2012 IBRA Sub-Region Profiles: Intactness, Tenure, Climate and Native Vegetation.
GIS Methods

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Overview

As part of the Biodiversity Audit II a number of summary statistics were calculated and supporting maps produced for each of Western Australia's 55 IBRA sub-regions. The summary statistics covered the following themes:

- area of the sub-region;
- level of intactness;
- tenure;
- land use;
- complementary conservation reserve system;
- indigenous lands;
- climate projections;
- native vegetation (vegetation associations).

The analysis was undertaken in 2012 based on spatial data current as of 2012 or available in 2012. For a number of the statistics historical data was also available enabling a 10-year change analysis to be undertaken to examine trends.

The information below describes the input spatial datasets and methods used to undertake the analysis. In the first section the general technical GIS methods are described. Table 1 lists the input datasets used in the calculation of the statistics and production of the maps. The following sections describe any additional methods, definitions and limitations for each reporting table.

The GIS Branch reports annually on a small number of these statistics therefore more up-to-date information will be available. These annual reports are available on the GIS Branch intranet site and details are noted in italics in the appropriate sections below.

Note: the analysis was undertaken in 2012 under the auspices of the Department of Environment and Conservation. Therefore the acronym of "DEC" is used in this document and in the reporting tables.

General GIS Methodology

All geoprocessing was undertaken in ArcGIS 10.1 (ESRI 2012) and the Spatial Analyst extension was used for any raster processes.

All input vector datasets were cleaned for errors to ensure area, length or count statistics would be accurate. Cleaning involved the removal of multipart polygons and geometry errors. A topology was built to check and remove overlapping polygons and where appropriate to identify and fill gaps. The same process was undertaken for any polyline datasets (roads and railways). Prior to cleaning, each dataset was assessed to determine in what circumstances overlaps or gaps were valid.

The 'Dissolve' tool was used to generalise datasets so only the linework and attributes relating to the reporting statistics remained in the spatial datasets.

Input raster datasets (land use and OzClim (CSIRO 2012) temperature and rainfall) were converted to vector format prior to processing.

Overlay tools (union or intersect) were used to combine spatial datasets. Datasets were combined when the reporting categories covered a number of input spatial datasets (e.g. intact habitat was a combination of remnant vegetation and wetland layers). Input datasets were also combined with the IBRA 7 spatial dataset in order to report by sub-region. All combined datasets were cleaned, as described above, prior to statistics being calculated to ensure the accuracy of the results.

Where possible all geoprocessing of datasets was completed at the whole of state level. In a few instances the datasets contained a very large number of features. In these cases the input datasets were split into four sections, along bioregional boundaries, and the geoprocessing steps run separately in order to minimise computer processing times.

The area of polygons was calculated in hectares and length of polylines in kilometres using the projected coordinate reference system 'Albers Equal Conic Area GDA Western Australia'.

The generation of the summary statistics required relational databases tools that were not available in ArcGIS 10.1. The attribute table of the final combined spatial dataset and any other required tabular information were imported into MS Access 2007 and summary reporting statistics were generated in this software.

Input Datasets

Table 1: List of input spatial datasets used in deriving summary statistics and maps for each sub-region. See Appendix 1 for list of custodian acronyms.

Theme	Dataset Name	Custodian	Date	Reporting Table Name											
				Total area of sub-region	IBRA sub-region map	Remnant vegetation	Tenure	Mining and petroleum	Land uses	Linear infrastructure	Complementary conservation initiatives	Indigenous	Climate projection 2030, 2050 and 2070	Change in temperature and rainfall (2050) maps	Native vegetation: dominant, unique and rare vegetation associations
IBRA	Interim Biogeographic Regionalisation for Australia (IBRA), Version 7, sub-regions	DSEWPaC	July 2012	x	x	x	x	x	x	x	x	x	x	x	x
Sub-region maps	NATMAP Digital Maps 2008: Landsat 7 Satellite Image of Australia	AGO/GA	1996 - 2003		x										
	Enhancement of Quickbird-2 (DigitalGlobe) satellite imagery for Browse Island	Landgate	18th July 2006		x										
Wetlands	Ramsar wetlands	DEC	September 2012	x		x									
	Directory of Important Wetlands	DEWHA	October 2008	x		x									
	GEODATA (Waterbodies)	GA	2003	x		x									
	State Topographic Geodatabase (Hydrology: Water Polygon)	Landgate	August 2012	x		x									
	Wheatbelt Wetlands	DEC	October 2008	x		x									
	Geomorphic Wetlands Augusta to Walpole	DEC	June 2003	x		x									
	Geomorphic Wetlands - Darkin - Duranillin (Area D)	DEC	March 2010	x		x									
	Geomorphic Wetlands Swan Coastal Plain	DEC	June 2012	x		x									
	Geomorphic Wetlands Cervantes Eneabba	DEC	October 2010	x		x									
	Geomorphic Wetlands - Cervantes (South)	DEC	June 2010	x		x									
Remnant Vegetation	Native vegetation current extent - Western Australia	DAFWA	June 2012	x		x									x

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Plantation	FPC Plantations	FPC	2012	x		x									x
	National Plantation Inventory	BRS	2006	x		x									x
	Private Growers Plantation Data (not complete)	Various	2010 - 2012	x		x									x
Tenure	State cadastral database	Landgate	June 2012			x	x				x				x
	State cadastral database	DoLA	2001				x								
	Existing DEC managed lands and waters	DEC	June 2012	x		x	x	x		x		x			x
	Existing CALM managed lands and waters	CALM	2001				x								
	Pastoral leases in Western Australia	Landgate	June 2012				x								
	DAFWA grazing leases (Ord River Regeneration Reserve)	DAFWA	2003	x		x	x								x
	Aboriginal Lands (Aboriginal Lands Trust estate)	DIA	July 2012				x								
Climate (including maps)	OzClim Climate Change Scenario Generator (http://www.csiro.au/ozclim/home.do)	CSIRO	November 2012										x	x	
Mining	Dead Mining Tenement Data (TENEGRAPH system)	DMP	3rd October 2012					x							
	Current Mining Tenement Data (TENEGRAPH system)	DMP	19th September 2012					x							
Petroleum	Western Australian Petroleum Titles (WAP-TITLE)	DMP	28th June 2001					x							
	Western Australian Petroleum Titles (WAP-TITLE)	DMP	5th October 2012					x							
	Western Australian Geothermal Titles (WAG-TITLE)	DMP	10th October 2012					x							
	Western Australian Petroleum Special Prospecting Authorities with Acreage Options(WAPSPAAO)	DMP	5th October 2012					x							

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Land use	Land Use of Australia, Version 4, 2005/2006	ABARE; BRS	September 2010						x						
	Land Use of Australia, Version 3, 1996/1997	BRS	March 2002						x						
Linear Infrastructure	Geodata Topo 250K Series 2	GA	8th October 2003							x					
	DEC strategic surveyed roads	DEC	6th November 2012							x					
	State Topographic Geodatabase (General Transport Theme)	Landgate	October 2012							x					
Complementary conservation initiatives	DEC covenants	DEC	October 2012								x				
	National Trust covenants	National Trust of Australia (WA)	June 2012								x				
	Land for Wildlife sites	DEC	September 2012								x				
Indigenous lands	National Native Title Register (Determinations) - boundaries and core attributes	National Native Title Tribunal	November 2012									x			
	Indigenous Protected Areas (IPA) - Declared	DSEWPaC	July 2012									x			
Native Vegetation	Pre-European vegetation	DAFWA	October 2012												x

Description of reporting tables

Total area of sub-region

The total area of the sub-region is reported along with other key snapshot statistics. Refer to remnant vegetation and tenure sections below for details.

