – Darling Plateau interface
Wannamal (Dp/D)

Dandaragan Plateau
Red Gully (Dp.1)
Coorang (Dp.2)
Clewley (Dp.3)
Mogumber (Dp.4)

Pinjarra Plain
Keysbrook (P.1)

Bassendean – Pinjarra transition OR Bassendean with fluvial features
Beermullah (B/P.1)
Mungala (B/P.2)
Muchea (B/P.3)
Bennet Brook (B/P.4)

Bassendean Dunes
Pinjar (B.1)
Gnangara (B.2)
Jandakot (B.3)
Riverdale (B.4)

Spearwood – Bassendean interface
Bibra (S/B.1)

Spearwood Dunes
Yanchep (S.1)
Balcatta (S.2)
Coogee (S.3)
Stakehill (S.4)

Quindalup Dunes
Cooloongup (Qu.1)
Becher (Qu.2)
Peelhurst (Qu.3)

Swan Coastal Plain Rivers
Moore River (R.1)
Swan River (R.2)
Ellen Brook (R.3)
Goergrup (R.4)

Estuaries
Moore River (E.1)
Swan River (E.2)

Wetland Management Objectives: Conservation, Resource Enhancement, Multiple Use

Swan Coastal Plain Lakes EPP: ha none identified

THREATENED ECOLOGICAL COMMUNITIES

Not determined

Not assessed, Presumed Totally Destroyed, Critically Endangered (floristic community type 3a, 3c, 19, 20c, Communities of tumulus springs, Shrublands and woodlands on Muchea Limestone, Stromatalite-like community of coastal freshwater lakes, Aquatic root mat community of caves of the Swan Coastal Plain), Endangered (floristic community type 2, 10a, 20a, 20b, Vulnerable (floristic community type 3b, 7, 8, 9, 15, 18, 30a), Data Deficient (14), Lower Risk

SECTION 3: SPECIFIC SITE DETAIL

Landscape Features: river – limestone cliff, ocean – limestone cliff, limestone ridge, Muchea limestone, ironstone, tall dune, open water, vegetated wetland, creek, river, estuary, island, vegetated uplands

Vegetation and Flora: not known, limited survey, detailed survey, not field surveyed (aerial photography interpretation only)
Structural Units: mapping
Scattered Native Plants:
Vegetation Condition: %Pristine, Excellent, Very Good, Good, Degraded, Completely Degraded with % Pristine, Excellent, Very Good, Good, Degraded, Completely Degraded with areas of severe localised disturbance
Total Flora: not known (estimated) (plot-generated list only) (estimated % expected flora)
Significant Flora: none recorded

Fauna: no known information Significant mammal species: Quenda (Friend 1996)

Linkage: no adjacent bushland; bushland canopy creekline linkage to north, south, east, west (Bushplan Site number/s); part of proposed Greenway 'Greenway number/s' eg 37 (Tingay, Alan & Associates 1997); part of regionally significant contiguous fragmented potential bushland/wetland linkage (Map 8)

Other Special Attributes:

SECTION 4: INTERNATIONAL AND NATIONAL SIGNIFICANCE

Not listed Wetlands of International Importance (RAMSAR); Directory of Important Wetlands in Australia; Listed on the Register of the National Estate; Indicative Place of the Register of the National Estate; Interim List of the Register of the National Estate; location for JAMBA/CAMBA species

SECTION 5: SELECTION CRITERIA AND RECOMMENDATIONS

Criteria: Representation of ecological communities, Diversity, Rarity, Maintaining ecological processes or natural systems, Scientific or evolutionary importance, General criteria for the protection of wetland, streamline and estuarine fringing and coastal vegetation, Criteria not relevant to determination of conservation value, but which may be applied when evaluating areas having similar values

Opportunities: Bushplan Site/part Bushplan Site subject to Peel Inlet – Harvey Estuary EPP/SPP Swan Coastal Plain Lakes EPP Gnangara Mound Crown Land EPP Swan and Canning Rivers EPP Western Swamp Tortoise Draft EPP; location of Declared Rare Flora (and) Scheduled Fauna, conservation category wetland/s; under MRS Parks and Recreation Reservation and/or TPS Parks and Recreation Zoning, Crown Reserve; **and/or Constraints:** Bushplan Site/part Bushplan Site private land, under MRS Urban/Urban Deferred Zoning, MRS Industrial Zoning, MRD regional road requirements, Basic Raw Materials Core areas/ Mineral Resource Area, Mineral Lease

Recommendation:

Implementation Status of System 6 Recommendation Areas within Perth's Bushplan

KEY

System 6 Implementation Status:-

Implemented – action has been taken that completely achieves each of the part recommendations.

Intent Being Met – action has been taken (or is ongoing) which, though it may vary from the specific recommendations, meets the intention of the recommendations.

Partially Implemented – refers to a situation where a recommendation has several parts actioned, or refers to several areas of which only some of the areas or actions have been implemented.

Largely Implemented – applies where the main objectives and the majority of part recommendations have been achieved.

Unresolved Issues/Not Implemented – applies to recommendations concerning which there remains one or more substantive issues to be resolved before the recommendations can proceed.

No Longer Appropriate (N/A) – situations where the intention of the recommendation is judged to be no longer appropriate. Other actions may have been taken that preclude the recommendation from being implemented, the area may no longer be considered to be significant, or it may have been specifically exchanged for an equivalent alternative area.

Inclusion in *Perth's Bushplan*:-

Whole – Whole or most of System 6 area included in Perth's Bushplan.

Part – Part area included in Perth's Bushplan.

Excluded – Not included in Perth's Bushplan.

Outside – Outside scope of study of Perth's Bushplan (i.e. marine areas or in the Darling Scarp or Plateau).

System 6 Implementation Status	Proportion of Recommendations Implemented	System 6 Implementation Comments and Outstanding Issues	Inclusion in Perth's Bushplan	Perth's Bushplan Site Number/s	Perth's Bushplan Comments
• M1 Two Rocks Open Space					
N/A	1/2	No Regional Park proposal for this area.	Part	BS284, BS397	The majority of M1 is being exchanged for Wilbinga (Part BS406). Improved conservation outcome.
• M2 Coastal Strip From Two Rocks To Burns Beach					
N/A	0/1	Regional Park no longer proposed.	Part	BS397, BS322, BS325	Boundaries extended to include coastal reserves.
• M3 Yanchep National Park					
Largely Implemented	4/5	Realignment of freeway extension.	Whole	BS288	Boundary altered in region of freeway extension.
• M4 Ridges MPA					
Largely Implemented	2/3	Mining leases need to be resolved before vesting can be changed to National Park.	Whole	BS381	Boundaries extended to include adjacent State Forest bushland.

System 6 Implementation Status	Proportion of Recommendations Implemented	System 6 Implementation Comments and Outstanding Issues	Inclusion in Perth's Bushplan	Perth's Bushplan Site Number/s	Perth's Bushplan Comments
• M5 Yeal Nature Reserve					
Largely Implemented	4/5	Ongoing liaison between State & Commonwealth in relation to maintenance of bushland on Commonwealth land.	Part	BS380	Part not included is outside the study area.
• M6 Neerabup National Park					
Partially Implemented	0/3	Land exchanges have not occurred and need to proceed; no longer recommended for Regional Park.	Whole	BS383, BS323	Boundary altered to exclude Mindarie tip.
• M7 Lakes Joondalup and Goollelal					
Implemented	2/2	Funding for the management of Yellagonga Regional Park made available to CALM for 1997/1998.	Whole	BS299, BS407	Slight adjustments to boundary.
• M8 Wanneroo Wetlands Eastern Chain					
Partially Implemented	1/3	Regional Park not yet established; Parks and Recreation reservation still to be amended for some parts.	Part	BS382, BS147, BS324, BS295, BS193, BS327, BS448	Some largely cleared lakes not protected in Perth's Bushplan as no longer considered regionally significant. Boundaries altered to exclude developed areas.
• M9 Melaleuca MPA					
Partially Implemented	0/2	CALM management plan required; proposed to become a Nature Reserve.	Whole	BS399	Boundaries extended to include adjacent bushland.
• M11 Warwick Woodland					
Implemented	1/1		Whole	BS202	
• M12 Reserve A20091 Marangaroo					
Implemented	1/1	Part of area has been developed for golf course.	Part	BS328	Boundary altered to exclude golf course.
• M13 Whiteman Park (Mussel Pool)					
Implemented	2/2	Managed by Ministry for Planning as Regional Park.	Whole	BS304	Slight change to boundaries to reflect Whiteman Regional Park boundary.
• M14 Reserve C1654					
Implemented	2/2	Bullsbrook Nature Reserve.	Whole	BS292	Boundaries extended to include adjacent bushland.
• M15 Pearce Aerodrome					
Partially Implemented	1/2	Ongoing liaison between State & Commonwealth in relation to maintenance of bushland on Commonwealth land.	Whole	BS294	Boundaries extended to include adjacent bushland.
• M17 Ellen Brook & Twin Swamps Wildlife Sanctuaries, Upper Swan					
Partially Implemented	0/1	Need for perimeter buffer progressing through the preparation of the Environmental Protection (Western Swamp Tortoise Habitat) Policy.	Whole	BS400, BS301	Boundaries extended to include adjacent bushland.

System 6 Implementation Status	Proportion of Recommendations Implemented	System 6 Implementation Comments and Outstanding Issues	Inclusion in Perth's Bushplan	Perth's Bushplan Site Number/s	Perth's Bushplan Comments
• M19 Swan River – Guildford to Walyunga National Park					
Partially Implemented	0/1	Darling Range portion included in Darling Range Regional Park, funding to be made available to CALM for management 1999/2000. Remaining areas protected through Swan Canning EPP.	Part	BS302	Part not included is outside the study area.
• M20 Jane Brook					
Implemented	2/2	Protected through Swan Canning EPP.	Part	BS302	Fringing vegetation remnants of a lesser condition are not included. These will be protected under the general recommendation for protection of vegetation complexes with less than 10% remaining (see Volume 1, Figure 4).
• M33 Helena River, Guildford to Darlington					
Largely Implemented	1/2	Not planned for inclusion in Regional Park. Protected through Swan Canning EPP.	Whole	BS215	Not all boundary mapped. Area included for protection includes parks and recreation area.
• M34 Helena Valley					
Unresolved	Issues 1/6	Darling Range portion included in Darling Range Regional Park, funding to be made available to CALM for management 1999/2000. Remaining areas protected through Swan Canning EPP.	Part	BS215, BS213	Part excluded is outside study area.
• M35 Star Swamp, North Beach					
Implemented	3/3		Whole	BS204	Boundaries extended to include adjacent bushland.
• M36 Reserve near Karrinyup					
Implemented	3/3		Whole	BS308	Boundaries extended to include adjacent coastal dune bushland.
• M37 Carine Swamps					
Implemented	1/1		Whole	BS203	
• M38 Careniup Swamp, Gwelup					
N/A	0/2	Degraded, no longer considered regionally significant.	Excluded		
• M39 Lake Gwelup					
Implemented	1/1		Whole	BS212	
• M40 Dianella Open Space					
Implemented	1/1		Whole	BS280	

