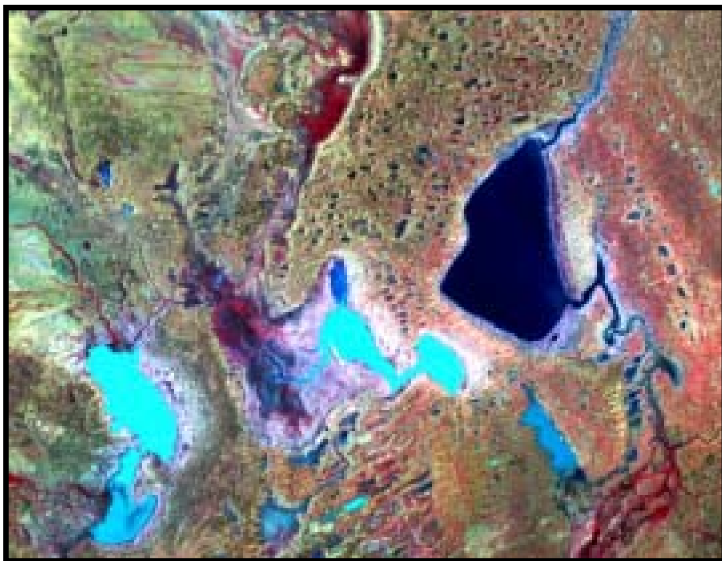


The Distribution of Wetlands in New South Wales

R.T. Kingsford, K. Brandis, R. Thomas,
P. Crighton, E. Knowles and E. Gale

2003

Natural Heritage Trust

NATIONAL PARKS & WILDLIFE SERVICE N.S.W

MURRAY-DARLING BASIN COMMISSION


Contents **Page**

List of Figures

List of tables

Executive Summary

Wetland conservation and river management for large regions depend upon data on distribution and extent of wetlands, which did not exist for the State of New South Wales (NSW) in eastern Australia. We used Landsat satellite imagery (TM for coast and MSS for inland) to map greatest extent of wetlands in the period 1984-1994, across NSW, including the Australian Capital Territory. About 5.6% of NSW (4.50 million ha) was wetland and most (89%) was floodplain, with freshwater lakes covering 297,732 ha (6.6%), saline lakes 15, 518 ha (<1%), estuarine wetlands 110,795 ha (2.5%) and coastal lagoons and lakes 65,871 ha (1.5%). Reservoirs covered about 121,000 ha. Most (99%) wetland area was at less than 250 m above sea level. About 96% of wetland area was in inland catchments (4.3 million ha), predominantly (93%) in regions where mean annual rainfall was less than 500 mm. Forty-six percent of inland wetlands were in the northwest of the State: Far north-west, Paroo, Warrego and Condamine-Culgoa River catchments. Estuarine wetlands covered the greatest area in the coastal region, followed by coastal lagoons and lakes, floodplain wetlands and freshwater lakes. Less than one percent of NSW wetland area was internationally important (Ramsar listed), 3% was in National Parks and Wildlife Service (NPWS) reserves and 21% was recognised as wetland of national importance (Directory of Important Wetlands in Australia). Wetlands were disproportionately in NPWS reserves on the coast (17.5%), compared to inland (2.4%). Potential threats to wetlands included water storages that could store 30,141,000 ML, mostly (65%) in inland catchments. Catchments with major cities (e.g. Sydney, Newcastle) also had large dams for water supply. Nineteen catchments had more than 10% of their catchment area covered by intensive agriculture, a product of water resource development and an index of land use, potentially impacting on wetlands. This distribution and extent of wetlands can be used to develop priorities for wetland management and conservation and guide river management planning.

1.0 Introduction

Wetlands are among the most threatened ecosystems in the world. Many countries have lost extensive areas of wetlands (Hollis 1990; 1992; Hollis and Jones 1991; Jones *et al.* 1995; Sparks 1995; Foote *et al.* 1996) and Australia is no exception (McComb and Lake 1988; Finlayson and Rea 1999; Kingsford 2000a). The major factor implicated in their destruction is water resource development and the draining of wetlands (McComb and Lake 1988; Hollis 1999; Lemly *et al.* 2000), although urbanisation particularly in coastal areas has also been significant (Adam 1995; Mitsch 1998). Wetlands also support high levels of biodiversity and have important cultural and economic values (Finlayson and Moser 1991). There is increasing international commitment to wetland conservation, with 133 contracting parties to the Convention on Wetlands (Ramsar, Iran 1971) (Davis 1994).

It is difficult to manage any natural resource without knowing its distribution and wetlands are no exception. Without a spatial context, effective conservation measures are difficult to implement because they should be contingent on the identification of threats and their operating scale (Barendregt *et al.* 1995; Kingsford *et al.* 1998). Effective conservation is further complicated for freshwater ecosystems because traditional conservation measures (e.g. reserves, Ramsar sites) focus on land, seldom adequately preserving the key natural resource of water (Kingsford *et al.* 2001). Reserves for wetlands remain a key bargaining chip for conservation of aquatic systems, still requiring some assessment of relative importance. It follows that without this information, priorities for wetland protection or rehabilitation cannot be derived nor regional rates of wetland loss determined nor conservation priorities for particular types of wetlands.

Despite the importance and necessity of determining the distribution of wetlands, relatively little is known about their global extent (5-19 million km^2) (Mitsch, 1998; Finlayson *et al.* 1999), with few countries having national or comprehensive regional wetland inventories (Finlayson and Spiers 1999, but see Wilen and Bates 1995). Australia has 17 regional inventories, mostly focused on small regions (Watkins 1999), but little knowledge about the distribution and extent of wetlands. Broad spatial analysis of the continental distribution of wetlands was attempted and an estimate of numbers, based on random selection of 10% of wetlands on 1:250,000 scale maps (Paijmans *et al*. 1985). Australia's Federal political system complicates matters further by devolving most responsibility for natural resource management to the States and so this means States determine priorities for wetland and river management, a picture no different to most countries of the world. Only Victoria has a statewide digital coverage of its wetlands using a wetland classification from North America (Corrick 1982). South Australia has digital coverage of the River Murray (Carruthers and Nicolson 1992). Some wetland data exist for particular areas in New South Wales, predominantly interpreted from aerial photography (King *et al.* 1995; Green *et al.* 1998; Earley, 2000; Wilton and Saintilan, 2000). Comparative use of these data is difficult because methodology has varied (Nicholson *et al.* 1994) and some data do not exist as digital layers. Five factors have deferred development of regional or statewide wetland coverages: the definition of a wetland (Finlayson *et al.* 1999), associated problems of classification (Pressey and Adam 1995), identification of a core set of attributes for collection, the appropriate scale and subsequent cost.

Collection of even 'essential' data for an inventory (see Finlayson *et al.* 1999) for large geographic regions is costly in time and resources. A fine scale may provide better boundary definition but will raise fractal problems in identification of boundaries and so there are always constraints on defining a wetland (Adam 1992; Stolt and Baker 1995).

We chose Landsat imagery as the most cost-effective option to map wetlands digitally across New South Wales so we could estimate the extent and distribution of wetlands within the major river catchments. These data will provide a foundation for strategic policies for wetland conservation, including river management planning and conservation of aquatic fauna and flora. Further, we examined the distribution of wetlands in relation to current land conservation measures at State, Federal and International levels (e.g. reserves, listings), the distribution of water resource development and intensive agriculture as potential major threats (Lemly *et al.* 2000), elevation, and climatic patterns affecting wetlands in each of the river catchments.

2.0 Statewide Wetland Mapping

2.1 Methods

2.1.1 Satellite image selection

We separated the 42 catchments that cover New South Wales into 22 coastal catchments (DLWC 1989) and 17 inland catchments (Murray-Darling Basin (AUSLIG 1997) and Far north-west (DLWC 1989)) (Appendix 1) (Fig. 1). The Far north-west included parts of four catchments within New South Wales: the Cooper, Bulloo, Lake Frome and Lake Bancannia (Fig. 1).

For the inland catchments we used Landsat Multi Spectral Scanner (MSS) data (80 m pixel). While for coastal wetlands, Landsat Thematic Mapper (TM) data (30 m pixel) were used to deal with more complex topography. Thirty-five Landsat MSS and 11 Landsat TM scenes covered inland and coastal catchments respectively. We chose satellite imagery within a 10 year period (1984 - 1993) for the inland part of the State (Fig. 1), as this covered most temporary flooding river systems in Australia (Kingsford *et al.* 1999a). In identifying suitable Landsat satellite images for inland catchments Monthly National Oceanographic and Atmospheric Administration (NOAA) satellite imagery was examined for extent of flooding during the period 1984-1993. Aerial surveys performed each year (1984 – 2001) provided data on wetland flooding across a systematic 10% of the State (Kingsford *et al.* 1999b). Annual rainfall patterns were examined at four locations within each river catchment (Bureau of Meteorology 1993) to determine the timing of large flood events and local flooding. The identification of rainfall patterns within each year narrowed the choice of imagery to a few months from which cloud free images were chosen. This allowed maximum delineation of wetland areas but incorporated a time lag, avoiding the mapping of flooded areas that were not wetland (e.g. town of Nyngan flooded in 1990). The periodicity of 16 days for Landsat imagery increased the chances of selecting optimal imagery, as cloud cover was a limitation. In areas where wetlands filled from local rainfall as opposed to floodwaters, additional imagery were chosen.

For coastal catchments where wetlands were less transient, cloud cover was the primary determinant of image suitability. Eleven Landsat TM images taken within a six month period (Sept. 1994 – Jan. 1995) were chosen for coastal catchments.

2.1.2 Satellite image analysis

Each Landsat image was rectified and georeferenced to 1:250,000 topographic maps for the inland and 1:25,000 for the coast. We used the Universal Transverse Mercator projection (Australian Map Grid) with 14-30 ground control points, evenly distributed across each image. For the inland, an unsupervised classification was performed using an Iterative Self-Organizing Data Analysis Technique (ISODATA) (ERDAS® 1999) to assign pixels to wetland based on the range of spectral values for water (open water and inundated vegetation) and vigorously growing vegetation. For coastal wetland classification a band five density slice was used to rapidly and accurately delineate water bodies (Frazier and Page 2000). A supervised classification (ERDAS® 2001) was used to identify areas of coastal wetland vegetation (e.g. mangroves) that adjoined coastal water bodies. The output grid was converted to a vector coverage using Arc/Info (ESRI® 2000).

To determine if pixels had been correctly assigned as wetland areas, we overlaid the vector coverage of wetlands on each satellite image and, compared it to available ancillary data: aerial survey data (Kingsford *et al.* 1999b), 1:100 000 and 1:250 000 mapsheets, Victorian wetlands (DNRE 1994) and AUSLIG water body data (AUSLIG 1994) (Appendix 1) for the inland, and 1:25 000 topographic maps and aerial photographs on the coast. These data discriminated between wetland and non-wetland areas with similar spectral signatures (e.g. dryland forests, cultivated crops, and hillslope shadows).

Areas delineated as wetlands (both coastal and inland) were then identified *a posteriori* by associating attributes from the ancillary data sets. We used a simple classification system with six major groups (Table 1). It was difficult to develop a more complex system when covering a large and diverse area such as New South Wales (80 million ha) where information available for classification varied enormously (Pressey and Adam 1995) or did not exist. More detailed classification of floodplain wetlands was not possible because of the poor availability of ancillary data and the variable spectral signature of floodplains. The finer resolution of the Landsat TM imagery allowed us to derive further subgroup classifications for coastal wetlands (Table 1). Following delineation of wetland areas, we compared the distribution and extent of wetlands in relation to elevation data with a 250 m contour (AUSLIG 2000) and mean annual rainfall between 1980 and 1999 (CSIRO 1999) (Appendix 1).

Table 1. Spatially derived wetland groups (and reservoirs) for inland (Murray-Darling Basin and Far north-west) and coastal wetlands across New South Wales.

Group	Description
Freshwater lake	Naturally occurring drainage basins of open water and not estuarine or coastal lagoons and lakes or saline on a 1:250,000 map (Auslig 1994) and where surface aquatic vegetation did not dominate spectral reflectance.
Floodplain wetland	River and creek channels and adjacent inundated vegetation, including including swamps, waterholes and shallow depressions.
Estuarine wetland	Open water bodies[a] and adjacent vegetation [a] at the mouth of a river open to the sea where salt water and freshwater mix (e.g. Port Stephens). Estuarine extent was determined by tidal influences (DLWC Estuaries Inventory 2000)
Saline lake	Inland naturally occurring drainage basins of saline open water, annotated as ‘salt’ or ‘salt lake’ on 1:250 000 topographic maps
Coastal lagoons and lakes	Open bodies of water [a] and adjacent vegetation [a] that were not obviously part of the river and were completely (e.g. Myall Lakes) or partly (e.g. Wamberal Lagoon) separated from the sea.
Reservoirs	Open bodies of water usually created by a wall or levee, including reservoirs, farm dams, off-river storages, mining and quarry dams, sewage ponds, evaporation basins, canals and open basins.

[a] Additional subgroups formed.

.

2.1.3 Accuracy Assessment

The value of any mapping is dependent on its accuracy, which can be estimated from an independent data set (Congalton 1991). Aerial photography data, with a higher resolution than satellite data, were compared to our classified wetland coverage. For inland wetlands, a subset of the Paroo and Warrego catchments was assessed using aerial photography, as these catchments had some of the highest proportion of wetlands in the inland (see Kingsford *et al.* 2001). We assessed the classification accuracy of our coastal wetland mapping using Landsat TM imagery in the Richmond catchment. Nine transects (5 km wide and 30 km long), covering 18% of the catchment, were chosen systematically to represent the topography of the catchment. Within each transect, points were generated randomly in each wetland polygon matched by non-wetland points. A hardcopy of each transect was printed with points overlaid on a topographic map. Each point on the map was located and its classification assessed against aerial photographs using a Luz Aero-Sketchmaster (Zeiss), producing an error matrix (Congalton 1991) and a Kappa statistic. The Kappa statistic is a measure of agreement based upon the difference between the actual agreement in the error matrix and the chance agreement (Congalton and Green 1999). This accuracy assessment was repeated for the classification of the Richmond catchment derived from Landsat MSS imagery.

Further, we used aerial photography over the entire north coast to assess accuracy. Random points in the wetland coverage were generated within 10 km of the coast to incorporate the greatest number of wetlands and this was similarly matched with non-wetland points. This produced 65 transects of which we were only able to use photographs on 36 transects (96 points) due to low cloud cover, high wind and a military exclusion zone. On the south coast, we used 1,142 randomly generated points and these were assessed against existing ortho-photos and visual recognition in the field.

