Biodiversity in the Peel-Harvey Catchment

PART TWO: The Bioregions

Peter Hick

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*This document is Part Two of Four.
The Final Report with all contracted phases completed in June 2004.

Contents (Part Two)

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Determining Biodiversity Assets

Given the complexity of biodiversity and the range of values, perspectives, and goals that influence how biodiversity is perceived, it is not surprising that there is no generally accepted universal scheme for establishing conservation priorities. Nor should there be!

Establishing biodiversity conservation priorities should be a conscious effort to assign values to species, habitats and/or ecosystems, and then to evaluate other criteria in relation to those values in order to arrive at a set of specific temporal and spatial priorities.

Priority setting is a complex process around which achieving consensus would be difficult if only one process existed. However, numerous approaches have been developed to support a range of conservation objectives, each one with its own strengths and weaknesses.

Priority is defined as something that has precedence or is established by order of importance or urgency. Importance implies that whatever is a priority is something having great value or significance. A "Draft Identification of Biodiversity Assets by criteria", (Table 1) prepared by Gary McMahon of the South West Catchment Council, has been adapted to reflect a biodiversity priority setting strategy for the Peel-Harvey Catchment. It is likely that this will evolve and be altered as case studies are examined and data sources are expanded.

The Assets of the Bioregions

By way of introduction the work of Russell Smith from Department of Conservation and Land Management and his colleagues has been reviewed and adapted to be relevant to the Peel-Harvey Catchment. The comprehensive work reported by them has prepared an analysis and strategy for the South West Natural Resource Management (2003) regions that also covered the Peel-Harvey Catchment. This has been selected to specifically cover the bioregions in the PHC (Figure 2.1) and their approach is being taken in this study.

The study of Damian Shepherd "Modelling the Conservation values of remnant Vegetation in the Blackwood Basin" (1998) is also very relevant to this study.

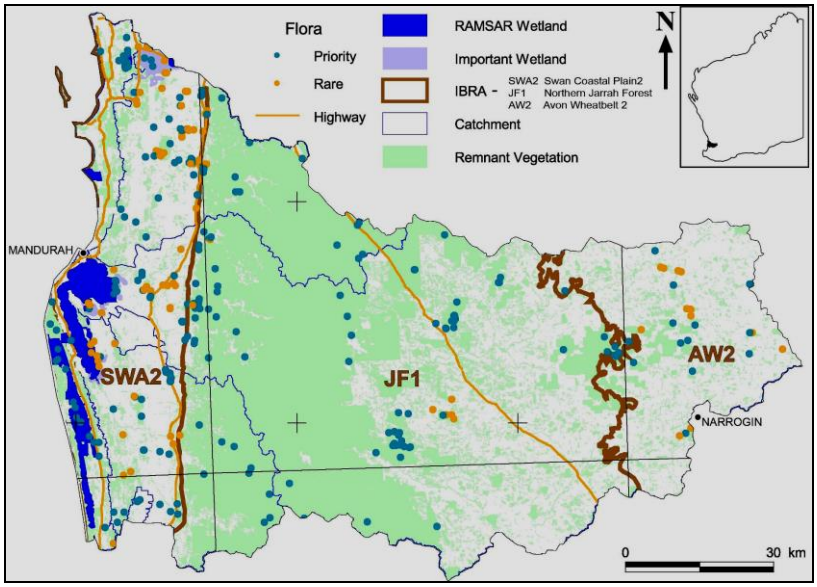


Figure 2.1: The three major IBRA bioregions that the Peel-Harvey Catchment covers and they are: the Coastal plain; the Jarrah forest; and, the Avon wheat belt area. This graphic was sourced from Conservation and Land Management and includes rare flora, RAMSAR wetlands and remnant vegetation.

A brief summary of the bioregions and the importance of their biodiversity as determined from their work follows. A description of the geomorphic units within them is included in the field validation section. The following two figures (Figures 2.2 and 2.3) are taken from the NRM

strategy and provide a rough guide to clearing status although a more detailed breakdown that is specific to the soils and landforms of the PHC is included in Part Three of this report, especially on the coastal plain.

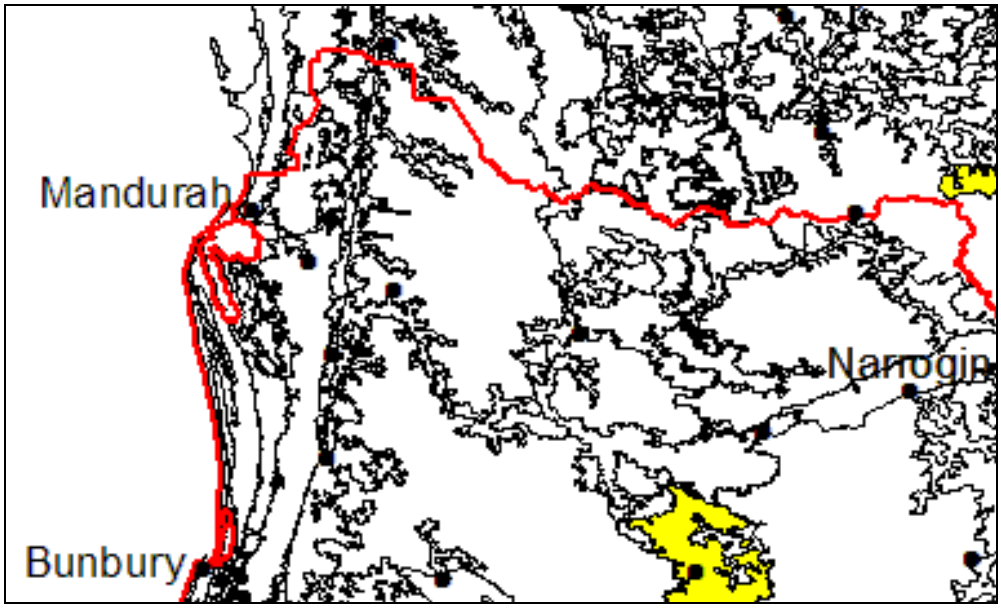


Figure 2.2: Areas with less than 20% of the original vegetation in the soil/landscape units remaining uncleared and in reserves. Source: Russell Smith (2003) CALM

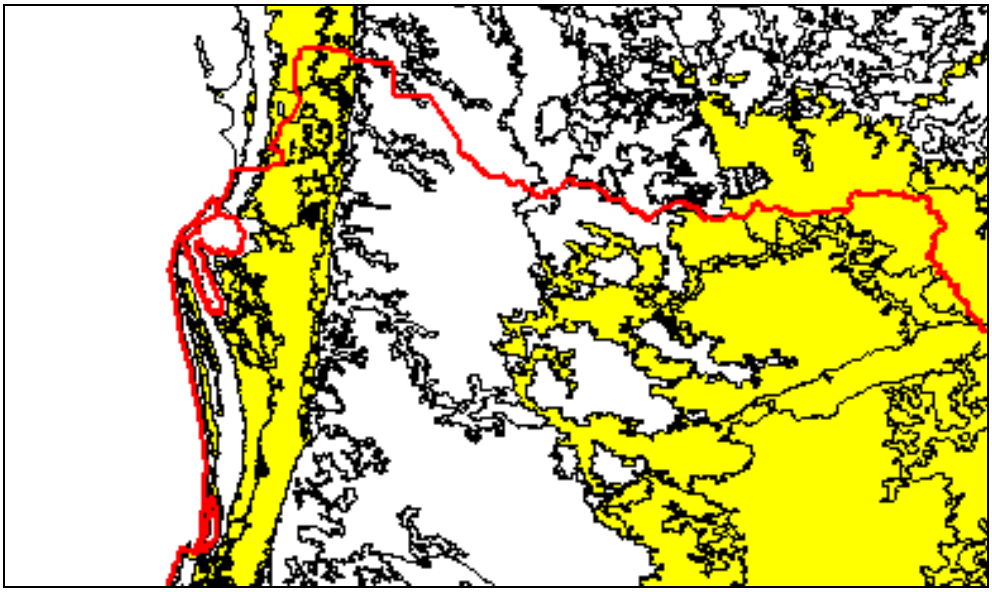


Figure 2.3: Areas with less than 30% of the original vegetation in the soil/landscape units remaining uncleared and in reserves. Source: Russell Smith (2003) CALM