System 6 Implementation Status	Proportion of Recommendations Implemented	System 6 Implementation Comments and Outstanding Issues	Inclusion in Perth's Bushplan	Perth's Bushplan Site Number/s	Perth's Bushplan Comments
• M41 Bennett Brook					
Largely Implemented	1/2	No longer plans for Regional Park. Protected through Swan Canning EPP.	Whole	BS305	Boundaries extended to include adjacent bushland.
• M42 Jackadder Lake, Woodlands					
Implemented	1/1		Excluded		No longer considered regionally significant.
• M43 Herdsman Lake					
Implemented	2/2	Funding for management of Herdsman Lake Regional Park made available to CALM 1997/1998.	Whole	BS281	Boundaries altered to follow park boundary
• M44 Swan River, Backwater, South Guildford					
Partially Implemented	1/3	No current plans for Regional Park. Protected through Swan Canning EPP. Management plan being progressed.	Whole	BS491	
• M45 Hazelmere Lakes					
N/A	0/1	No longer considered regionally significant bushland.	Excluded		No longer considered regionally significant.
• M46 Swanbourne Beach and Rifle Range					
Unresolved Issues	0/5	Small part included in Bold Park Regional Park being managed by the Kings Park & Botanic Garden; Management plans still required. Defence land.	Whole	BS315	Boundaries extended to include adjacent bushland.
• M47 Bold Park, City Beach					
Implemented	2/2	Largely included in Bold Park Regional Park being managed by the King's Park & Botanic Garden.	Whole	BS312	Boundaries extended to include adjacent parkland.
• M48 Lake Claremont					
Implemented	1/1		Whole	BS220	Boundaries extended to include adjacent parkland.
• M49 Kings Park					
Implemented	1/1		Whole	BS317	
• M50 Swan Foreshore, Maylands					
Unresolved Issues	0/3	No current plans for Regional Park. Largely reserved for Parks and Recreation. Protected through Swan Canning EPP. Update of management plan still required.	Whole	BS314	

System 6 Implementation Status	Proportion of Recommendations Implemented	System 6 Implementation Comments and Outstanding Issues	Inclusion in Perth's Bushplan	Perth's Bushplan Site Number/s	Perth's Bushplan Comments
• M51 Swan River Saltmarshes, Belmont and Maylands					
Unresolved Issues	1/2	No current plans for Regional Park. Protected through Swan Canning EPP.	Whole	BS313	
• M52 Perth Airport					
Unresolved Issues	0/1	Ongoing liaison between State & Commonwealth in relation to maintenance of bushland on Commonwealth land.	Part	BS386	Excluded areas are proposed for development in airport extensions and commercial developments.
• M53 Reserve C29880, Forrestfield					
Partially Implemented	0/2	Part-cleared and developed. MRS amendment progressing.	Part	BS319, BS440	Boundaries adjusted to include bushland only.
• M54 Foreshore Reserve, Peppermint Grove					
Unresolved Issues	0/2	Management plan for conservation of threatened community required; No current plans for Regional Park.	Whole	BS403	
• M55 Buckland Hill, Mosman Park					
Partially Implemented	0/1	Undeveloped portion of the site has been set aside for Public Open Space and is included in proposed Vlamingh Parklands.	Excluded		The area is not considered to be regionally significant bushland.
• M56 Foreshore Reserves, Mosman Park					
Partially Implemented	1/3	Part included in proposed Vlamingh Parklands. Management plan required.	Whole	BS334	Boundaries extended to exclude cleared areas.
• M57 Minim Cove Foreshore, Mosman Park					
Partially Implemented	1/3	Included in proposed Vlamingh Parklands. Management plan for protection of shell deposits required.	Whole	BS335	
• M58 Blackwall Reach Foreshore, Bicton					
Largely Implemented	2/3	No current plans for Regional Park.	Whole	BS331	Boundaries have been adjusted to include surrounding bushland in Parks and Recreation.
• M59 Point Resolution Foreshore, Dalkeith					
Largely Implemented	3/4	No current plans for Regional Park.	Whole	BS221	
• M60 Aquatic Reserve, South Perth					
Intent Being Met	1/2	Forms part of Swan Estuary Marine Park. Regional Park no longer proposed.	Outside (Estuarine)		
• M61 Aquatic Reserve, Attadale					
Largely Implemented	2/3	No current plans for Regional Park. Part of the Swan Estuary Marine Park.	Part (Estuarine area outside)	BS331	Boundaries have been adjusted to exclude open water which is managed by CALM as part of the Marine Park.

System 6 Implementation Status	Proportion of Recommendations Implemented	System 6 Implementation Comments and Outstanding Issues	Inclusion in Perth's Bushplan	Perth's Bushplan Site Number/s	Perth's Bushplan Comments
• M62 Pelican Point, Crawley					
Largely Implemented	3/4	No current plans for Regional Park. Part of Swan Estuary Marine Park.	Part (Estuarine area outside)	BS402	Boundaries have been adjusted to exclude the open water which is managed by CALM as part of the Marine Park and extended to include adjacent bushland.
• M63 Harry Sandon Park, Attadale					
Largely Implemented	1/2	Management plan required.	Whole	BS226	Boundaries extended to include adjacent bushland.
• M64 Wireless Hill Park, Ardross					
Implemented	1/1		Whole	BS336	
• M65 Point Heathcote Foreshore, Applecross					
Unresolved Issues	0/2	No current plans for Regional Park. Management plan required.	Whole	BS329	
• M66 Mount Henry, Manning					
Largely Implemented	1/2	No current plans for Regional Park.	Whole	BS227	Boundaries have been extended to match the management plan (Brooker *et al.* 1993).
• M67 Canning River Foreshore, Salter Point to Clontarf					
Largely Implemented	2/3	No current plans for Regional Park.	Whole	BS333	Boundaries extended to include adjacent bushland.
• M68 Canning River, Riverton Bridge to Nicholson Road Bridge					
Implemented	4/4	Funding for Canning River Regional Park made available to CALM for management 1997/1998.	Whole	BS224	Boundaries extended to include adjacent conservation wetlands.
• M69 Kenwick Swamp					
Partially Implemented	0/3	Mechanisms for providing buffer required. Still owned by UWA, therefore not Class A reserve.	Whole	BS387	Boundaries extended to include adjacent wetlands and bushland.
• M70 Heathland, Wattle Grove					
N/A	0/0	Cleared, no longer regionally significant.	Excluded		
• M71 Cantonment Hill, Fremantle					
Implemented	1/1		Whole	BS490	
• M72 Sir Frederick Samson Park, Samson					
Largely Implemented	2/3	Addition of adjacent bushland lots to reserve being progressed by council.	Whole	BS59	
• M73 Booragoon Lake					
Implemented	1/1		Whole	BS337	
• M74 Bull Creek					
Partially Implemented	1/4	Negotiation regarding Reserve C32563 and adjoining Vacant Crown Land.	Whole	BS338	Boundaries have been adjusted to incorporate wetland in exchange for area of adjacent grassland which now acts as fire break between bushland and adjacent buildings.

System 6 Implementation Status	Proportion of Recommendations Implemented	System 6 Implementation Comments and Outstanding Issues	Inclusion in Perth's Bushplan	Perth's Bushplan Site Number/s	Perth's Bushplan Comments
• M75 Upper Canning and Southern Rivers					
Largely Implemented	2/3	No current plans for Regional Park.	Part	BS246, BS224, BS255	Part excluded is outside study area.
• M76 Mary Carroll Park, Gosnells					
Largely Implemented	4/5	Protection of private property through planning mechanisms.	Whole	BS124	Boundaries altered to exclude developed area.
• M83 Reserve C2457, Mundijong					
Implemented	1/1		Whole	BS352	Boundaries extended to include adjacent bushland.
• M88 Land North of Keysbrook					
N/A	0/2	No longer considered regionally significant.	Excluded		
• M90 Quarantine Station and Explosive Magazine Reserve, Woodman Point					
Largely Implemented	4/5	Funding for Woodman Point Regional Park will be made available to CALM for management 1998/1999.	Whole	BS341	
• M91 Reserve A24309, Coogee					
Largely Implemented	1/2	Funding for management of Beeliar Regional Park made available to CALM 1997/1998; Local authority requires funding for management plan.	Whole	BS346	Boundaries extended to include adjacent bushland.
• M92 Cockburn Wetlands, Western Chain					
Implemented	2/2	Funding for Beeliar Regional Park made available to CALM for management 1998/1999.	Whole	BS247 BS435 BS429 BS261 BS346	Boundaries altered to exclude developed areas.
• M93 Cockburn Wetlands-Eastern Chain					
Largely Implemented	2/3	Funding for Beeliar Regional Park made available to CALM for management 1997/1998. Parks and Recreation reservation progressing.	Whole	BS244 BS254 BS256 BS391 BS392 BS393	Boundaries altered to exclude developed areas.
• M94 Jandakot Airport					
Unresolved Issues	0/1	Ongoing liaison between State & Commonwealth in relation to maintenance of bushland on Commonwealth land.	Whole	BS388	Boundaries extended to include adjacent bushland.
• M95 Forrestdale Lake					
Intent Being Met	0/1	No longer planned for Regional Park. Nature Reserve.	Whole	BS345	Boundaries extended to include adjacent bushland and wetlands.
• M96 Garden Island					
Implemented	1/1		Whole	BS63	Boundaries altered to include bushland area only.
• M97 Reserve C36110, Wandi					
Implemented	2/2		Whole	B347	Boundaries extended to include adjacent bushland.

System 6 Implementation Status	Proportion of Recommendations Implemented	System 6 Implementation Comments and Outstanding Issues	Inclusion in Perth's Bushplan	Perth's Bushplan Site Number/s	Perth's Bushplan Comments
• M98 Reserve C31874, Casuarina					
Partially Implemented	1/1	One third of area has been developed as prison; remainder is managed for conservation.	Whole	BS273	Boundaries adjusted to exclude developed prison area.
• M99 Reserve A25886, West of Byford					
Implemented	1/1		Whole	BS348	Boundaries extended to include adjacent bushland.
• M100 Reserve C28167, South of Byford					
Implemented	1/1		Whole	BS353	
• M101 Cape Peron, Shoalwater Bay and Warnbro Sound					
Implemented	5/5	Regional Park recommendation is no longer appropriate as area is now Shoalwater Islands Marine Park.	Part (Marine area outside)	BS367	Terrestrial area only.
• M102 Lake Richmond, Rockingham					
Partially Implemented	1/4	Included in Rockingham Lakes Regional Park. Funding for management will be made available to CALM 1998.	Whole	BS358	Boundaries extended to include upland bushland and provide buffer area.
• M103 Lakes Cooloongup and Walyungup					
Implemented	1/1	Included in Rockingham Lakes Regional Park. Funding for management will be made available to CALM 1998/1999.	Whole	BS356	Boundaries adjusted to exclude developed areas and include adjacent bushland.
• M104 Reserves C31102 and C33581, Leda					
Implemented	3/3	Reserve C33581 now a Nature Reserve.	Whole	BS349	Boundaries extended to include adjacent bushland north and south.
• M105 Lowlands Property West of Serpentine					
Largely Implemented	2/3	There is no Regional Park proposal for area. Conservation zoning under Town Planning Scheme.	Whole	BS368, BS371, BS372	Boundaries altered to include bushland only.
• M106 Port Kennedy					
Intent Being Met	2/2	Funding for Rockingham Lakes Regional Park made available to CALM for management 1998. Portion of area set aside for tourism development.	Part	BS377	Boundaries adjusted to exclude development area.
• M107 Peelhurst, Singleton and Madora					
Largely Implemented	2/3	Recommendation revised through planning development proposals with greater emphasis on coastal reserve.	Exclude		Degraded. No longer considered regionally significant. Only metropolitan portion within *Perth's Bushplan* study area.
• M108 Geogrup Lakes					
Partially Implemented	3/6	Area outside metropolitan area is included in Peel Regional Plan. Reserve purposes still to be amended.	Part	BS394	Part excluded is outside study area. Otherwise boundary is extended to include adjacent bushland and wetlands.
• C46 Carnac Island					
Largely Implemented	2/3	Management plan required.	Whole	BS473	