Please see the GIS Branch intranet site for the latest annual statistics in the following report:

- *DPaW-Managed and Other IUCN Terrestrial Lands by IBRA Sub-Regions Report. Statistic: Percentage of sub-region within DEC-managed conservation reserves (IUCN Ia – IV).*

Remnant vegetation

The extent of intact habitat, namely remnant vegetation and non-vegetated wetland habitats is reported across tenure categories. The extent cleared and extent of islands not covered by the spatial datasets is reported. Extents are reported as both an area (hectares) and percentage of the sub-region.

Please see the GIS Branch intranet site for the latest annual statistics in the following report:

- *Statewide Vegetation Statistics (Full report). Statistic: Extent of Remnant Vegetation including on DEC-managed lands.*

Definitions

Remnant Vegetation component

Remnant vegetation is defined as intact natural areas. Within the Intensive Land Use Zone (ILZ), DAFWA capture and update the remnant vegetation dataset by visually inspecting the areas using the latest available orthophotography and removing cleared areas. The dataset is periodically updated for the ILZ. Within the ILZ, commission errors were minimized by removing any remnant vegetation that is mapped as state or private plantation. Commission errors may remain as the private plantation spatial data, available to DPaW, is not complete.

In the Extensive Land Use Zone (ELZ) the exclusion of cleared areas has been undertaken around some mine sites and within 100km of the following towns: Kununurra, Derby, Broome, Fitzroy Crossing, Halls Creek, Port Hedland, Karratha, Onslow, Tom Price, Newman and Carnarvon. Various orthophoto image dates have been used from the period of 2004 – 2010. All other areas within the ELZ are assumed to be intact.

Additional intact habitats (wetlands) component

The DAFWA remnant vegetation dataset generally does not capture naturally non-vegetated natural areas in the ILZ. These natural areas include intact water bodies, rocky outcrops, mud flats, sand dunes and salt lakes. Spatial datasets that mapped some of these were investigated for inclusion in the reporting. A number of statewide and south west wetland datasets were identified and are described below. There is no statewide spatial data of the other natural features mentioned above.

Wetlands, lakes, perennial watercourses, estuaries, saltpans, perennial pools, basins (largely salt lakes in the Wheatbelt) were all included as intact habitat. See Table 1 for full details of datasets used and Table 2 for categories included. For the ILZ all wetland categories were visually inspected, using the latest available orthophotography, in a number of example areas to assess if the wetland values are generally

intact. As a result of this non-perennial watercourses and a number of categories in the geomorphic wetland datasets were not included. Refer to the comments in Table 2 for details. Condition information is available for the Swan Coastal Plain geomorphic wetland dataset so only conservation category and resource enhancement wetlands were included. For those towns in the ELZ where remnant vegetation has been mapped, non-perennial watercourses within 100km of Carnarvon and Port Hedland were included as these are intact. All other non-perennial watercourses in the ELZ are classed as remnant vegetation by DAFWA. Visual checks were also undertaken around mine site areas to ensure areas disturbed by mining were not brought back into the dataset by the inclusion of any of the wetland features listed in Table 2.

The area of remnant vegetation and intact non-vegetated wetland habitats was reported on for the tenure categories listed and defined in Tables 3 and 4.

Not all islands are captured in the DAFWA remnant vegetation dataset. This could be due to one of two reasons: (1) not mapped, or (2) were viewed by DAFWA as having non-vegetated natural areas. These unmapped islands have been reported on separately.

Cleared areas are defined as all areas not classed as remnant vegetation, intact wetlands or unmapped islands.

Limitations

The availability and currency of the remnant vegetation and datasets that define non-vegetated natural habitats are the main limitation. The remnant vegetation extent does not represent the extent in 2012 as the dataset is not updated for all areas on an annual basis. Therefore it is likely that some cleared areas are still mapped as remnant vegetation and have been misclassified as 'intact'. It is also likely that some non-vegetated natural areas have been misclassified as 'cleared' as no spatial data is available. For the wetland datasets used, there is limited information available on the condition of the wetlands so some of these areas may have been misclassified as 'intact'.

Table 2: Description of wetland categories included in the non-vegetated natural habitats dataset.

Wetland Dataset Name	Wetland Categories	Rationale and details of visual inspections	Applicable sub-regions
Ramsar Wetlands	Existing wetlands only		All
Directory of Important Wetlands	All	- The inclusion of this data was reviewed for each sub-region. - This dataset has not been used in the SWA02 sub-region as it includes too many disturbed and developed areas. All wetlands are identified in the other datasets and these better delineate the undisturbed parts of the wetland.	All sub-regions excluding SWA02
GEODATA (Waterbodies)	1. Lakes 2. Perennial watercourses (all areas) 3. In the ELZ un-disturbed non perennial watercourses within 100km zones around towns have been included.	- Non-perennial watercourses in the ILZ have not been included. Visual inspection using the latest available orthophotography determined that these creeks are not intact due to grazing or cropping and many are eroded. - The only non-perennial watercourses in the ELZ that were required to be included were those within the 100km zones of Carnarvon and Port Hedland. All other towns were inspected and no inclusions were required.	All
State Topographic Enhancement Project Data (TGDB) - Hydrology: Water Polygon	1. Estuaries 2. Saltpans 3. Natural Lakes 4. Perennial pools 5. Perennial watercourses (all areas) 6. In the ELZ un-disturbed non perennial watercourses within 100km zones around towns have been included.	- The inclusion of estuaries ensured the portion of watercourses at river mouths were included in the dataset. Generally these areas were within the IBRA boundaries. - The saltpan category only relate to saltpans in the Shark Bay area and these were largely captured as remnant in the remnant vegetation dataset. - Non-perennial watercourses in the ILZ have not been included in the ILZ. See comments above under GEODATA. - Non-perennial watercourses within the 100km zones around Carnarvon and Port Hedland were included. See comments for GEODATA.	All
Wheatbelt wetlands	Basins with a dominant vegetation category of open water or sedges.	- Channels were not included for the same reasons as ILZ non-perennial watercourses. See comments for GEODATA. - Granite outcrops were not included as data is not available for other areas of the South West of WA.	Coverage: • Majority of AVW01, AVW02, COO02, MAL02; part for ESP02, MAL01, • Minority of ESP01, GES02, JAF01, JAF02, SWA01, YAL02

