The extension of vegetation complex mapping to landform boundaries within the Swan Coastal Plain landform and forested region of south-west Western Australia.

Webb A, Kinloch J, Keighery G, Pitt G

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INTRODUCTION

Vegetation complexes (*complex)* of the south-west of Western Australia have been mapped by Heddle *et al.* (1980) and Mattiske & Havel (1990) at scales of 1:250,000 and 1:50,000, respectively. Heddle *et al.* (1980) mapped the extent of the Darling System (System 6) and Mattiske & Havel (1999) mapped the extent of forest vegetation as covered by the Regional Forest Agreement (RFA) together with an extension over the very southern portion of the Swan Coastal Plain landform. The extent of these mapping products is shown in Map 1.

The join and overlapping of different scale *complex* mapping on the Swan Coastal Plain and Whicher Scarp landforms and along the Darling Scarp interface (Map 2) is a problem affecting the accurate mapping and calculation of *complex* extents which is required for assessing and monitoring significance of impacts on native vegetation and for guiding State development planning decisions.

In lieu of a significantly more detailed project to extend 1:50,000 mapping over the currently 1:250,000 mapped extent of the Swan Coastal Plain, Whicher Scarp and Dandaragan Plateau landforms, an interim solution presented in this document is the extension and consolidation of the existing mapping.

This involved extending and consolidating the 1:250,000 mapping to the boundary of the Swan Coastal Plain and Dandaragan Plateau landforms and the extension and consolidation of the 1:50,000 mapping to the boundaries of the Whicher Scarp and Darling Plateau landforms. This has removed overlaps and different scale joins ensuring that the full extent of each landform is mapped at the same scale (Map 3).

As the landforms are significantly different in geology, soils and vegetation they do not share vegetation complexes. This within a landform allows for the meaningful and repeatable calculation of comprehensive *complex* statistics for use in State development and land use planning.

The mapping as presented in this document from this point onwards is called the "*1:250,000 extension*".

METHODS

Soil landscape mapping (DAFWA 2007) was used as the basis for the *1:250,000 extension* and the extension and consolidation of mapping was correlated as close as possible to major landform boundaries as defined by DAFWA (2007).

The extension of 1:250,000 mapping over the very southern extent of the Swan Coastal Plain was based on vegetation mapping as undertaken by Webb *et al.* (2009) and their correlation of on-ground vegetation to DAFWA (2007) soil landscape phases.

The extension of 1:50,000 mapping over the Whicher Scarp was a continuation of *complexes* as defined by Mattiske & Havel (1998) and their correlation to soil-landscape phases (DAFWA 2007). For areas on the western side of the scarp where soil landscape mapping was incomplete as a result of mine footprints, *complex* boundaries adopted for the Scarp and the adjacent Cartis *complex* were those as mapped in Hagan *et al.* (2011) through the interpretation of pre-mine contours.

In the consolidation of map overlaps along the Darling Scarp interface north of Bunbury, soil landscape phases and their associated landform allocation was used to guide which scale of mapping was kept or deleted in the seamless joining of landforms.

Mapping associated with the Whicher and Darling Scarps required, in places, the creation of new *complex* polygons; where this was required boundaries were correlated with soil-landscape phase boundaries or were manually drawn based on aerial image and contour interpretation. Where new polygons had to be named or existing polygons renamed, names used were correlated to existing *complex* names for the same landscape locations.

RESULTS

The result of this work is the extension of same-scale vegetation complex mapping out to major landform and biogeographic boundaries. This provides uniform mapping within a landform which allows for like-for-like *complex* comparisons. For the majority of the study area this has had minimal change on calculated vegetation *complex* extents that were available prior to the 1:250,000 extension.

The only area of notable complex change as a result of this mapping is in the very southern portion of the Swan Coastal Plain, where the 1:250,000 application of the Webb *et al.* (2009) mapping has resulted in a different interpretation of vegetation patterns in the Abba and Ludlow vegetation complexes to that as mapped by Mattiske & Havel (1998).

Differences in regards to the Abba vegetation *complex* are in the interpretation of the 'Abba deep sandy rises' soil landscape phase (DAFWA 2007). This phase is characterised by *Banksia* woodlands on Bassendean sands overlying Abba Plain alluvium and was considered part of the Abba vegetation complex (Ad) by Mattiske & Havel (1998) whereas Webb *et al.* (2009) considered it a continuation of the Bassendean landform comparable to the Heddle *et al.* (1980) Southern River vegetation *complex*. It has been mapped as the latter in this *1:250,000 extension*.