Approximate distribution of Pre-European Vegetation

The following three tables (Tables 2.1, 2.2 and 2.3) have been adapted from Smith (2003) and are included as a useful guide to the current approximate distribution within the PHC of pre-European vegetation, poorly-conserved vegetation, and reservation status within the soil-landscape systems that occur in the Peel-Harvey Catchment. As the tables have been prepared for the entire SWCC NRM region, the data should be seen in relative terms where some of the units extend beyond the catchment.

Table 2.1: Soil-Landscape Systems within the Peel-Harvey Catchment, derived Smith (2003) show: the pre-European and current extent of vegetation in these systems and as a percentage of its original extent within the SW NRM Region; and within the whole South West Agricultural Region. The final column indicates the extent to which the Soil-Landscape System occurs outside the SW NRM Region. * Indicates the systems that are restricted to the SW NRM Region although they may not necessarily lie entirely within the Peel-Harvey Catchment.

Soil-landscape Unit Name	Vegetation	Current Extent in SW NRM Region (ha)	Total Current Extent in SW Agric. Region (ha)	Pre-European Ext. SW NRM Region (ha)	Total Pre-European Ext. in SW Agric. Region (ha)	**% of Orig. Remaining in SW NRM Region**	% of Orig. Remaining in SW Agric. Region	% Current Ext. outside SW NRM Region
Quindalup South System	Mixed coastal scrub	5163	79658	10937	117627	**47.2**	67.7	6.5
Spearwood System	Tuart-Marri forest and woodland	26086	135338	54301	274910	**48.0**	49.2	19.3
Bassendean System	Banksia-paperbark woodlands and mixed heaths	22327	205252	86456	377580	**25.8**	54.4	10.9
Forrestfield System	Jarrah-Marri forest and woodlands	2993	4662	21626	28504	**13.8**	16.4	64.2
Pinjarra System	Jarrah-Marri-Wandoo-paperbark forest and woodland	6450	10996	130804	165803	**4.9**	6.6	58.7
*Eulin Uplands system	Jarrah-Marri-Wandoo forest and woodland	35930	35930	125995	125995	**28.5**	28.5	100.0
Marradong Upland System	Jarrah-Marri-Wandoo forest and woodland	67778	68064	139746	140043	**48.5**	48.6	99.6
*Quindanning System	Marri-Wandoo-York gum-jam woodland	27459	27459	114952	114952	**23.9**	23.9	100.0
Darling Plateau System	Jarrah-Marri-Wandoo forest and woodland	570489	712928	662554	819755	**86.1**	87.0	80.0
Murray Valleys System	Jarrah-Marri-Wandoo forest and woodland with mixed shrubland	46327	103298	60159	132250	**77.0**	78.1	44.8
Dryandra System	Marri-Wandoo woodland (W), Wandoo-Yorkgum-Salmon gum woodland (E), Powderbark and Mallet on ridges.	37765	37885	172548	173122	**21.9**	21.9	99.7
*Narrogin system	Mainly York gum/Jam woodands. Some heath and Powderbark on isolated mesas	6523	6790	45826	45826	**14.2**	14.8	96.1
*Norring System	Wandoo-swamp Sheoak-Salmon gum woodland, ti tree-paperbark scrub and samphire flats.	4377	4377	27574	27574	**15.9**	15.9	100.0
*Pumphreys Bridge System	Wandoo-Sheoak-Jam woodland, ti tree scrub and samphire flats	2530	2530	18861	18861	**13.4**	13.4	100.0
Pingelly System	York gum-Wandoo-Salmon gum woodlands. Powderbark, Mallet and Sheoak on ridges.	4173	17162	43341	186617	**9.6**	9.2	24.3
*Whinbin System	Wandoo-York gum-Salmon gum woodlands. Mallet-Dryandra scrub.	7108	7108	88652	88652	**8.0**	8.0	100.0

Poorly-Conserved Vegetation

Similarly, Table 2.2 documents the poorly conserved vegetation in the SW NRM Region derived from the regional work of Smith (2003). It is based on a calculation in the SW NRM Region where the vegetation is 70% or more cleared (ie. 30% or less of the original areal extent remains as shown in the preceding Figure 2.2) and where 10% or more of the present extent occurs within the region. * Indicates soil-landscape systems where the current extent of remnant vegetation is less than 5000 ha and where there is less than 30% of the original extent remaining in the SW Agricultural region.

Table 2.2: Poorly conserved vegetation in the SW NRM Region derived Smith (2003) and adapted to Soil-Landscape Systems that occur in the Peel Harvey Catchment.

Soil-landscape Unit Name	Current Extent in SW NRM Region (ha)	Total Current Extent in SW Agric. Region (ha)	Pre-European Extent in SW NRM Region (ha)	Total Pre-European Extent in SW Agric. Region (ha)	% of Original Remaining in SW NRM Region	% of Original Remaining in SW Agric. Region	% Current Extent in SW NRM Region
Pinjarra System	6450	10996	130804	165803	**4.9**	**6.6**	58.7
*Pingelly System	4173	17162	43341	186617	**9.6**	**9.2**	24.3
*Pumphreys Br Sys	2530	2530	18861	18861	**13.4**	**13.4**	100.0
*Forrestfield System	2993	4662	21626	28504	**13.8**	**16.4**	64.2
Narrogin system	6523	6790	44907	45826	**14.5**	**14.8**	96.1
*Norring System	4377	4377	27574	27574	**15.9**	**15.9**	100.0
Dryandra System	37765	37885	172548	173122	**21.9**	**21.9**	99.7
Quindanning System	27459	27459	114952	114952	**23.9**	**23.9**	100.0
Bassendean System	22327	205252	86456	377580	**25.8**	**54.4**	10.9

Table 2.3: The reservation status of vegetation associated with Soil-Landscape Systems that principally occur in the Peel-Harvey catchment but calculated for the entire SW NRM Region. Shaded rows indicate soil-landscape systems where vegetation is poorly reserved, with 30% or less in any type of reserve and 20% or less in IUCN I-IV reserves.