Wetland Dataset Name	Wetland Categories	Rationale and details of visual inspections	Applicable sub-regions
Geomorphic wetlands (all layers except Swan Coastal Plain)	1. Lakes 2. Estuaries (waterbody)	- The playa category in the Cervantes –Eneabba layer was not included as these wetland areas were captured in the TGDB. - The barlkarra category in the Cervantes –Eneabba layer was not included as visual inspection of orthophotography revealed these are generally not intact. - The dampland, sumpland, floodplain, palusplain and paluslope categories in all geomorphic layers were not included as visual inspection of orthophotography showed these are generally not intact. If they are intact they are captured in the remnant vegetation dataset. - Rivers were not included as they are adequately captured by the TGDB and the remnant vegetation dataset.	Geomorphic Wetlands Augusta to Walpole: • Part coverage of WAR01 and minor coverage of JAF02 Geomorphic Wetlands - Darkin - Duranillin (Area D): • Minor coverage of JAF01 and JAF02 Geomorphic Wetlands Cervantes Eneabba • Part coverage of GES02 and minor coverage of SWA02 Geomorphic Wetlands - Cervantes (South) • Minor coverage GES02 and SWA02
Geomorphic wetlands Swan Coastal Plain	Conservation or resource enhancement wetlands that are 1. Lakes 2. Estuaries (waterbody)	- Multiple use wetlands have been excluded as these are highly modified. - Rivers were not included as they are adequately captured by the TGDB (watercourses) and the remnant vegetation dataset.	Coverage: • Majority of SWA02; part for SWA01; • Minority of AVW02, GES02, JAF01 and JAF02.

Tenure

This table reports on the extents of various tenure categories, both in DEC-managed lands and in other lands. Extents are reported as both an area (hectares) and percentage of the sub-region, and are compared between 2002 and 2012. The number of reserves/titles are also reported for the tenure categories within DEC-managed lands, and compared between 2002 and 2012.

Please see the GIS Branch intranet site for the latest annual statistics in the following report:

- *DPaW-Managed and Other IUCN Terrestrial Lands by IBRA Sub-Regions Report. Statistic: DEC-managed lands (extent only).*

Additional Methodology

Counts were based on the name of the reserve, or in the absence of a formal name, the reserve/title number. Any parcels with no name and no reserve/title number were counted in consultation with the Tenure Officer. See limitation section for more details. Reserves/titles were counted in a sub-region if ≥5% of the entire reserve/title falls within the sub-region. Any reserves/titles where <5% falls within the sub-region were visually inspected to determine whether they should be counted. See limitation section for more details. The number of reserves/titles was then summed for each sub-region according to the reporting categories.

Note: before calculating bioregional or state totals from these statistics please read the limitations section.

Definitions

The definitions of each of the tenure reporting categories are provided in Table 3. Table 4 defines which tenure categories were used in each report table.

The distribution of Commonwealth owned defence land was extracted from the state cadastre. Commonwealth land was then classed as being for defence purposes or other purposes (i.e. airports) using the latest available orthophoto imagery, AUSLIG 100k maps (Geoscience Australia 2008) and local knowledge. The full list of Commonwealth owned defence lands captured in this analysis were:

> Campbell Barracks (Swanbourne) (SWA02); Leeuwin Barracks (Fremantle) (SWA02); Irwin Barracks (Karrakatta) (SWA02); Pearce RAAF Base (SWA02 and SWA01); Curtin RAAF Base (DAL01); Learmonth RAAF Base (CAR01); HMAS Stirling (Garden Island) (SWA02); North West Cape defence reserve (including the Harold Holt Naval Communication Station) (CAR01); Defence reserve (NOK01, DAL01, CEK01 and CEK03); Military training area (SWA02); Bindoon training area (JAF01); Northam army training camp (JAF01 and AVW02); Department of Defence communication station (GES01); Commonwealth owned rifle range (near Kalgoorlie) (COO03)

Aboriginal Lands Trust holdings comprise vested crown reserves, pastoral leases, general purposes leases and freehold lands and are reported on as a subset of the tenure category they sit below. For example, if the extent of “Pastoral leases” is reported as 50,000 ha and the extent of “Pastoral leases held by Aboriginal Lands Trust” is reported as 1000 ha, this indicates that of the 50,000 ha of pastoral leases, 1000 ha are held by the Aboriginal Lands Trust.

Table 3: Description of tenure categories.

Tenure Category		Description
DEC-managed lands	**Conservation reserves (IUCN Ia - IV)**	Any lands managed by DEC that have been assigned an IUCN category of Ia, II, III or IV. This includes all nature reserves, national parks, conservation parks, marine nature reserves and marine management areas, and some marine parks, 5(1)(g) reserves, 5(1)(h) reserves and miscellaneous reserves.
	DEC-managed lands proposed for conservation	Any lands managed by DEC that are proposed to enter the reserve system for conservation. This includes all former leasehold and Crown freehold department interest lands. In 2001, there was no Crown freehold department interest category, and executive director leasehold was the equivalent of former leasehold.
	Conservation reserves (IUCN V & VI)	Any lands managed by DEC that have been assigned an IUCN category of V or VI. This includes some marine parks, 5(1)(g) reserves, 5(1)(h) reserves and miscellaneous reserves.
	State forest / timber reserves	Any state forests or timber reserves that are managed by DEC.
	Other DEC-managed lands	Any lands managed by DEC that have no IUCN category assigned, and are not proposed for conservation and are not a state forest or timber reserve. This includes some 5(1)(g) reserves, 5(1)(h) reserves and miscellaneous reserves, and all executive body freehold. In 2001 this category also includes Crown freehold managed by DEC.
Other lands	**Unallocated crown lands***	Any crown lands in which no interest is known to exist (other than under the Commonwealth Native Title Act 1993) and which are not reserved or declared. Any lands managed by DEC are excluded from this category.
	Other crown reserves*	Any crown lands reserved for various purposes in the public interest (i.e. recreation, drainage). This includes vested (i.e. in local government), unvested and leased reserves. This may also include some crown reserves leased to the Commonwealth for defence purposes. Any lands managed by DEC are excluded from this category.
	Commonwealth lands (defence)	Any lands owned by the Commonwealth and used for defence purposes. This includes army barracks, air force and navy bases, training areas, defence reserves, communication stations and rifle ranges owned by the Commonwealth. See listed above all defence land included in this category.
	Other public lands (roads and water bodies)	Any crown lands (excluding crown lands with a lease) that do not fit into the above categories. This includes public roads and public water bodies. Any lands managed by DEC are excluded from this category.
	Pastoral leases	Any crown lands on which a pastoral lease exists. Any DEC purchased pastoral lands are excluded from this category.
	Other leasehold lands	Any crown lands on which a lease exists, excluding pastoral leases and leases on crown reserves. This may include some crown lands leased to the Commonwealth for defence purposes. Any lands managed by DEC are excluded from this category. Note that this category was not present in the 2001 cadastral dataset.
	Freehold lands	Any lands that are privately owned.
	No tenure category assigned	Any lands that do not have a tenure category assigned in both the state cadastral dataset and DEC-managed lands and waters. This category can arise where the state cadastral dataset is incomplete (i.e. road casings have not been digitised) or is missing attribute data. Areas with no data due to the misalignment between the cadastral boundaries and the IBRA boundaries (i.e. along the coastline) have also been assigned to this category.