In the coastal plain extension Mattiske & Havel (1998) split the Ludlow Plain land system as defined by Tille & Lantzke (1990) into three Ludlow units (LW, Lw & Lv) corresponding to:

- Ludlow (LW) - elevated dunes of Tall Tuart north of the Sabina River;
- Ludlow (Lv) - two small portions of Ludlow and Buayanyup Riverine vegetation; and
- Ludlow (Lw) - all other vegetation of the land system, predominantly wetland vegetation.

The Ludlow Plain land system, which is the extension of the Spearwood landform south of the Capel River, was found by Webb *et al.* (2009) to be more complex than previously thought. In their mapping they recognised it to support uplands of both Tuart forest and *Banksia* woodlands, and the

wetlands to include *Melaleuca*-Flooded Gum woodlands, Flooded Gum-Blackbutt- Marri low forests and deeply inundated *Melaleuca* claypans.

In the *1:250,000 extension* the uplands were considered extensions of the Karrakata Central & South *complex* and the wet woodlands and forests comparable to the Yoongarillup *complex*. The *Melaleuca* claypans which are associated with the geologically unique Cokelup soils (Tille & Lantzke 1990, DAFWA 2007) are also floristically unique and in the *1:250,000 extension* have been allocated their own vegetation *complex* called the Cokelup *complex*. The Mattiske & Havel (1998) Ludlow *complexes* (LW, Lw & Lv) which did not correspond to any Heddle *et al.* (1980) *complexes* are not included in the *1:250,000 extension*.

As a result of the *1:250,000 extension* some vegetation *complex* characteristics as described by Heddle *et al.* (1980) have been updated and a new description defined for the Cokelup *complex*. The updated and the new Cokelup *complex* descriptions are found in Appendix 1.

Appendix 2 provides revised State development planning *complex* statistics as a result of the *1:250,000 extension*, these should replace those as presented in EPA (2006).

REFERENCES:

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Department of Agriculture and Food – refer to DAFWA