Acronyms and Frequently Used Abbreviations in this Volume

AgWA	Agriculture Western Australia
AHC	Australian Heritage Commission
ANCA	Australian Nature Conservation Agency
ANZECC	Australian and New Zealand Environment and Conservation Council
CALM	Department of Conservation and Land Management
CAMBA	China Australia Migratory Birds Agreement
CER	Consultative Environmental Review
DCE	Department of Conservation and Environment
DEP	Department of Environmental Protection
DOLA	Department of Land Administration
EIA	Environmental Impact Assessment
EPA	Environmental Protection Authority
EPP	Environmental Protection Policy
ERMP	Environmental Review and Management Plan
GIS	Geographic Information System
IBRA	Interim Biogeographic Regionalisation for Australia
JAMBA	Japan Australia Migratory Birds Agreement
MfP	Ministry for Planning
MRS	Metropolitan Region Scheme
NPNCA	National Parks and Nature Conservation Authority
PCA	Planning Control Area
PEP	Perth Environment Project
PER	Public Environmental Review
PMR	Perth Metropolitan Region
RAOU	Royal Australasian Ornithologists' Union
SCP	Swan Coastal Plain
SF	State Forest
SPP	Statement of Planning Policy
TPS	Town Planning Scheme
UNESCO	United Nations Environment and Science Conservation Organisation
WAPC	Western Australian Planning Commission
WATSCU	WA Threatened Species and Communities Unit
WAWA	Western Australia Water Authority
WRC	Water and Rivers Commission

APPENDIX 4

Introductory Guide to the Bushplan Site Description and Map

This introductory guide has been prepared for use with information on individual Bushplan Sites and explains both the Bushplan Site description and the Bushplan Site map.

The guide summarises Volume 2 of Perth's Bushplan. Perth's Bushplan Volume 2 contains three parts:

— Part A which details the information in this Introductory Guide

— Part B which contains descriptions of all Bushplan Sites

— Part C which contains maps of all Bushplan Sites.

All sources of information used in Perth's Bushplan Volume 2 are listed in the references in Part A. Only major references are listed in this guide.

Bushplan Site Description

A general proforma was developed to present the information collated on each Bushplan Site. This introductory guide presents sections of this proforma along with a brief explanation of the category of information. All text from the proforma is shown in **'Times bold'** font.

NAME

Each Bushplan Site name is in keeping with well used names of the area or is derived from a boundary road. The suburb in which it is located follows the name. A named described Bushplan Site may contain a series of Site numbers

Boundary Definition: protected area boundary management boundary management/bushland boundary bushland boundary bushland group boundary conservation wetland boundary vegetation complex boundary

The boundary of the Bushplan Site delineates the area of regionally significant bushland (or habitat for native fauna) which has been recognised in Perth's Bushplan. Generally only the bushland within the Bushplan Site boundary is recognised and proposed to be protected.

The type of boundary is selected from one or more of seven categories allocated to Bushplan Sites.

- protected area boundary — boundary matches current Parks and Recreation, CALM managed lands or Crown Reserves with a conservation purpose
- management boundary — boundary selected for ease or viability of management
- management/bushland boundary — combination of management boundary and mapped bushland boundary
- bushland boundary — boundary fully encompasses mapped bushland areas
- bushland group boundary — boundary encompasses several mapped bushland areas
- conservation wetland boundary — boundary matches verified conservation category wetland boundary or boundary adjusted to include all of a conservation category wetland
- vegetation complex boundary — boundary follows boundary of the area of a single complex

While the boundaries of the Bushplan Sites are as accurate as possible using aerial photograph interpretation and some ground checking, the final determination of the boundaries of the area to be identified and managed for conservation involves consideration of:

- individual area ground-checking of bushland boundaries
- management design criteria such as
  - reduction of the bushland edge-to-area ratio
  - establishment of a foreshore reserve or management buffer area
  - connectivity with other sites and natural areas
- cadastral boundaries
- existing planning constraints.

Where there are discrepancies between the mapped native vegetation and survey records of bushland in the Bushplan Site, the 'boundary category' is annotated with the following statement:

'Areas of bushland within the boundaries of the Bushplan Site are not accurately mapped. The boundary has been drawn to include any unmapped bushland'.

SECTION 1: CADASTRAL INFORMATION

Bushplan Site no.

Map no.

Map sheet series ref. no.

System 6 (1983): All System area bushland, total area described Part System area bushland, only bushland described Area of bushland goes beyond System area boundaries, all bushland described Part System area bushland and part scattered native plants (canopy), all vegetation described

Other Names

Area (ha):

Local Authorities (Suburb)

Zoning

MRS:

TPS:

Ownership Categories

Lot/Reserve numbers (Purpose), Street name

Bushplan Site number:

The arbitrary number assigned to each Bushplan Site. For example, Kings Park is Bushplan Site number 317 and Cardup Brook Bushland is Bushplan Site numbers 66, 351 and 271.

Map number

Refers to the map page (in Perth's Bushplan, Volume 2) on which the Bushplan Site is located.

Map sheet series reference number

Refers to the Australian 1: 25 000 Topographic Survey Map Sheet Series from which the map pages are derived, for example 2034 IV SW.

System 6

The System 6 reference number is cited then the portion of the System 6 area included within the Bushplan Site is described.

Other Names

Any other known names or reference codes.

Area (ha)

The area defined by the Bushplan Site boundary is recorded as Total Area, followed by the area of mapped native vegetation and the presence of open water.

Local Authorities (Suburb)

For example, City of Nedlands (Shenton Park).

Zoning

Metropolitan Region Scheme (MRS) and Town Planning Scheme (TPS).

Ownership Category

Ownership categories identified in the Bushplan Site are listed. There could be one or more of the following:

Commonwealth Government — vested in Commonwealth Government
State Government — vested in State Government
Local Government — vested in local government
Private — owned freehold by private person(s), State or local government, for commercial purposes by a private person or company

Lot/Reserve numbers (purpose), Street name

Street names and Lot or Reserve numbers (with the Reserve purpose in brackets) are listed.

SECTION 2: REGIONAL INFORMATION

LANDFORM AND SOILS

Dandaragan Plateau/Gingin Scarp
Colluvial Sand (Qs: S6)
Laterite (Ql: G2, LA1)
Leederville Formation (Klb: ST1)
Osborne Formation (Ko: ST2)

Darling Plateau (Darling Range)/Darling Scarp
Laterite (Ql: G2, LA1)
Darling Scarp – gravels and laterite (Czl: for example G2, LA1)
Even-grained Granite (Ae, Aes: M3, GR) (Am: GN

Foothills
Colluvial Deposits (Qc: for example Msg, Csg, Ms3, Smg, S5)
Colluvial Sand (Qs: for example S6)

Yoganup Formation (Qpr: for example S12)
Ridge Hill Sandstone (Qph: SS)
Armadale Shale (Pa: SH)

Pinjarra Plain
Guildford Formation (Qpa: for example FS, Ms2, Mgs1, Cs, Sc) (Qha: for example Cp, S14, Msc1)
Alluvial/Colluvial Deposit (Qha/Qc: for example G1)
Alluvial/Colluvial Deposit (Pinjarra Plain / Ridge Hill) (Qha/Qc: for example FS3)
Muchea Limestone (Qpm: for example LS5)

Bassendean Dunes
Bassendean Sands (Qpb: S8)

Bassendean Dunes/Pinjarra Plain
Bassendean Sands over Guildford Formation (Qpb/Qpa: S10)

Spearwood Dunes
Sands derived from Tamala Limestone (Qts: S7)
Tamala Limestone (Qtl: for example LS1, LS2)

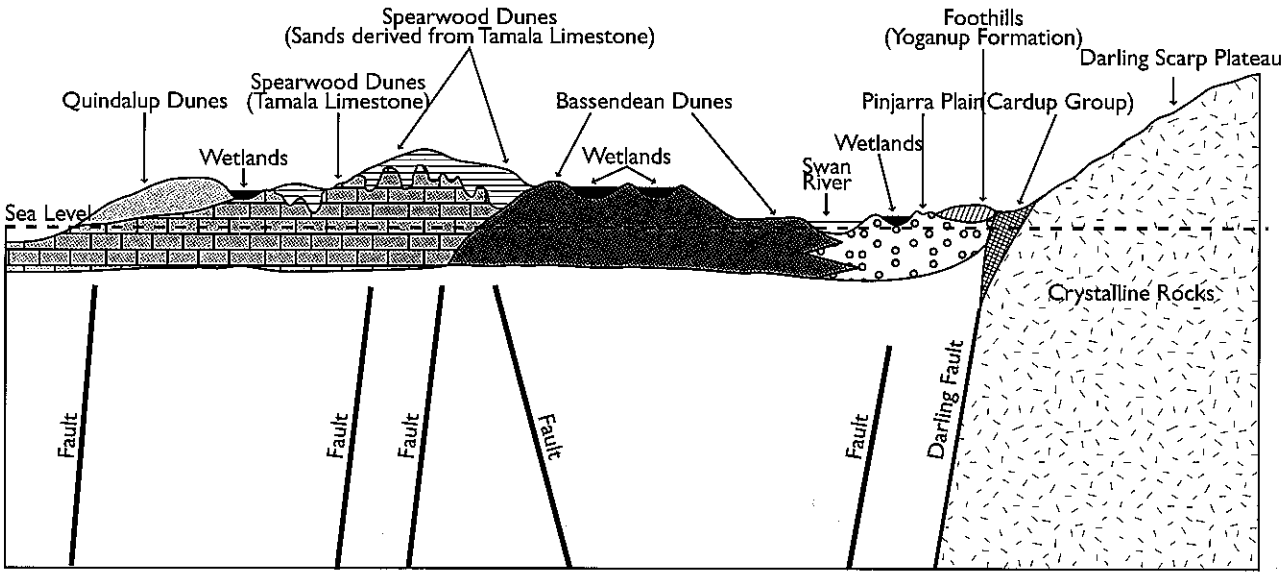
Quindalup Dunes (Holocene dunes)
Safety Bay Sands (Qhs: for example S1, S2, S13, LS4)

Wetlands (within the Quindalup, Spearwood, Bassendean Dunes or Pinjarra Plain)
Holocene Swamp Deposits (Qhw: for example Cps, Scp, Spc, Spm, Ms5) (Qrw: for example Sp1, Sp2)

Lagoonal and estuarine Deposits (within the Quindalup Spearwood Bassendean Dunes Pinjarra Plain)
Lagoonal and Estuarine Deposits (Vasse) (Qhg: for example M5, Sm2)

Lagoonal Deposits in Bassendean Dunes (Qpw: for example S9)

The major landform units of the Swan Coastal Plain are illustrated on the transect of the Plain below. The Dandaragan Plateau is not shown in this transect. It occurs in the north of the area covered by Perth's Bushplan between the Plain and the Darling Plateau.



Foothills (Ridge Hill Shelf)

Yoganup Formation

Cardup Group

Bassendean Dunes

Bassendean Sand

Pinjarra Plain

Guildford Formation

Spearwood Dunes

Tamala Limestones

Sands derived from Tamala Limestones

Quindalup Dunes

Safety Bay Sands

Adapted with permission from Fact Sheet 15. The Geology of Perth.
Department of Minerals and Energy, Western Australia.

The soils are listed under the major landform elements distinguished in the transect from west to east of the Swan Coastal Plain. A key to the symbols used to describe the geology units and soils is given overleaf.