2.1.4 Rescaling of coastal wetland mapping

Coastal and inland wetland catchments mapped with different resolutions had to be scaled prior to joining, to provide a complete statewide coverage. To determine the scaling factor, the Richmond catchment was mapped with MSS imagery, as well as TM imagery (Fig. 2), using methods developed for inland catchments. Ninety-four percent of the wetland area identified with Landsat TM imagery in the Richmond catchment was also identified using Landsat MSS imagery (Fig. 2) but with considerably fewer polygons: 783 compared to 5,021. Landsat MSS image analysis did not identify any wetlands smaller than 0.608 hectares. So we applied a filter to the Landsat TM classified images, deleting all polygons less than this threshold. This left less than a half percentage difference between the amount of area estimated by the Landsat TM imagery compared to the Landsat MSS imagery. This error was considered adequate for statewide analysis. This coarse filter (<0.608 ha) was applied to all coastal catchments using Arc/Info (ESRI® 2000), producing a separate MSS scale coastal coverage, allowing combination of the coastal and inland catchments into a single wetland coverage for New South Wales. We retained the original TM scale coverage of coastal wetlands comparisons within or among catchments on the NSW coast.

2.2 Results

2.2.1 Wetlands of New South Wales

We mapped almost 4.5 million ha of wetlands in New South Wales or 5.6% of the land area of the state (Table 2; Fig. 3). Most wetland area (96%) was in the inland, in the catchments of the Murray-Darling Basin and far west of the State (Fig. 3), with nearly half of all wetland area (46%) in the Far north-west, Paroo, Warrego and Condamine-Culgoa River catchments (Table 3). Of the wetland types across the State, floodplain wetlands were the most ubiquitous, forming 90% of all wetland area and covering 5 % of the land surface (Table 2). Freshwater lakes and estuarine areas were most of the remaining wetland area in the State, with comparatively small areas of saline lakes and coastal lagoons and lakes (Table 2). There were 2,294 freshwater lakes, 194 coastal lagoons and lakes and 218 salt lakes in the State, compared to 3,056 reservoirs. Most wetland area, >95%, in New South Wales is below 250 m above sea level (70% of the State's land area), and in parts of the State that receive less than 500 mm of annual rainfall (about half of the land area of the State), 93% (Figs 4a, b).

2.2.2 Inland wetlands

Almost 4.3 million ha of wetland was mapped in inland New South Wales (Fig. 3), 6.5% of the State, most (93%) of which were floodplains (Tables 2 and 4). There were 2,204 freshwater and 218 saline lakes in the inland and 1,898 reservoirs (Table 2). There was slightly more than a 30% greater extent of wetlands in areas of the State below 250 m above sea level, compared to the land surface area (Fig. 4a). 68% of the inland has annual rainfall less than 500 mm but about 96% of the wetlands are in this climatic region (Fig. 4b).

Table 2. Total area of wetlands and reservoirs (ha), and wetland areas in National Parks and Wildlife Service (NPWS) reserves, State Forests, State Environmental Planning Policy (SEPP) No. 14, A Directory of Important Wetlands in Australia (DIWA), and Ramsar listed (Davis 1994) within three regions: New South Wales (NSW) (includes the Australian Capital Territory), the inland (Murray-Darling Basin and Far north-west) and the coast (coastal catchments). Number of freshwater lakes, saline lakes, coastal lakes and lagoons and reservoirs given. Percentages were wetland area relative to total land area within a region or, for conservation land measures (NPWS, State Forests, SEPP14, DIWA, Ramsar), relative to wetland area within a region. Categories of conservation land measures were inclusive.

					Conservation Land Measure									
Region[a]	Group	Area	%[b]	No.[c]	NPWS		State Forests		SEPP 14		DIWA		Ramsar	
					Area	%[d]	Area	%[d]	Area	%[d]	Area	%[d]	Area	%[d]
Inland	Saline Lake	18,518	<0.1	218	0	0	0	0	-	-	7,816	0.2	0	0
(66,580,816 ha)	Freshwater Lake	295,805	0.4	2,204	18,726	0.4	915	<0.1	-	-	160,951	3.7	1,362	<0.1
	Floodplain Wetland	4,003,979	6.0	-	84,909	2.0	136,201	3.2	-	-	672,910	15.6	18,490	0.4
	All wetlands	4,318,302	6.5	-	103,635	2.4	137,116	3.2	-	-	841,677	19.5	19,852	0.5
	Reservoir	84,416	0.1	1,898	2,881	-	61	-	-	-	393	-	0	0
Coastal	Freshwater Lake	1,927	<0.1	90	196	0.1	16	0.8	144	0.1	1,429	0.8	100	0.1
(13,977,498 ha)	Estuarine	110,795	0.8	-	13,001	6.9	224	0.2	23,761	12.6	46,107	24.5	4,360	2.3
	Coastal Lagoons and lakes	65,871	0.5	194	17,755	9.4	44	0.1	6,741	3.6	42,825	22.8	10,363	5.5
	Floodplain Wetland	9,304	0.1	-	1,912	1.0	78	0.8	1,386	0.7	1,950	1.0	0	0
	All wetlands	187,897	1.3	-	32,864	17.5	362	0.2	32,032	17.0	92,311	49.1	14,823	7.9
	Reservoir	37,058	0.3	1,158	512	-	30	-	45	-	164	-	140	-
New South Wales	Saline Lake	18,518	<0.1	218	0	0	0	0	-	-	7,816	0.2	0	0
(80,558,314 ha)	Freshwater Lake	297,732	0.4	2,294	18,922	0.4	931	<0.1	144	<0.1	162,380	3.6	1,462	<0.1
	Estuarine	110,795	0.1	-	13,001	0.3	224	<0.1	23,761	0.5	46,107	1.0	4,360	0.1
	Coastal Lagoons and lakes	65,871	0.1	194	17,755	0.4	44	<0.1	6,741	0.1	42,825	1.0	10,363	0.2
	Floodplain Wetland	4,013,283	5.0	-	86,821	1.9	136,279	3.0	1,386	<0.1	674,860	15.0	18,490	0.4
	All wetlands	4,506,199	5.6	-	136,499	3.0	137,478	3.1	32,032	0.7	933,988	20.7	34,675	0.8
	Reservoir	121,474	0.2	3,056	3,393	-	91	-	45	-	557	-	140	-

[a]Land areas in parentheses
[b]Relative to land area in each region
[c]Numbers are counts of lakes, lagoons or reservoirs which may include more than one polygon
[d]Relative to wetland area within each region

Table 3. Areas (ha) of catchments, total wetlands of wetland groups and their proportions and reservoirs in inland New South Wales. Percentage of total wetland area in each of the 17 catchments (1-17, see Fig. 1) and numbers of discrete freshwater lakes, saline lakes and reservoirs. Percentages for Total wetland were relative to catchment land area and for wetland groups, relative to total wetland area.

Catchment Name [a]	Catchment	Total Wetland		Saline Lake			Freshwater Lake			Floodplain		Reservoir	
	Area	Area	% [b]	Area	%	No. [c]	Area	%	No. [c]	Area	%	Area	No. [c]
Paroo (Total) (1)	7,412,774	996,455	13	14,085	1	155	36,754	4	23	945,616	95	688	30
NSW	4,115,249	666,913	16	8,854	1	118	26,300	4	18	631,759	95	177	7
Qld	3,297,525	329,542	10	5,231	2	37	10,454	3	5	313,857	95	511	23
Warrego (Total) (2)	6,354,301	851,077	13	520	<1	15	7,275	1	4	843,282	99	1,643	61
NSW	1,138,944	311,952	27	520	<1	15	411	<1	3	311,021	100	1,000	9
Qld	5,215,357	539,125	10	0	0	0	6,864	1	1	532,261	99	643	52
Condamine- Culgoa (Total) (3)	16,359,717	1,453,923	9	1,071	<1	1	16,888	1	29	1,435,964	99	11,037	340
NSW	2,611,171	738,867	28	0	0	0	15,898	2	8	722,969	98	102	24
Qld	13,748,546	715,056	5	1,071	<1	1	990	<1	21	712,995	100	10,935	316
Darling (4)	11,258,100	581,135	5	0	0	0	130,730	22	140	450,405	78	2,983	121
Border and Moonie (Total) (5)	6,299,664	108,832	2	0	0	0	180	<1	14	108,652	100	8,457	191
NSW	2,463,285	60,949	2	0	0	0	180	<1	14	60,769	100	3,309	88
Qld	3,795,253	47,883	1	0	0	0	0	0	0	47,883	100	5,148	103
Gwydir (6)	2,659,603	58,907	2	0	0	0	115	<1	2	58,792	100	15,650	193
Namoi (7)	4,195,075	52,677	1	0	0	0	6,902	13	4	45,775	87	8,721	162
Castlereagh (8)	1,739,480	16,949	1	0	0	0	0	0	0	16,949	100	1,041	121
Macquarie-Bogan (9)	7,463,395	421,516	6	0	0	0	2,173	1	36	419,343	99	13,391	239
Lachlan (10)	9,064,850	471,011	5	0	0	0	25,217	5	24	445,794	95	7,769	163
Murrumbidgee (11)	8,152,712	277,369	3	0	0	0	14,436	5	33	262,933	95	18,526	337
Lake George (12)	94,069	13,018	14	0	0	0	12,923	99	3	95	1	57	3
Murray catchments [d]	5,081,152	372,717	7	800	<1	34	21,697	6	55	350,220	94	11,179	271
Upper Murray (Total) (13)	1,535,302	940	<1	0	0	0	3	<1	2	937	100	23,535	54
NSW	520,544	292	<1	0	0	0	1	<1	1	291	100	6,967	26
Vic	1,014,758	648	<1	0	0	0	2	<1	1	646	100	16,568	28
Murray-Riverina (14)	1,502,859	262,430	17	20	<1	1	2,360	1	8	260,050	99	3,468	85
Benanee (15)	2,129,292	63,834	3	0	0	0	3,615	6	13	60,219	94	0	0

Catchment Name [a]	Catchment	Total Wetland		Saline Lake			Freshwater Lake			Floodplain		Reservoir	
	Area	Area	% [b]	Area	%	No. [c]	Area	%	No. [c]	Area	%	Area	No. [c]
Lower Murray (Total) (16)	5,813,578	280,882	5	2,449	1	42	127,448	45	62	150,985	54	2,269	259
NSW	928,457	46,161	5	780	2	33	15,721	34	33	29,660	64	744	160
SA	4,885,121	234,721	5	1,669	1	9	111,727	48	29	121,325	52	1,525	99
Far north-west[e] (17)	6,543,731	274,322	4	8,344	3	51[f]	38,823	14	1,864[g]	227,155	83	511	160
Total of all wetlands[h]	66,580,816	4,318,302	6.5	18,518	0.4	218	295,805	6.9	2,204	4,003,979	92.7	84,416	1,898

[a]For Murray-Darling Basin catchments that extended across State borders, a catchment total including separate state portions (NSW – New South Wales, Qld – Queensland, Vic – Victoria, SA – South Australia) is given. For all other catchments areas are the NSW portions only

[b] Percentages of wetland area relative to total land area within the catchment

[c]Numbers of wetlands are counts of lakes, lagoons or reservoirs which may include more than one polygon

[d]All catchments in the Murray totalled

[e]Includes Lake Bancannia and NSW portions of Lake Frome, Cooper Creek and Bulloo River (see Fig. 1).

[f]50% of these wetlands are <5 ha (53 ha or 0.6% of wetland area).

[g]62% of these wetlands are <5 ha (2,836 ha or 1% of wetland area).

[h]Does not include parts of catchments within other States

Table 4. Areas (ha) of catchments, total wetlands, wetland groups and their proportions and reservoirs in coastal New South Wales. Percentage of total wetland area in each of the 22 coastal catchments (18-39, see Fig. 1) and numbers of discrete freshwater lakes, coastal lagoons, lakes and reservoirs. Percentages for Total wetland were relative to catchment land area and for wetland groups, relative to total wetland area.

Catchment Name	Catchment	Total Wetland		Freshwater Lake			Estuarine		Coastal lakes and lagoons			Floodplain		Reservoir	
	Area	Area	%[a]	Area	%	No.[b]	Area	%	Area	%	No.[b]	Area	%	Area	No.[b]
Tweed (18)	132,561	3,708	3	1	<1	1	3,439	93	199	5	3	69	2	263	43
Brunswick (19)	27,367	724	3	0	0	0	713	98	9	1	3	2	<1	14	2
Richmond (20)	703,082	9,072	1	45	<1	15	6,965	77	657	7	9	1,405	15	423	60
Clarence (21)	2,265,802	16,105	1	197	1	4	10,810	67	3,173	20	15	1,925	12	252	36
Bellinger (22)	305,264	4,592	2	0	0	0	3,988	87	409	9	13	195	4	78	46
Macleay (23)	1,140,210	4,965	0	34	1	3	2,882	58	642	13	8	1,407	28	337	61
Hastings (24)	448,394	8,383	2	54	1	2	4,553	54	3,693	44	12	83	1	92	20
Manning (25)	821,838	5,708	1	0	0	0	3,822	67	1,201	21	7	685	12	155	68
Karuah (26)	449,803	44,384	10	5	<1	3	25,822	58	18,424	42	11	133	<1	147	62
Hunter (27)	2,142,494	5,979	0	64	1	10	4,851	81	2	<1	1	1,062	18	8,632	270
Macquarie-Tuggerah Lakes (28)	183,225	22,768	12	20	<1	3	3,350	15	19,392	85	15	6	<1	203	41
Hawkesbury-Nepean (29)	2,181,872	15,841	1	1,086	7	10	13,674	86	0	0	0	1,081	7	10,084	303
Georges-Cook (30)	182,177	12,514	7	1	<1	1	12,158	97	336	3	5	19	<1	930	43
Illawarra-Port Hacking (31)	80,029	5,181	6	0	0	0	1,686	33	3,492	67	8	3	<1	39	13
Shoalhaven (32)	724,089	4,465	1	1	<1	1	3,001	67	690	15	3	773	17	1,247	30
Clyde (33)	328,449	13,060	4	0	0	0	6,414	49	6,633	51	22	13	<1	98	9
Deua (34)	149,543	804	1	0	0	0	513	64	291	36	10	0	0	5	4
Tuross (35)	215,890	3,717	2	4	<1	3	665	18	3,031	82	16	17	<1	3	4
Bega-Dry (36)	284,302	2,977	1	3	<1	3	687	23	2,271	76	24	16	1	174	25
Towamba (37)	216,600	2,144	1	9	<1	3	802	37	1,326	62	9	7	<1	27	6
Genoa (38)	111,352	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Snowy (39)	883,155	806	0	403	50	28	0	0	0	0	0	403	50	13,855	12
Total of all wetlands	13,977,498	187,897	1.3	1,927	1	90	110,795	59	65,871	35	194	9,304	5	37,058	1,158

[a]Percentages of wetland area relative to total land area within the catchment

[b]Numbers of wetlands are counts of lakes, lagoons or reservoirs which may include more than one polygon

The highest proportion of wetlands in NSW were in two catchments, Warrego and Condamine-Culgoa, with 27% and 28% of their respective areas covered by wetlands but this only applied to the NSW part of the catchment (Table 3). The Condamine-Culgoa had the highest wetland area of any catchment in inland New South Wales, covering about 740,000 ha (Table 3). The Paroo and Murray-Riverina catchments had the next highest proportion of wetland with 16% and 17% of land area covered respectively. Nine of the 17 catchments in NSW had more than 200,000 ha of wetland and the remainder of the catchments had less than 100,000 ha of wetland (Table 3). Most catchments with lower areas of wetland also had a low proportion of wetlands, apart from Lake George catchment, which ranked fifth, in terms of wetland proportion. Twelve of the 17 catchments each had 6% or less of wetland area in their catchment (Table 3). These included most of the major regulated rivers: Darling, Border and Moonie, Gwydir, Namoi, Macquarie-Bogan, Lachlan, Murrumbidgee, Upper Murray and Lower Murray (Table 3). The Murray River and its tributaries flow through four of the catchments (Table 3). The Murray-Riverina catchment included most of the floodplain of this river and when all catchments of the Murray River were combined, the proportion (7%) was similar to that of other regulated river catchments (Table 3). Seven of the inland catchments cross over into another state. Data were available for all of the catchments (six) within the Murray-Darling Basin (Table 3). Most of the wetland area and higher proportions in the Paroo, Warrego and Condamine-Culgoa were on the New South Wales side of the border whereas there were similar proportions for the Lower Murray River catchments and the Border and Moonie Rivers on both sides of the border (Table 3).