Soil-landscape Unit Name	Current Extent in SW NRM Region (ha)	SW NRM Region Present Extent in IUCN 1-IV (ha)	**% Total in IUCN I-IV in SW NRM Region**	SW NRM Region Present Extent Other Reserves (ha)	**% Total in other Reserves including State forest**	SW NRM Region Present Extent in Freehold Land (ha)	SW Agric. Region Present Extent in IUCN I-IV (ha)	**% in all reserves**
Pumphreys Bridge System	2530	120	**5**	772	**31**	1638	120	**35**
Norring System	4377	636	**15**	670	**15**	3070	636	**30**
Forrestfield System	2993	51	**2**	648	**22**	2294	104	**23**
Narrogin system	6523	425	**7**	1490	**23**	4607	500	**29**
Whinbin System	7108	1812	**25**	1090	**15**	4206	1812	**41**
Pinjarra System	6450	632	**10**	1484	**23**	4334	655	**33**
Pingelly System	4173	1317	**32**	228	**5**	2627	4725	**37**
Quindanning System	27459	169	**1**	5427	**20**	21864	169	**20**
Dryandra System	37765	1013	**3**	24369	**65**	12383	1013	**67**
Marradong Upland System	67778	1044	**2**	39741	**59**	26994	1083	**60**
Quindalup South System	5163	1549	**30**	595	**12**	3019	29998	**42**
Murray Valleys System	46327	12763	**28**	22206	**48**	11357	21550	**75**
Spearwood System	26086	7129	**27**	6428	**25**	12529	27466	**52**
Bassendean System	22327	1403	**6**	3311	**15**	17613	44745	**21**
Darling Plateau System	570489	48066	**8**	457312	**80**	65111	64768	**89**

Prioritising the Threatening Processes

A very good summary of the prioritisation of the generic processes and elements of change that can threaten biodiversity in the South West Catchments has been adapted from Russell Smith's Integrated NRM strategy (Table 2.4). This provided a framework for adaptation to prioritise the threats to Biodiversity for the Peel Harvey Catchment.

Following the field validation program (reported in Part Three) a reassessment of priorities was undertaken based on the knowledge gained at the sites visited and conclusions subsequently drawn. These priorities are subjective and likely to change with varied circumstances and interpretation. For example, Salinity in the JF1 (Jarrah bio-region) has been downgraded to priority 3 because we have a good understanding of the process, the aerial extent of the problem is defined, many remediation programs are in place as tree-planting is highly profitable, so concentration on higher priorities in the PHC may be more appropriate.

The priority rankings are only slightly different; some threats are not relevant in the PHC and have been excluded from the table. The changes reflect the fact that the PHC is only about 15% of the SWCC area and as it occupies the Northern-most part of the SW, proximal to the city, producing a slightly different emphasis of basic priorities and consequences.

Table 2.4: A prioritisation of threatening processes acting on Biodiversity assets within the SW NRM Region as developed by Russell Smith (2003) and adapted by the observations of this study to reflect the suggested different priorities that may be more appropriate within the Peel Harvey Catchment.

Threatening Processes	**Significance of Assets Threatened**	**Nature of the Threat (Occurrence)**	**Nature of the Threat (Rate of Spread)**	**Nature of the Threat (Capacity to Degrade)**	**SW-NRM Priority**	**PHC Priority**	**Knowledge of Threatening Process**
Salinity - regional scale	Major	M	M	H	1	***2***	Good
Salinity - subreg scale - JF ***(Jarrah)*** bioregion	Major	M	M	H	1	***3***	Good
Salinity - subreg scale - AW ***(wheat belt)*** bioregion	Major	H	M	H	1	***1***	Good
Estuarine contamination - nutrients	Major	H	L	H	1	***1***	Good
Surface water use (impoundment)	Major	H	H	H	1	***2***	Medium
Fragmentation of natural ecosystems	Major	H	M	H	1	***1***	Medium
Cont. loss of habitat - general regional ***(Tuart dec)***	Major	M	L	H	1	***1***	Medium/poor
Fire management - inappropriate regimes	Major	H	M	H	1	***1***	Medium
Plant diseases - *Phytophthora cinnamomi*	Major	M	L	H	1	***1***	Good
Streambank and other erosion	Medium	H	L	H	2	***2***	Good
Chemical and pesticide contamination	Medium	L	L	H	2	***2***	Poor
Environmental weeds - subgroup B	Major	H	H	M	2	***2***	Good
Pest animals - introduced predators - natural systems	Major	H	L	M	2	***2***	Good
(Pest) animals - introduced ***(Agricultural)*** competitors - natural systems	Major	H	M	M	2	***1***	Medium
Estuarine contamination - other	Major	L	L	H	3	***3***	Medium
Salinity - subregional scale - SCP bioregion	Minor	L	L	H	3	***3***	Good
Soil acidity	Major	L	L	H	3	***3***	Medium/poor
Environmental weeds subgroup A	Medium	L	H	M	3	***2***	Poor
Disruption of coastal processes - inappropriate coastal development	Major	L	L	H	3	***2***	Medium
Waterlogging ***(and drainage)***	Medium	L	M	H	3	***2***	Medium
Climate change	Major	H	L	L	4	***2***	Poor
Pest animals - high populations of native animals - natural systems	Medium	H	L	L	4	***4***	Poor
Coast biodiversity decline - inappropriate recreation and tourism activities	Minor	M	M	M	4	***2***	Good
Wastewater and stormwater discharge	Minor	L	L	L	5	***4***	Medium
Groundwater use	Minor	H	H	L	5	***4***	Poor
Soil erosion by water - sheet erosion and rilling	Minor	L	L	L	5	***4***	Good
Erosion of sand by coastal processes	Minor	H	L	L	5	***3***	Good
Environmental weeds - subgroup C	Medium	M	L	L	5	***4***	Medium
Disruption of marine processes - inappropriate coastal development	Minor	L	L	M	5	***4***	Poor

Asset Classes

Table 2.5: Draft Identification of Biodiversity Assets by criteria (McMahon)
* Rich. = Richness, Dist = Distinctiveness, Rep = Representativeness.

Asset Class	Criteria: Biological				Social
	Rich	Rarity	Dist	Rep*	Utility
Comprehensive, adequate and representative (CAR) terrestrial and marine conservation reserve system					
Current and potential national parks, nature reserves and cons. parks.	✓		✓	✓	✓
Management of the protected area system					
Listed and potential Ramsar Wetlands	✓		✓		✓
Wetlands of national significance	✓		✓	✓	✓
Wetlands of regional significance	✓		✓	✓	✓
World heritage properties	✓		✓		
Recovery of threatened species and ecological communities that are listed under relevant national and State legislation,					
Declared Rare Flora		✓	✓		
Gazetted Rare Fauna		✓	✓		
Threatened Ecological Communities		✓	✓		
Priority Flora		✓	✓		
Priority Fauna		✓	✓		
Establishment and management of functional landscape/seascapes					
Veg associations with <30% of pre-European extent remaining		✓	✓		
Veg associations with <10% of pre-European extent remaining		✓	✓	✓	
Those landscapes with <30% remnant vegetation remaining		✓	✓		
Those landscapes with <10% remnant vegetation remaining		✓	✓	✓	
Substantial areas of remnant native veg (i.e. >40 ha)			✓	✓	✓
Restricted or rare natural ecosystems (i.e. <2,000 ha present extent)		✓		✓	
Other areas managed for conservation			✓		✓
Large scale landscape corridors/linkages – >500m wide and linking C.A.R. reserves			✓	✓	✓
Disjunct (isolated), relictual or outlying species or populations		✓	✓		
Areas of high species diversity					
High number of species within a common area	✓	✓	✓	✓	✓
High proportion of species of restricted geographic range	✓	✓	✓	✓	✓
The overlap of botanical and zoological provinces/districts	✓	✓	✓	✓	✓
Natural diversity recovery catchments (WA State Salinity Strategy)			✓		✓
Rare abiotic (e.g. mound springs, rare soils) and biotic (e.g. stromatolites) features		✓	✓		✓