Key to symbols in the diagram above

Table 4: Key to Environmental Geology Series Symbols

Geology Units

Ae and Aes	Even-grained Granite
Am	Migmetite
Czl	Laterite
Klb	Leederville Formation
Ko	Osborne Formation
Pa	Armadale Shale
Qc	Colluvium
Qha	Alluvium – Holocene
Qhg	Lagoonal and Estuarine Deposits
Qhs	Safety Bay Sands
Qpa	Alluvium – Pleistocene
Qpb	Bassendean Sand
Qph	Ridge Hill Sandstone
Qpm	Muchea Limestone
Qpr	Yoganup Formation
Qpw	Lagoonal Deposits in Bassendean Sand
Qrw	Swamp Deposits
Qtl	Tamala Limestone
Qs	Colluvial Sand
Qts	Sand derived from Tamala Limestone

Soil Units

- Letters

The main 'soil fraction' is given first in capitals, followed by fractions in decreasing importance in lower case

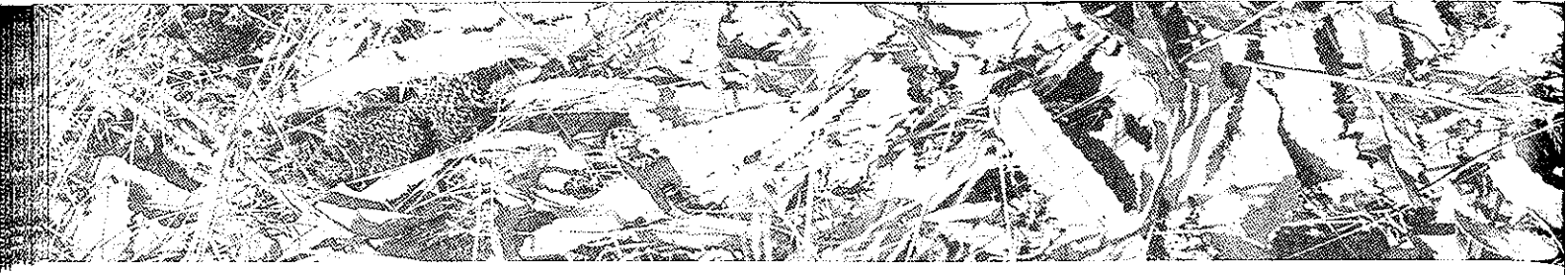
- Numbers indicate mappable units of a similar character

C	clay
M	silt
G	gravel
P	organic material
S	sand
ST	siltstone
SH	shale

Rocks

Double capitals

DO	dolerite
FS	ironstone
GN	gneiss
GR	granite
LA	laterite
LS	limestone



Source of information

Environmental Geology Series maps of the Perth Metropolitan Region, published by Geological Survey of Western Australia, Department of Minerals and Energy, Perth, Western Australia.

VEGETATION AND FLORA

Vegetation Complexes

Plateaus
Mogumber Complex – South (Dandaragan Plateau)

Scarps
Reagan Complex (Gingin Scarp, Dandaragan Plateau)

Foothills
Coonambidgee Complex (Dandaragan Plateau)
Forrestfield Complex (Ridge Hill Shelf, Darling Plateau)

Pinjarra Plain
Guildford Complex
Swan Complex
Dardanup Complex
Serpentine River Complex
Beermullah Complex
Yanga Complex

Bassendean Dunes
Bassendean Complex – North
Bassendean Complex – Central and South
Bassendean Complex – North Transition
Bassendean Complex – Central and South Transition

Combinations of Bassendean Dunes/Pinjarra Plain/Spearwood Dunes
Southern River Complex
Cannington Complex

Spearwood Dunes
Karrakatta Complex – North
Karrakatta Complex – North Transition
Karrakatta Complex – Central and South
Cottesloe Complex – North
Cottesloe Complex – Central and South

Quindalup Dunes
Quindalup Complex

Wetlands
Herdsman Complex
Pinjar Complex

Marine (lagoonal and estuarine) Deposits
Yoongarillup Complex
Vasse Complex

The vegetation complexes found in each Bushplan Site are listed. Vegetation complexes were described and mapped in 1980 (Heddle *et al.* 1980) for the Darling System (the area between Moore River and Capel and east to Toodyay and Bridgetown). Vegetation complexes are groupings of vegetation types, developed on units characterised by particular soil, geomorphic and climatic characteristics.

Description of Vegetation Complexes

Dandaragan Plateau

MOGUMBER COMPLEX – SOUTH: Open woodland of *Eucalyptus calophylla*, with some admixture of *E. marginata* and a second storey of
E. todtiana – Banksia attenuata – B. menziesii –
B. ilicifolia.

Gingin Scarp

REAGAN COMPLEX: Vegetation ranges from low open woodland of *Banksia* species – *E. todtiana* to closed heath depending on the depth of soil.

Foothills (Ridge Hill Shelf)

COONAMBIDGEE COMPLEX: Vegetation ranges from a low open forest and low woodland of *E. todtiana – B. attenuata – B. menziesii – B. ilicifolia* with localised admixtures of B. prionotes to an open woodland of *E. calophylla – Banksia* species

FORRESTFIELD COMPLEX: Vegetation ranges from open forest of E. calophylla – *E. wandoo – E. marginata* to open forest of *E. marginata – E. calophylla – Allocasuarina. fraseriana – Banksia* species. Fringing woodland of *E. rudis* in the gullies that dissect this landform.

Pinjarra Plain

GUILDFORD COMPLEX: A mixture of open forest to tall open forest of *E. calophylla – E. wandoo – E. marginata* and woodland of E. wandoo (with rare occurrences of *E. lane-poolei*). Minor components include *E. rudis – M. rhaphiophylla.*

SWAN COMPLEX: Fringing woodland of *E. rudis – M. rhaphiophylla* with localised occurrence of low open forest of *Casuarina obesa* and *M. cuticularis.*

DARDANUP COMPLEX: Mosaic of vegetation types characteristic of adjacent vegetation complexes such as Serpentine River, Southern River and Guildford.

SERPENTINE RIVER COMPLEX: Closed scrub of *Melaleuca* species and fringing woodland of *E. rudis – M. rhaphiophylla* along streams.

BEERMULLAH COMPLEX: Mixture of low open forest of C. obesa and open woodland of *E. calophylla – E. wandoo – E. marginata.* Minor components include closed scrub of *Melaleuca* species and occurrence of *Actinostrobus pyramidalis.*

YANGA COMPLEX: Predominantly a closed scrub of *Melaleuca* species and low open forest of *C. obesa* on the flats subject to inundation. On drier sites the vegetation reflects the adjacent vegetation complexes of Bassendean and Coonambidgee.

Bassendean Complex

BASSENDEAN COMPLEX – NORTH: Vegetation ranges from a low open forest and low open woodland of *Banksia* species – *E. todtiana* to low woodland of *Melaleuca* species and sedgelands which occupy the moister sites.

BASSENDEAN COMPLEX – CENTRAL AND SOUTH: Vegetation ranges from woodland of *E. marginata – C. fraseriana – Banksia* spp. to low woodland of *Melaleuca* species, and sedgelands on the moister sites. This area includes the transition of *E. marginata* to *E. todtiana* in the vicinity of Perth.

BASSENDEAN COMPLEX – NORTH – TRANSITION VEGETATION COMPLEX: A transition complex of low open forest and low woodland of *Banksia* species – *E. todtiana* on a series of high sand dunes. The understorey species reflect similarities with both the Bassendean-North and Karrakatta-North vegetation complexes.

BASSENDEAN COMPLEX – CENTRAL AND SOUTH – TRANSITION VEGETATION COMPLEX: Woodland of *E. marginata – E. calophylla* with well defined second storey of *Allocasuarina fraseriana* and *B. grandis* on the deeper soils and a closed scrub on the moister sites. The understorey species reflect similarities with the adjacent vegetation complexes.

Combinations of Bassendean Dunes/Pinjarra Plain/Spearwood Dunes

SOUTHERN RIVER COMPLEX: Open woodland of *E. calophylla – E. marginata – Banksia* species with fringing woodland of *E. rudis – M. rhaphiophylla* along creek beds.

CANNINGTON COMPLEX: Mosaic of vegetation from adjacent vegetation complexes of Bassendean, Karrakatta, Southern River and Vasse.

Spearwood Dunes

KARRAKATTA COMPLEX – NORTH: Predominantly low open forest and low woodland of *Banksia* spp. *E– E. todtiana,* less consistently open forest of *E. gomphocephala – E. todtiana – Banksia* species.

KARRAKATTA COMPLEX – NORTH – TRANSITION VEGETATION COMPLEX: A transition complex of low open forest and low woodland of *Banksia* species – *E. todtiana* on the transition zone of a series of high sand dunes between Bassendean-North and Karrakatta-North.

KARRAKATTA COMPLEX – CENTRAL AND SOUTH: Predominantly open forest of *E. gomphocephala – E. marginata – E. calophylla* and woodland of *E. marginata – Banksia* species.

COTTESLOE COMPLEX – NORTH: Predominantly low open forest and low woodland of *B. attenuata – B menziesii – E. todtiana;* closed heath on the limestone outcrops.

COTTESLOE COMPLEX – CENTRAL AND SOUTH: Mosaic of woodland of *E. gomphocephala* and open forest of *E. gomphocephala – E. marginata – E. calophylla;* closed heath on the limestone outcrops.

Quindalup Dunes

QUINDALUP COMPLEX: Coastal dune complex consisting mainly of two alliances – the strand and fore-dune alliance and the mobile and stable dune alliance. Local variations include the low closed forest of *M. lanceolata – Callitris preissii* and the closed scrub of *Acacia rostellifera.*

Wetlands

HERDSMAN COMPLEX: Sedgelands and fringing woodland of *E. rudis – Melaleuca* species.

PINJAR COMPLEX: Vegetation ranges from woodland of *E. marginata – Banksia* species to a fringing woodland of *E. rudis – M. preissiana* and sedgelands.

Marine (lagoonal and estuarine) Deposits

YOONGARILLUP COMPLEX: Woodland to tall woodland of *E. gomphocephala* with *Agonis flexuosa* in the second storey. Less consistently an open forest of *E. gomphocephala – E. marginata – E. calophylla.*

VASSE COMPLEX: Mixture of the closed scrub of *Melaleuca* species fringing woodland of *E. rudis – Melaleuca* species and open forest of *E. gomphocephala – E. marginata – E. calophylla.*

Note: *E.* = *Eucalyptus,*
M. = *Melaleuca,*
C. = *Casuarina,*
B. = *Banksia,*
A. = *Allocasuarina*

Source of Information

Heddle EM, Loneragan OW & Havel JJ 1980 Vegetation of the Darling System. IN: Department of Conservation and Environment 1980 *Atlas of Natural Resources, Darling System, Western Australia.* Department of Conservation and Environment, Perth, Western Australia.