Floodplain wetlands were the dominant wetland type in most inland catchments (Table 3). There was more than 70% of wetland area identified as floodplain in all but two of the catchments and, in twelve catchments (Paroo, Warrego, Condamine-Culgoa, Border and Moonie, Gwydir, Castlereagh, Macquarie-Bogan, Lachlan, Murrumbidgee, Upper-Murray, Murray-Riverina and Benanee), there was more than 90% floodplain wetland (Table 3). The Lake George and Upper Murray catchments had little floodplain wetland (Table 3). Two catchments had more than half a million hectares of floodplain wetland in New South Wales, Paroo and Condamine-Culgoa, while another seven each had more than 200,000 ha of floodplain in New South Wales (Warrego, Darling, Macquarie-Bogan, Lachlan, Murrumbidgee, Murray-Riverina, Far north-west).

The Darling catchment had the greatest area of freshwater lakes (130,730 ha) of any inland catchment, primarily the Menindee Lakes, and the Far north-west had an order of magnitude more in the number of freshwater lakes (1,864), although 60% were less than five hectares (Table 3). Freshwater lake area exceeded 10,000 ha in each of seven other catchments: Paroo, Condamine-Culgoa, Lachlan, Murrumbidgee, Lake George, Lower Murray and Far north-west. Nearly all wetland area in the Lake George catchment was freshwater lake (99%). Other catchments with less than 10% of their wetland areas as freshwater lakes were Far north-west, Lower Murray, Darling and Namoi. In contrast, the Castlereagh, Murray-Riverina, Upper Murray, Macquarie, Gwydir, Border and Warrego had little (<1%) or no freshwater lake area.

Saline lakes covered 0.02 % of the state (Table 2) and they were only present in five inland catchments, Far north-west, Paroo, Warrego, Murray-Riverina and Lower Murray (Table 3). The Paroo River catchment had almost half the number of saline lakes and, with the Far north-west, these two catchments covered 93% of all saline lake area in New South Wales (Table 3).

2.2.3 Coastal wetlands

There were about 188,000 ha of wetland in coastal New South Wales, 1.3% of the coastal land area (Table 2). Estuarine wetlands (59%) and coastal lagoons and lakes (35%) dominated the coastal wetlands (Table 4) with much smaller areas of floodplain wetlands and freshwater lakes (Table 2). 98% of wetlands were below 250 m above sea level, although this area was only 41% of coastal catchments (Fig. 4a). In contrast to inland catchments, rainfall on the coast was much higher and so coastal wetlands were more wide spread across the different climatic zones (Fig. 4b).

The highest wetland proportion (12%), relative to land area, was in the Macquarie-Tuggerah Lakes catchment (Table 4) with >5% proportion in the Karuah, Georges-Cooks and Illawarra-Port Hacking catchments (Table 4). Two catchments, Macquarie-Tuggerah Lakes and Karuah, had more than 20,000 ha of wetland area and another four catchments had more than 10,000 ha of wetland area: Clarence, Hawkesbury-Nepean, Georges-Cooks and Clyde. In contrast, the Snowy, Deua and Brunswick catchments had less than 1,000 ha of wetland area in NSW, while the Genoa catchment had none in NSW (Table 4).

In 14 of the 22 coastal catchments estuarine wetlands accounted for 50% or more of the wetlands in the catchment, and more than 80% in six of these catchments (Table 4). The Snowy and Genoa catchments in NSW do not open to the sea and so had no estuarine wetlands (Fig. 3).

There were 194 coastal lagoons and lakes (Table 4). Clyde (22) and Bega-Dry (24) had more coastal lagoons and lakes than other coastal catchments with another seven catchments with 10 or more coastal lagoons and lakes: Clarence, Bellinger, Hastings, Karuah, Macquarie-

Tuggerah, Deua, and Tuross (Table 4). Coastal lagoons and lakes ranked second in terms of area in most coastal catchments to estuarine areas (Table 4). There were two catchments with most of the area of coastal lagoons and lakes, Karuah and Macquarie-Tuggerah (Table 4) and they represented more than 60% of wetland area in Macquarie-Tuggerah Lakes, Illawarra-Port Hacking, Tuross and Bega-Dry wetlands.

Floodplain wetlands ranked lowest in wetland area in most coastal catchments, accounting for only 5% of wetland area (Table 4). Floodplain wetlands were proportionally greater than 10% in the Richmond, Clarence, Macleay, Manning, Hunter and Shoalhaven (Table 4). Floodplain wetlands did not occur in Deua and Genoa catchments and in all other coastal catchments accounted for less than 10% of wetlands (Table 4).

Compared to inland, there were few freshwater lakes in the coastal catchments and they covered a small part of the land area (Table 2). The Snowy catchment had the largest number of freshwater lakes, while only three other catchments had ten or more: Richmond, Hunter and Hawkesbury-Nepean (Table 4). In seven coastal catchments there were no freshwater lakes mapped (Table 4).

2.2.4 Accuracy Assessment

For inland NSW we assessed accuracy of image analyses in the Paroo and Warrego River catchments (Kingsford *et al.* 2001), the overall accuracy was 86% with a Kappa statistic of 0.76.

For coastal catchments, the overall accuracy of Landsat TM imagery for the Richmond catchment at the subgroup level was 80% with a Kappa statistic of 0.66 (Appendix 2). For the Landsat MSS imagery analysis of the Richmond catchment, the overall accuracy was 65% with a Kappa statistic of 0.33 (Appendix 2). The accuracy of the north coast mapping (the Tweed catchment in the north to the Macquarie-Tuggerah Lakes catchment in the south) was 85% with a Kappa statistic of 0.80 (Appendix 2). The overall accuracy of the south coast mapping was 90%, and the Kappa statistic was 0.87 (Appendix 2).

2.3 Discussion

2.3.1 Wetland mapping and classification

All mapping of natural resources, including wetlands, has limitations on its interpretation governed by the methodology. It is a static spatial coverage that does not reflect the considerable variability of flooding and drying patterns of wetland systems (Roshier *et al.* 2001). This coverage primarily provided an estimate of current wetland extent and cannot be used to determine extent of wetland loss with a temporal component except if comparisons are made over time or possibly catchments. The scale of resolution limits the number of small wetlands that could be identified. Landsat MSS and TM imagery have spatial resolutions (pixel size) of about 80 m and 30 m respectively (Richards 1993). This means that the wetland coverage for the whole State effectively translates to a map resolution of 1:250,000 while the coastal mapping can be used at a scale of 1:100,000 (Richards 1993). This wetland data layer will be useful for catchment scale analyses but should not be used for property planning.

Potential errors related primarily to misclassification of wetlands as non-wetland areas and vice versa because spectral reflectance varied with the landscape, and misclassification among wetland groups (Table 1). Accuracy assessments for our image analyses were generally high (>80%) with Kappa statistics > 0.66 (Appendix 2). Most errors were due to misclassification of non-wetland polygons as floodplain wetlands, probably on the interface between floodplain and non-wetland (Kingsford and Thomas 2002). Occasionally dense vegetation along dry creek beds was classified as floodplain wetlands and farm dams and reservoirs were classified as floodplain wetlands because they had been constructed in creek lines. Ancillary data sets limited this source of error, which was primarily confined to small wetland areas. We were confident that we mapped all major wetland areas previously identified in the State (e.g. EA 2001; Crabb 1997; Seddon *et al.* 1997).

Wetland classification has similar limitations to all ecological classifications (Pressey and Adam 1995; Finlayson *et al.* 1999) because it represents our attempts to categorise considerable hydrological, ecological and geomorphological variability, at different spatial and temporal scales. The most robust classifications are usually those that are not severely impacted by spatial and temporal variation. Difficulties encountered trying to differentiate types of wetland meant that we adopted a coarse classification system, that included most wetlands under the Ramsar definition (Finlayson *et al*. 1999). This was because availability of ancillary data varied over the landscape. For example, information for inland floodplains (e.g. vegetation communities) was patchy. Similarly, in some estuarine areas, there was sufficient ancillary information to separate different vegetation communities (e.g. salt marsh, mangroves) but this could not be sustained over all coastal areas.

3.0 GIS analyses of wetland conservation and threats

3.0.1 Conservation measures

Most conservation measures currently available for wetlands focus on patches of land and this remains the focus of most conservation effort. There are five land conservation measures: National Parks and Wildlife Service reserves, State Forests, State Environmental

Planning Policy No. 14 (SEPP 14) for coastal wetlands (Farrier *et al.* 1999), the Directory of Important Wetlands in Australia (DIWA) (EA 2001) and listing of wetlands of international importance under the Ramsar Convention (Davis 1994). Of these, the aim of State Forest is primarily for timber production, as well as conservation of ecosystems (e.g Flora Reserves), viability of such areas remains contingent on water and so these areas have become 'quasi' conservation areas for wetlands (e.g. Barmah-Millewa Forest, Leslie 2001).

3.1 Methods

3.1.1 Wetland Analyses

We used GIS analyses to determine the area of wetlands and reservoirs protected under five measures of conservation. The wetland coverage for each catchment was clipped in Arc/Info (ESRI® 2000), using the relevant digital boundaries for conservation measures (NPWS 2002a; State Forests 2002; Planning NSW 2002; EA 2000) (Appendix 1). Wetlands listed in the DIWA (EA 2001) were identified on the statewide wetland coverage.

Water resource development is a major threat to wetlands (Kingsford 2000; Lemly *et al.* 2000) and catchment data were collated on the proportion of intensive agriculture (National Land and Water Audit 2001a), data for the number of weirs (DLWC 2001) and storage capacity of dams (Kingsford 1995; National Land and Water Audit 2001b) within each of the catchments.

3.2 Results

3.2.1 Conservation measures

Less than one percent of the State's wetland area was listed as internationally significant (Ramsar Convention), while 3% was part of National Parks and Wildlife Service (NPWS) reserves and 21% of the State's wetland area was of national importance (DIWA) (Table 2; Fig. 5). There were three percent of the State's wetlands in State Forests (mostly inland) and 0.7% protected under SEPP 14 (Table 2). The largest area of Ramsar listed wetland was in the Macquarie catchment. The largest areas of wetlands in NPWS reserves were in inland catchments but the greatest proportion of wetlands were reserved in coastal catchments (Table 2).

Despite 96% of wetlands occurring in inland catchments, only 0.5% of this area was Ramsar listed and only 2.4% of this area in NPWS reserves, with more wetland area (3.2%) in State Forests even though 20% was defined as nationally important (DIWA) (Table 2). There were Ramsar listed wetland areas in four catchments, Condamine-Culgoa, Gwydir, Macquarie-Bogan and Far north-west, with the latter two covering the more extensive areas (Table 5). The highest proportions of wetland areas in NPWS reserves were in the Darling (5%), Paroo (4%), Macquarie-Bogan (4%) and Condamine-Culgoa (3%), which corresponded to the larger areas reserved (Table 5). Another three catchments Warrego, Lachlan, and Far north-west, had more than 3,000 ha reserved but most catchments had few areas of wetland reserved and the Namoi and Lake George had no reserved wetland (Table 5). Most wetland area in State Forests (14-31%) was in the Murray-Riverina, Benanee and Lower Murray catchments (Table 5). There were three catchments, Macquarie, Lake George and Murray-Riverina, with more than 50% of the wetland area listed as nationally

Table 5. Areas (ha) of wetland covered by different land conservation measures (NPWS, State Forests, DIWA, Ramsar) in each of the 17 inland catchments in New South Wales (1-17, see Fig 1) and major threats in terms of water resource development and area covered by intensive agriculture. Percentages were relative to total wetland area within a catchment.