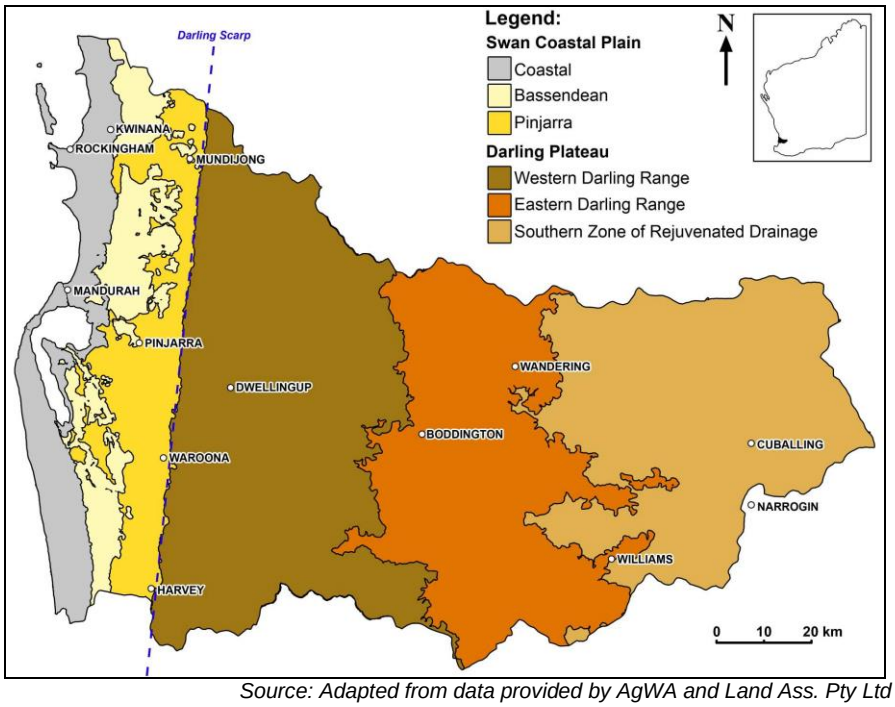
Stratification of Biodiversity Assets based on Landform

It was decided to stratify the field observation sites for the validation of the integrated maps on the basis of geomorphic elements rather than sub-catchments or the soil/landscape units used by Russell Smith. This is covered in detail in Part 3. However, the decision was consciously made because it is important to know not only how much native vegetation remains but also where it lies in the landscape, as this will greatly affect biodiversity conservation values. Two factors influenced this decision. First, detailed knowledge of the soil classification system, and second, confidence in the ability to accurately geo-locate the sites using Global Positioning to within 5m. The sites are shown in Figure 2.5

From the spreadsheet of Validation Sites it will be possible to locate all sites in the future to monitor change and, it should be noted that, as it is felt that most “hands-on“ land managers have a good concept of landform, (gravely outcrops, rocky slopes, river terraces, etc.) they also usually understand what might grow and live in them. Management is based on landform.

Similarly, commonly used names have been used wherever possible in the spreadsheet as taxonomic correctness cannot be guaranteed and may not in all cases be well understood.

The subdivision of the Swan Coastal Plain was simplified to descriptions of the Aeolian and Fluvial elements. The Quindalup, Spearwood and Bassendean dunes were grouped but where good representative sites (Figure 2.4) were selected the primary soil descriptions were recorded. Similarly, the fluvial elements of the Pinjarra plain have been treated together in the site descriptions (as well as the fact that adequate examples of remnant vegetation are difficult to find in each soil type). The Ridge Hill Shelf has been grouped in with the laterised units.



Source: Adapted from data provided by AgWA and Land Ass. Pty Ltd

Figure 2.4: The major distribution of soils and landform associations based on compiled pedological and physiographic surveys from various sources by the Department of Agriculture.

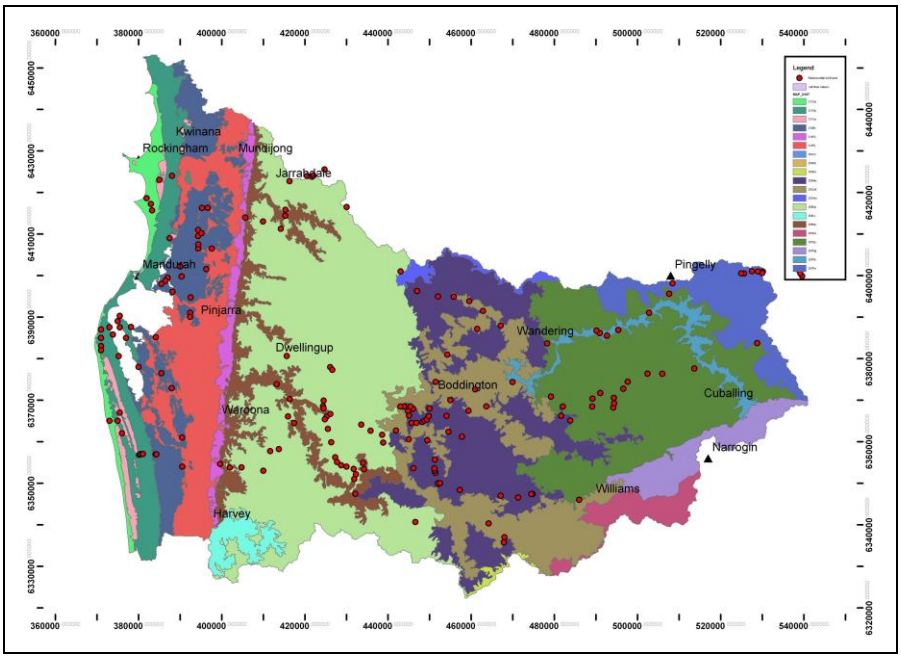


Figure 2.5: Soils and Landscape units derived from various acknowledged sources with the Field Validation Sites overlaid. These units were used for the stratification for field validation spreadsheet.

The upper catchments of the Harvey and Serpentine have been mapped in broad scale in the Atlas of Australian Soils and the System Six area. However, for practical reasons the soil/landform units developed in the western parts of the Murray-Hotham catchment are entirely adequate for the purposes of grouping the field observation data.

Stream order

The concept of Stream Order in a dissected catchment, such as the Murray is somewhat subjective but does give a priority to the distribution of landforms within a large catchment and is a useful tool to assist in ranking landform and fluvial development. Strahler (1977) described a simple methodology that has been adopted here.

Basically, for this particular use in description of the catchment (Figure 2.6), a small creek line in the head of a valley can be considered as a fifth order stream, when two of these combine the subsequent stream is considered to be fourth order (eg. Congellin Brook). When two or more fourth order streams combine they produce a third order stream, (eg. 14 Mile Brook), two third order streams produce a second (eg. Hotham and Williams Rivers) until they join the Murray which is considered as a first order stream. However the system tends to fall down on the coastal plain with the artificial drainage network.