Floristic Community Types

*not sampled, types inferred, not sampled insufficient vegetation, not sampled, types not inferred

Supergroup 1 – Foothills/Pinjarra Plain

1a *Eucalyptus haematoxylon – E. marginata* woodlands on Whicher foothills
1b Southern *Eucalyptus calophylla* woodlands on heavy soils
2 Southern wet shrublands
3a *Eucalyptus calophylla – Kingia australis* woodlands on heavy soils
3b *Eucalyptus calophylla – E. marginata* woodlands on sandy clay soils
3c *Eucalyptus calophylla – Xanthorrhoea preissii* woodlands and shrublands
S8 *Eucalyptus wandoo* Woodlands (Scarp)

Supergroup 2 – Seasonal Wetlands

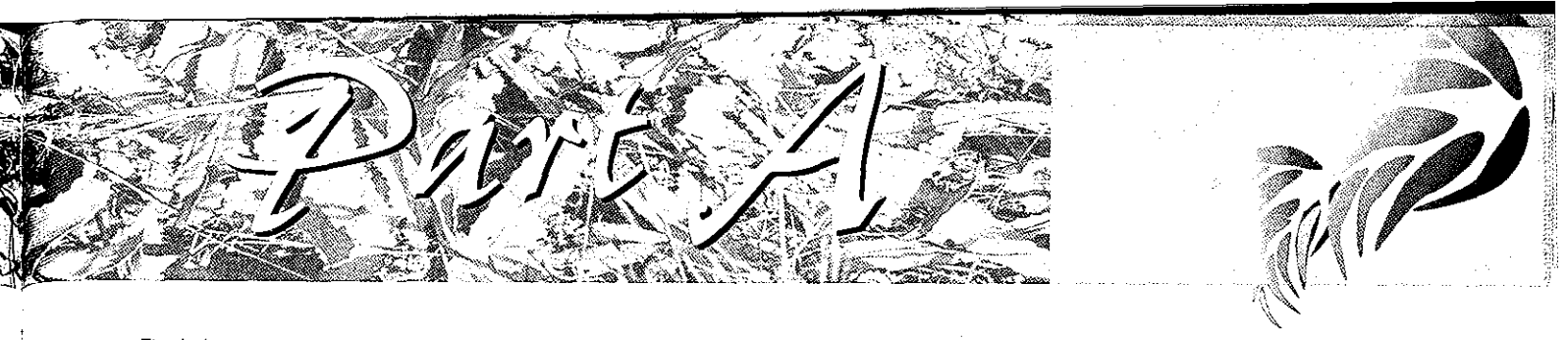
4 *Melaleuca preissiana* damplands
5 Mixed shrub damplands
6 Weed dominated wetlands on heavy soils
7 Herb rich saline shrublands in clay pans
8 Herb rich shrublands in clay pans
9 Dense shrublands on clay flats
10a Shrublands on dry clay flats
10b Shrublands on southern ironstones
11 Wet forests and woodlands
12 *Melaleuca teretifolia* and/or *Astartea* aff. *fascicularis* shrublands
13 Deeper wetlands on heavy soils
14 Deeper wetlands on sandy soils
15 Forests and woodlands of deep seasonal wetlands
16 Highly saline seasonal wetlands
17 *Melaleuca rhaphiophylla – Gahnia trifida* seasonal wetlands
18 Shrublands on calcareous silts
19a Sedgelands in Holocene dune swales
19b Woodlands over sedgelands in Holocene dune swales
S1 *Astartea* aff. *fascicularis – Melaleuca* species dense shrublands
S2 Northern *Pericalymma ellipticum* dense low shrublands
S3 Wet sedgelands on sandy clays
S4 *Regelia ciliata* Dandaragan Plateau wetlands
S5 *Acacia saligna* wetlands
S6 Northern dense low shrublands
S7 Northern woodlands to forests over tall sedgelands alongside permanent wetlands
S17 *Eucalyptus rudis – Agonis linearifolia* wetlands in Bassendean Dunes
S19 Dense tall shrublands
S20 Northern shrublands on sandy clays

Supergroup 3 – Uplands centred on Bassendean Dunes and Dandaragan Plateau

20a *Banksia attenuata* woodlands over species rich dense shrublands
20b Eastern *Banksia attenuata* and/or *Eucalyptus marginata* woodlands
20c Eastern shrublands and woodlands
20d Dandaragan Plateau shrublands and woodlands
21a Central *Banksia attenuata – Eucalyptus marginata* woodlands
21b Southern *Banksia attenuata* woodlands
21c Low lying *Banksia attenuata* woodlands or shrublands
22 *Banksia ilicifolia* woodlands
23a Central *Banksia attenuata – B. menziesii* woodlands
23b Northern *Banksia attenuata – B. menziesii* woodlands
23c North-eastern *Banksia attenuata – B. menziesii* woodlands
S9 *Banksia attenuata* woodlands over dense low shrublands
S10 *Calothamnus sanguineus* dense low shrublands on sandy laterites
S16 Mixed dense shrublands on yellow brown sands
S18 *Eucalyptus marginata – E. calophylla* Woodlands on laterites

Supergroup 4 – Uplands centred on Spearwood and Quindalup Dunes

24 Northern Spearwood shrublands and woodlands
25 Southern *Eucalyptus gomphocephala – Agonis flexuosa* woodlands
26a *Melaleuca huegelii – M. acerosa* shrublands of limestone ridges
26b Woodlands and mallees on limestone
27 Species poor mallees and shrublands on limestone
28 Spearwood *Banksia attenuata* or *B. attenuata – Eucalyptus* woodlands
29a Coastal shrublands on shallow sands
29b *Acacia* shrublands on taller dunes
30a2 *Callitris preissii* and/or *Melaleuca lanceolata* forests and woodlands
30b Quindalup *Eucalyptus gomphocephala* and/or *Agonis flexuosa* woodlands
30c2 Woodlands and shrublands on Holocene dunes (re-allocated from 30c)
S11 Northern *Acacia rostellifera – Melaleuca acerosa* shrublands
S12 Rottnest Island *Melaleuca lanceolata* and/or *Callitris preissii* forests and woodlands
S13 Northern *Olearia axillaris – Scaevola crassifolia* shrublands
S14 *Spinifex longifolius* grassland and low shrubland



Floristic community types are regional groups related to the combination of different plant species in communities. These were identified in 1994 (Gibson et al. 1994) and 1996 (DEP 1996) using a series of studies of the flora of the Swan Coastal Plain. Floristic community types were distinguished by comparing the species present in over 1,100 10x10 metre plots located on the Swan Coastal Plain south of the Moore River. The 1994 study identified 43 floristic community types and the 1996 study a further 23 types (indicated as new subgroups or supplementary groups).

Floristic community types are identified in Bushplan Sites in two ways:

(i) plots were located in the area of the Bushplan site and the floristic community type was determined by analysis

(ii) the floristic community types were inferred from information on the floristics of the area and the area's geographic location. An 'asterisk' indicates an inferred floristic community type (i.e. not sampled, types inferred).

Floristic community types could not be determined when the remaining vegetation was too disturbed to sample or not enough was known about the vegetation (i.e. not sampled, insufficient vegetation).

Sources of Information

Department of Environmental Protection 1996 *System 6 and Part System 1 Update Program.* Unpublished bushland plot and area records and analysis.

Gibson N, Keighery BJ, Keighery GJ, Burbidge AH & Lyons MN 1994 *A Floristic Survey of the Southern Swan Coastal Plain.* Unpublished Report for the Australian Heritage Commission prepared by the Department of Conservation and Land Management and the Conservation Council of Western Australia (Inc).

WETLANDS
No wetlands mapped

Wetland Types: lake, sumpland, dampland, artificial lake, floodplain, palusplain, paluslope, river, creek, artificial channel, estuary (waterbody), estuary (peripheral), includes wetlands not previously described (survey reference)

Wetland types on the Swan Coastal Plain have been identified and mapped. These are defined in the table below.

Wetland types

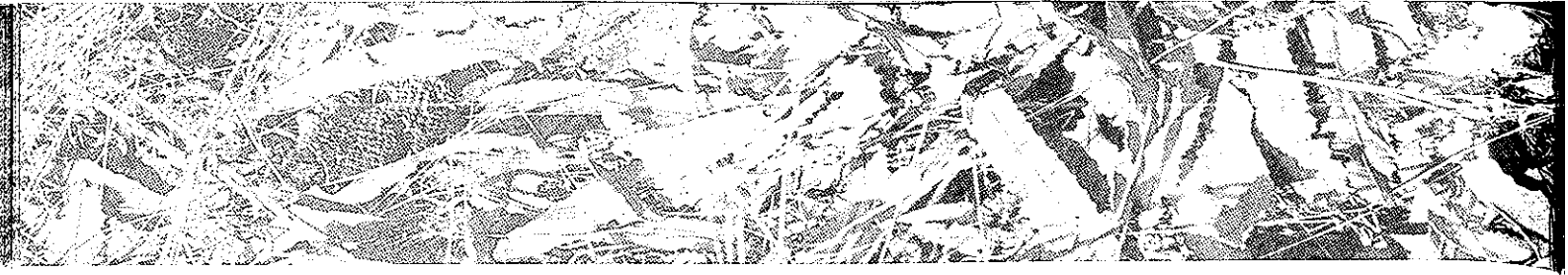
Water Longevity	Landform				
	Basin	Channel*	Flat	Slope	Highland
Permanent inundation	lake*	river	–	–	–
Seasonal inundation	sumpland	creek	floodplain	–	–
Seasonal waterlogging	dampland	trough#	palusplain	paluslope	palusmont#

Not used on Swan Coastal Plain in the Perth Metropolitan Region

*Artificial Channels and Artificial Lakes are man-made channels and lakes

Estuaries

ESTUARY (waterbody)	that part of an estuary which is permanently or seasonally inundated
ESTUARY (peripheral)	that part of an estuary subject to seasonal waterlogging



Sources of Information

Separate chapters by various authors and maps in Hill AL, Semeniuk CA, Semeniuk V & Del Marco A 1996 *Wetlands of the Swan Coastal Plain. Volumes 1 & 2.* Prepared for the Water and Rivers Commission and the Department of Environmental Protection, Western Australia.

Natural Wetland Groups

Darling Plateau
Walyunga (D.1)
Little Dardanup (D.2)
Nalyerin (D.4)
Brockman (D.6)

Dandaragan Plateau – Darling Plateau interface
Wannamal (Dp/D)

Dandaragan Plateau
Red Gully (Dp.1)
Coorang (Dp.2)
Clewley (Dp.3)
Mogumber (Dp.4)

Pinjarra Plain
Keysbrook (P.1)

Bassendean – Pinjarra transition OR Bassendean with fluvial features
Beermullah (B/P.1)
Mungala (B/P.2)
Muchea (B/P.3)
Bennett Brook (B/P.4)

Bassendean Dunes
Pinjar (B.1)
Gnangara (B.2)
Jandakot (B.3)
Riverdale (B.4)

Spearwood – Bassendean interface
Bibra (S/B.1)

Spearwood Dunes
Yanchep (S.1)
Balcatta (S.2)
Coogee (S.3)
Stakehill (S.4)

Quindalup Dunes
Cooloongup (Qu.1)
Becher (Qu.2)
Peelhurst (Qu.3)

Swan Coastal Plain Rivers
Moore River (R 1)
Swan River (R 2)
Ellen Brook (R 3)
Goergrup (R 4)

Estuaries
Moore River (E 1)
Swan River (E 2)

Twenty-one natural wetland groups have been identified in the Perth Metropolitan Region. These regional wetland groups have been defined by comparing geomorphic setting, wetland origin and water maintenance

Wetland Management Objectives: Conservation, Resource Enhancement, Multiple Use

All wetlands are placed in management categories. The area or length of each conservation category wetland is given.