	Land Conservation Measure[a]								Threat		
Catchment	NPWS		State Forests		DIWA[b]		Ramsar		Intensive	Number of	Storage capacity
	Area	%	Area	%	Area	%	Area	%	Agriculture[c]	weirs	($\times 10^3$ML)[d]
Paroo (1)	26,605	4	0	0	181,962	27	0	0	0.04	16	0
Warrego (2)	3,036	1	0	0	1,095	0	0	0	0.8	42	0
Condamine-Culgoa (3)	18,527	3	0	0	37,716	5	3,161	<1	10.4	27	0
Darling (4)	29,237	5	0	0	82,755	14	0	0	0.6	9	1,896
Border (Moonie)[e] (5)	0	0	0	0	0	0	0	0	22.2(14.6)	67	568
Gwydir (6)	82	<1	0	0	28,304	48	708	1	25.7	71	1,368
Namoi (7)	0	0	0	0	6,776	13	0	0	19.9	111	880
Castlereagh (8)	0	0	0	0	0	0	0	0	20.0	37	14
Macquarie (9)	15,183	4	125	0	218,326	52	15,743	4	25.8	332	1,716
Lachlan (10)	3,268	<1	5,766	1	78,584	17	0	0	22.9	323	1,482
Murrumbidgee (11)	146	<1	14,676	5	7,481	3	0	0	25.9	339	4,206
Lake George (12)	0	0	0	0	12,833	99	0	0	15.4	-	-
Murray catchments	903	<1	116,549	31	150,863	40	0	0		118	6,613
Upper Murray (13)	0	0	0	0	0	0	0	0	8.4	15	5,652
Riverina (14)	0	0	95,725	36	148,879	57	0	0	30.1	101	206
Benanee (15)	903	1	14,223	22	1,964	3	0	0	2.2	2	75
Lower Murray (16)	0	0	6,601	14	20	<1	0	0	9.3	0	680
Far north-west (Lake Bancannia)[e] (17)	6,648	2	0	0	34,982	13	240	<1	0.05(0)	12	8
Total	103,635	2.4	137,116	3.2	841,677	19.5	19,852	<1		1,504	18,751

[a] Conservation measure areas are mutually inclusive
[b] Directory of Important Wetlands in Australia (2001)
[c] National Land and Water Resources Audit (2001b) for catchments that cross the New South Wales border, proportions included areas outside the state border.
[d] Derived from Kingsford (1995) and National Land and Water Resources Audit (2001c) and where storage capacities differed, the larger storage capacity was used. Interstate catchments storage capacities included areas outside New South Wales.
[e] Separate estimates for agricultural land proportion only in parentheses

important (DIWA) and a further two, Paroo and Gwydir, with 20-50% of the wetland area listed (Table 5). Most other catchments had relatively low areas of wetlands of national importance. The largest areas (>30 000 ha) of inland wetlands listed in the DIWA were in the Macquarie, Paroo, Murray-Riverina, Darling, Lachlan, Condamine-Culgoa and Far north-west catchments. The Border-Moonie and Castlereagh catchments had no wetlands with conservation measures (Table 5).

Wetlands on the coast, representing only 4% of the state's wetland area had areas of nearly 8% Ramsar listed, 17.5% in NPWS reserves, almost 50% in the DIWA and 17% under SEPP 14 (Table 2). There was little wetland area (0.2%) in State Forests on the coast. Five coastal catchments had Ramsar listed wetland area: Clarence, Karuah, Hunter, Georges-Cook and Snowy (Table 6). Most of this wetland area was in the Karuah (75%) and the Hunter (22%) (Table 6). In all coastal catchments with wetland, a proportion of wetland area was in NPWS reserves (Table 6). The Hunter catchment (57%) had the highest proportion of wetlands in NPWS reserves. The Brunswick, Richmond, Hastings, Manning, Karuah, Towamba and Snowy had more than 20% of their wetlands reserved and the Tweed, Bellinger, Macleay, Shoalhaven, Tuross had 10-20% of their wetlands reserved (Table 6). There was variable coverage of SEPP 14 in each of the coastal catchments (Table 6). Tweed, Brunswick, Richmond, Bellinger, Macleay, Hastings, Manning, Karuah, Hunter, Shoalhaven, Deua, Bega-Dry and Towamba had 20-47% of their wetland area under SEPP 14 (Table 6). The larger areas (>5,000 ha) listed in the DIWA were in the Clarence, Karuah, Macquarie-Tuggerah, and Clyde (Table 6). The Macleay, Karuah, Hunter, Illawarra-Hacking and Shoalhaven catchments had about 50% or more of their wetland area listed in the DIWA (Table 6). No wetland area in Bellinger were in DIWA.

Table 6. Areas (ha) of wetland covered by different conservation land measures (NPWS, State Forests, SEPP14, DIWA, Ramsar,) in each of the 22 coastal catchments in New South Wales (18-39, see Fig 1) and major threats in terms of water resource development and area covered by intensive agriculture. Percentages were relative to total wetland area within a catchment.

	Conservation Land Measure[a]										Threat		
Catchment	NPWS		State Forests		SEPP 14[b]		DIWA[c]		Ramsar		Intensive	Number of	Storage capacity
	Area	%	Area	%	Area	%	Area	%	Area	%	Agriculture[d]	weirs	($\times 10^3$ML)[e]
Tweed (18)	689	19	0	0	841	23	853	23	0	0	22.8	36	17
Brunswick (19)	171	24	0	0	294	41	0	0	0	0	30.8	7	0
Richmond (20)	2,370	26	62	1	3,506	39	1,787	20	0	0	9.9	188	34
Clarence (21)	1,399	9	0	0	1,943	12	11,502	71	59	<1	5.1	106	7
Bellinger (22)	556	12	45	1	1,513	33	0	0	0	0	11.9	23	0
Macleay (23)	904	18	34	1	1,430	29	2,452	49	0	0	14.3	42	19
Hastings (24)	3,527	42	0	0	3,333	40	2,975	35	0	0	3.7	48	2
Manning (25)	1,147	20	0	0	2,134	37	1,758	31	0	0	6.1	27	4
Karuah (26)	12,973	29	170	<1	8,962	20	35,249	79	11,224	25	6.6	11	0
Hunter (27)	3,388	57	0	0	2,807	47	3,873	65	3,099	52	12.1	123	1,670
Macquarie-Tuggerah Lakes (28)	168	1	0	0	691	3	9,516	42	0	0	34.0	49	89
Hawkesbury-Nepean (29)	1,494	9	0	0	98	1	1,069	7	0	0	19.0	444	2,929
Georges-Cook (30)	443	4	0	0	0	0	974	8	400	3	8.5	47	124
Illawarra-Port Hacking (31)	132	3	0	0	225	4	3,702	71	0	0	23.1	25	1
Shoalhaven (32)	819	18	0	0	1,129	25	3,486	78	0	0	13.7	48	178
Clyde (33)	981	8	0	0	1,448	11	9,223	71	0	0	1.6	15	7
Deua (34)	61	8	0	0	285	35	76	9	0	0	3.5	6	5
Tuross (35)	571	15	21	1	341	9	1,126	30	0	0	7.5	8	0
Bega-Dry (36)	161	5	30	1	543	18	1,324	44	0	0	9.1	56	16
Towamba (37)	639	30	0	0	509	24	1,023	48	0	0	1.6	5	0
Genoa (38)	0	0	0	0	0	0	0	0	0	0	1.5	0	0
Snowy (39)	271	34	0	0	0	0	343	43	41	5	11.8	24	5,494
Total of all wetlands	32,864	17.5	362	0.2	32,032	17.0	92,311	49.1	14,823	7.9		1338	10,596

[a] Conservation measure areas are mutually inclusive

[b] State Environmental Planning Policy 14

[c] A Directory of Important Wetlands in Australia (EA 2001)

[d] National Land and Water Resources Audit (2001b)

[e] Derived from Kingsford (1995) and National Land and Water Resources Audit (2001) and where storage capacities differed, the larger storage capacity was used.

3.2.2 Water resource development and intensive agriculture

Nine of the 17 inland catchments had more than 10% of their catchment area used for intensive agriculture (Table 5) and four catchments (Far north-west, Paroo, Warrego and Darling), in the northwest of the State, had less than one percent of their land area utilised by intensive agriculture. Of the inland catchments the Murray-Riverina, Gwydir, Macquarie-Bogan, Murrumbidgee, Lachlan and Border catchments had more than 20% of their catchment area used for agriculture. On the coast, Macquarie-Tuggerah Lakes, Brunswick, Illawarra-Port Hacking and Tweed catchments all had more than 20% of their catchment area used for agriculture (Table 6).

The potential capacity of dams across the State was 29,347,000 ML and inland catchments accounted for 64% of this capacity (Tables 5 and 6). Nine catchments had storage capacities greater than 1,000,000 ML; Upper Murray, Murrumbidgee, Darling, Macquarie, Lachlan, Gwydir, Snowy, Hawkesbury-Nepean and Hunter (Tables 5 and 6). The Far north-west, Castlereagh, Illawarra-Port Hacking, Hastings, Manning and Deua catchments had low storage capacities, compared to other catchments. The Paroo, Warrego, Condamine-Culgoa, Brunswick, Bellinger, Karuah, Tuross, Towamba and Genoa catchments had no storage capacity (Tables 5 and 6).

The Macquarie, Lachlan, Murrumbidgee and Hawkesbury- Nepean catchments had more than 300 weirs, while the Murray-Riverina, Namoi, Richmond, Hunter, and Clarence, had more than 100 (Tables 5 and 6). The Lower Murray and Genoa catchments had no weirs and the Upper Murray, Darling, Paroo, Far north-west, Towamba, Tuross, Deua, Brunswick, Benanee, and had less than 20 each (Tables 5 and 6).

3.3 Discussion

3.3.1 Wetland distribution

Australia is a continent without a reasonable estimate for wetland area (Watkins 1999; Finlayson *et al.* 1999). An estimate of 1.5 million ha of wetland for Australia and New Zealand left out inland floodplains because they were ephemeral and impacted by agriculture (Aselmann and Crutzen 1989). Although Paijmans *et al*. (1985) estimated a total of 37,560 wetlands of 13 different types, no continental estimate was given and this analysis included some lakes that were extinct (e.g. Willandra Lakes). Cumulative area of 851 wetland sites in Australia, listed as nationally important, amounts to about 58 million hectares (EA 2001) but this includes substantial land areas (e.g. 84% of Kakadu site in northern Australia; Coongie Lakes, Paroo overflow) (Watkins 1999). Our study provided an opportunity to estimate wetland coverage on the continent. New South Wales is about 10% of the continent and includes a cross-section of coastal and arid parts of temperate Australia, and five of the twelve river basins on the continent (AWRC 1987; Pressey and Adam 1995) but we did not have any tropical regions. There were estimates of wetland area for coastal and inland regions (Table 2), including estimates for the Murray-Darling Basin (Kingsford *et al.* 1999c) and the Far north-west of New South Wales (Fig. 1; Table 3).

Using area estimates for the 12 river basins (AWRC 1987; Kingsford 2000a), Australia could have about 34 million ha of wetland or about 4% of the continent, given some assumptions. Wetland proportion (ratio of wetland area to land area) is one percent for the six coastal river basins (South-East Coast, North-East Coast, Tasmania, South Australian Gulf, South-West Coast and Indian Ocean), reflecting wetland proportion within coastal New South Wales (Table 4) and distribution of wetlands in relation to elevation (Fig. 4a). The proportional estimate of about 2.7% (692,000 ha) for the State of Victoria (Hull 1996), including coastal areas and large inland areas, provides support for this assumption (Table 2). The Western Plateau river basin is arid, has low run-off and few rivers (AWRC 1987) and so was assumed to have a wetland proportion of one percent. The Lake Eyre Basin was assumed conservatively to have 10% wetland proportion, based on data for other unregulated desert river systems within the Murray-Darling Basin (Kingsford *et al.* 2001) and its major river systems and wetlands (Kingsford *et al.* 1999c; Puckridge *et al.* 2000; Roshier *et al*. 2001; Timms 2001). There are large floodplains and wetland areas in the two remaining river basins in the tropics (Timor Sea, Gulf of Carpentaria) and these were assumed to have a similar conservative wetland estimate of 10%. Our estimate for wetland area on the continent did not include peatlands, mound springs, karsts, or coral reefs. Apart from the latter two, these are unlikely to contribute much further to total wetland area, although significant in their own right, as they cover a relatively small area (Rieley *et al.* 1996). Substantial karst areas exist under the Nullabor Plain. Alternatively, if the extent of wetland area were similar across the continent to New South Wales (i.e. 6%), then 46 million ha of Australia would be covered by wetlands. These estimates are 30-50% higher than the estimate used for Australia to determine minimum wetland extent (Finlayson *et al.* 1999) and this is because few global or national studies of wetlands in Australia have adequately identified the extent of temporary inland floodplains. For a complete picture of wetlands across the continent, equivalent data are needed for other States or river basins.

As the driest inhabited continent, Australia and New South Wales probably have one of the lowest wetland areas or proportions of wetland to land area. There are estimates of wetland area for most parts of the world: 229 million ha for Eastern Europe (Stevenson and Frazier 1999), 152 million ha for South America and 154,000 ha for Europe (Aselmann and Crutzen 1989). Proportions of wetlands to land area range from 20% in Canada's northern region, 11.8% for Eastern Europe (Stevenson and Frazier 1999) to about 1.3% in the Middle East (Frazier and Stevenson 1999).

Reflecting our low rainfall and the distribution of wetlands in low rainfall areas (Fig. 4b), New South Wales has relatively few lakes. In North America where comparative data exist, floodplain and riverine wetlands comprise about 70%, lakes about 14% (not including the Great Lakes) and estuarine areas about 15% of wetlands of land area (United States Fish and Wildlife Service 1998 data in Davidson *et al.* 1999). The proportion of lakes is about double that found in New South Wales where most wetland areas were floodplains (Table 2). In a study of lakes in part of inland NSW, Seddon and Briggs (1998) estimated 567 lakes, lower than our estimate (2,204), covering 615,634 ha, considerably higher than ours (295,805 ha) (Table 2). But, their work included lakes greater than 100 ha, a slightly smaller area of inland New South Wales and the large extinct lakes of Willandra boosting the area estimate (Seddon and Briggs 1998). Freshwater lakes occurred in many different catchments but the distribution of salt lakes was polarised towards the most arid regions of the State. Most saline lakes were in the Paroo and Far north-west catchments (Table 3).

In contrast to inland areas, there was little floodplain wetland area on the coast where most wetland was estuarine (Tables 2 and 3). Although there were more catchments on the coast of New South Wales occupying about 17% of the land area, the coastal region only had about 4% of the wetland area of the State's wetlands (Table 2; Fig. 3). Four main factors probably contributed to this distribution. First, coastal catchments are considerably smaller than inland catchments (Fig. 1) and, second, much of the land in coastal catchments (about 60%) is 250 m above sea level, compared to less than 30% in inland catchments (Fig. 4a). Most wetlands in New South Wales occur below 250 m above sea level, primarily because water is likely to run-off elevated areas and not form wetlands. Third, most (96%) of the mean annual run-off from rivers on the south-east coast flow out to sea, compared to only 24% of the flow in the Murray-Darling Basin which covers much of inland New South Wales (National Land and Water Audit 2001b). Finally, urbanisation, draining and modification of flow patterns on coastal rivers in New South Wales have significantly impacted on dependent wetlands, including floodplains (Goodrick 1970; Pressey and Middleton 1982; Pressey 1989; Pressey and Harris 1988; Pressey 1993).