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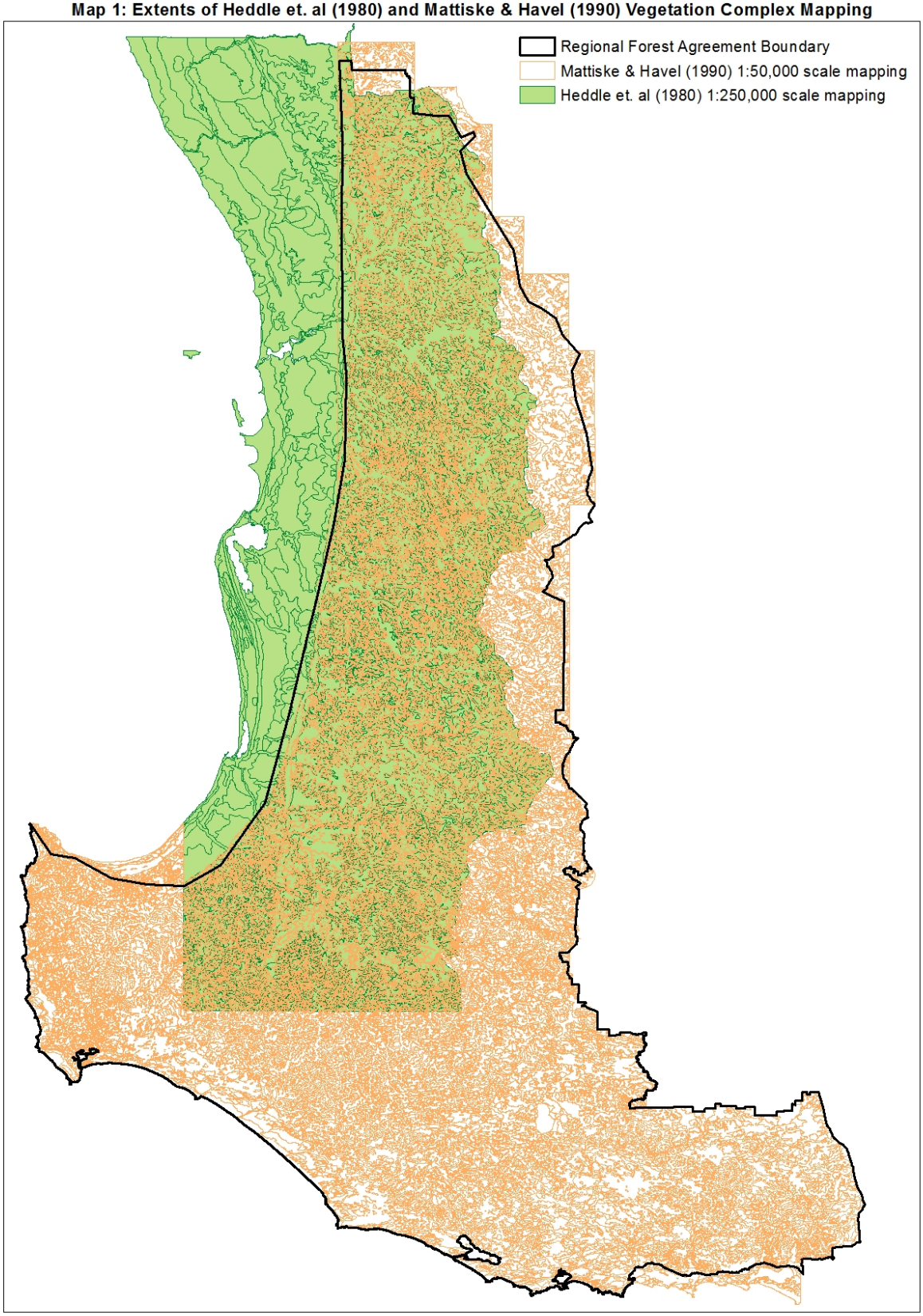
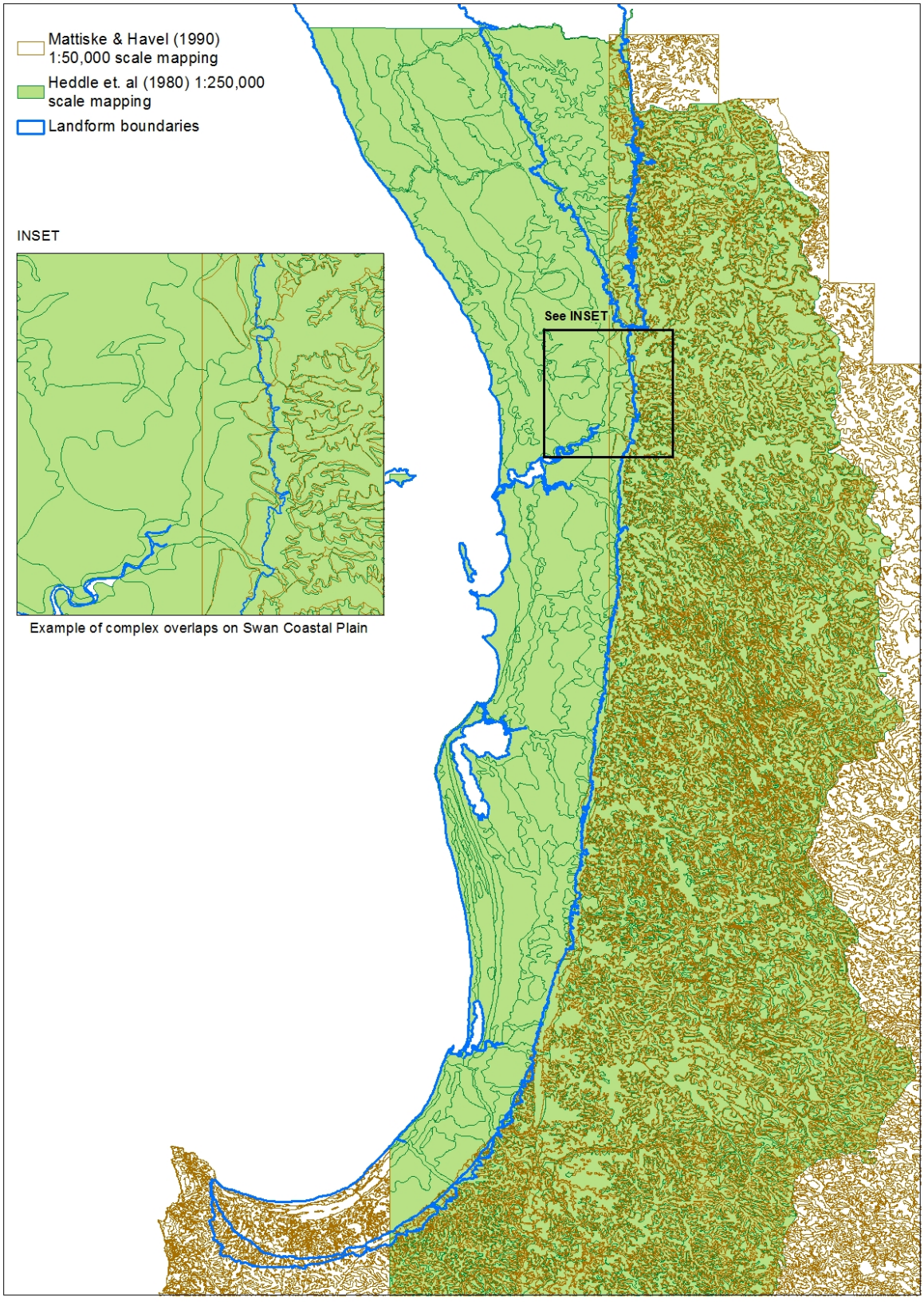
Map 1: Extents of Heddle et. al (1980) and Mattiske & Havel (1990) Vegetation Complex Mapping