The wetland management categories are:

- Conservation wetlands: Conservation Category Wetlands are wetlands for which the appropriate management regime has the objective of preserving their natural attributes and functions. 'Wetlands recognised at the international, national or regional level, "High Conservation" and "Conservation" wetlands identified using Bulletin 374 (EPA 1990) assessment; wetlands 96–100*% vegetated, sections of extensive wetlands' (Hill and Del Marco 1996).
- Resource Enhancement: Resource Enhancement Category Wetlands are wetlands for which the appropriate management objective should be restoration through maintenance and enhancement of natural attributes and functions. These are: 'Wetlands 10–94*% vegetated and Bulletin 374 (EPA 1990) "Resource enhancement" and "Open space" wetlands are not identified above' (Hill and Del Marco 1996).
- Multiple Use: Multiple Use Category Wetlands are wetlands most appropriately managed for their use and development in the context of water, town and environmental planning. These are: 'Wetlands 0–9% vegetated, Bulletin 374 "Multiple Use" (EPA 1990) wetlands not identified above' (Hill and Del Marco 1996).

*In Perth's Bushplan channel wetlands that are 75% – 100% vegetated are Conservation Category Wetland status.

Sources of Information

Environmental Protection Authority 1990 *A Guide to wetland management in Perth* (Bulletin 374). Environmental Protection Authority, Perth,
Western Australia.

Hill AL & Del Marco A 1996 Wetland evaluation. *IN: Hill et al. 1996a Wetlands of the Swan Coastal Plain. Volume 1: Wetland mapping, classification and evaluation, Main Report.* Prepared for the Water and Rivers Commission and the Department of Environmental Protection, Western Australia.

Swan Coastal Plain Lakes EPP: ha none identified

The Environmental Protection (Swan Coastal Plain Lakes) Policy (referred to as the Swan Coastal Plain Lakes EPP) was gazetted in December 1992 (Government of Western Australia 1992) to protect 'Swan Coastal Plain Lakes', a

selection of permanently and seasonally inundated wetlands on the Swan Coastal Plain.

The following two categories were used in describing lakes as distinguished under the Swan Coastal Plain Lakes Environmental Protection Policy (EPP):

(i) 5ha, 10ha etc — the area of each lake defined by the EPP within the Site

(ii) none identified — no area of EPP lake in the Site

Source of Information

Government of Western Australia 1992 *Environmental Protection (Swan Coastal Plain Lakes) Policy 1992*. Government Gazette, WA, 11 December, 1992, pp5969–75.

THREATENED ECOLOGICAL COMMUNITIES

Not determined

Not assessed. Presumed Totally Destroyed. Critically Endangered (floristic community type 3a, 3c, 19, 20c, Communities of tumulus springs, Shrublands and woodlands on Muchea Limestone, Stromatalite-like community of coastal freshwater lakes, Aquatic root mat community of caves of the Swan Coastal Plain), Endangered (floristic community type 2, 10a, 20a, 20b), Vulnerable (floristic community type 3b, 7, 8, 9, 15, 18, 30a), Data Deficient (14), Lower Risk

Ecological communities are defined as 'naturally occurring biological assemblages that occur in a particular type of habitat'. Threatened ecological communities are those that have been assessed and assigned to one of four categories related to the status of the threat to the community. The following six categories of ecological communities are distinguished as described below. The first four are threatened ecological communities.

Presumed Totally Destroyed

An ecological community which has been adequately searched for but for which no representative occurrences have been located. The community has been found to be totally destroyed or so extensively modified throughout its range that no occurrence of it is likely to recover its species composition and/or structure in the foreseeable future.

Critically Endangered (CR)

An ecological community which has been adequately surveyed and found to have been subject to a major contraction in area and/or which was originally of limited distribution and is facing severe modification or destruction throughout its range in the immediate future, or is already severely degraded throughout its range but capable of being substantially restored or rehabilitated.

Endangered (EN)

An ecological community which has been adequately surveyed and found to have been subject to a major contraction in area and/or was originally of limited distribution and is in danger of significant modification throughout its range or severe modification or destruction over most of its range in the near future.

Vulnerable (VU)

An ecological community which has been adequately surveyed and found to be declining and/or has declined in distribution and/or condition and whose ultimate security has not been assured and/or a community which is still widespread but is believed likely to move into a category of higher threat in the near future if threatening processes continue or begin operating throughout its range.

Data Deficient

An ecological community for which there is inadequate data to assign it to one of the above categories and/or

which is not yet evaluated with respect to status of threat. (Usually an ecological community with poorly known distribution or biology that is suspected to belong to any of the above categories. These ecological communities have a high priority for survey and/or research.)

Lower Risk

A community which has been adequately surveyed and evaluated and available information suggests that it does not qualify for one of the above categories of threat.

The 19 threatened ecological communities found in the Perth Metropolitan Region are listed below.

Floristic Community Types

Supergroup 1 – Foothills/Pinjarra Plain		
2	Southern wet shrublands	EN
3a	*Eucalyptus calophylla – Kingia australis* woodlands on heavy soils	CR
3b	*Eucalyptus calophylla – Eucalyptus marginata* woodlands on sandy clay soils	VU
3c	*Eucalyptus calophylla – Xanthorrhoea preissii* woodlands and shrublands	CR
Supergroup 2 – Seasonal Wetlands		
7	Herb rich saline shrublands in clay pans	VU
8	Herb rich shrublands in clay pans	VU
9	Dense shrublands on clay flats	VU
10a	Shrublands on dry clay flats	EN
15	Forests and woodlands of deep seasonal wetlands	VU
18	Shrublands on calcareous silts	VU
*19	Sedgelands in Holocene dune swales	CR
Supergroup 3 – Uplands centred on Bassendean Dunes and Dandaragan Plateau		
20a	*Banksia attenuata* woodlands over species rich dense shrublands	EN
20b	Eastern *Banksia attenuata* and/or *Eucalyptus marginata* woodlands	EN
20c	Eastern shrublands and woodlands	CR
Supergroup 4 – Uplands centred on Spearwood and Quindalup Dunes		
Quindalup Dunes		
30a	*Callitris preissii* and/or *Melaleuca lanceolata* forests and woodlands	VU
Restricted floristic community type mosaics		
Shrublands and woodlands on Muchea Limestones		CR
Freshwater communities		
Communities of Tumulus Springs		CR
Stromatalite-like microbialite community of coastal freshwater lakes (Lake Richmond)		CR
Aquatic root mat community of caves of the Swan Coastal Plain		CR

Source of Information

English VJ & Blyth J 1997 *Identifying and Conserving Threatened Ecological Communities in the South West Botanical Province*. Project Number N702, Final Report to Environment Australia. Department of Conservation and Land Management, Como, Western Australia.

SECTION 3: SPECIFIC SITE DETAIL

Landscape Features: river – limestone cliff, ocean – limestone cliff, limestone ridge, Muchea limestone, ironstone, tall dune, open water, vegetated wetland, creek, river, estuary, island, vegetated uplands

The appropriate features are listed.

Vegetation and Flora: not known, limited survey, detailed survey, not field surveyed (aerial photography interpretation only)

Vegetation and flora information has been collated from survey and many published and unpublished studies. For ease of reference these are listed at the beginning of 'Vegetation and Flora' and repeated as necessary under each of the other headings.

The surveys and published and unpublished studies are categorised under the following headings to give an estimate of the completeness of the survey information:

- not known — area not visited, studies not known
- limited survey — area visited on a limited basis (generally once or twice); principal vegetation units described. (The majority of the survey work to locate floristic study plots falls into this category; all plots are listed by code and study source, see Floristic Community Types)
- detailed survey — multiple visits, the entire area traversed, vegetation generally mapped, flora list prepared
- not field-surveyed (aerial photography interpretation only) — area not visited within the time of the project.

Sources of Information

These are too numerous to list. Refer to Perth's Bushplan Volume 2, Part B.

Structural Units: mapping

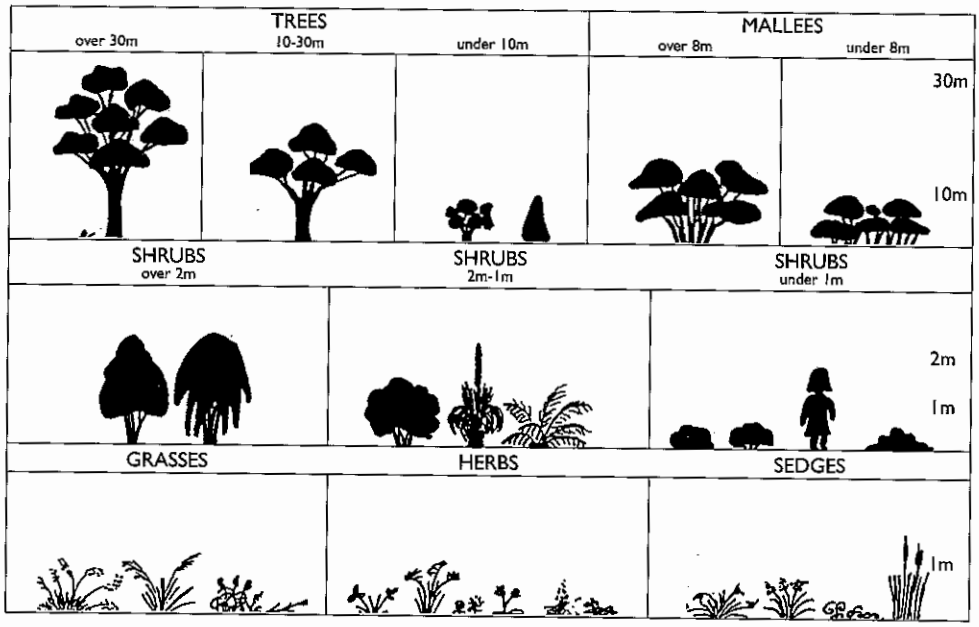
Descriptions under this section refer to the dominant layer and the dominant species in this layer. If a vegetation map is available for the Site or part of the Site this is referenced. The diagram following illustrates the layers distinguished and the table below lists the descriptions available for each layer.

Figure 3: Categories of vegetation information used to describe vegetation structure (Keighery B J 1994a)

Each layer of vegetation in a plant community is described according to life form, height, cover and dominant species.

- Life Form/Height

Each layer in the community is described according to the divisions shown below.



- Cover

A measure of the plant cover in each layer is recorded. Plant cover (or crown cover) is the total area under an imaginary line bounding the extremities of all the plants in each layer described. To simplify the estimation of cover, cover 'classes' are used:

Cover Classes	2–10%	10–30%	30–70%	over 70%

Not all layers will be present in a site. Table 11 is used to name the vegetation structural classes from the information on the life form, height and cover.

- Dominant Species

The principal species in each layer are included in the description of the structural layers.

Vegetation Layers

Life Form/ Height Class	Canopy Cover (percentage)			
	100 – 70%	70 – 30%	30 – 10%	10 – 2%
Trees over 30m	Tall Closed Forest	Tall Open Forest	Tall Woodland	Tall Open Woodland
Trees 10 – 30m	Closed Forest	Open Forest	Woodland	Open Woodland
Trees under 10m	Low Closed Forest	Low Open Forest	Low Woodland	Low Open Woodland
Tree Mallee	Closed Tree Mallee	Tree Mallee	Open Tree Mallee	Very Open Tree Mallee
Shrub Mallee	Closed Shrub Mallee	Shrub Mallee	Open Shrub Mallee	Very Open Shrub Mallee
Shrubs over 2m	Closed Tall Scrub	Tall Open Scrub	Tall Shrubland	Tall Open Shrubland
Shrubs 1 – 2m	Closed Heath	Open Heath	Shrubland	Open Shrubland
Shrubs under 1m	Closed Low Heath	Open Low Heath	Low Shrubland	Low Open Shrubland
Grasses	Closed Grassland	Grassland	Open Grassland	Very Open Grassland
Herbs	Closed Herbland	Herbland	Open Herbland	Very Open Herbland
Sedges	Closed Sedgeland	Sedgeland	Open Sedgeland	Very Open Sedgeland

Sources of Information

These are too numerous to list. Refer to Perth's Bushplan Volume 2, Part B. Diagram and Scale — Keighery BJ 1994 *Bushland Plant Survey. A Guide to Plant Community Survey for the Community.* Wildflower Society of WA (Inc), Nedlands, Western Australia.