3.3.2 Wetland loss and threatening processes

Wetland loss is difficult to estimate because of the problems of spatial and temporal variability, usually necessitating temporal analyses over a number of years (Kingsford and Thomas 2002). This difficulty is exacerbated when attempting estimates over large spatial scales but such data are often needed for policy and management. Most wetland loss in inland Australia is due to water resource development (Kingsford 2000). Using wetland proportion of 10.4% for the three catchments not affected by river regulation and water resource development (Far north-west, Paroo, Warrego) compared to the rest of New South Wales, we estimate that about 40% of wetland area in inland New South Wales may have disappeared. This is likely to be conservative because it does not account for small wetlands destroyed by cultivation or wetlands affected by altered flow regimes.

Most of the key threats to wetlands around the world are well known (Allan and Flecker 1993; Lemly *et al*. 2000) and many parts of the world have experienced significant reductions in wetland areas as a result of these processes. Most threats are anthropogenic and, of these, development of water resources, including dam building, diversion and floodplain development (Kingsford 2000a; Lemly *et al.* 2000) is probably the most deleterious and pervasive. About 89% of all surface water used in New South Wales (9,000,000 ML in 1996/97) was for irrigation and this increased by 52% in the period between 1983/84 and 1996/97 (National Land and Water Audit 2001b). Collation of data on water resource development and intensive agriculture provided some indication of which wetlands were most likely to be affected in each of the catchments in New South Wales (Tables 5 and 6).

Generally, catchments with a high storage capacity of dams and high percentages of intensive agricultural activity had a low proportions of wetlands and conversely catchments with few dams had the higher proportions of wetlands (Tables 5 and 6). There was a disproportionate distribution of wetlands in the northwest of New South Wales (Fig. 3; Table 3). Just four of the catchments (Paroo, Warrego, Far north-west, Condamine-Culgoa), covering about 18% of the land surface in the state, had about 46% of the wetlands (Fig. 3; Table 3). Of these, the three most western river catchments have little water resource development or agricultural development (Table 5) as most of their areas are used for rangeland grazing. There is good evidence of an inverse relationship between water resource development and wetland area (Lemly *et al.* 1999; Kingsford 2000a). The Condamine-Culgoa has undergone considerable water resource development during the 1990s (Kingsford 2000b; Sheldon *et al.* 2000; McGinness and Thoms in press). The satellite imagery used for mapping the wetlands of the Condamine-Culgoa catchment were of the 1990 flood and so much of the recent water resource development is unlikely to be reflected in the distribution of wetlands in this catchment. Modelling indicates a 50% reduction in median annual flows (Sheldon *et al.* 2000) and a 75% reduction at the terminal wetland system of Narran Lakes (DNR 2000). Given current water resource development in this catchment, perhaps as much as half of the floodplain wetland identified in New South Wales (i.e. about 350,000 ha) may degrade over the next fifty years with floodplain vegetation replaced by terrestrial vegetation (Kingsford 2000a,b). The Castlereagh catchment was an exception, with relatively little water resource development (29,000 ML diverted in 1983-84; AWRC 1987) and little wetland area (Table 3). It is not a major river system and it has a mean annual flow that is about one fifth or less of the other major rivers in the Murray-Darling Basin (AWRC 1987). The Lake George catchment was another catchment with reasonably high wetland proportion (Table 3). It is an endorheic basin where river flows fill one large lake (Lake George) and it has little water resource development.

Most major regulated rivers (Murray, Murrumbidgee, Lachlan, Macquarie, Namoi, Gwydir, Border Rivers) had a significant amount of potential storage capacity and about 20% or more of their catchments under intensive agriculture. Many of the wetland areas on these major floodplain rivers have reduced in area as a result (Kingsford 2000a, b). Arguably the Snowy River was the most impacted catchment in New South Wales with a storage capacity that was only rivalled by the Upper Murray River (Tables 5 and 6). Until recently, about 99% of the flows in the Snowy River were diverted westward through the Snowy Mountains Scheme to the Murrumbidgee and Murray Rivers (Bevitt *et al.* 1998).

Anthropogenic threats to wetlands in coastal New South Wales come primarily from drainage and alteration of particularly the floodplain through agricultural development (Pressey and Middleton 1982; Pressey and Harris 1988; Pressey 1993) or urbanisation (Adam 1995). Ten of the 22 coastal catchments had more than 10% of their area under intensive agriculture. This was probably the main factor responsible for wetland loss and degradation on the coast (Goodrick 1970; Pressey 1993). Major populations such as Sydney in the Hawkesbury-Nepean and Georges-Cooks, Newcastle in the Hunter and Wollongong in the Shoalhaven also have large water resource developments (Table 6) that may reduce wetland flooding on the floodplains of these rivers. But the influence of major urban centres through provision of food and transport is likely to be much more widespread (Adam 1995). For most other catchments in New South Wales, urban development is unlikely to be a serious threat to wetlands because it is relatively sparse (Tables 5 and 6). About 83% of the continent's 19.3 million people are concentrated within 50 km of the coast (Newton *et al.* 2001).

3.3.3 Wetland conservation

The main pillar for conservation of wetlands has been traditionally site based (Amezaga *et al.* 2002), such as National Parks and Wildlife Service (NPWS) reserves. This site-based approach is also used to list wetlands of international importance under the Ramsar Convention, SEPP 14 or wetlands of national importance (DIWA) (Tables 2 and 5). About 3% of the 4.50 million ha of wetland in New South Wales is in NPWS reserves (Table 2) and this means wetland systems are under represented in reserves which cover about 7.2% of the land in New South Wales (NPWS 2002a). Reserved wetlands are also likely to be a biased sample of the biodiversity (Margules and Pressey 2000). There are now 186 sites listed as nationally important in NSW (EA 2001), covering 933,988 ha (Table 2). This estimate varies considerably from that held by the Commonwealth for the same sites (2,335,356 ha) (EA 2001), probably because of the inclusion of land areas (Watkins 1999) in the latter estimate.

The figure for reserved area varied across the State with a disproportionate amount of wetland area protected on the coast, compared to inland New South Wales (Tables 2, 5 and 6). As with other parts of the world (La Peyre *et al.* 2000), planning and protection measures were better on the coast of New South Wales, where there was more knowledge with planning policies and high relative measures of conservation. There is good site based reservation of wetlands in coastal catchments with many catchments having between 10% and 60% (Karuah) of their wetlands reserved (Table 6) and these catchments are also well covered by lists of wetlands of national importance (Tables 2 and 6).

Reservation of sites will not adequately protect biodiversity (Margules and Pressey 2000) and effective conservation of wetlands will only occur if there is integration of river management planning and wetland conservation (Kingsford *et al.* 1998; Amezaga *et al.* 2002). The primary objective of developing a digital wetland data layer for the state of New South Wales was to influence land and water management planning to produce more effective conservation. This information can help management authorities determine priorities for wetland conservation at different spatial scales (e.g. catchment, State). Lack of data for the distribution and extent of wetlands has hampered effective wetland conservation in New South Wales (Pressey and Harris 1988) and around Australia (Lane and McComb 1988; Watkins 1999).

An effective foundation of wetland distribution and abundance allows assessment of developments, potentially affecting wetlands, against relative importance of a wetland at catchment or statewide scale. So, the concentration of wetlands in the northwest of New South Wales should ensure that this area receives the primary focus for wetland conservation. Catchment management bodies and river management authorities can use the wetland data to determine which wetlands exist within their catchment and may be affected by consumptive water use and other threats.

4.0 Conclusions

Wetlands are among the more diverse ecosystems in the world but many have disappeared or been affected by anthropogenic impacts. There are many processes of catchment management that can affect wetlands and floodplains but management of these processes to mitigate their impacts can be difficult if the distribution and extent of wetlands is not known.

This analysis of wetland extent, distribution and conservation can be an important tool for good catchment, river and wetland management and conservation throughout New South Wales. Statewide priorities can be set for wetland conservation and management. Within catchments, wetland areas and potential threatening processes can be identified so that management can be targeted to mitigate these impacts. The wetland distribution can be used as a stratification tool for investigations of the distribution of other fauna and flora groups that depend on wetlands and could provide a basis for future analysis of wetland loss. Such wetland information at a national level would allow similar priority setting for wetland conservation across the continent. But, this is not a panacea, as with all natural resource management, further loss of wetlands can only be avoided with political, community and bureaucratic commitment to their conservation. Understanding and management of threats at different spatial scales remains the key.

Acknowledgements

Funding to map coastal wetlands and far west of New South Wales was provided through the Natural Heritage Trust Fund and funding to map wetlands in the Murray-Darling Basin was provided by the Murray-Darling Basin Commission and New South Wales National Parks and Wildlife Service. We thank Paul Adam and Bob Pressey for comments that improved this manuscript. We thank the National Land and Water Resources Audit for use of their data.

References

Adam, P. (1992). Wetlands and wetland boundaries: problems, expectations, perceptions and reality. *Wetlands (Australia)* **11**, 60-67.

Adam, P. (1995). Urbanization and transport. In 'Conserving Biodiversity: Threats and Solutions'. (Eds Bradstock, R., Auld, T.D, Keith, D.A., Kingsford, R.T., Lunney, D. and Sivertsen, D.) pp. 55-75. (Surrey Beatty and Sons, Sydney.)

Allan, J. D., and Flecker, A. S. (1993). Biodiversity conservation in running waters. *BioScience* **43**, 32-43.

Amezaga, J. M., Santamaría, L., and Green, A. J. (2002) Biotic wetland connectivity - supporting a new approach for wetland policy. *Acta Oecologica* **23**, 213-222.

Aselmann I. and Crutzen P.J. (1989). Global distribution of natural freshwater wetlands and rice paddies, their net primary productivity, seasonality and possible methane emissions. *Journal of Atmospheric Chemistry* **8**, 307-358.

AUSLIG (1994) GEODATA TOPO-250K (Series 1) Topographic Data. (Geoscience Australia: Belconnen, ACT)

AUSLIG (1997) Australia's River Basins. (Geoscience Australia: Belconnen, ACT)

AUSLIG (2000) GEODATA 9 Second DEM (DEM-9S). (Geoscience Australia: Belconnen, ACT)

AWRC (Australian Water Resources Council) (1987). 1985 Review of Australia's water resources and water use. **Vol. 1 and 2**. (Department of Primary Industries and Energy. Australian Government Printing Service: Canberra.)

Barendregt, A., Wassen, M. J., and Schot, P. P. (1995). Hydrological systems beyond a nature reserve, the major problem in wetland conservation of Naardermeer (the Netherlands). *Biological Conservation* **72**(3), 393-405.

Bevitt, R. L., Erskine, W., Gillespie, G., Harris, J., Lake, P. S., Miners, B., and Varley, I.(1998) Expert panel environmental flow assessment of various rivers affected by the Snowy Mountains Scheme. Report to the New South Wales Department of Land and Water Conservation, Sydney.

Bureau of Meteorology (1993). ‘Climate Data Compact Disc (CDCD) Release 2’. (Space Time Research Pty Ltd., Australia.)

Carruthers, S. and Nicolson, K (1992). River Murray Wetland Database: a Framework based on Thompson and Pressey Wetland Surveys. Department of Environment and Planning. Internal Report. (Adelaide)

Congalton, R. C., and Green,. K. (1999). ‘Assessing the Accuracy of Remotely Sensed Data: Principles and Practices.’ (Lewis Publishers/CRC Press: USA.)

Congalton, R. G. (1991). A Review of Assessing the Accuracy of Classification of Remotely Sensed Data. *Remote Sensing of Environment* **37**, 35-46.

Corrick, A. H. (1982). Wetlands of Victoria III. Wetlands and Waterbirds between Port Phillip Bay and Mount Emu Creek. *Proceedings of the Royal Society of Victoria.* **94**, 69-87.

Crabb, P. (1997). ‘Murray-Darling Basin Resources.’ (Murray-Darling Basin Commission: Canberra.) 300pp.

CSIRO (1999). Mean Annual and Monthly Rainfall (mm). (CSIRO, Land and Water: Canberra, ACT.)

Davidson, I., Vanderkam, R., and Padilla, M. (1999). Review of wetland inventory information in North America. In 'Global review of wetland resources and priorities for inventory'. (Eds C.M. Finlayson and A.G. Spiers.) pp. 457-492.

Davis, T. J. (1994). The Ramsar Convention Manual. A guide to the Convention of Wetlands of International Importance especially as waterfowl habitat. (Ramsar Convention Bureau: Gland, Switzerland.)

DLWC (Department of Land and Water Conservation) (1989). Catchment boundaries of New South Wales. (DLWC: Parramatta NSW.)

DLWC (Department of Land and Water Conservation) (2000) Estuaries Inventory (DLWC: Parramatta, NSW)

DLWC (Department of Land and Water Conservation) (2001) Weir Inventory Database (DLWC: Parramatta, NSW)

DNR (Department of Natural Resources) (2000). Draft Water Allocation and Management Plan (Condamine-Balonne Basin) June 2000 (Draft WAMP). (Department of Natural Resources: Brisbane, Queensland.)

DNRE (Department of Natural Resources and Environment) (1994) Current wetlands environments and extent (DNRE: East Melbourne, Victoria).

Early, O. (2000). Modeling wetland loss in the Richmond Catchment: an example of historical vegetation modeling. In '4th International Conference on Integrating GIS and Environmental Modeling (GIS/EM4): Problems, Prospects and Research Needs'. (University of Colorado; Banff, Alberta, Canada)

EA (Environment Australia) (2000). Ramsar Site Boundaries in Australia. (Environment Australia: Canberra)

EA (Environment Australia) (2001a). 'A Directory of Important Wetlands in Australia.' 3rd Edition. (Environment Australia: Canberra.)

EA (Environment Australia) (2001b). Directory of Important wetlands in Australia Spatial Database. (Environment Australia, Strategic Development: Canberra, ACT)

ERDAS®, (1999). 'ERDAS® Imagine Field Guide.' 5th edition, (ERDAS® Inc.: Atlanta, Georgia)

ERDAS®, (2001). ERDAS® Imagine 8.5. (ERDAS® Inc.: Atlanta, Georgia)

ESRI®, (2000). ARC© Version 8.0.2. Environmental Systems Research Institute, Inc.(ESRI®, Inc.: Redlands, US.)

Farrier, D. Lyster, R., and Pearson, L. (1999). 'The Environmental Law Book.' 3rd Edition. (Legal Centre Publishing: Redfern).