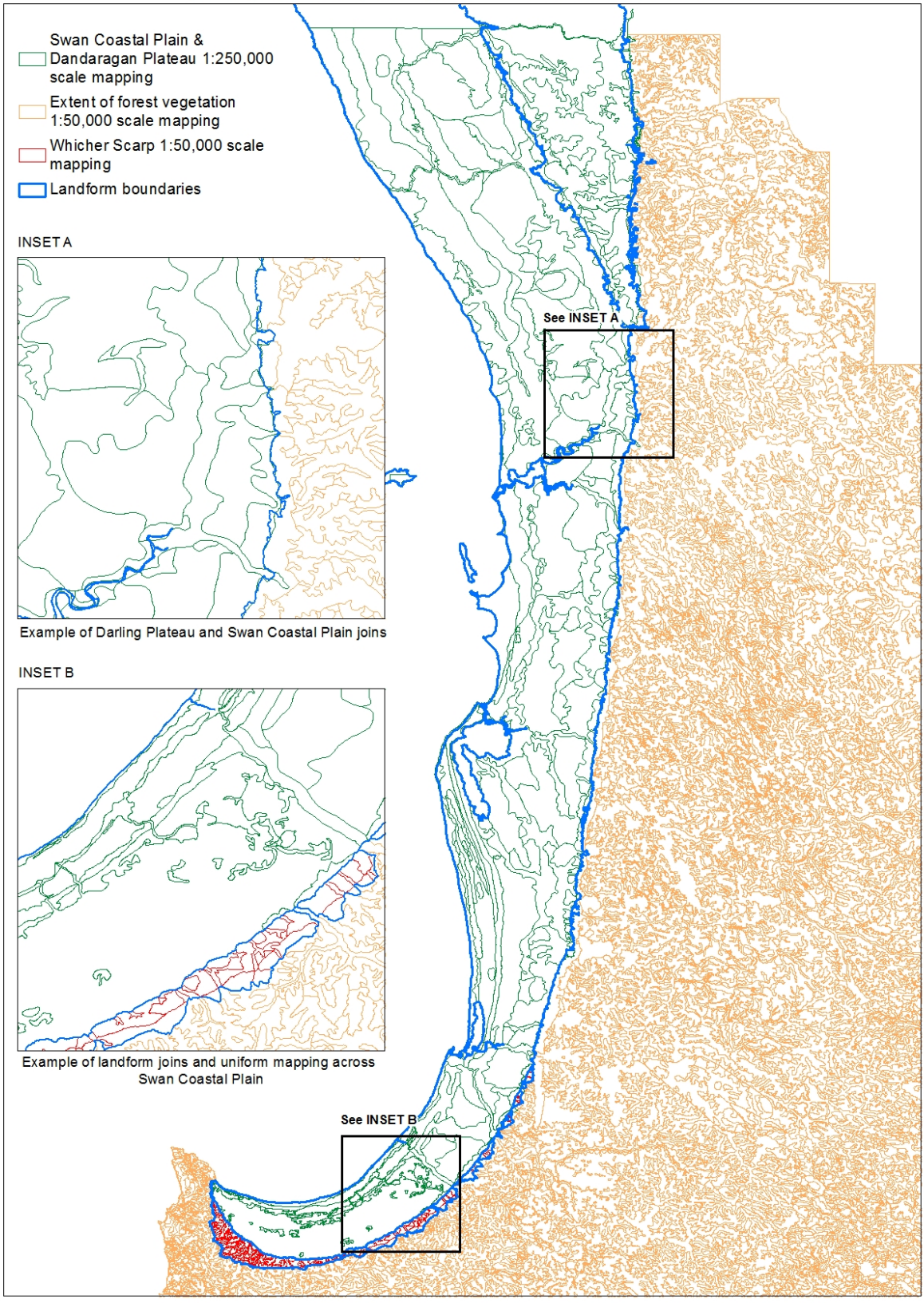


Map 2: Joins and overlaps of Heddle et. al (1980) and Mattiske & Havel (1990) Vegetation Complex Mapping



Example of complex overlaps on Swan Coastal Plain

Map 3: Vegetation Complex Mapping as a result of 1:250,000 extension



Appendix 1:

Updated Heddle *et.al* (1980) vegetation complex descriptions as a result of the *1:250 000 extension*.

30. ***Abba Complex*** *is dominated by an open-forest of marri, jarrah, banksia and a woodland of marri (Table 3.5). Abba is similar to Forrestfield and Guildford but differs in the absence of wandoo and the presence of the occasional mountain gum adjacent to the Whicher Scarp. Common plant species include Nuytsia floribunda, Kingia australis, Persoonia longifolia and Banksia grandis. The low-lying areas along the creeks and on the flood plains support a woodland of E. rudis, Melaleuca spp., with common species including M. preissiana, M. rhaphiophylla, Regelia ciliata, Hypocalymma angustifolia, Pericalymma ellipticum, Hakea varia, Acacia saligna, Astartea scoparia, A. leptophylla, Viminaria juncea and sedges of the Chaetanthus, Schoenus, Hypolaena and Anarthria genera.*

42. ***Southern River Complex*** *consists of an open-woodland of marri, jarrah, banksia on the elevated areas and a fringing woodland of E. rudis, M. rhaphiophylla (Swamp paperbark) along the streams (Table 3.5). South of the Murray River Agonis flexuosa occurs in association with the flooded gum and swamp Paperbark.*

49. ***Karrakatta Complex-Central and South*** *reflects the cooler, moister conditions in the southern section, with the vegetation consisting predominantly of an open-forest of tuart, jarrah, marri (Table 3.5). Seddon (1972) refers to the mixed nature of the vegetation in the region, and he classifies the tuart, jarrah, marri as a marginally tall open-forest. However with the exception of the Ludlow area there is generally insufficient tall tuarts, so "open-forest" has been adopted. In deeper sands on the eastern fringes the tuart is replaced by jarrah, with marri on localised moister sites. Common species in the tuart, jarrah, marri open-forest include B. attenuata, B. menziesii (north of Mandurah), B. grandis, A. fraseriana and to a lesser extent peppermint (Agonis flexuosa). South of the Capel River peppermint dominates (possibly the result of historical modification) and in areas south of Bunbury Tuart can be lacking. Shrub species include Jacksonia sternbergiana, J. furcellata, Acacia cyclops, A. saligna, Hibbertia* spp., *Allocasuarina humilis, Calothamnus quadrifidus and Grevillea preissii. On deeper sands of the jarrah woodland, the understory species show changes and include Hibbertia hypericoides, Conospermum stoechadis, Hovea trisperma and Bossiaea eriocarpa.*

55. ***Quindalup Complex*** *is restricted to the coastal dunes and can be subdivided mainly into two alliances. The strand and fore dune alliance contain Angianthus cunninghamii, Trachyandra divaricatum, Arctotheca populifolia, Atriplex isatidea, Cakile maritima, Leucophyta brownii, Carpobrotus virescens, Pelargonium capitatum, Senecio lautus, Actites megalocarpus, Spinifex longifolius, Tetragonia implexicoma, T. decumbens. The mobile and stable dune alliance contains Acacia cyclops, Anthocercis littorea, Lepidosperma gladiatum, Myoporum insulare, Nitraria billardierei, Olearia axillaris, Scaevola crassifolia, S. nitida, Spyridium globulosum, Westringia rigida and Wilsonia backhousei. The vegetation differs in its physiognomy and species composition from one place to another because of the variations in the dune environment caused by edaphic and topographical factors and the degree of shelter from salt-laden winds (McArthur 1957; Smith 1957). The low closed-forest of Melaleuca lanceolata, Callitris preissii is restricted to small localised pockets (Table 3.5). This formation was once more widespread along the coast (Baird1958, Seddon 1972). Other local variations include remnant occurrences of E. foecunda, Pittosporum ligustrifolium, Santalum*

acuminatum, Exocarpus sparteus and Acacia rostellifera (Seddon 1972).Within Geographe Bay a low closed Peppermint forest extends directly to the fore dune and is characterised by an understory of Spyridium globulosum, Hibbertia cuneiformis, Acacia littorea, Pimelea argentea and Lepidosperma gladiatum.