* Descriptions incorporate definitions published on the Landgate website (Landgate, 2013)

Table 4: Tenure categories used in the various reporting tables. A grey cell indicates that the tenure category was not reported on.

Tenure Category		Total area of sub-region	Remnant vegetation	Tenure	Mining and petroleum	Indigenous	Native vegetation
DEC-managed lands	**Conservation reserves (IUCN Ia - IV)**	DEC-managed conservation reserves (IUCN Ia - IV)	Conservation reserves (IUCN Ia - IV)	Conservation reserves (IUCN Ia - IV)	DEC-managed conservation reserves (IUCN Ia - IV)	DEC-managed lands	DEC-managed lands: IUCN Ia - IV
	DEC-managed lands proposed for conservation		DEC-managed lands proposed for conservation	DEC-managed lands proposed for conservation	DEC-managed lands proposed for conservation		DEC-managed lands: Proposed for conservation
	Conservation reserves (IUCN V & VI)		Conservation reserves (IUCN V & VI)	Conservation reserves (IUCN V & VI)	DEC-managed conservation reserves (IUCN V & VI)		DEC-managed lands: IUCN V- VI
	State forest / timber reserves		Other DEC-managed lands	State forest / timber reserves	Other DEC-managed lands		DEC-managed lands: Non-IUCN
	Other DEC-managed lands			Other DEC-managed lands			
Other lands	**Unallocated crown lands**		Other public lands	Unallocated crown lands		All other lands	Other lands: Public lands
	Other crown reserves			Other crown reserves			
	Commonwealth lands (defence)			Commonwealth lands (defence)			
	Other public lands (roads and water bodies)			Other public lands (roads and water bodies)			
	Pastoral leases		Leasehold lands	Pastoral leases			Other lands: Leasehold lands
	Other leasehold lands			Other leasehold lands			
	Freehold lands		Freehold lands	Freehold lands			Other lands: Freehold lands
	No tenure category assigned		No tenure category assigned	No tenure category assigned			

Limitations

No cadastre dataset was released exactly 10 years ago. The 2001 cadastre dataset is the closest historical dataset available. This provides an 11 year historical comparison. The 2001 cadastre dataset contains many land parcels which are missing attribute data and it is expected that other parcels could be misclassified. In the absence of metadata for this historical dataset, it is not possible to quantify the level of misclassification. It is expected however that the attributing of the cadastral data improves with time, which should be taken into consideration when interpreting the results.

Much of the land which had no tenure category assigned in 2001 will have been attributed and consequently distributed between other reporting categories in 2012. The majority of this is expected to have been distributed to the "Other public lands (roads and water bodies)" category, as public roads were progressively digitised and attributed, though increases in other categories is also possible as attributing improves. Similarly, in 2002 there is not data to differentiate pastoral leases from other leasehold lands. Therefore it is likely that the total extent shown for pastoral leases in 2002 includes both pastoral leases and other leasehold lands.

Aboriginal Lands Trust data are only available for 2012 and hence no historical comparison could be made. The extents shown are a subset of the category they sit below. These values should therefore not be summed since they are not mutually exclusive.

The total number of reserves/titles in each sub-region should not be summed together since reserves that cross IBRA boundaries could be counted in more than one sub-region (see information in definitions section). The sub-region totals from these tables should not be used to calculate bioregional or an overall state total.

Where reserves/titles on DEC-managed lands and waters are unnamed, the reserve/title number was used to base the count on. In the absence of a name, this was the most accurate attribute on which to classify reserves/titles. Using this method, the situation arises where several adjacent parcels have different reserve/title numbers and therefore were counted as being unique. For example, executive body freehold was typically counted using the title number which can result in a high count in the “Other DEC-managed lands” category. However, if adjacent parcels become reserved in the future, it is likely that they will be reserved under one reserve number.

Where less than 5% of a reserve/title falls within a sub-region, the reserve/title was visually inspected to assess whether it should be counted in that sub-region. When assessing whether a reserve should be counted in that sub-region, various factors were considered including extent of the reserve within the sub-region. For example, if the extent of the reserve within the sub-region was large (>1000 ha), it was included. Also orthophotos were examined to determine if different ecological communities are likely to be present in the portion of the reserve in each sub-region. Any islands which were reserved but fell below the 5% threshold (due to boundary misalignments or miscapture) were included. Small areas such as slivers were typically excluded. All marine parks were excluded from the counts unless they were entirely inland (i.e. Swan Estuary Marine Park and Walpole-Nornalup Inlets Marine Park). Each year date was inspected as additions or removal of areas from department-managed land may affect

which sub-regions it is assigned to. Visual inspections were repeated by two GIS Analysts. We acknowledge that there is a degree of subjectivity using this approach. Therefore a list of reserves/titles which are within two or more sub-regions and fell below the 5% threshold has been provided along with the sub-regions they were counted in (Table 5). This information can be referred to in future time series analyses.

Table 5: List of reserves/titles which are in two or more sub-regions but fall below the 5% threshold in one of these sub-regions. Each of these reserves/titles were visually inspected to determine which sub-region/s they should be counted in. These sub-regions are listed against each reserve/title.