Finlayson, C. M., and Rea, N. (1999). Reasons for the loss and degradation of Australian wetlands. *Wetlands Ecology and Management* **7**, 1-11.

Finlayson, C. M. and Spiers, A. G (Eds). (1999) Global Review of Wetland Resources and Priorities for Inventory. (Environmental Research Institute of the Supervising Scientist: Jabiru, Australia)

Finlayson, C. M., Davidson, N. C., Spiers, A. G., and Stevenson, N. J. (1999). Global wetland inventory - current status and future priorities. *Marine and Freshwater Research* **50**, 717-727.

Finlayson, M., and Moser, M. (1991). 'Wetlands' (International Waterfowl and Wetlands Research Bureau, Toucan Books Ltd: London.)

Foote, A. L., Pandey, S., and Krogman, N. T. (1996). Processes of wetland loss in India. *Environmental Conservation* **23**(1), 45-54.

Frazier, P., and Page, K. (2000). Water Body Detection and Delineation with Landsat TM Data. *Photogrammetric Engineering and Remote Sensing*. **66**(12), 1461-1468.

Frazier, S. and Stevenson, N. (1999). 'Review of wetland inventory information in the Middle East' (Wetlands International- Africa, Europe, Middle East: The Netherlands).

Galloway, R. W., Story, R., Cooper, R., and Yapp, G. A. (1984) Coastal Lands of Australia. CSIRO Division of Water and Land Resources, Natural Resources Series No. 1. (Canberra.)

Gibbs, J. P.(2000) Wetland loss and biodiversity conservation. *Conservation Biology* **14**, 314-317.

Goodrick, G. (1970). A survey of wetlands of coastal New South Wales. C.S.I.R.O. Division Wildlife Research, Technical Memo. No. 5. (Canberra.)

Green, D., Shaikh, M., Maini, N., Cross, H., and Slaven, J. (1998). Assessment of environmental flow needs for the Lower Darling River. Department of Land and Water Conservation Report to the Murray-Darling Basin Commission. (Parramatta.)

Hollis, G. E. (1990). Environmental impacts of development on wetlands in arid and semi-arid lands. *Hydraulic Science Journal* **35**, 441-428.

Hollis, T. (1992). The causes of wetland loss and degradation in the Mediterranean. In 'Managing Mediterranean wetlands and their birds.' (Eds C. M. Finlayson, G. E. Hollis, and T. J. Davis,) pp. 83-90. (IWRB Special Publ. No. 20, Slimbridge: UK.)

Hollis, G. E. (1999). Future wetlands in a world short of water. In 'Wetlands for the future'. Contributions from INTECOL's V International Wetlands Conference. (Eds, A.J. McComb and J. A. Davis) pp. 5-18. (Gleneagles Publishing: Adelaide.)

Hollis, G. E., and Jones, T. A (1991). Europe and the Mediterranean Basin. In 'Wetlands'. (Eds M. Finlayson, M. and M. Moser.) pp. 27-56. (International Waterfowl and Wetlands Research Bureau, Slimbridge, Facts on File Limited: Oxford.)

Hull, G. (1996). 'Victoria. A Directory of Important Wetlands in Australia.' 2nd Edn. pp. 605-757. (Australian Nature Conservation Agency: Canberra.)

Jones, D., Cocklin, C., and Cutting, M. (1995). Institutional and landowner perspectives on wetland management in New Zealand. *Journal of Environmental Management* **45**(2), 143-161.

King, A. M., Green, D. L., and Brady, A. T. (1995). Wetlands of the Paroo River and Cuttaburra Creek. Department of Land and Water Conservation, Technical Service Division, TS 95.132. (Sydney).

Kingsford, R. T. (1995). Ecological effects of river management in New South Wales. In 'Conserving Biodiversity: Threats and Solutions.' (Eds R. Bradstock, T. D. Auld, D. A.

Keith, R. T. Kingsford, D. Lunney and D. Sivertsen) pp. 144-161. (Surrey Beatty and Sons: Sydney.)

Kingsford, R. T. (2000a). Ecological impacts of dams, water diversions and river management on floodplain wetlands in Australia. *Austral Ecology* **25**, 109-127.

Kingsford, R. T. (2000b). Protecting or pumping rivers in arid regions of the world? *Hydrobiologia* **427**, 1-11.

Kingsford, R. T. and Johnson, W. J. (1998). The impact of water diversions on colonially nesting waterbirds in the Macquarie Marshes in arid Australia. *Colonial Waterbirds* **21**, 159-170.

Kingsford, R. T., Bedward, M. and Porter, J. (1994) Wetlands and waterbirds in northwestern New South Wales. National Parks and Wildlife Service Occasional Paper 19, 105pp.

Kingsford, R. T., Boulton, A. J., and Puckridge, J. T. (1998). Challenges in managing dryland rivers crossing political boundaries: lessons from Cooper Creek and the Paroo River, central Australia. *Aquatic Conservation: Marine and Freshwater Ecosystems* **8**, 361-378.

Kingsford, R. T., Curtin, A. L., and Porter, J. (1999a). Water flows on Cooper Creek in arid Australia determine 'boom' and 'bust' periods for waterbirds. *Biological Conservation* **88**, 231-248

Kingsford, R. T., Wong, P. S., Braithwaite, L. W., and Maher, M. T. (1999b). Waterbird abundance in eastern Australia, 1983-1992. *Wildlife Research* **26**,351-366.

Kingsford, R. T., Thomas, R. F., and Knowles, E. (1999c). GIS for wetlands in the Murray-Darling Basin. Final Report to Murray-Darling Basin Commission. (National Parks and Wildlife Service: Hurstville, Sydney)

Kingsford, R. T., Thomas, R. F., and Curtin, A. L. (2001). Conservation of wetlands in the Paroo and Warrego catchments in arid Australia. *Pacific Conservation Biology* **7**, 21-33.

Kingsford, R.T. and Thomas R.F. (2002). Use of satellite image analysis to track wetland loss on the Murrumbidgee River floodplain in arid Australia, 1975-1998. *Water Science and Technology* **45**(1), 45-53.

Lane, J. A. K., and McComb, A. J. (1988). Western Australian wetlands. In 'The Conservation of Australian wetlands.' (Eds A. J. McComb and P. S. Lake) pp.127-146. (Surrey Beatty and Sons: Sydney.)

Langford-Smith, T., and Rutherford, J. (1966). 'Water and land: two case studies in Irrigation.' (Australian National University Press: Canberra.)

La Peyre, M. K. G., Reams, M. A., and Mendelssohn, I. A.(2000) State wetland protection: A matter of context? *Coastal Management* **28**, 287-302.

Lemly, A. D., Kingsford, R. T., and Thompson, J. R. (2000). Irrigated agriculture and wildlife conservation: conflict on a global scale. *Environmental Management* **25**, 485-512.

Margules, C. R. and Pressey, R. L. (2000) Systematic conservation planning. *Nature* **405**, 243-253.

McComb, A. J., and Lake, P. S. (1988). 'The conservation of Australian wetlands.' (Surrey Beatty and Sons: Sydney.)

McGinness, H. M., and Thoms, M. C. (in press). Water resource development and floodplain carbon dynamics. *Verhandlung Internationale Vereinigung für theoretische und angewande Limnologie* .

Mitsch, W.J. (1998). Protecting the world's wetlands: threats and opportunities in the 21st century. In 'Wetlands for the Future' (Eds A. J. McComb and J. A. Davis) pp19-31. (Gleneagles Publishing: Adelaide).

National Land and Water Resources Audit (2001a). Australian Agriculture Assessment 2001. (Commonwealth of Australia: Canberra.)

National Land and Water Resources Audit (2001b). Australian Water Resources Assessment 2000. (Commonwealth of Australia: Canberra.)

Newton, P.W., Baum, S., Bhatia, K., Brown, S.K., Cameron, A.S., Foran, B.D., Grant, T., Mak, S.L., Memmott, P.C., Mitchell, V.G., Neate, K.L., Pears, A., Smith, N., Stimson, R.J., Tucker, S.N. and Yencken, D. (2001). Human Settlements in 'Australia State of the Environment Report 2001' (CSIRO Publishing on behalf of the Department of Environment and Heritage, Canberra.)

Nicholson, K., Heron, S., and Bennett, M. (1994). Geographical data for Murray-Darling Basin floodplain wetland management. In 'Murray-Darling Basin floodplain wetlands management.' (Eds T. Sharley and C. Huggan) pp. 65-74. Proceedings of the floodplain wetlands management workshop, Albury NSW 20-22 October 1992.

NPWS (NSW National Parks and Wildlife Service) (2002a) NSW National Parks and Wildlife Service (NPWS) Estate. (NPWS: Hurstville, NSW)

NPWS (NSW National Parks and Wildlife Service) (2002b) Annual Report 2001-2002 (NSW National Parks and Wildlife Service, Sydney) 157 p.

Paijmans, K. (1978). Feasibility report on a national wetland survey. Technical Memorandum 78/6. pp. 24. (CSIRO Div. of Water & Land Resources, Canberra).

Paijmans, K., Galloway, R. W., Faith, D. P., Fleming, P. M., Haantjens, H. A., Heyligers, P. C., Kalma, J. D., and Loffler, E. (1985). Aspects of Australian wetlands. CSIRO Div. of Water & Land Resources, Technical Paper No.44 pp. 71

Planning NSW (2002) Coastal Wetlands (State Environmental Planning Policy No. 14)- SEPP 14. (Planning NSW: Sydney)

Pressey, R. L. (1989) Wetlands of the Lower Clarence Floodplain, Northern Coastal New South Wales. *Proceedings of the Linnean Society of New South Wales* **111**, 143-155.

Pressey, R. L. (1993). Wetlands of the Lower Macleay Floodplain, Northern Coastal New South Wales. *Proceedings of the Linnean Society of New South Wales* **111**, 157-168.

Pressey, R. L. and Adam, P. (1995). A review of wetland inventory and classification in Australia. *Vegetation* **118** (1-2), 81-101.

Pressey, R. L. and Harris, J. H. (1988). Wetlands of New South Wales. In 'Conservation of Australian Wetlands.' (Eds A. J. McComb and P. S Lake) pp. 35-57. (Surrey Beatty and Sons: New South Wales, Australia.)

Pressey, R. L. and Middleton, M. J. (1982). Impacts of flood mitigation works on coastal wetlands in New South Wales. *Wetlands* **2**, 27-44.

Puckridge, J. T., Walker, K. F., and Costelloe, J. F. (2000). Hydrological persistence and the ecology of dryland rivers. *Regulated Rivers: Research and Management* **16**, 385-402.

Richards, J.A. (1993). 'Remote Sensing Digital Image Analysis. An Introduction'. Second, Revised and Enlarged Edition. (Springer-Verlag:Berlin, Germany.)

Rieley J.O., Ahmad Shah nad A.A., and Brady M.A. (1996). The extent and nature of tropical peat swamps. In 'Tropical lowland peatlands of South East Asia.' (Eds E. Maltby, C. P. Immirzi and R. J. Safford) (IUCN: Gland Switzerland.)

Roshier, D. A., Whetton, P. H., Allan, R. J., and Robertson, A. I. (2001). Distribution and persistence of temporary wetland habitats in arid Australia in relation to climate. *Austral Ecology* **26**, 371-384.

Seddon, J. A. and Briggs, S. V. (1998) Lakes and lakebed cropping in the western division of New South Wales. *Ranglands Journal*, **20**, 237-254

Seddon, J., Thornton, S., and S. Briggs (1997). An Inventory of Lakes in the Western Division of NSW. (NSW National Parks and Wildlife Service: Canberra) 109pp.

Sheldon, F., Thoms, M. C., Berry, O., and Puckridge, J. T. (2000). Using disaster to prevent catastrophe: referencing the impacts of flow changes in large dryland rivers. *Regulated Rivers: Research and Management* **16**, 403-420.

Sparks, R. E. 1995 Need for ecosystem management of large rivers and their floodplains. *BioScience* **45** (3), 168-182.

State Forests (2000) State Forests Boundaries. (State Forests of NSW: Pennant Hills, NSW)

Stevenson, N. and Frazier, S. (1999). 'Review of wetland inventory information in Eastern Europe' (Wetlands International: The Netherlands).

Stolt, M. H., and Baker, J. C. (1995). Evaluation of National Wetland Inventory maps to inventory wetlands in the southern Blue Ridge of Virginia. *Wetlands* **15**, 346-353.

Timms, B. V. (2001). Large freshwater lakes in arid Australia: A review of their limnology and threats to their future. *Lakes and Reservoirs: Research and Management* **6,** 183-196.

Watkins, D. (1999). Review of wetland inventory information in Oceania. In 'Global review of wetland resources and priorities for inventory'. (Eds C. M. Finlayson and A. G. Spiers) pp. 357-418. (Environmental Research Institute of the Supervising Scientist: Jabiru, Australia)

Wilen, B. O. and Bates, M. K. (1995). The US fish and Wildlife Service's National Wetlands Inventory project. *Vegetation* **118**(1-2), 153-169.

Wilton, K. M. and Saintilan, N. (2000). 'Protocols for Mangrove and Saltmarsh Habitat Mapping.' (Australian Catholic University: Sydney.)