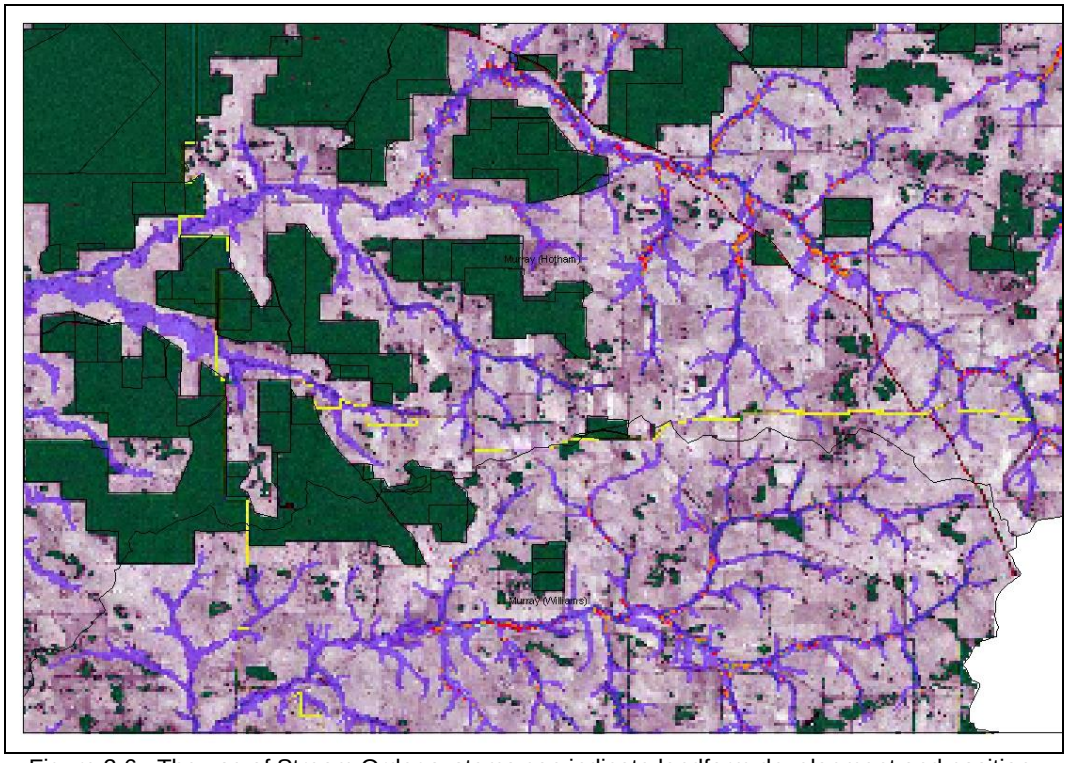


Figure 2.6: The use of Stream Order systems can indicate landform development and position.

Subdivision of the Catchment into Geomorphological Units

Aeolian Coastal Landforms

The **Quindalup** unit **(Q)** parallels the coast and is an unconsolidated sequence of calcareous sand dunes that are often separated from the Spearwood dunes by linear lake systems. They are characterised by a low heath-like vegetation dominated by acacias and melaleucas.

The **Spearwood** unit **(K + Y)** was originally a calcareous dunefield that has, with time, leached the calcareous fraction to a calcite capping now overlain by variable depths of yellow to brown sands. These are often referred to as Tuart sands being the provenance of *E. gomphocephala*. Jarrah, Marri and Banksia can also occur in the Spearwood system. The Eastern boundary is also likely to have lakes or swampy wetland chains adjoining the Bassendean system.

The **Bassendean** unit **(B + J)** is low hills of grey siliceous sands dominated by Banksia shrublands and swales (joels) that may have melaleucas, casuarinas and other codominants

Fluvial Coastal Landforms.

The **Pinjarra** plain **(Pin)** unit consists of generally unconsolidated riverine materials stretching from the foot of the Ridge Hill shelf to beneath the Bassendean dunes. The pre-European vegetation was dominated by Jarrah, Marri, Banksia, Nuytsia, Rivergum and Melaleucas survived in the wetter areas. Blackboys, both Kingia and Xanthorroea Sp., would have dominated certain areas. Almost all natural vegetation has disappeared from the Pinjarra plain

Lateritic Landforms.

Areas dominated by duricrust, gravels and sand.

The **Dwellingup** unit **(D)** consists of a gently undulating landscape with gravels or duricrust in the surface. Several prominent hills (Monadnocks) emerge from the general level; these are mainly mantled with lateritic materials but some have exposures of rock on the flanks.

The **Norrine** unit **(No)** consists of lateritic residuals usually bounded by low escarpments. The unit may be made up of several small residuals in which case the surrounding pedimented areas are also included. The soils are yellow earthy sands usually with fine gravel throughout the profile. The pedimented areas have strong non-wetting properties and are often subject to severe erosion following clearing. These same areas are also often highly saline in the surface soil. In both the Dwellingup and Norrine units the coarse sandy gravely soils are highly permeable and overlie an impermeable substrate and so are ideal for water catchment.

The **Goonaping** unit **(G)** is a landscape of gentle slopes and occurs in association with the Dwellingup unit in heads of valleys and on divides. It is dominated by grey sands, often with ferruginous gravel in lower horizons, and with a scatter of water-worn quartz pebbles on the surface. The Goonaping unit has been combined with the Dwellingup unit in the spatial analysis.

The **Yarragil** unit **(Yg)** comprises both slopes and floors of up to third order streams in the western part of the catchment. The valleys are characterised by flat swampy floors, up to 200 m in width, and flanked by smooth gravely slopes. The swampy floors are occupied by bright yellow-brown earths, often with bog iron ore at shallow depth.

The **Pindalup** unit **(Pn)** comprises the valley slopes and floors of up to fourth order streams in the eastern part of the Darling Range. The Pindalup valleys have moderate slopes, often broken by erosion scars producing steeper elements, and a swampy valley floor. As in the Yarragil valleys the floor has little value as forest but the dense swamp vegetation is important as a fauna habitat.

The **Ridge Hill Shelf** unit **(RH)** comprises gently sloping laterite spurs at the foot of the Darling Scarp. The soils are gravely yellow duplex profiles with yellow sandy flanks

Erosional landforms.

Areas of stripped and redistributed lateritic materials

The **Murray** unit **(My)** comprises the valley sides and floor of the Murray River. The unit has 90-120 m relief, steep slopes, and an overall width of 2-3 km. A narrow sandy terrace, about 200 m in width, stands at about 10 m above river level. Soils on the slopes are mainly red or yellow earths developed in colluvial material and often with incorporated rock fragments and gravels. The Murray unit has many aspects which make it suitable for passive and active recreation.

The **Coolakin** unit **(Ck)** comprises the valley slopes and floors in a zone immediately east of the zone of Pindalup valleys. The valleys are similar to those of the Pindalup unit, but differ in that there is more stripping of lateritic materials, more relief, and only minor development of a valley floor. Soils of the upper slopes are often very gravely but in lower slope positions sandy duplex soils are common.

The **Michibin** unit **(Mb)** consists mainly of slopes but may extend over local divides and sometimes includes minor valleys. Rock outcrops and associated shallow soils are common on upper slopes with yellow duplex soils or red earths in lower slope positions. In both the Coolakin and Michibin units saline patches may develop in lower topographic situations. Erosion gullies may develop downslope from extensive rock outcrop.

The **Noombling** unit **(No)** is a landscape of gentle slopes and local divides and is mapped in the eastern part of the catchment. Rock outcrops are common in upper slope positions; yellow duplex soils occupy lower slopes. The Noombling landscape is well suited to agriculture both for grazing and cropping. Saline patches may develop in middle and lower slope positions following clearing. The combination of rock outcrop and moderately impermeable soils means that runoff is considerable and erosion is common.