Scattered Native Plants

In some areas of the Bushplan Site bushland was not present but there were areas of native plants that could provide habitat.

Vegetation Condition: % Pristine, Excellent, Very Good, Degraded, Completely Degraded with % Pristine, Excellent, Very Good, Good, Degraded, Completely Degraded with areas of severe localised disturbance.

The degree of change in the vegetation due to land uses is described according to the scale in the table below.

Wherever possible vegetation condition is given as an estimate of the percentage of the bushland area in a range of conditions (Table 12) selected from two categories, for example:

'>75% Excellent to Very Good with <25% Good to Degraded'.

In many bushland areas there are pockets of completely degraded vegetation and these are referred to as 'areas of severe localised disturbance'.

At times there was not sufficient information available from which to determine a range and a single condition has been given.

Condition Scale

Pristine

Pristine or nearly so, no obvious signs of disturbance.

Excellent

Vegetation structure intact, disturbance affecting individual species and weeds are non-aggressive species.

Very Good

Vegetation structure altered, obvious signs of disturbance.
For example, disturbance to vegetation structure caused by repeated fires, the presence of some more aggressive weeds, dieback, logging and grazing.

Good

Vegetation structure significantly altered by very obvious signs of multiple disturbance. Retains basic vegetation structure or ability to regenerate it.
For example, disturbance to vegetation structure caused by very frequent fires, the presence of some very aggressive weeds at high density, partial clearing, dieback and grazing.

Degraded

Basic vegetation structure severely impacted by disturbance. Scope for regeneration but not to a state approaching good condition without intensive management.
For example, disturbance to vegetation structure caused by very frequent fires, the presence of very aggressive weeds, partial clearing, dieback and grazing.

Completely Degraded

The structure of the vegetation is no longer intact and the area is completely or almost completely without native species. These areas are often described as 'parkland cleared' with the flora composing weed or crop species with isolated native trees or shrubs.

Sources of Information

These are too numerous to list. Refer to Perth's Bushplan Volume 2, Part B.

Scale — Keighery BJ 1994 *Bushland Plant Survey. A Guide to Plant Community Survey for the Community.* Wildflower Society of WA (Inc), Nedlands, Western Australia.

Total Flora: not known, (estimated), (site generated list only), (estimated % expected flora)

A measure of the native vascular plant flora has been collated from many published and unpublished studies. Survey information additional to the regional surveys is referenced in each case. The sources are categorised according to the level of detail of survey to give an indication of the percentage of the flora the survey recorded.

Categories were:

- not known — area not visited, studies not known to exist
- plot-generated list only — a list extracted from amalgamated floristic study plots
- estimate % — quoted as percentage of the expected flora, the following

ranges were used in most cases: >50%, >75% and >90% expected flora

- estimate — estimate of expected total flora based on knowledge of plant comminutes in the Site.

Significant Flora: none recorded

Significant flora known to occur in each area are listed by name. These names are annotated with codes related to the conservation status of the taxa (plant species, subspecies and varieties). These are:

R = Declared Rare Flora
1 = Priority 1: Poorly Known Taxa
2 = Priority 2: Poorly Known Taxa
3 = Priority 3: Poorly Known Taxa
4 = Priority 4: Rare Taxa

Other taxa with special features are also listed. A list of these significant taxa and the features that distinguish them is found in Perth's Bushplan Volume 2, Part A. The sources of this information, other than CALM database and regional surveys, are referenced individually.

Sources of Information

These are too numerous to list. Refer to Perth's Bushplan Volume 2, Part B.

Fauna: no known information Significant mammal species: Quenda (Friend 1996)

Information on the fauna of particular Bushplan Sites has been collated from Museum of Natural Science fauna surveys, Quenda sightings by the public reported to CALM's Quenda Database, bird survey data collected by Birds Australia (previously RAOU) and published and unpublished studies. These studies are referenced in each instance.

The sources are categorised to indicate the scope of the survey, that is, the faunal groups surveyed, the comprehensiveness of the survey and the significance of the particular species recorded for the Site. As survey techniques and best time of survey varies between faunal groups, the comprehensiveness is related to the group surveyed. The categories are:

Survey Information

- no known information — compilers of the Directory were not aware of any information on the Bushplan Site
- scope of survey — birds, mammals, reptiles, amphibians and/or invertebrates

Comprehensiveness of survey

- single visit — sight records from one visit
- multiple visit — repeated visits, may involve sight records and trapping over several days in one or several years
- structured survey — longer-term study involving multiple visits and permanent traplines; generally involves collection of data on birds, mammals, reptiles, amphibians and/or invertebrates all seasons

Significant species

- birds — refers to species of conservation significance (Table 15). Four categories:
  1 species listed under the Wildlife Conservation Act 1950
  2 species listed on the JAMBA/CAMBA agreements
  3 habitat specialists with a reduced distribution on the Swan Coastal Plain
  4 wide-ranging species with reduced populations on the Swan Coastal Plain
- mammals — species that are listed as threatened under the Wildlife Conservation Act 1950 or those that have few populations on the Swan Coastal Plain
- reptiles and amphibians — species that have reduced ranges or few recent records on the Swan Coastal Plain
- invertebrates — species listed as 'Specially Protected' or 'Priority' fauna are described where locations are known. Most records are allocated to a suburb and not a specific bushland area and so are not included in the Bushplan Site Descriptions

Source of Information

These are generally too numerous to list. Refer to Perth's Bushplan Volume 2, Part B.

Friend A 1996 CALM Bandicoot survey 1991–1996. Database of Bandicoot sitings reported by the public. Department of Conservation and Land Management, Como, Western Australia.

RAOU (now Birds Australia) 1996 *Database of Western Australian Birds Project (RAOU Tracking Database).*

Western Australian Museum of Natural Science 1996 *Specimen Records of Ash Grey Mouse, Wambenger and Honey Possum* from Western Australian Museum of Natural Science Mammals Database.

Linkage: no adjacent bushland; bushland canopy creekline linkage to north, south, east, west (Bushplan Site number/s); part of proposed Greenway 'Greenway number/s' eg 37 (Tingay, Alan & Associates 1997); part of regionally significant contiguous fragmented potential bushland/wetland linkage (Map 8)

The following standard descriptions are used to describe each Bushplan Site in relation to the surrounding area:

- no adjacent bushland
- bushland canopy creekline linkage to north, south, east, west (Bushplan Site number/s)
- part of proposed Greenway 'Greenway number/s' e.g. 37 (Tingay, Alan & Associates 1997) as shown in Volume 1 Map 6
- part of regionally significant contiguous or regionally significant fragmented or regionally significant potential bushland/wetland linkage (after Perth's Bushplan Volume 1 Map 6)

Source of Information

Tingay, Alan & Associates 1997 *A Strategic Plan for Perth's Greenways – Draft.* Prepared for a series of government agencies and community groups.

Other Special Attributes:

In many cases some section of, or all of, a Bushplan Site has been recognised as having significance at a regional level by previous studies or identification processes. When known and accessible these are listed in this section. Examples of such studies/processes are:

- Regional and Local Government studies
- Classification by the National Trust of natural areas or landscapes that meet a series of heritage values. Classified Landscapes are entered onto the Register of the National Trust of Western Australia
- Natural Areas identified by the interim 'Environmental and Landscape Audits' prepared for the Department of Planning and Urban Development in the early 1990s
- 'Threatened and Poorly Reserved Plant Communities' identified by the Environmental Protection Authority (1994). This series of bushland areas on the Swan Coastal Plain was considered to be in need of interim protection under the System 6 Update.

Sources of Information

These are too numerous to list. Refer to Perth's Bushplan Volume 2, Part B.

SECTION 4: INTERNATIONAL AND NATIONAL SIGNIFICANCE

Not listed, Wetlands of International Importance (RAMSAR), Directory of Important Wetlands in Australia, Listed on the Register of the National Estate, Indicative Place of the Register of the National Estate, Interim List of the Register of the National Estate, location for JAMBA/CAMBA species

Some Bushplan Sites are covered by national and/or international policies and agreements. These policies and agreements are listed and described below.

Wetlands of International Importance (Ramsar)

The Convention on Wetlands of International Importance Especially as Waterfowl Habitat, known as the Ramsar Convention after the Iranian town of Ramsar where it was adopted in 1971, provides a framework for international cooperation in the conservation and wise use of wetlands. One of the nine Ramsar sites in WA (Forrestdale and Thomson's Lakes) is in the Perth Metropolitan Region.

Source of Information

Environment Australia 1998 *Wetlands listed under the RAMSAR Convention.* Wetlands Unit Ramsar Database, Environment Australia, Canberra, Australian Capital Territory.

Directory of Important Wetlands in Australia

The Directory of Important Wetlands in Australia provides the most complete compilation available presently of Australia's nationally important wetlands. The Directory is the result of cooperative work between Federal, State and Territory nature conservation agencies and was compiled to assist in the conservation and wise management of wetlands.

Source of Information

Australian Nature Conservation Agency 1996
A Directory of Important Wetlands in Australia (Second Edition). ANCA, Canberra, Australian Capital Territory.

Register of the National Estate

The Heritage Commission was established by the Commonwealth Government in 1975 with the aim of helping Australians identify and appreciate the National Estate and of promoting the conservation of Aboriginal and Torres Strait Islander places, natural environment places and historical places considered part of the National Estate. The Commission compiles the Register of the National Estate.

Sources of Information

Australian Heritage Commission 1994.

JAMBA and CAMBA Bird Species

Some of the Bushplan Sites are visited by birds that migrate between the northern and southern hemispheres each year. Conservation of these birds is supported by two international agreements covering these birds and their habitats. These agreements are between the Government of Australia and the governments of Japan and the People's Republic of China, the former being the Japan-Australia Migratory Bird Agreement (JAMBA, signed on 6 February 1974) and the latter the China-Australia Migratory Bird Agreement (CAMBA, signed on 20 October 1986).

Sources of Information

See Fauna references; otherwise refer to Perth's Bushplan Volume 2, Part B.

SECTION 5: INCLUSION CRITERIA AND RECOMMENDATIONS

Criteria: Representation of ecological communities, Diversity, Rarity, Maintaining ecological processes or natural systems, Scientific or evolutionary importance, General criteria for the protection of wetland, streamline and estuarine fringing and coastal vegetation, Criteria not relevant to determination of conservation value, but which may be applied when evaluating areas having similar values

The criteria used for the determination of the significance of bushland areas are listed below and described in Volume 1, Appendix 3.

The criteria used are, in outline:

REPRESENTATION OF ECOLOGICAL COMMUNITIES: A number of areas selected to represent the range of ecological communities and the places in which these communities merge.

DIVERSITY: Areas with a high diversity of flora and/or fauna species or communities in close association.

RARITY: Areas containing rare or threatened communities or species, or species of restricted distribution.

MAINTAINING ECOLOGICAL PROCESSES OR NATURAL SYSTEMS: Maintenance of ecological processes or natural systems at a regional or national scale.

SCIENTIFIC OR EVOLUTIONARY IMPORTANCE: Areas containing evidence of evolutionary processes either as fossilised material or as relict species and areas containing unusual or important geomorphological or geological sites; Areas of recognised scientific and educational interest as reference sites or as examples of the important environmental processes at work.