56. ***Yoongarillup Complex*** *is dominated by the only extensive woodlands of Tuart in the Darling System. A characteristic feature of these woodlands is the large numbers of Peppermint (Agonis flexuosa) in the second storey. On more restricted patches, this tuart woodland is replaced by an open-forest of tuart, jarrah, marri which has strong affinities with the Karrakatta-Central and South complex (Table 3.5). Understory species include Banksia attenuata, Hibbertia hypericoides, Macrozamia fraseri, Hypocalymma robustum and Jacksonia furcellata. South of Bunbury Tuart becomes rare and Melaleuca, Flooded gum woodlands to open-forests become common often including marri and Banksia littoralis with understory species including Hakea varia, Agrostocrinum hirsutum, Baumea juncea and Gahnia trifida.*

57. ***Vasse Complex*** *is dominated by a mixture of closed-scrub of Melaleuca spp., fringing woodland of E. rudis, Melaleuca spp., and open-forest of tuart, jarrah, marri (Table 3.5). The actual location of the various components appears to be determined on the basis of drainage, periods of flooding and depth of sand. Other species include Melaleuca rhaphiophylla, M. preissiana, M. cuticularis, Casuarina obesa (Bunbury north), M. lateritia and Acacia saligna. In areas subject to periodic inundation like the flat areas around the opening of the Peel Inlet near Mandurah and the coastal wetlands from Dunsborough to Forrest Beach, samphire (Tecticornia and Sarcocornia spp.) grows extensively.*

76. ***Cokelup Complex*** *is dominated by a closed-scrub/woodland of Melaleuca spp. over sedges and annually renewed herbs on fresh seasonally inundated clay flats. Common species include M. viminea, M. rhaphiophylla, M. osullivanii, M. acutiflorus and M. incana with sedges Lepidosperma longitudinale, Gahnia trifida, Chorizandra enodis; the annually renewed herbs of the complex are very diverse. The complex has a fringing open-forest that can include E. rudis, Corymbia calophylla, B. littoralis and E. gomphocephala when adjacent to the Ludlow Tuart forest, the fringing understory is often Regelia ciliata, Kunzea micrantha and K. glabrescens. This complex is found on the northern edge of the Abba Complex in the southern extent of the Swan Coastal Plain, it is the only complex south of the Capel River with heavy clay soils. The clay soils of the complex overlays coastal limestone, the term Cokelup has been applied to these soils (Tille& Lantzke 1990).*

Appendix 2:

Revised Appendix 3, Table 4 State development planning statistics as presented in EPA (2006)

The previous vegetation complex mapping situation made the accurate calculation of landform statistics difficult, this was due to a level of subjectivity particularly within the SCP landform in regards to:

- Which complexes of different name and scale should be merged to form an entire coverage of the SCP landform;
- what scale of mapping to use for statistic calculation where there is an overlap of different scale mapping, and;
- inaccurate statistics being created by different scale complex boundaries joining on an arbitrary straight line rather than along ecological attributes.

With the *1:250,000 extension* this subjectivity is removed albeit with some alteration of previously understood vegetation complex extents and associated statistics. Table 1 below shows the extent remaining statistics for vegetation complexes of the Swan Coastal Plain landform as a result of the *1:250,000 extension* as compared to those presented in EPA (2006).

It should be noted that vegetation complex statistics can vary irrespective of the *1:250,000 extension* due to the currency of remnant vegetation mapping. In Table 1 remnant vegetation extent is based on mapping as provided by DAFWA in 2016. The currency of that mapping varies from 2012 to 2015 due to the availability of orthophotos (Map 1).