Depositional landforms.

Alluvial valleys

The **Williams** unit **(W)** comprising valley floors, occurs along the lower sections of the Hotham, Williams, Bannister, Crossman Rivers and Marradong Creek. It is seldom more than 1 km in width. The adjacent valley slopes are included in the Michibin and Coolakin units. The lower slopes have gritty duplex soils or rarely red earths which merge with the sandy duplex soils of the floor. The flat topography is well suited to agriculture but is often narrow and broken by river meanders. The lower terrace is subject to flooding.

The **Biberkine** unit **(Bk)** consists of the valley floors of major tributary streams in the middle and eastern parts of the catchment. The adjacent valley slopes are included in the Noombling unit. The soils on the main terrace are yellow duplex soils and, in the lower terraces, are shallow brown sandy or sandy loams deposited over a variety of substrata. The Biberkine unit is topographically well suited to agriculture but commonly has saline patches which have spread from the adjacent slopes.

The **Popanyinning** unit **(Pg)** consists of the broad valley floor of the middle and upper reaches of the south branch of the Hotham River. The adjacent slopes are included in the Noombling unit. The main valley floor has yellow duplex soils which differ from those of the Biberkine unit in having solodic properties; the clay horizon tends to be columnar and commonly there is lime in the subsoil. The lower terrace is usually a sandy material and is much dissected by present stream activity. Sand dunes, with weak podzol development, occur sporadically along the valley floor. The unit is well suited to agriculture but commonly has saline patches. The sand dunes often have a scatter of aboriginal artefacts and presumably were used as camp sites.

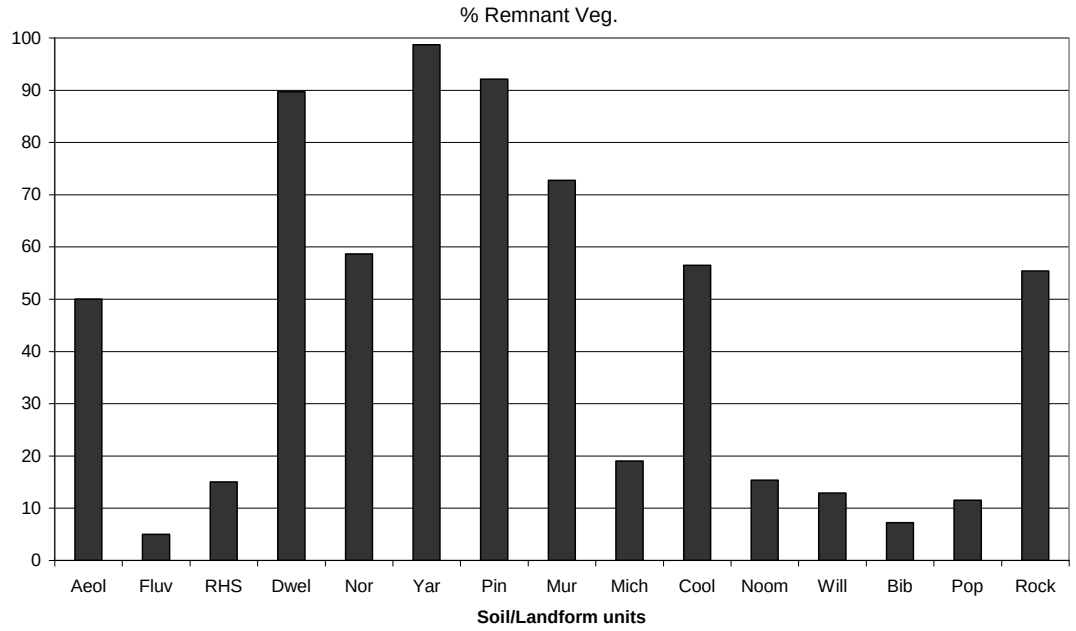


Figure 2.7: The distribution of the soil/landform units used as a basis for the field validation as a function of proportions of remnant vegetation vs. cleared land. The units are closely aligned with their suitability for historic agricultural purposes. This has been complied from published data and determinations from Land Monitor data.

Coastal Plain Bioregion

Description

The Swan Coastal Plain Bioregion (SCP) has been sub-divided to cover those parts relevant to the PHC. It extends from the Kwinana area south to Harvey and represents all the parts of the plain that have surface drainage flowing into the Peel Inlet and Harvey Estuary. It contains a wide variety of vegetation, ranging from shrub-lands on coastal limestone and ironstone soils to Banksia and Eucalypt woodlands on sands and loams and tall open forest on heavier alluvial soils. Rainfall ranges between 600 and 1000 mm annually and the climate is Mediterranean. The bioregion forms a low-lying belt 25 km to 30 km wide, bordered to the east by the Darling Scarp and the Precambrian Yilgarn Block. The Coastal Plain is covered by shoreline and associated dune deposits from the Pleistocene and Holocene that overlie Paleozoic and Neogene deposits of the Perth Basin.

Heavier soils are predominantly cleared and drained for agriculture with largest areas of remnant vegetation comprising Banksia and Tuart woodlands on deeper sandy coastal soils. Eucalypt woodlands dominated by Marri and Jarrah can be found on the sandy loams, loams, and heavy alluvial loams. Paperbark low woodland dominates swampy areas and small areas of species-rich shrub lands occur on seasonally wet ironstone soils.

Noted for its diverse waterbird fauna that inhabit and breed in coastal estuaries and lakes. The Plain also includes large micro-tidal estuarine systems, such as the Peel-Harvey Estuary and a number of lakes cut off from the sea by barrier dunes. The Plain is also transected by rivers flowing west from the Darling Plateau (notably the Murray, Serpentine and Harvey), and minor streams interspersed by permanent and seasonal wetlands.

Because of the degradation and loss of natural ecosystems within the bioregion the original suite of native vertebrate fauna has reduced or is absent over much of it. There is a general lack of knowledge of the status of the invertebrate fauna, but it is probably in the same general condition. Within the SCP bioregion fifteen plants, one reptile (Western Swamp Tortoise) and one crustacean (Crystal Cave Crangonyctoid) species have been declared as Critically Endangered, nineteen plants and one bird (Carnaby's Cockatoo) as Endangered under WA state legislation. Vulnerable species include eighteen plants, four mammals, one bird, and two

reptiles. One species *Dasyornis broadbenti litoralis* (Rufous Bristlebird - western subspecies) is extinct in the subregion.

Threatened flora

Threatened flora includes the critically endangered Abba Bell (*Darwinia* sp. Williamson), Butterfly-leaved Brachysema (*Brachysema papilio*), McCutcheon's Grevillea (*Grevillea mccutcheonii*) and Western Prickly Honeysuckle (*Lambertia echinata subsp. occidentalis*) that is restricted to small remnant areas of ironstone heathland.

Threatened fauna

Threatened fauna includes the marsupial Chuditch (*Dasyurus geoffroii*), Western Ring-tailed Possum (*Pseudocheirus occidentalis*), Brush-tailed Phascogale (*Phascogale tapoatafa*) and Quenda or Southern Brown Bandicoot (*Isoodon obesulus fusciventer*). The threatened Australasian Bittern (*Botaurus poiciloptilus*) has been sighted at Lake Mealup, part of the Peel-Harvey system, and the rare Freckled Duck (*Stictonetta naevosa*) and Hooded Plover (*Charadrius rubricollis*) have been sighted on the Peel-Harvey estuary.