	Name or reserve/title number	Sub-region/s in which it was counted
1	Arthur River Nature Reserve	AVW02 and JAF01
	Beagle Islands Nature Reserve	GES02
	Beaumont Nature Reserve	ESP02 and MAL01
	Browse Island Nature Reserve	ITI03
	Bulgin Nature Reserve	AVW02
	Cane River Conservation Park	PIL03 and PIL04
	Cape Arid National Park	COO01, ESP02 and MAL01
	Carrolup Nature Reserve	AVW02 and JAF02
	Cheadanup Nature Reserve	MAL02
	Coalseam Conservation Park	AVW01
	Dardanup Conservation Park	JAF02 (2012 only)
	Devonian Reef Conservation Park	DAL01
	Eneminga Nature Reserve	SWA02
	Fitzgerald River National Park	ESP01
	Frank Hann National Park	MAL02
	Freycinet, Double Islands Etc Nature Reserve	CAR02 and YAL01
	Gillingarra Nature Reserve	JAF01
	Great Victoria Desert Nature Reserve	GVD02, GVD03, NUL01 and NUL02
	Greater Beedelup National Park	WAR01 (2012 only)
	Gum Link Road Nature Reserve	WAR01 (2002 only)
	Hilliger National Park	JAF02 (2012 only)
	Jilbadji Nature Reserve	AVW01 and COO02
	Karijini National Park	PIL02 and PIL03
	Karroun Hill Nature Reserve	COO02 and YAL02
	Lake King Nature Reserve	MAL02
	Lake Muir National Park	JAF02 (2012 only)
	Lake Wannamal Nature Reserve	JAF01 (2002); JAF01 and SWA01 (2012)
	Millstream Chichester National Park	PIL01, PIL02 and PIL04
	Mount Lindesay National Park	JAF02 (2012 only)
	Mount Manning - Helena and Aurora Ranges Conservation Park	COO02 and MUR01 (2012 only)
	Mount Manypeaks Nature Reserve	ESP01
	Muntz Nature Reserve	MAL01
	Nuytsland Nature Reserve	COO01, ESP02, HAM01, MAL01 and NUL02
	Ord River Nature Reserve	NOK02 and VIB01
	Queen Victoria Spring Nature Reserve	GVD01 and MUR01
	R 25591	SWA01
	R 41986	GES02

	Name or reserve/title number	Sub-region/s in which it was counted
	R 43282	MAL02
	R 49742	ESP02 (2012 only)
	Shannon National Park	JAF02 and WAR01
	Stirling Range National Park	AVW02, ESP01 and JAF02
	Toolonga Nature Reserve	CAR02, MUR02 and YAL01
	Twongkup Nature Reserve	AVW02
	Walyormouring Nature Reserve	AVW01
	Wambyn Nature Reserve	JAF01
	Wandana Nature Reserve	GES01 and YAL02
	Whicher National Park	JAF02 (2012 only)
	Yenyening Lakes Nature Reserve	AVW01
2	2745/507	SWA01 (2012 only)
	ex Barnong	YAL02
	ex Mooloogool	GAS03, MUR01 and MUR02
	ex Mt Elvire	MUR01
	ex Nanutarra	PIL03 and PIL04
	ex Twin Peaks	MUR02 (2012 only)
	Nanga	CAR02 and YAL01
3	Boyanup State Forest	JAF02 and SWA02
	Collie State Forest	JAF01 and JAF02
	Denmark Catchment State Forest	JAF02 and WAR01
	Granite Peaks State Forest	JAF02 and WAR01
	Harris River State Forest	JAF01
	Jarrahwood State Forest	JAF02 and SWA02
	Millbrook State Forest	JAF02 and SWA02
	Milyeannup State Forest	JAF02 and WAR01
	Nannup State Forest	JAF02 and WAR01
	O 60 25	JAF02
	O 68 25	JAF02
	South Blackwood State Forest	JAF02
	South East Nannup State Forest	JAF02 and WAR01
	Wellington State Forest	JAF01 and JAF02 (2002); JAF02 (2012)
4	142200656	JAF01 (2002 only)
	VICTOL 10322	GES02 (2012 only)

1: Conservation reserves (IUCN Ia – IV)

2: DEC-managed lands proposed for conservation

3: State forest / timber reserves

4: Other DEC-managed lands

Mining and petroleum

For 2001/02 and 2012 the number of live mining tenements and active petroleum titles in DEC-managed conservation reserves and other DEC-managed lands is reported. The total land area that these tenements and titles cover is also reported for both year dates. Change is also assessed between the two periods.

Definitions and Additional methodology

Refer to Table 4 for the tenure reporting categories.

Mining (live) tenements

In the report live mining tenements are defined as all tenements with a tenure status of "live" (pending tenements were not included). The tenement categories were determined from the "TYPE" field in the tenements dataset and cover all mining licenses, leases and claims, including miscellaneous licenses where mining related on-ground works are being carried without mineral extraction, such as tailing treatments and infrastructure construction.

A dataset of live mining tenements was not available for 2001/02. This information was extracted from the live and dead tenements datasets listed in Table 1. The 2001/2002 live mining tenements are defined as:

- dead tenements with a grant date earlier than December 31 2002 and an end date later than December 31 2002 (captured within the DMP Dead Tenements dataset)
- live tenements with a grant date earlier than December 31 2002 (dataset: DMP Current Mining Tenements).

This approach assumes that all live tenements in 2002 that have since expired are captured in the dead tenements dataset. This may or may not be the case in reality, refer to limitations for more information. Spatial data from these two data sources were attributed appropriately and merged into a single 2001/02 dataset.

The 2012 live mining tenements are defined as tenements with a status of "live" at the date of data extraction (September 19 2012).

Counts of mining tenements are based on unique tenement ID numbers ("TENID" field) within the tenement datasets.

Petroleum (active) titles

Active petroleum titles include granted production licenses and leases and exploration permits. In 2012 these are captured within the DMP WAP-TITLE and WAPSPAAO datasets. Geothermal exploration permits have also been included in petroleum titles as part of exploration permits and are captured in the DMP WAG-TITLE dataset. Refer to Table 1 for full list of datasets used.

The 2001/2002 petroleum titles are defined as registered, active titles at the snapshot date of June 2001. This dataset may not be complete, refer to Limitations for more information.

The 2012 petroleum titles are defined as all currently granted (active) petroleum titles (as at October 2012). Spatial data from the three data sources were attributed appropriately and merged into a single 2012 dataset.

Counts of petroleum titles are based on unique title ID numbers ("TITLE_ID" field) within the petroleum datasets.

Land area

The Land area of mining (live) tenements or petroleum (active) titles is the total areal extent of a tenement or title. The combined land area of mining (live) tenements and petroleum (active) titles represents the land area that is covered by either a mining tenement or petroleum title or both. Given that a mining tenement and petroleum title may overlap the combined total area will not necessarily be the sum of the land area of tenements and titles.

2001/2002 and 2012 is recorded as the percent change in the total land area between tenements, titles and combined tenements and titles.

Refer to Limitations for more information.

Limitations

The definition of live tenements for 2001/2002 is based on the current dead and live tenements datasets supplied by DMP. We have assumed that all tenements that were live in 2002 but have since expired are captured in the dead tenements dataset. We have also assumed that the tenure status and grant date attributes in the live tenements dataset have picked up additional tenements that were live in 2002 (and are still live in 2012). This definition is based on the data supplied and has been verified by DMP.

Petroleum titles for 2001/2002 were supplied by DMP as a snapshot at June 2001. Prior to 2002 petroleum titles were archived spatially without attributes and are currently stored by DMP in a separate database. There is an on-going back capture program capturing historical titles individually but it is only partially complete. Therefore it cannot be assumed that all expired titles issued prior to January 2002 are within this snapshot dataset.