Map 1: Currency of aerial image used in the 2016 mapping of remnant vegetation (DAFWA 2016)

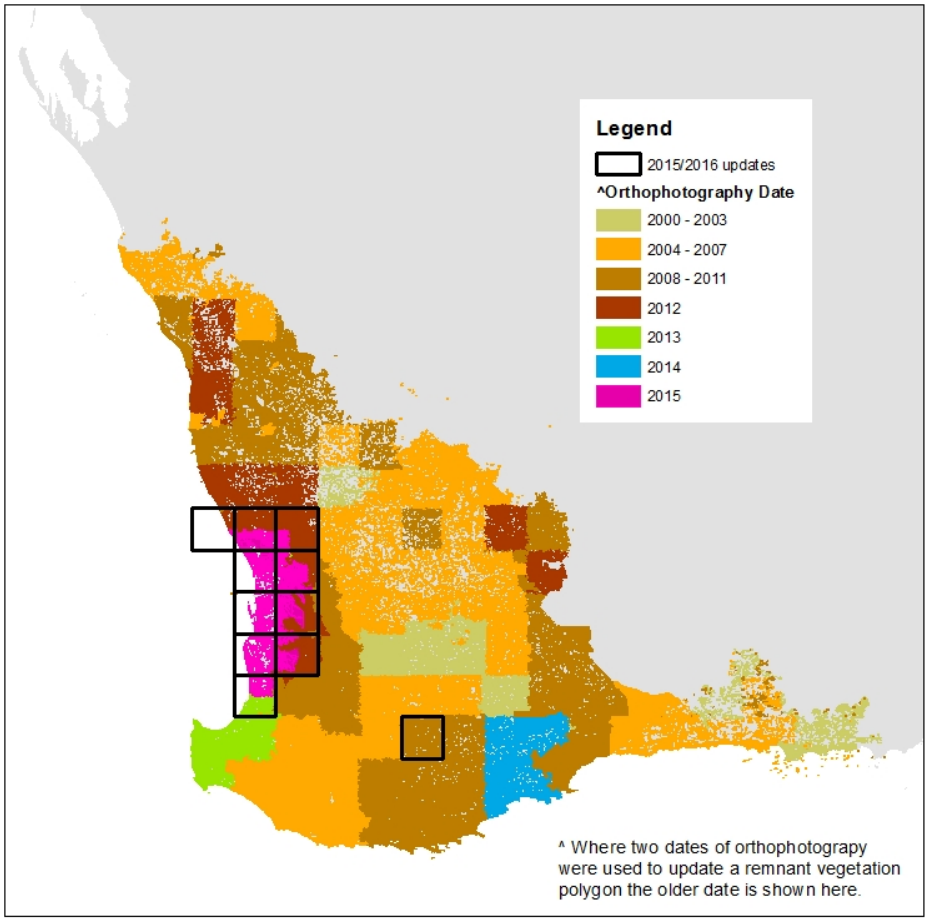


Table 1: Vegetation Complex statistics for the Swan Coastal Plain, a comparison of the 1*:250,000 extension* and EPA Guidance Statement 10, Appendix 3, Table 4 (EPA 2006).