Threatened ecological communities

There is a high number of Threatened and restricted ecological communities in the SCP Bioregion because of the extent of agricultural clearing and urbanisation. Within the Swan Coastal Plain Bioregion eleven Threatened Ecological Communities have been declared as Critically Endangered, five as Endangered, and nine as Vulnerable, under WA State legislation (25 TECs in total)

An unusual threatened ecological community is the Stromatolite-like microbialite community dependent on fresh ground water of coastal brackish lakes such as Lakes Clifton and Richmond.

Ecosystems containing plant species threatened by dieback (*Phytopthora cinnamomi*) can be considered at risk. This disease eliminates numerous species of structurally and floristically dominant plant families such as the Proteaceae and Myrtaceae from ecosystems.

Conservation reserves and remnant vegetation

The major reserve within the Coastal Plain Bioregion is the Yalgorup National Park (Tuart forest, coastal heath on limestone, saline lakes). Many small reserves are vulnerable to the effects of adjoining land uses and changes in local hydrology. A number of critically endangered flora are found only, or predominantly on narrow road reserves. Much of the remnant vegetation on private property has been degraded by grazing, weed infestation, changes in hydrology or plant disease. However, there is at least one very important remnant of SCP natural vegetation on the property "Lowlands" near Pinjarra and an effort to identify other remnants of poorly conserved vegetation is crucial.

Wetlands

The Western Australian Water and Rivers Commission have prepared a comprehensive wetland atlas for the Swan Coastal Plain from Wedge Island to Dunsborough, including assessment of the preliminary management categories (into 3 categories: Conservation, Resource Enhancement and Multiple Use Wetland) for 4 700 basin and flat wetlands in the Wedge Island to Mandurah area. The wetlands of significance within the Peel-Harvey Catchment are principally restricted to the coastal plain and western scarp and are shown in Figure 2.8. This list is most likely in need of up-dating as further work is reported.

Four wetlands in the region are listed in the Directory of Australian Wetlands, Barraghup Swamp, Benger Swamp, the Lake McLarty system and the Peel-Yalgorup system, with the last also being Ramsar site (that is they have been formally recognized as wetlands of international importance under the Ramsar Convention).

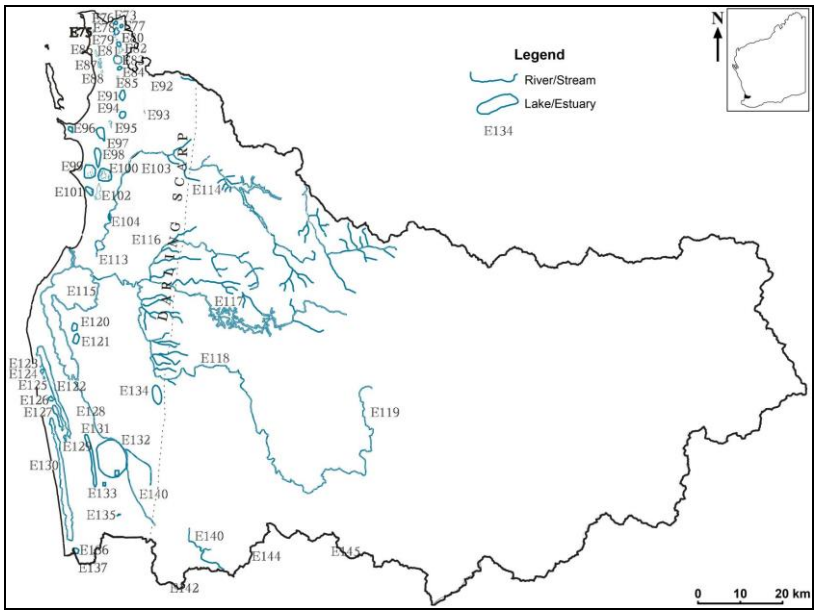


Figure 2.8: Regionally Significant Wetlands, adapted from WAWRC (1991) data by Wells (2004) for the Peel-Harvey Catchment Plan.

Regionally Significant Wetlands

The distribution of nationally and regionally significant wetlands is principally confined to the Coastal Plain and Scarp regions. However, the peripheral vegetation of permanent and ephemeral water bodies associated with the major inland rivers in the catchment do have significant biodiversity values and may be at some increasing risk from salinity and ingress of agricultural animals and fire.

Table 2.6: Regionally significant wetlands for ecosystem maintenance in the Peel-Harvey Catchment (WAWRC, 1991). This list is incomplete and will most likely be up-dated as further work is reported.

Map#	Wetland	Map#	Wetland
E73	Piney Lakes	E113	Goegerup Lake
E76	North Lake	E114	Serpentine R Complex
E77	Roe Swamp	E115	Peel-Harvey Estuary
E78	Bibra Lake	E116	North Dandalup River
E79	South Lake	E117	South Dandalup River
E80	Little Rush Lake	E118	Murray River
E81	Lake Yangebup	E119	Hotham River Lake
E82	Kogolup Lakes	E120	Lake Mealup
E83	Thomson Lakes	E121	Lake McLarty
E84	Banganup Lake	E122	Lake Clifton
E85	Wattleup Lake	E123	Duck Pond
E86	Lake Coogee	E124	Boundary Lake
E87a	Brownman Swamps (Henderson)	E125	Linda's Lagoon
E87b	Market Garden Swamps	E126	Lake Pollard
E88	Lake Mt Brown	E127	Lake Yalgorup and Martin Tank
E91	The Spectacles	E128	Lake Hayward
E92	West Byford Reserve Wetlands	E129	Lake Newnham
E93	S-W Byford Reserve Wetlands	E130	Lake Preston
E94	Bollard Bulrush Swamp	E131	Hamden Wetland
E95	Leda Swamp	E132	Riverdale Wetland
E96	Lake Richmond	E133	Harvey Flats Nature Reserve
E97	Lake Cooloongup	E134	Coolup Reserves Wetland
E98	Lake Walyungup	E135	Wellard Road Nature Reserve
E99	Becher Wetlands	E136	Myalup Swamp
E100	Stakehill Road Swamps	E137	Mialla Lagoon
E101	Peel Hurst Wetlands	E140	Harvey River
E102	Anstey Swamp	E142	Ernest River Complex(divide)
E103	Lowlands Wetlands	E144	Harris River Complex (divide)
E104	Guanarup &Yalbanberup Pools	E145	Nalyerin Lake(divide)

Drainage systems

The Peel-Harvey catchment is cleared and drained extensively on the coastal plain, allowing agricultural and urban development. The problems associated with the efficiency of over 1500kms of public and 2500kms of private artificial, trapezoidal, and straight, waterways are well documented (Bradby K, 1997). Apart from the continuing Landcare effort whereby a significant proportion of "streamlining" of the smaller private drains and a few drain modification pilot projects (eg Coolup Main Drain and Dirk Brook), the fundamental problem of the drains being managed solely for flood protection has not changed. Drains continue to be the main conduit for nutrients and sediment to flow into the estuary with their potential to act as nutrient-filtering natural waterways forgone.