Areas of tenements and titles are reported as the area of the registered tenement/title boundaries as they appear spatially with the DMP's TENGRAPH system and do not usually reflect the actual extent of on-ground activity.

Current dominant land uses

This table reports on the dominant land uses across each sub-region in 1996/97 and 2005/06 and assesses change between the two periods.

Definitions

The land use data is classified using the Australian Land Use and Management (ALUM) Classification system. While the classification system has remained relatively stable over the time period used in this analysis, there are differences in the categories which were mapped in 1996/97 compared to 2005/06. For this reason, it was necessary to group the ALUM categories into broader reporting categories which met the needs of this report. Table 6 describes each of the reporting categories and lists the associated ALUM codes.

Note for some sub-regions it may be appropriate to combine the 'Pastoralism' and Agriculture (intensive use)' reporting categories. See information in limitations section.

Table 6: Descriptions of each of the dominant land use reporting categories and their corresponding ALUM categories and codes. Each reporting category is made up of one or more ALUM codes.

Reporting category*	Primary ALUM category	Tertiary ALUM codes^
Conservation (1) Nature conservation. Definition is based on the CAPAD classification system so it can be inferred the lands are IUCN I-VI. Also includes non-IUCN lands described as "other conserved area" (heritage agreements, voluntary conservation agreements and registered property agreements). (2) Natural water features (lake, river, marsh/wetland, estuary/coastal water) classed as conservation and natural environments. Ramsar wetlands and wetlands in the Directory of Important wetlands are in this class.	(1) Conservation and natural environments (2) Water	(1) 1.1.1, 1.1.2, 1.1.3, 1.1.4, 1.1.5, 1.1.6, 1.1.7 (2) 6.1.1, 6.3.1, 6.5.1, 6.6.1
Miscellaneous (non-intensive use) (1) Includes largely unmodified natural systems which are managed primarily for the sustainable use of ecosystems. The definitions are based on CAPAD classes and include lands managed for biodiversity, surface water supply, groundwater and landscape. (2) Lands that are largely unused (in the context of prime use) but may have ancillary uses (defence, stock route, residual native cover, rehabilitation). Includes areas with largely unmodified natural systems.	Conservation and natural environments	(1) 1.2.0, 1.2.2 (2) 1.3.0, 1.3.1, 1.3.3
Traditional indigenous use Lands that are largely unmodified natural systems and are managed primarily for traditional indigenous use.	Conservation and natural environments	1.2.5
Pastoralism Grazing by domestic stock on native vegetation where there has been limited or no deliberate attempt at pasture modification. Some change in species composition may have occurred.	Production from relatively natural environments	2.1.0
Native forestry Commercial production from native forests and related activities on public and private land. Production is for wood (saw-log and pulpwood) or such things as oil, wildflowers, firewood or fence posts.	Production from relatively natural environments	2.2.0
Plantation forestry Land on which plantations of trees or shrubs (native or exotic species)	(1) Production from dryland agriculture and	3.1.0, 3.1.1, 3.1.2, 4.1.0

Reporting category*	Primary ALUM category	Tertiary ALUM codes^
have been established (dryland or irrigated) for production or environmental and resource protection purposes. This includes farm forestry. Production can be hardwood, softwood or non-sawlog/non-pulpwood (i.e. oil, wildflowers, firewood or fence posts).	plantations (2) Production from irrigated agriculture and plantations	
Agriculture (intensive use) Includes dryland and irrigated cropping, horticulture, intensive animal production and grazing on modified pastures.	(1) Production from dryland agriculture and plantations (2) Production from irrigated agriculture and plantations (3) Intensive Uses	3.0.0, 3.2.0, 3.5.4, 4.0.0, 4.2.0, 4.5.4 and all tertiary codes under 3.3.0, 3.4.0, 4.3.0. 4.4.0, 5.1.0, 5.2.0
Urban Includes manufacturing, industrial, residential, services, transport and communication.	Intensive Uses	5.0.0, 5.3.0 and all tertiary codes under 5.4.0, 5.5.0, 5.7.0
Mining Mines, quarries and tailings. Includes mined or tailing areas undergoing rehabilitation.	Intensive uses	5.8.0
Water (not classified) Natural water features (lake, river, marsh/wetland, estuary/coastal water) that have not been classified according to intensity of use. These natural water features could be used for (i) conservation; (ii) production from relatively natural environments; (iii) intensive use. As these water features have not been fully classified it was decided to report on them separately in this report.	Water	6.1.0, 6.3.0, 6.5.0, 6.6.0
Water (man-made/man modified) Man-made water features. These include reservoirs (non-farm uses), water storage (intensive use/farm dams), evaporation basins and effluent ponds.	Water	6.2.0, 6.2.3, 6.2.4
No Data Unclassified areas and areas around the coast which are missing data due to the different capture scales of the land use mapping and the IBRA spatial datasets.		

* Definitions have been taken directly or synthesised from the report by the Australian Bureau of Agricultural and Resource Economics and Sciences (2011).

^ Only tertiary codes present in Western Australia are listed. More information on the tertiary codes is available in the above report.

Limitations

There are differences in the methods BRS used to assign ALUM categories between the 1996/97 and 2005/06 datasets. In many cases, it is not possible to break down the reporting categories any further (i.e. to further break down urban into residential and industrial) due to the differences in how land use categories were mapped between the dataset dates. Doing so could be misleading when comparing the extent of a land use between the two reporting time-periods. By grouping tertiary ALUM classifications into the reporting categories, we have largely overcome any differences that the mapping methods may produce on the extent of individual tertiary classifications. Despite this, caution should be applied when making comparisons between the two dates.

Further investigation of the data revealed that the reporting category of "Pastoralism" is affected by the different methods of capture used in 1996/97 (relies on census data) and 2005/06 (used satellite imagery and remnant vegetation spatial datasets). For the majority of the non-intensive sub-regions the

change in capture method had minimal impact. However, for the sub-regions, which are more intensively modified it, is recommended that the totals for the reporting categories of "Pastoralism" and "Agriculture (intensive use)" be combined to minimize the impact of the different capture methods. The intensively modified sub-regions are: AVW01, AVW02, ESP01, ESP02, GES01, GES02, JAF01, JAF02, MAL01, MAL02, SWA01, SWA02, WAR01

The most recent land use data available for the whole state is 2005/06, therefore any land which has undergone a change in land use between 2006/06 and 2012 will not be reflected in the statistics. For example, any land acquired by DEC since 2005/06 may not be represented under the 'Conservation' category. To obtain an overall snapshot of current lands managed by DEC, the land use statistics should be considered in combination with the tenure data (see the Tenure reporting table).

The land use data are mapped using a 0.01 decimal degree cell size (approximately 1 km). Therefore any land uses whose extent is less than the resolution of the dataset will not be captured and will instead be classified to the surrounding land use. For example, there are several nature reserves less than this pixel size (particularly in the Avon Wheatbelt, Jarrah Forest and Swan Coastal Plain IBRA regions) which have not been captured and assigned to the 'Conservation' category. Similarly, many agricultural dams are unlikely to be captured and assigned to the 'Water (man-made/man-modified)' category.