Appendix 1

Metadata Statements

Current wetlands environments and extent (WETLAND_1994)

Unique Id	ANZVI0803001066
Title	Current wetlands environments and extent (WETLAND_1994)
Custodian	Department of Natural Resources and Environment
Jurisdiction	Victoria

Description

Abstract	Polygons showing the current extent and types of wetlands in Victoria based on photography taken during the 1970's and 80's. Wetlands are classified into primary categories based on water regimes and subdivided into sub areas based on vegetation or hydologic attributes. The polygon boundaries were derived from digitizing marked up aerial photography interpretation.
Search Word(s)	WATER Wetlands
Geographic Extent Name(s)	Victoria
Bounding Box	34.0 S 141.0 E 150.2 E 39.2 S

Dataset Currency

Beginning Date	01JAN1965
Ending Date	01JAN1992

Dataset Status

Progress	Complete
Maintenance and Update	Not Planned

Dataset Access

Stored Data Format(s)	Digital - Arc/Info Revision 7 Librarian layer
Available Format Type(s)	Digital - - All major formats available
Access Constraints	Not Documented

Data Quality

Lineage	Data Set Source: The data has been prepared primarily from standard Survey and Mapping Victoria photo runs with some local revisions based on other historical sources. Collection Method: Aerial photograhy interpretation. Processing Steps: The data has been inserted into covers based on 1:100,000 mapsheet tiles via one or more of four processes: * Pre ARC/INFO data: Prior to the availability of ARC/INFO, an in-house developed digitizing program known as DIGIT running on a PDP11 computer at ARI was used. The marked aerial photography was positioned on a digitizer using two reference points corresponding to six figure grid references. These points defined the orientation and scale of the photograph. The arcs defining wetlands on the photograph were then digitized. The coordinates generated were then converted to be expressed as values relative to the grid reference used as the wetland ID and stored on disk for subsequent plotting. This existing digital linework and associated attribute data was subsequently imported into ARC/INFO via the use a FORTRAN based conversion utility which created GENERATE input files. Further errror checking and editing processes were then applied to bring data from this source up to a comparable standard to data entered directly into ARC/INFO. * Direct digitizing from aerial photography: A facility is provided in the Wetlands Mapping System to digitize data directly from aerial photographs. This facility uses the ARC/INFO photo registration process which requires a minimum of five tic points to be defined. This process is used for editing or adding individual wetlands. * Digitizing from 1:25,000 survey map overlays: Some 1:100,000 mapsheets have been processed by digitizing in ARC/INFO using marked up transparent overlays of 1:25,000 mapsheets. * Scanning of 1:25,000 survey map overlays: On more complex mapsheets the marked up overlays have been scanned into SCITEX format files. These files have then been converted into ARC/INFO GENERATE input files and imported into ARC/INFO for final editing and adding of attributes.
Positional Accuracy	Precision: 10m to 100m Determination: Deductive estimate. Ad-hoc comparisons with 1:25,000 layer data and various sorts of imagery indicated good correlation in terms of shape and size but with errors of the order indicated above in terms of position and/or rotation. When resources permit, the 1:25,000 library hydrology and roads layers should be used to identify layer inconsistencies which may indicate specific wetlands which require translation, rotation or boundary modifications.
Attribute Accuracy	The classification scheme used is based on photo interpretation and ground surveys carried out by Departmental research staff under the direction of research scientist Andrew Corrick.
Logical Consistency	The Wetland Mapping System includes processes for checking: *node, label and intersect errors. *validation of category codes prior to insertion in the library.
Completeness	All wetlands with an area of 1 hectare or more should be present.

Contact

Contact Organisation	Department of Natural Resources and Environment
Contact Position	Data Manager
Address	PO Box 500 East Melbourne VIC 3002 Australia
Phone	(03) 8636 2385
Facsimile	(03) 8636 2813
Email Address	mark.o'brien@nre.vic.gov.au

Other

Metadata Date	08AUG2000
Additional Metadata	none

State Forests Boundaries

ANZLIC unique identifier: ANZNS0167000004
Title: State Forests Boundaries
Custodian: State Forests of New South Wales
Jurisdiction: New South Wales

Description

Abstract:

The State Forest Boundary data set shows the dedicated boundaries of all State Forests in New South Wales. The data is based on the LIC cadastre with operational boundaries like LIC Topographic drainage and State Forest roads replacing any LIC cadastre dataset features for drainage and LIC road arcs. All boundaries are checked by State Forests for accuracy before this cover is assembled.The data set is in progress with estimated completion by 30-6-2000.

ANZLIC search words:

- BOUNDARIES Administrative
- FORESTS

Spatial domain:

Geographic extent name:

NEW SOUTH WALES,New South Wales,NSW - General

Geographic extent polygon:

141 -37.5, 154 -37.5, 154 -28, 141 -28, 141 -37.5

Note: The format for each Geographic extent name is: `Name - Identifier - Category - Jurisdiction` (as appropriate)

Geographic bounding box:
The bounding box encloses the maximum extents of the dataset. There may be voids or gaps within the bounding box, depending on the defined coverage of the dataset. Outer bounding rectangle as Latitude/Longitude coordinates based on the WGS84 datum (expressed as both Degrees Minutes Seconds and as decimal Degrees):

- **North bounding latitude:** 28 00 00.0 S (-28)
- **South bounding latitude:** 37 30 00.0 S (-37.5)
- **East bounding longitude:** 154 00 00.0 E (154)
- **West bounding longitude:** 141 00 00.0 E (141)

Data currency

Beginning date: Not Known

Ending date: 30 June 2000 (2000-06-30)

Dataset status

Progress: In Progress

Maintenance and update frequency: As required

Access

Stored data format:

Digital Database, Vector data, Map, Text Report

Available format type:

Digital Magnetic Tape **Non-digital** Paper Map **Non-digital** Paper Text

Access constraints:

Available on a case by case basis under Licence.

Data quality

Lineage:

The State Forest boundary dataset is based on the LIC cadastre layer. All arcs are checked by State Forest Estates Unit before this cover is assembled. Where the boundary is a drainage or road feature, the LIC surveyed drainage and LIC surveyed road arcs are replaced with operational arcs from the LIC Topographic data drainage layer and the operational State Forest roading layer.

Positional accuracy:

The State Forest boundaries dataset is based on the LIC cadastre. Tolerances are set to 0.00001m when arcs are transferred from other covers to stop any arc movement. All arcs are conflation checked back to the LIC cadastre on completion. All map joins are edgematched to 0.05m.

Attribute accuracy:

The State Forest Boundaries dataset has been assembled by GIS staff by building the data from other covers. All arcs and polygons are checked for the correct attributes with frequency reports generated for assessment. Edgematching procedures were carried out on all tile joins for arc and polygon attributes.

Logical consistency:

Logical consistency checks performed include dangle checks, intersect errors, label errors, polygon closures, topology and frequency reports.

Completeness:

The State Forest Estate boundaries dataset is 95% complete. All State Forest will be completed by the 30-6-2000.

Contact information

Contact organisation: State Forests of New South Wales

Contact position: Manager GIS Operations - GIS Unit

Postal address: Building 2, State Forests Head Office

Postal address: 423 Pennant Hills Road

Locality: Pennant Hills

State: NSW

Country: Australia

Postcode: 2120

Telephone: 02 9980 4268

Facsimile: 02 9481 0614

Electronic mail address: davidl@sf.nsw.gov.au

Metadata information

Metadata date: 22 March 2000 (2000-03-22)

Metadata Reference: http://canri.nsw.gov.au/nrdd/records/ANZNS0167000004.html

This dataset description **complies** with ANZLIC Core Metadata Guidelines Version 1 and XML DTD ANZMETA 1.1 (metadata validation date: 2003-03-03)

Catchment Boundaries of New South Wales

ANZLIC unique identifier: ANZNS0359000831
Title: Catchment Boundaries of New South Wales
Custodian: Department of Land and Water Conservation (DLWC)
Jurisdiction: New South Wales

Description

Abstract:

This data set shows the administrative catchment boundaries as defined under the NSW Conservation Act. Boundaries east of the Lachlan were gazetted around 1986. Western boundaries have not been gazetted and, hence, have the label (Not notified) attached to them. The Western catchment boundaries are more appropriately described as sub-catchments as they do not straddle the Darling River. The data set is taken from the NSW broad scale topographic base developed by CaLM (LIC) in map form in the Atlas of New South Wales. The data has been digitised from 1:100 000 base maps by the Soil Conservation Service of New South Wales.

ANZLIC search words:

- BOUNDARIES Administrative

Spatial domain:

Geographic extent name:

NEW SOUTH WALES,New South Wales,NSW - General

Geographic extent polygon:

141 -37.5, 154 -37.5, 154 -28, 141 -28, 141 -37.5

Note: The format for each Geographic extent name is: `Name - Identifier - Category - Jurisdiction` (as appropriate)

Geographic bounding box:
The bounding box encloses the maximum extents of the dataset. There may be voids or gaps within the bounding box, depending on the defined coverage of the dataset. Outer bounding rectangle as Latitude/Longitude coordinates based on the WGS84 datum (expressed as both Degrees Minutes Seconds and as decimal Degrees):

- **North bounding latitude:** 28 00 00.0 S (-28)
- **South bounding latitude:** 37 30 00.0 S (-37.5)
- **East bounding longitude:** 154 00 00.0 E (154)
- **West bounding longitude:** 141 00 00.0 E (141)

Data currency

Beginning date: 01 January 1989 (1989-01-01)

Ending date: 31 December 1989 (1989-12-31)

Dataset status

Progress: Complete

Maintenance and update frequency: Not Planned

Access

Stored data format:

Non-digital Map, Spatial Database (GIS/LIS)

Available format type:

Digital Magnetic Disk **Non-digital** Paper Map

Access constraints:

Nil

Data quality

Lineage:

Catchment taken from Atlas of NSW, delineated on 1: 100 000 topographic maps and digitised to create NSW coverage.

Positional accuracy:

Broad scale only.

Attribute accuracy:

All lines and polygons labelled.

Logical consistency:

Visual check only.

Completeness:

Complete

Contact information

Contact organisation: Department of Land and Water Conservation (DLWC)

Contact position: Data Coordinator - Land Information Systems Unit (NRIS)

Postal address: 10 Valentine Avenue

Postal address: 10 Valentine Avenue

Locality: Parramatta

State: NSW

Country: Australia

Postcode: 2150

Telephone: 02 9895 7608

Facsimile: 02 9895 7742

Electronic mail address: pbliss@dlwc.nsw.gov.au

Metadata information

Metadata date: 15 April 1999 (1999-04-15)

Metadata Reference: http://canri.nsw.gov.au/nrdd/records/ANZNS0359000831.html

This dataset description **complies** with ANZLIC Core Metadata Guidelines Version 1 and XML DTD ANZMETA 1.1 (metadata validation date: 2003-03-03)

Coastal Wetlands (State Environmental Planning Policy No. 14) - SEPP 14

ANZLIC unique identifier: ANZNS0157000002
Title: Coastal Wetlands (State Environmental Planning Policy No. 14) - SEPP 14
Custodian: PlanningNSW
Jurisdiction: New South Wales

Description

Abstract:

Boundary data on approximately 1900 coastal wetlands of State significance and covered by State Environmental Planning Policy No. 14 (SEPP 14) as defined in The Coastal Wetalnds Survey report, 27 October 1989. SEPP 14 places planning and development controls under the Environmental Planning and Assessment Act, 1979 over the wetlands, which are illustrated on 82 hard copy printed maps. These maps are the definitive source of the wetlands boundaries although digital representation is available. Coverage extends along the NSW coastline (and up to 30 kms inland) from the Queensland border to the Hawkesbury River and from Wollongong to the Victorian Border.

ANZLIC search words:

- VEGETATION
- WATER Wetlands Conservation

Spatial domain:

Geographic extent name:

BALLINA (A),New South Wales,250 - Local Government Areas

Geographic extent polygon:

153.361 -29.003, 153.608 -29.003, 153.608 -28.706, 153.361 -28.706, 153.361 -29.003

Geographic extent name:

BEGA,New South Wales,SJ55-04 - 250K Map Sheet

Geographic extent polygon:

148.5 -36, 150 -36, 150 -37, 148.5 -37, 148.5 -36

Geographic extent name:

BEGA VALLEY (A),New South Wales,550 - Local Government Areas

Geographic extent polygon:

149.355 -37.507, 150.083 -37.507, 150.083 -36.129, 149.355 -36.129, 149.355 -37.507

Geographic extent name:

BELLINGEN (A),New South Wales,600 - Local Government Areas

Geographic extent polygon:

152.389 -30.569, 153.06 -30.569, 153.06 -30.182, 152.389 -30.182, 152.389 -30.569

Geographic extent name:

BYRON (A),New South Wales,1350 - Local Government Areas

Geographic extent polygon:

153.327 -28.767, 153.638 -28.767, 153.638 -28.463, 153.327 -28.463, 153.327 -28.767

Geographic extent name:

COFFS HARBOUR,New South Wales,SH56-11 - 250K Map Sheet

Geographic extent polygon:

153 -30, 154.5 -30, 154.5 -31, 153 -31, 153 -30

Geographic extent name:

COFFS HARBOUR (C),New South Wales,1800 - Local Government Areas

Geographic extent polygon:

152.795 -30.451, 153.212 -30.451, 153.212 -30.039, 152.795 -30.039, 152.795 -30.451

Geographic extent name:

COPMANHURST (A),New South Wales,2250 - Local Government Areas

Geographic extent polygon:

152.297 -29.684, 153.106 -29.684, 153.106 -28.972, 152.297 -28.972, 152.297 -29.684

Geographic extent name:

EUROBODALLA (A),New South Wales,2750 - Local Government Areas

Geographic extent polygon:

149.542 -36.367, 150.306 -36.367, 150.306 -35.502, 149.542 -35.502, 149.542 -36.367

Geographic extent name:

GOSFORD (C),New South Wales,3100 - Local Government Areas

Geographic extent polygon:

150.983 -33.581, 151.484 -33.581, 151.484 -33.112, 150.983 -33.112, 150.983 -33.581

Geographic extent name:

GREAT LAKES (A),New South Wales,3400 - Local Government Areas

Geographic extent polygon:

151.648 -32.704, 152.57 -32.704, 152.57 -32.067, 151.648 -32.067, 151.648 -32.704

Geographic extent name:

GREATER TAREE (C),New South Wales,3350 - Local Government Areas

Geographic extent polygon:

151.752 -32.169, 152.804 -32.169, 152.804 -31.444, 151.752 -31.444, 151.752 -32.169

Geographic extent name:

HASTINGS,New South Wales,SH56-14 - 250K Map Sheet

Geographic extent polygon:

151.5 -31, 153 -31, 153 -32, 151.5 -32, 151.5 -31

Geographic extent name:

HASTINGS (A),New South Wales,3750 - Local Government Areas

Geographic extent polygon:

152.061 -31.73, 152.975 -31.73, 152.975 -31.116, 152.061 -31.116, 152.061 -31.73

Geographic extent name:

KEMPSEY (A),New South Wales,4350 - Local Government Areas

Geographic extent polygon:

152.269 -31.312, 153.089 -31.312, 153.089 -30.502, 152.269 -30.502, 152.269 -31.312

Geographic extent name:

KIAMA (A),New South Wales,4400 - Local Government Areas

Geographic extent polygon:

150.599 -34.794, 150.866 -34.794, 150.866 -34.601, 150.599 -34.601, 150.599 -34.794

Geographic extent name:

LAKE MACQUARIE (C),New South Wales,4650 - Local Government Areas

Geographic extent polygon:

151.33 -33.204, 151.738 -33.204, 151.738 -32.874, 151.33 -32.874, 151.33 -33.204

Geographic extent name:

LISMORE (C),New South Wales,4850 - Local Government Areas

Geographic extent polygon:

153.073 -29.073, 153.449 -29.073, 153.449 -28.517, 153.073 -28.517, 153.073 -29.073