The overarching issue with the current drainage system is nutrient export which is caused in part, through its efficiency in water conveyance. The artificial drains do not replicate the natural ability of a waterway to assimilate and remove the nutrient and sediments loads, to the ultimate degradation of the receiving waters i.e. the Murray, Serpentine and Harvey Rivers and eventually the Peel-Harvey Estuary. Further as many of these public and private drains are unfenced, the uncontrolled access by livestock and the resulting erosion and direct nutrient contribution is a significant issue in itself. Many of the underlying principles that are currently applied to drainage management such as the 'three-day rule' and the conveyance capacity are based theories derived for past practices and conditions and this also inhibits the achievement of more satisfactory environmental outcomes.

Layer to be inserted on generation: Map of Modified Drainage Network

Jarrah Forest Bioregion

Description

The Jarrah Forest Bioregion that is within the Peel-Harvey Catchment includes the traditional milling towns of Dwellingup and Jarrahdale and extends east of Boddington. It incorporates the area east of the Darling Scarp, overlying Archaean granite and metamorphic rocks of an average elevation of 300 m, capped by an extensive lateritic duricrust, dissected by later drainage and broken by occasional granite hills known as monadnocks

Rainfall declines from 1300 mm on the scarp to approximately 500 mm in the east and north and with it the vegetation ranges from Jarrah - Marri forest in the west with the localised Eucalypts, Bullich and Blackbutt in the valleys grading to Wandoo and Marri woodlands in the east with Powder Bark on breakaways. There are extensive but localised sand sheets with Banksia as low woodlands. Heath-like associations are found around granite rocks and as a common understorey of forests. There are areas of swamp vegetation dominated by Paperbarks and Swamp Yate.

Threatened flora and fauna and other notable species

Populations of Critical Weight Range mammals such as Southern Brown Bandicoot (*Isoodon obesulus fusciventer*), Chuditch (*Dasyurus geoffroii*), Woylie (*Bettongia penicillata ogilbyi*) and Brush-tailed Phascogale (*Phascogale tapoatafa*) have increased throughout the State forest following the establishment of fox baiting as part of the Western Shield program.

Some species such as the Quokka (*Setonix brachyurus*) and Western Ring-tailed Possum (*Pseudocheirus occidentalis*) are often restricted to riparian habitat. Populations of these have remained static. Wandoo and Wandoo/Powderbark woodlands in the eastern zone such as in Dryandra forest support such threatened and priority species as the Numbat (*Myrmecobius fasciatus*), Woylie (*Bettongia penicillata ogilbyi*) and Tammar (*Macropus eugenii derbianus*).

The region is home to rare plants such as eastern zone Critical status Late hammer Orchid (*Drakaea confluens*) and Dwarf Spider Orchid (*Caladenia bryceana* subsp *bryceana*).
Rare birds include Muir`s Corella (*Cacatua pastinator pastinator*), Western Whipbird (*Psophodes nigrogularis*), Western Bristlebird (*Dasyornis longirostris*), Noisy Scrub-Bird (*Atrichornis clamosus*).

Critical Weight Range mammals (which are those most vulnerable to fox predation) include the Southern Brown Bandicoot (*Isoodon obesulus*), Chuditch (*Dasyurus geoffroii*), and Red-tailed Phascogale (*Phascogale calura*). Rare frogs within the region are the White-bellied Frog (*Geocrinia alba*), Yellow-bellied Frog (*G. vitellina*), and Sunset Frog (*Spicospina flammocaerulea*).

Threatened ecological communities

Several ecological communities in the eastern section of the bioregion may be found to be threatened by secondary salinity once the results of the wheatbelt biological survey have been analysed.

Conservation reserves and remnant vegetation

The largest is Lane Poole Reserve of 55,000 hectares, ranging from the steeply forested valley slopes, rock-rimmed pools and tall Blackbutt, Jarrah and Marri forest of the Murray River near the Darling Scarp to the more open, undulating jarrah and wandoo woodlands further east.

Avon Wheatbelt Bioregion

Description

The Avon Wheatbelt bioregion is partially represented in the Peel Harvey Catchment although good examples of the typical upland systems are preserved in some of the reserves, there are few pristine examples of the broad valley systems. These were invariably selected for farming and are at risk from salinisation. The region is probably better thought of as the "Dryandra Bioregion" which is typical of an area of active drainage dissecting a Tertiary plateau in Yilgarn Craton. It is characterized by gently undulating rises, low hills with abrupt breakaways and continuous stream channels that flow in most years.

Dryandra is significant, comprising 17 relatively large separate blocks (28,000Ha) managed for conservation and nature-based tourism by DCLM. Dryandra owes its existence to the need, during the depression, for tannin for preserving leather and for water catchment areas for steam locomotives. Plantations of Brown Mallet (*E. astringens*) grew well and today are mixed in with the original vegetation. This mainly consists of Proteaceous scrub-heaths, rich in endemics, and mallee-heaths on residual lateritic uplands and derived sandplains and mixed eucalypt woodlands including those dominated by *Eucalyptus wandoo* (Wandoo), *Eucalyptus loxophleba (York Gum), Eucalyptus salubris (Brown Gimlet), Eucalyptus salmonophloia (Salmon Gum), and Eucalyptus longicornis (Red Morrel)* on Quaternary alluvials and eluvials. The climate is Semi-arid (Dry) Warm Mediterranean.

Threatened flora and fauna and other notable species

Threatened fauna include the Chuditch (*Dasyurus geoffroii*), Numbat (*Myrmecobius fasciatus*), Black-flanked Rock-wallaby (*Petrogale lateralis lateralis*) and the Kengoor or Red-tailed Phascogale (*Phascogale calura*), all of which are predated by the fox.

Threatened flora include the critically endangered Matchstick Banksia (*Banksia cuneata*), which is restricted mainly to a remnant of *Banksia* shrubland on deep sands on private property, Shy Featherflower (*Verticordia fimbrilepis* subsp*. fimbrilepis*) with a number of its populations restricted to narrow road verges and Boscabel Conostylis (*Conostylis setigera* ssp*. dasys*) which is known only from a single population on private property.

Threatened ecological communities

Only one listed at present, that being the perched wetlands in the catchment divides of the Wheatbelt region. The extensive stands of living Swamp Sheoak (*Casuarina obesa*) and Paperbark (*Melaleuca strobophylla*) are recorded across the lake floor at Toolibin Lake and several other wetlands. Others are likely to be indentified within the Peel-Harvey catchment after the analysis of the results of the Wheatbelt Biological Survey is completed in Dec. 2003.

Conservation reserves and remnant vegetation

Tutanning nature reserve is located on the catchment divide with the Avon region, and it contains a high density of rare and geographically restricted flora and supports populations of several marsupials susceptible to fox predation (Numbat, Quenda, Woylie, Tammar, Red-tailed Phascogale, Brushtail Possum) that has disappeared from most of the Australian or Western Australian mainland.

Dryandra State forest has a vascular flora of at least 850 species, more than Mt Lesueur (a well recognised area of high species richness) Yilliminning Rock reserve which is vested in the Shire of Narrogin has 36 recorded lichen species, including two restricted to this rock (*Paraparmelia sammyi, P. sargentii*) and has 238 vascular plant species on its 86 ha.

The Maradong reserve also contains numerous threatened species. The Peel Harvey Catchment component of the Wheatbelt is fortunate to have significant examples of reserves and remnant vegetation when compared with only 10.2% of the original native vegetation of the complete Avon-Wheatbelt bioregion being considered as remnants, of which two thirds occurs on private property. Although much remnant vegetation on private property has degraded there are still areas that have been well managed and are of very high conservation value.