The resolution and raster nature of the dataset also means that the coastline of the land use data will not align perfectly with the coastline of the IBRA dataset. Any 'gaps' caused by this misalignment have been assigned to the category 'No data'.

For further information on the BRS land use mapping data, see Australian Bureau of Agricultural and Resource Economics and Sciences (2011) and Bureau of Rural Sciences (2006a, b, 2010a, b).

Linear infrastructure

This table reports on the total length of roads, DEC-surveyed roads and railway lines. The length of road/railway line by the area of the sub-region is also reported. The purpose of this statistic is to get an indication of the level of fragmentation/development within each sub-region.

Definitions

Roads (sub-region) are all operational sealed, unsealed roads and tracks identified in the GEODATA 250K dataset including roads under construction. Foot tracks and ferry routes were excluded.

Roads (Strategic Survey Roads) are all roads that have been identified by the Department as strategic and that have been surveyed and are within conservation parks, nature reserves and national parks. Refer to Limitations for more information.

Railways are all operational railways and railways under construction identified in the State Topographic Geodatabase, General Transport Theme dataset. Dismantled and abandoned railways were excluded.

The length per hectare figure was calculated to obtain the proportion of roads and railways by sub-region area as an indication of the level of fragmentation/development in a sub-region.

Limitations

The GEODATA 250K dataset and the Landgate topographic database were compared to determine the most appropriate roads data. The GEODATA 250K dataset is not current (2003) but is captured in a consistent way across the state. It also represents roads as a single centre line only. It was for these two reasons that this dataset was used. The Landgate topographic dataset (2012) is more current for some areas of the state but it is a dataset compiled primarily for cartographic purposes where many roads are represented by two or more parallel lines. Converting these dual lines and other polygonal features such as roundabouts to centre lines was beyond the resources available in this project.

The DEC surveyed roads dataset is not complete. Only roads considered to be strategic and those that have been field verified are contained in the dataset. Some tracks are not captured and some captured tracks may or may not exist. Also, some roads on DEC-Managed Lands are not maintained by DEC but by local government and may or may not be captured. The currency of the dataset varies across the State due to the ongoing nature of the field verification program. For these reasons only those DEC roads that are in conservation parks , nature reserves and national parks have been used.

Complementary conservation initiatives to the formal conservation reserve system

This table reports on the extent of land, across a sub-region, held under each initiative and the combined total. Statistics for both 2002 and 2012 are reported and change between the two periods is assessed.

Please see the GIS Branch intranet site for the latest annual statistics in the following report:

- *DPaW-Managed and Other IUCN Terrestrial Lands by IBRA Sub-Regions Report. Statistic: Nature conservation covenants.*

Definitions

Land held by the following private conservation organisations was included: Bush Heritage, Greening Australia and the Australian Wildlife Conservancy. Nature conservation covenants include both DEC and the National Trust of Australia conservation covenant programs.

A piece of land may have more than one conservation initiative over it. Therefore overlaps between private conservation organisations' land, conservation covenants and Land for Wildlife properties will occur. The combined total represents the total extent of land which is covered by one or more initiative.

No 2002 datasets were available. The extent of complementary conservation initiatives in 2002 was therefore calculated using the acquisition/registration date of each property. These dates were obtained either from the spatial data, from tabular data provided by the custodian, or directly from the private conservation organisations and their websites.

Limitations

DEC covenant spatial data is not captured in a consistent way so can include non-natural areas such as building envelopes. Some boundaries represent the whole land parcel where others only represent the

areas with natural values. The National Trust covenant dataset includes bushland and wetland areas as well as areas that have been re-vegetated or rehabilitated.

Land for Wildlife sites can be de-registered. If this occurs, the site is removed from the spatial dataset. Furthermore, any site that has not been assessed will not be entered in the spatial data. Therefore, the 2002 statistics will not include any sites that were de-registered in 2012, and the 2012 statistics will not include any sites that have not been assessed. Extents provided for Land for Wildlife may therefore be an underestimate.

Indigenous

This table reports on the extent of land, across a sub-region, where Native Title exists and extent of land where an Indigenous Protected Area (IPA) agreement is in place. Statistics for both 2002 and 2012 are reported and change between the two periods is assessed.

Please see the GIS Branch intranet site for the latest annual statistics in the following report:

- *DPaW-Managed and Other IUCN Terrestrial Lands by IBRA Sub-Regions Report. Statistic: Commonwealth Indigenous Protected Areas.*

Definitions

Native title determinations include those where either exclusive or non-exclusive native title exists. Areas where native title has been extinguished or does not exist were excluded.

See Table 4 for a breakdown of the tenure categories included in DEC-managed lands and all other lands, and Table 3 for descriptions of each of these categories. Both the 2002 and 2012 extent of native title determinations on DEC-managed lands are calculated using the boundaries of 2012 DEC-managed lands. This allows the extent of native title determinations to be compared without the confounding effect of changes to the extent of DEC-managed lands.

The extent of native title determinations and indigenous protected areas in 2002 were calculated using the determination date and gazettal date respectively. These dates were obtained from the 2012 spatial data. It is assumed that all native title determinations or IPAs in place in 2002 are still in the 2012 dataset.

Limitations

Coastal native title determinations and IPAs often contain areas outside the IBRA boundaries. This can occur where different coastline datasets are used, or where the indigenous lands extend into coastal waters. Only areas within the IBRA boundaries are reported on in the statistics. Any areas outside the IBRA boundaries are excluded, which in the case of indigenous lands extending into coastal waters, can amount to large areas being excluded.

Climate projection 2030, 2050 and 2070 (including maps of change in temperature and rainfall)

The table shows the projected values of each climate variable for medium and high impact scenarios for the years 2030, 2050 and 2070. The table also provides information on the change (anomaly), from the base climate (1990), for the aforementioned year dates and the maps show the patterns of change across the sub-region for 2050 only. The climate variables are:

- Minimum annual temperature
- Maximum annual temperature
- Mean annual rainfall

Additional Methodology

The scenarios were generated through Ozclim (CSIRO 2012). The definition section below describes the input parameters. The projections are based on a 25km x 25km grid cell size. The sub-regions have a range of shapes with some having areas which are less than 25km across (e.g. Swan Coastal Plain 2 and Esperance Plains 2). Therefore to ensure the full range of climate values across a region were included, all grid cells that were within or partly within the sub-region were used to calculate the statistics.

The summary statistics calculated for each of the climate variables were:

- Projected average
- Average change from base climate
- Range (minimum and maximum) change from base climate.

Maps were produced showing the patterns of regional change in the projected climate variables for 2050 only. The change classes presented in these maps are based on the range of change values across Australia.