Vegetation Complex	SYSTEM 6	***1:250,000 Extension*:** Pre-European extent (ha)	**EPA (2006):** G10 pre-1750 extent (ha)	Pre-Euro extent difference (ha) (those with > 10ha difference highlighted)	***1:250,000 Extension*:** Current extent (ha)	**EPA (2006):** G10 extent (1997/98) in the System 6/part System 1 area (ha)	***1:250,000 Extension*:** Percentage remaining (%)	**EPA (2006):** G10 % remaining (1997/98) in the System6/part System 1 area
Mogumber Complex-North	58	21,879.99	21,880	-0.06	10,437.86	9,638	47.7	44.1
Mogumber Complex-South	59	14,821.71	13,720	1,101.59	5,725.83	5,477	38.6	39.9
Karamal Complex-North	60	3,207.15	3,207	0.00	717.37	597	22.4	18.6
Karamal Complex-South	61	24,017.08	24,017	-0.11	15,254.32	14,278	63.5	59.4
Cullula Complex	62	25,620.59	25,194	426.50	13,264.84	11,931	51.8	47.4
Wannamal Complex	63	2,347.77	2,275	72.93	1,264.61	742	53.9	32.6
Reagan Complex	65	9,180.69	9,097	84.19	3,109.90	3,455	33.9	38.0
Gingin Complex	66	7,113.48	7,114	-0.03	823.93	922	11.6	13.0
Moondah Complex	64	17,713.44	17,715	-1.56	7,237.69	6,864	40.9	38.7
Southern River Complex	42	58,735.91	57,979	756.60	10,883.90	11,501	18.5	19.8
Bassendean Complex-North	43	74,150.22	74,147	3.00	53,212.71	53,384	71.8	72.0
Bassendean Complex-Central And	44	87,298.40	87,477	-178.11	22,522.87	23,624	25.8	27.0
Bassendean Complex-North	45	17,674.86	17,675	-0.02	16,080.50	16,308	91.0	92.3
Bassendean Complex-Central And	46	2,178.42	2,178	-0.02	2,143.61	2,178	98.4	100.0
Karrakatta Complex-North	47	25,579.38	25,579	-0.12	9,556.02	9,444	37.4	36.9
Karrakatta Complex-North Transition	48	5,260.38	5,260	-0.01	4,678.52	4,803	88.9	91.3
Karrakatta Complex-Central and	49	52,943.69	49,912	3,031.22	12,589.61	14,729	23.8	29.5
Caladenia Complex	50	9,659.67	9,660	0.01	5,374.79	5,309	55.6	55.0
Cottesloe Complex-North	51	21,412.45	21,412	-0.03	14,804.40	15,216	69.1	71.1
Cottesloe Complex-Central And South	52	44,676.11	44,995	-319.30	14,724.58	18,474	33.0	41.1
Herdsman Complex	53	8,309.43	8,309	-0.03	2,815.90	2,875	33.9	34.6
Pinjar Complex	54	4,892.64	4,893	-0.03	1,465.70	1,294	30.0	26.4
Quindalup Complex	55	38,402.33	38,238	164.33	21,009.12	18,000	54.7	47.1
Abba Complex	30	50,862.85	53,302	-2,439.15	3,395.79	3,198	6.7	6.0
Coonambidgee Complex	31	6,272.47	6,272	0.15	2,854.30	2,830	45.5	45.1
Guildford Complex	32	90,482.78	92,497	-2,013.91	4,558.97	4,662	5.0	5.0
Swan Complex	33	15,056.27	15,783	-726.64	2,041.45	2,454	13.6	15.6
Dardanup Complex	34	8,948.33	9,504	-555.68	504.74	754	5.6	7.9

Vegetation Complex	SYSTEM 6	***1:250,000 Extension*:** Pre-European extent (ha)	**EPA (2006):** G10 pre-1750 extent (ha)	Pre-Euro extent difference (ha) (those with > 10ha difference highlighted)	***1:250,000 Extension*:** Current extent (ha)	**EPA (2006):** G10 extent (1997/98) in the System 6/part System 1 area (ha)	***1:250,000 Extension*:** Percentage remaining (%)	**EPA (2006):** G10 % remaining (1997/98) in the System6/part System 1 area
Serpentine River Complex	35	19,855.41	19,855	-0.01	1,973.77	2,103	9.9	10.6
Beermullah Complex	36	6,707.27	6,707	-0.04	442.42	402	6.6	6.0
Bootine Complex	37	3,874.66	3,875	-0.01	620.43	527	16.0	13.6
Yanga Complex	38	26,176.45	26,177	-0.07	4,308.52	4,884	16.5	18.7
Mungala Complex	39	5,905.29	5,905	-0.01	613.82	597	10.4	10.1
Cannington Complex	40	16,584.17	16,661	-77.17	1,969.74	1,659	11.9	10.0
Moore River	41	6,844.91	5,828	1,016.96	2,324.35	1,733	34.0	29.7
Cokelup Complex	99	3,010.96			315.92		10.5	
Yoongarillup Complex	56	27,801.19	24,767	3,034.53	10,034.67	11,140	36.1	45.0
Vasse Complex	57	15,306.19	11,190	4,116.38	4,899.64	3,287	32.0	29.4
Forrestfield Complex	29	22,812.92	20,052	2,761.18	2,824.57	3,518	12.4	17.5

Metadata (Parks and Wildlife 21/9/2016 analysis)

Data	Currency	Source
Reviewed but not signed off SW Forest vegetation complexes	28/07/2016	Parks and Wildlife (in prep)
Reviewed but not signed off Whicher Scarp vegetation complexes	8/06/2016	Parks and Wildlife (in prep)
Reviewed but not signed off Swan Coastal Plain vegetation complexes	28/07/2016	Parks and Wildlife (in prep)
Native vegetation extent (referred to in this document as	30/03/2016	DAFWA/ Parks and Wildlife
DPaW-managed lands and waters	30/06/2016	Parks and Wildlife

Source of G10 information EPA (2006)