GENERAL CRITERIA FOR THE PROTECTION OF WETLAND, STREAMLINE AND ESTUARINE FRINGING VEGETATION AND COASTAL VEGETATION: Conservation category wetland areas including fringing vegetation and associated upland vegetation; Coastal vegetation within the accepted coastal management zone.

CRITERIA NOT RELEVANT TO DETERMINATION OF REGIONAL SIGNIFICANCE BUT WHICH MAY BE APPLIED WHEN EVALUATING AREAS HAVING SIMILAR VALUES: Attributes which taken alone do not establish regional significance, but which can add to the value of bushland and enhance its contribution to Perth's Bushplan.

Opportunities: Bushplan Site/part Bushplan Site subject to Peel Inlet-Harvey Estuary EPP Swan Coastal Plain Lakes EPP Gnangara Mound Crown Land EPP Swan and Canning Rivers EPP Western Swamp Tortoise Draft EPP; location of Declared Rare Flora (and) Fauna, conservation category wetland/s; under MRS Parks and Recreation Reservation and/or TPS Parks and Recreation Zoning, Crown Reserve; **and/or Constraints:** Bushplan Site/part Bushplan Site private land; under MRS Urban/Urban Deferred Zoning, MRS Industrial Zoning, MRD regional road requirements, Basic Raw Materials Core areas/ Mineral Resource Area, Mineral Lease

Opportunities and constraints are listed in the categories below for a whole Bushplan Site or part of a Bushplan Site.

Opportunities: Bushplan Site/part Bushplan Site

- subject to
  - Peel Inlet-Harvey Estuary Environmental Protection Policy (EPP)/Statement of Planning Policy (SPP)
  - Swan Coastal Plain Lakes EPP
  - Gnangara Mound Crown Land EPP

Swan and Canning Rivers EPP
Western Swamp Tortoise Draft EPP

- location of
  Declared Rare Flora and/or Scheduled Fauna
  Conservation Category Wetland/s
- under Metropolitan Region Scheme (MRS) Parks and Recreation (P&R) Reservation; and/or Town Planning Scheme (TPS) Parks and Recreation Zone, Crown Reserve

Constraints: Bushplan Site/part Bushplan Site

- Private land
- Metropolitan Region Scheme Urban/Urban Deferred Zoning
- Metropolitan Region Scheme Industrial Zoning
- Main Roads Department regional road requirements
- Basic Raw Materials Core areas/ Mineral Resource Area
- Mineral Lease

Sources of Information

These are too numerous to list. Refer to Perth's Bushplan Volume 2, Part B.

Recommendation

The Bushplan Site specific recommendations are restricted to a limited set of options framed to reflect the circumstances of the Bushplan Site. Five broad categories (or types) of recommendation are recognised. The recommendations used in the Directory are listed below.

Category 1 • Private land where reservation under the Metropolitan Region Scheme for Parks and Recreation, purchase and reservation under the *Land Administration Act* is proposed or in progress. Two variations exist:

Recommendation 1a
The Bushplan Site be reserved for Parks and Recreation in the Metropolitan Region Scheme and be purchased for [either] National Park, Conservation Park, Nature Reserve [or] Regional Park.

Recommendation 1b
The Bushplan Site be reserved for Parks and Recreation in the Metropolitan Region Scheme, purchased and added to [named] National Park, Conservation Park, Nature Reserve [or] Regional Park.

Category 2 • Private and/or Crown land where the most suitable means of achieving conservation protection and management, generally through mechanisms complementary to the formal CALM conservation reserve system, will be determined in consultation/negotiation with the land owner(s). There are two broad approaches within this category:

Recommendation 2a
The conservation values of the Bushplan Site be protected through one or more of a range of complementary mechanisms to encourage and secure conservation management on private lands. The specific approach to be determined in consultation/negotiation with the land owner(s), but will generally include conservation covenants/management agreements.

Recommendation 2b

As much as possible of the conservation values of the Bushplan Site be protected and managed for conservation. The area to be protected, and means of protection to be determined through a process of negotiation with the land owner(s), but will primarily involve mechanisms available in planning legislation.

Category 3 • Private or Crown reserve land where the current owner/reserve management body is known to be managing and intends managing the Bushplan Site for conservation. Two (Private and Crown reserve) variations exist:

Recommendation 3a

The private ownership and management intent of the Bushplan Site is endorsed. Appropriate mechanisms to support and reinforce existing management for conservation and provide long-term security be applied in consultation with the land owner(s).

Recommendation 3b

The existing care, control and management intent of the reserve is endorsed. Long-term security and support for conservation management of the Bushplan Site be enhanced by: amending the purpose of the reserve to include conservation; and applying appropriate mechanisms in consultation with the reserve management authority.

Category 4 • Endorsement of existing reservation.

Recommendation 4

The existing purpose, care, control and management of Reserve (Number) is endorsed.

Category 5 • Private and/or Crown land where the best means of achieving conservation management is to be further considered in the public comment period.

Recommendation 5

The most appropriate mechanism for the protection of this Bushplan Site be considered through the public comment period in consultation with the land owner(s).

Bushplan Site Map (see map following)

Each Bushplan Site is shown on a map. An example of a map is shown on the opposite page. Each map shows:

Bushplan Site — Boundary and Features

The Bushplan Site boundary is drawn to encompass the areas of regionally significant bushland. In a few cases the boundary includes non-bushland areas that are regionally significant habitat for fauna or areas vital to the management of the bushland.

Bushplan Site Number

Bushplan Site Lot Boundaries and No.

Native Vegetation

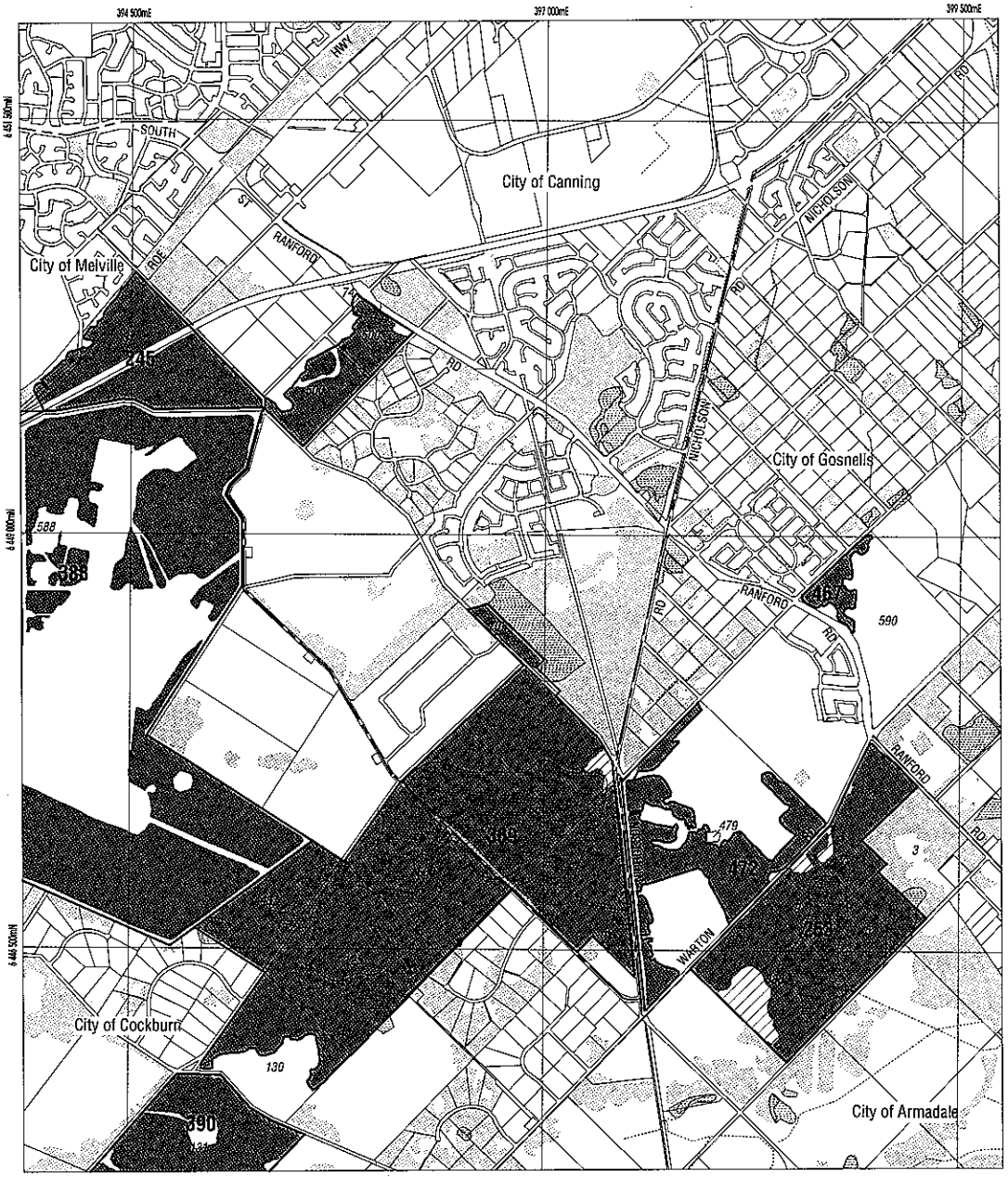
Areas of native vegetation mapped by Agriculture WA from 1997 aerial photography corrected to account for the curvature of the earth (called orthophotographs). Not all areas of native vegetation are encompassed in Bushplan Sites.

Bushland Areas with some level of protection

Areas of land currently considered protected in some way. These are mostly Parks and Recreation Reserves. All bushland in this category is recognised as being regionally significant in Perth's Bushplan.

Conservation Category Wetlands

Areas of wetland in need of recognition and protection because of their natural values.



LEGEND

- 447/2 — Bushplan Sites With Regionally Significant Bushland
- Other Native Vegetation
- Conservation Category Wetlands
- Bushplan Sites With Some Existing Protection
- 696 — Lot Number, Location Number
- Channel Wetlands
- Local Government Boundary

2033 - I NE

IV	NW / NE / SW / SE	
III	2033	II

1 : 25 000 AMG Reference Grid showing Perth's Bushplan Map Sheet Breakdown

PERTH'S BUSHPLAN MAP INDEX

N

SCALE

0 500 1000
Metres

Produced by Project Mapping Section
Land Information Branch, Ministry for Planning, Perth W.A. November 1998

ntw-map17//environ/bushplan//bushv2map2.dgn

Cadastral Data supplied by Department of Land Administration, W.A.

Wetlands Data supplied by Water and Rivers Commission

Native Vegetation Extent for Study Area supplied by Agriculture Western Australia

An Example of a Bushplan Site Map

Map 2

Bushplan Site — Location Details

Boundary of Map Sheet

Maps are drawn at a scale slightly smaller than the Metropolitan Street Directory.

AMG Grids (grid interval 2500m)

These lines show the standard map grid for Australia and allow the map to be compared accurately with other maps.

Local Government Areas

Local Government area boundaries are indicated.

Street Names

Selected Streets/Roads/Places etc. are named.

Channel Wetlands

These may be rivers, creeks, brooks or drains.

6. Acknowledgments

Urban Bushland Advisory Group

System 6 Update Technical Working Group

System 6 Update Steering Committee

Department of Environmental Protection

Conservation Branch Volunteers

Department of Conservation and Land Management

Water and Rivers Commission

Museum of Western Australia

Ministry for Planning

Agriculture Western Australia

Individuals, community groups and organisations through submissions