Definitions

The Global Climate Change Model (GCM) used in both scenarios was CSIRO Mk3.5 (CSIRO: CSIRO Mk3.5 on OzClim). For more information see https://wiki.csiro.au/confluence/display/ozclim/Science#Science-CSIRO35. The base climate was 1990.

The parameters used in the scenarios are as follows:

Medium Impact Scenario:

Emission Scenario: Medium CO_2 emissions, peaking around 2030 (SRES Marker Scenario A1B)
Climate Sensitivity (Rate of Global Warming): Moderate rate of global warming. This corresponds to a global warming of 2.6°C for a doubling of CO2 from 280 ppm to 560 ppm.

High Impact Scenario:

Emission Scenario: High CO2 emissions, increasing throughout the 21st century (SRES Marker Scenario A1FI)
Climate Sensitivity (Rate of Global Warming): High rate of global warming corresponds to a global warming of 4.2°C for a doubling of CO2 from 280 ppm to 560 ppm.

Limitations

The GCM's used in the projected scenarios above don't account for all factors driving changes in the climate. Therefore they should be interpreted along with information on past climate change. For example the models predict that rainfall will decrease in the North West of Australia but in actual fact rainfall has been high in recent years. This is likely due to aerosols drifting south from Asia. This effect is not taken into account in the GCM models.

Native vegetation: dominant, unique and rare vegetation associations

The pre-European and current extents and percent remaining of dominant, unique and rare vegetation associations, in each sub-region, are reported. Additionally current extent is reported against tenure categories.

Please see the GIS Branch intranet site for the latest annual statistics in the following report:

- *Statewide Vegetation Statistics (Full report). Statistic: All statistics except 'Currently remaining on other lands'.*

Definitions

Dominant vegetation associations are those which together occupied 85% of the sub-region at the time of European settlement. The 85% cutoff is determined by considering first, the largest vegetation association of a sub-region.

Unique vegetation associations are those which are largely restricted to only one sub-region at the time of European settlement. Specifically they are defined as those vegetation associations where 85% of the area falls within one sub-region.

Rare vegetation associations are those which together occupied ≤ 1% of the state at the time of European settlement.

The current extent of each vegetation association was reported on for the tenure categories listed and defined in Tables 3 and 4.

Vegetation Association descriptions can be viewed here (worksheet "Veg Assoc Descriptions").

Additional Methodology

Dominant, unique and rare vegetation associations were identified as outlined below.

Dominant:

1. For each vegetation association, calculated the percentage of the sub-region it occupies based on the pre-European extent;
2. The list of vegetation association percentages was then sorted in descending order and the cumulative total of the percentages was calculated;
3. For each sub-region, a list of the vegetation associations where the cumulative total was ≥85% was produced. The last vegetation association included in the list was the one which brought the cumulative total to at least 85%.

Unique:

1. For each vegetation association, calculated the percentage of the total pre-European statewide extent that occurs in each of the sub-regions;
2. For each sub-region, listed the vegetation associations where the percentage, calculated in the above step, was ≥85%.

Rare:

1. For each vegetation association, calculated the percentage of the state it occupies based on the pre-European extent;
2. The list of vegetation association percentages was then sorted in ascending order.
3. The cumulative total of the percentages was calculated and those where the cumulative total is ≤1% were designated as rare;
4. For each sub-region, a list of the rare vegetation associations occurring within it was produced.

For each of the vegetation associations identified in the above categories, information on the pre-European extent, current extent, percentage remaining and current extent remaining on DEC-managed lands was extracted from the 2012 Statewide Vegetation Statistics report (Government of Western Australia 2013). Additional processing was undertaken to extract current extent remaining on other lands.

Limitations

These statistics should be used to provide a general overview of the status of vegetation communities within a sub-region noting the limitations in regard to scale, availability of more detailed vegetation mapping, line work misalignment and remnant vegetation mapping. These limitations are outlined in the 2012 Statewide Vegetation Statistics report README document (Government of Western Australia 2013) and are summarised below.

Scale

The original Beard's vegetation associations, which the pre-European mapping dataset is based on, were mapped at the 1:250,000 scale and so are not designed to inform at a finer scale. The vegetation associations indicate what vegetation types may occur in the area (either common vegetation communities or mosaics). Care should be taken when using vegetation associations with finer scale mapping such as the 1:5,000, 1:10,000 or 1:20,000 remnant vegetation mapping. It cannot be assumed that in heavily cleared areas that the range of vegetation communities described by one vegetation association will all be represented in the few remaining remnants. In these instances, advice from an experienced ecologist with knowledge of the vegetation types of the area should be sought. More detailed vegetation type mapping may be required before an assessment of the levels of retention and protection of a vegetation type can be undertaken.

As noted above some vegetation associations are mosaics. This may influence whether a vegetation association meets the criteria of dominant, unique or rare.

Availability of more detailed vegetation type mapping

For some parts of the state, more detailed vegetation type mapping is available and should be used in preference to the pre-European (Beard's) mapping.

Line work misalignment

There is some misalignment between the pre-European vegetation and the sub-region datasets. Vegetation associations (or parts thereof) could therefore be assigned to the incorrect sub-region. Where a vegetation association was identified as being rare within a sub-region, it was visually checked and where it was deemed that its inclusion was due to boundary misalignments it was removed from the list. The misalignments have a much reduced effect on dominant and unique vegetation associations and these were not checked.

There is also misalignment between the pre-European vegetation dataset and the DEC-managed lands and state cadastral datasets. The misalignment could mean that vegetation associations (or parts thereof) are aligned with incorrect tenure categories.

Remnant vegetation mapping

The inconsistent distinction between cleared areas and non-vegetated "natural areas" in the remnant vegetation dataset and the incomplete capture of islands could mean the extent of areas cleared could be overestimated (percentage remaining underestimated). Care should be taken when using these statistics for vegetation associations which have no or low vegetation cover in their undisturbed state. Take particular note of those with 'bare areas', 'sparse', 'succulent steppe', or 'banksia-xylomelum alliance' in the descriptions (note: this list is not exhaustive so advice from an ecologist should be sought).

Acknowledgements

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Appendix

Acronyms used in Table 1:

ABARE: Australian Bureau of Agricultural and Resource Economics

AGO: Australian Greenhouse Office

BRS: Bureau of Rural Sciences

CALM: WA Department of Conservation and Land Management

CSIRO: Commonwealth Scientific Industrial Research Organisation

DAFWA: WA Department of Agriculture and Food

DEC: WA Department of Environment and Conservation

DEWHA: Department of the Environment, Water, Heritage and the Arts

DIA: WA Department of Indigenous Affairs

DMP: WA Department of Mines and Petroleum

DoLA: WA Department of Land Administration

DSEWPaC: Department of Sustainability, Environment, Water, Population and Communities

FPC: WA Forest Products Commission

GA: Geosciences Australia