Geographic extent name:

MACLEAN,New South Wales,SH56-07 - 250K Map Sheet

Geographic extent polygon:

153 -29, 154.5 -29, 154.5 -30, 153 -30, 153 -29

Geographic extent name:

MACLEAN (A),New South Wales,5000 - Local Government Areas

Geographic extent polygon:

153.001 -29.69, 153.376 -29.69, 153.376 -29.301, 153.001 -29.301, 153.001 -29.69

Geographic extent name:

MAITLAND (C),New South Wales,5050 - Local Government Areas

Geographic extent polygon:

151.398 -32.812, 151.743 -32.812, 151.743 -32.607, 151.398 -32.607, 151.398 -32.812

Geographic extent name:

MALLACOOTA,New South Wales,SJ55-08 - 250K Map Sheet

Geographic extent polygon:

148.5 -37, 150 -37, 150 -38, 148.5 -38, 148.5 -37

Geographic extent name:

NAMBUCCA (A),New South Wales,5700 - Local Government Areas

Geographic extent polygon:

152.399 -30.929, 153.019 -30.929, 153.019 -30.49, 152.399 -30.49, 152.399 -30.929

Geographic extent name:

NEWCASTLE,New South Wales,SI56-02 - 250K Map Sheet

Geographic extent polygon:

151.5 -32, 153 -32, 153 -33, 151.5 -33, 151.5 -32

Geographic extent name:

NEWCASTLE (C),New South Wales,5900 - Local Government Areas

Geographic extent polygon:

151.606 -32.965, 151.817 -32.965, 151.817 -32.791, 151.606 -32.791, 151.606 -32.965

Geographic extent name:

PORT STEPHENS (A),New South Wales,6400 - Local Government Areas

Geographic extent polygon:

151.592 -32.88, 152.204 -32.88, 152.204 -32.58, 151.592 -32.58, 151.592 -32.88

Geographic extent name:

RICHMOND RIVER (A),New South Wales,6600 - Local Government Areas

Geographic extent polygon:

152.688 -29.345, 153.484 -29.345, 153.484 -28.712, 152.688 -28.712, 152.688 -29.345

Geographic extent name:

SHELLHARBOUR (A),New South Wales,6900 - Local Government Areas

Geographic extent polygon:

150.637 -34.645, 150.903 -34.645, 150.903 -34.532, 150.637 -34.532, 150.637 -34.645

Geographic extent name:

SHOALHAVEN (C),New South Wales,6950 - Local Government Areas

Geographic extent polygon:

149.976 -35.646, 150.849 -35.646, 150.849 -34.641, 149.976 -34.641, 149.976 -35.646

Geographic extent name:

SYDNEY,New South Wales,SI56-05 - 250K Map Sheet

Geographic extent polygon:

150 -33, 151.5 -33, 151.5 -34, 150 -34, 150 -33

Geographic extent name:

TWEED (A),New South Wales,7550 - Local Government Areas

Geographic extent polygon:

153.106 -28.544, 153.585 -28.544, 153.585 -28.159, 153.106 -28.159, 153.106 -28.544

Geographic extent name:

TWEED HEADS,New South Wales,SH56-03 - 250K Map Sheet

Geographic extent polygon:

153 -28, 154.5 -28, 154.5 -29, 153 -29, 153 -28

Geographic extent name:

ULLADULLA,New South Wales,SI56-13 - 250K Map Sheet

Geographic extent polygon:

150 -35, 151.5 -35, 151.5 -36, 150 -36, 150 -35

Geographic extent name:

ULMARRA (A),New South Wales,7600 - Local Government Areas

Geographic extent polygon:

152.858 -30.156, 153.394 -30.156, 153.394 -29.564, 152.858 -29.564, 152.858 -30.156

Geographic extent name:

WOLLONGONG,New South Wales,SI56-09 - 250K Map Sheet

Geographic extent polygon:

150 -34, 151.5 -34, 151.5 -35, 150 -35, 150 -34

Geographic extent name:

WOLLONGONG (C),New South Wales,8450 - Local Government Areas

Geographic extent polygon:

150.634 -34.555, 151.065 -34.555, 151.065 -34.132, 150.634 -34.132, 150.634 -34.555

Geographic extent name:

WYONG (A),New South Wales,8550 - Local Government Areas

Geographic extent polygon:

151.198 -33.404, 151.638 -33.404, 151.638 -33.045, 151.198 -33.045, 151.198 -33.404

Note: The format for each Geographic extent name is: `Name - Identifier - Category - Jurisdiction` (as appropriate)

Geographic bounding box:
The bounding box encloses the maximum extents of the dataset. There may be voids or gaps within the bounding box, depending on the defined coverage of the dataset. Outer bounding rectangle as Latitude/Longitude coordinates based on the WGS84 datum (expressed as both Degrees Minutes Seconds and as decimal Degrees):

- **North bounding latitude:** 28 00 00.0 S (-28)
- **South bounding latitude:** 38 00 00.0 S (-38)
- **East bounding longitude:** 154 30 00.0 E (154.5)
- **West bounding longitude:** 148 30 00.0 E (148.5)

Data currency

Beginning date: 27 October 1989 (1989-10-27)

Ending date: Current

Dataset status

Progress: Complete

Maintenance and update frequency: As required

Access

Stored data format:

Digital Map, Spatial Database (GIS/LIS), Text Report, GenaMap Ver 7.2 under HP-UX 10.2, vector coverage. Geographics, approximately 1900 polygons represent the wetlands. NON DIGITAL printed maps based on the Land Information Centre (LIC) 1:25000 topographic map.

Available format type:

Digital GenaMap, Arc/Info, DGN, DXF, ASCII **Non-digital** Printed map **Non-digital** Report Circular No. B10 (Department of Urban Affairs and Planning)

Access constraints:

Contact the GIS Manager, Department of Planning, to discuss user requirements, access constraints and costs.

Data quality

Lineage:

For the wetlands survey, the NSW coastline, coastal plain areas and major estuarine river system were covered by an aerial photographic survey, carried out in 1981. The survey followed specifications set up by the Department of Urban Affairs and Planning and are described in the 'Coastal Wetlands Survey' Report. The wetland boundaries were identified from the aerial photos on a botanical basis, using their vegetation features. They were delineated using stereoscopic interpretation (at up to 7 times magnification) of 1:25000 aerial photos. As the photographic scale closely approximated the 1:25000 scale of the LIC topographic map series, the transfer from photograph to map was carried out at close to one time magnification with minimum distortion. For a number of key areas, the photographic interpretations were checked and verified by inspections on the ground. The coastal wetland maps compilation was finished in 1984, and they are amended approximately every 12 months. A major aerial photo re-survey of the coastal area was carried out by LIC in 1986, and subsequently the wetland boundaries were then updated. The compiled maps were hand digitised using Genamap GIS software. The digitising accuracy is estimated to be 0.5 mtr on the 1:25000 maps. The wetlands polygons are labelled with numbers allocated in a sequential order from north to south between the Queensland border and the Hawkesbury River, and south to north from the Victorian border to Wollongong.

Positional accuracy:

Coastal wetlands are under continuous temporal changes. This is why they are amended every 12 months. The positional accuracy of the wetland boundaries is considered to be around 25 mts on 1:25000 maps.

Wetlands on the printed 1:25000 maps are defined by the outside edge of the thick black line which delineates the wetland area. The outer edge was followed in the digital version.

Attribute accuracy:

The attribute of this data set is the vegetation/land cover type. This attribute is not mapped but is kept in a manual file system ordered by the coastal wetland number. The wetlands are delineated on 1:25000 maps without additional details about their composition (vegetation features). No attempt has been made to subdivide the wetlands into different types of botanical communities. Consequently, the wetlands delineation was made based on their vegetataion features as botanical indicators, and not the geomorphic ones. The interpretation criteria developed for botanical indicators establishes the seven components which could be recognised from the aerrial photgraphs and which characterises the wetlands, as well as seven vegetataion land cover types which are not included in the definition of wetland. The criteria is detailed in the Coastal Wetlands Survey reports.

Logical consistency:

The tests for logical consistency involve a visual check of maps, especially in the preparatory statges of map production and a topological check for the digitised 'GenaMap' GIS product.

Consistency checks reveal that the boundaries of some wetlands that cross the common border of adjacent maps have not been edge matched. Consequently, there may be offsets between the two parts of a wetland, or in some cases one part of a wetland may not appear. Also the wetland identifier is not shown for a small nimber of wetlands (2%).

Completeness:

Most wetlands were delineated if they could be unambiguously identified on the photographs. A limit of approximately 4 hectares was chosen as a minimum size for the mapping of Sedgeland, Freshwater Swamp and Wet Meadow components on a flood plain. For the other four wetland types, the minimum size delineated was limited only by the optical factors of interpretation.

Consistency checks reveal that the boundaries of some wetlands that cross the common border of adjacent maps have not been edge matched. Consequently, there may be offsets between the two parts of a wetland, or in some cases one part of a wetland may not appear. Also the wetland identifier is not shown for a small nimber of wetlands (2%).

Contact information

Contact organisation: Planning NSW

Contact position: GIS Manager

Postal address: GPO 3927

Postal address: 20 Lee Street

Locality: Sydney

State: NSW

Country: Australia

Postcode: 2000

Telephone: 02 9762 8097

Facsimile: 02 9762 8713

Electronic mail address: paul.hartley@planning.nsw.gov.au

Metadata information

Metadata date: 29 November 2002 (2002-11-29)

Metadata Reference: http://canri.nsw.gov.au/nrdd/records/ANZNS0157000002.html

This dataset description **complies** with ANZLIC Core Metadata Guidelines Version 1 and XML DTD ANZMETA 1.1 (metadata validation date: 2003-03-03)

NSW National Parks and Wildlife Service (NPWS) Estate

ANZLIC unique identifier: ANZNS0208000008
Title: NSW National Parks and Wildlife Service (NPWS) Estate
Custodian: NSW National Parks and Wildlife Service
Jurisdiction: New South Wales

Description

Abstract:

Boundaries of areas in NSW which are under the management of the NSW NPWS. Areas include National Parks, Nature Reserves, Regional Parks, State Recreation Areas, Aboriginal Areas and Historic Sites.

ANZLIC search words:

- BOUNDARIES Reserve
- LAND Ownership Reserve

Spatial domain:

Geographic extent name:

NEW SOUTH WALES,New South Wales,NSW - General

Geographic extent polygon:

141 -37.5, 154 -37.5, 154 -28, 141 -28, 141 -37.5

Note: The format for each Geographic extent name is: `Name - Identifier - Category - Jurisdiction` (as appropriate)

Geographic bounding box:
The bounding box encloses the maximum extents of the dataset. There may be voids or gaps within the bounding box, depending on the defined coverage of the dataset. Outer bounding rectangle as Latitude/Longitude coordinates based on the WGS84 datum (expressed as both Degrees Minutes Seconds and as decimal Degrees):

- **North bounding latitude:** 28 00 00.0 S (-28)
- **South bounding latitude:** 37 30 00.0 S (-37.5)
- **East bounding longitude:** 154 00 00.0 E (154)
- **West bounding longitude:** 141 00 00.0 E (141)

Data currency

Beginning date: 01 January 1897 (1897-01-01)

Ending date: 30 June 2002 (2002-06-30)

Dataset status

Progress: In Progress

Maintenance and update frequency: Quarterly

Access

Stored data format:

Digital vector coverage

Available format type:

Digital Arc/Info coverage, export file **Digital** shape file, DXF format, ungenerated format

Access constraints:

The dataset is available to all organisations and individuals. A licence agreement is required to obtain the dataset. A fee may be charged to consultants, commercial organisations and local councils. This is to cover the cost of transfer of the data, not for the data itself. Some additional field and interior linework for additions has been retained in a separate coverage and is mainly available for NSW NPWS internal use.

Data quality

Lineage:

Updates are made on the occurrence of the gazettal of new reserves or additions to reserves. These are documented on a plan or a map by the Estates and Survey Unit, NPWS. The Spatial Systems Unit, NPWS captures the reserve boundaries from the Digital Cadastral Database or digitises from these plans. The source maps used are of the best available scales of 1:4 000, 1:10 000, 1:25 000, 1:50 000 or 1:100 000.

Positional accuracy:

All linework is being progressively checked by the Estates and Survey Unit. This is detailed in the checkdate field in a separate coverage. Linework which has been captured from the Digital Cadastral Database is also detailed in the linework field in a separate coverage. The positional accuracy of all other linework is dependent upon the scale of the source maps.

Attribute accuracy:

All attributes have been checked by the Spatial Systems Unit and the Estates and Survey Unit, and logical checks have been carried out. The non-interpretive nature of the data ensures that the attributes are highly accurate.

Logical consistency:

There is a one-to-one relationship between the field's code and name. The field code is a numerical version of the field res_no. Fields name_short and type_abbr are derived from the field name. Areas of public land within reserves are labelled Outside NPWS Estate. A map derived from the dataset should show such inholding in a different shade to the remainder of the dataset, such as white. All polygons are closed, with one label per polygon. There are no dangling arcs.

Completeness:

Gazettal information and linework are complete at 2 Feb 2000.

Contact information

Contact organisation: NSW National Parks and Wildlife Service

Contact position: Manager - GIS Group

Postal address: Head Office

Postal address: 43 Bridge Street

Locality: Hurstville

State: NSW

Country: Australia

Postcode: 2220

Telephone: 02 9585 6611

Facsimile: 02 9585 6466

Electronic mail address: gis@npws.nsw.gov.au

Metadata information

Metadata date: 08 January 2002 (2002-01-08)

Metadata Reference: http://canri.nsw.gov.au/nrdd/records/ANZNS0208000008.html

Additional metadata

Some additional field and interior linework for additions has been retained in a separate coverage. Further data quality information is held for each area as detailed under 'Positional Accuracy' above.

This dataset description **complies** with ANZLIC Core Metadata Guidelines Version 1 and XML DTD ANZMETA 1.1 (metadata validation date: 2003-03-03)

Weir Inventory Database

ANZLIC unique identifier: ANZNS0359000768
Title: Weir Inventory Database
Custodian: Department of Land and Water Conservation (DLWC)
Jurisdiction: New South Wales

Description

Abstract:

The purpose of this database is to help set priorities to increase fish passage past dams and weirs in NSW rivers and streams. It includes the location, purpose and structural data on weirs, dams and other barriers to fish migration.

ANZLIC search words:

- ECOLOGY Monitoring
- ECOLOGY Habitat
- FISHERIES Freshwater
- HUMAN ENVIRONMENT Structures and Facilities
- WATER Lakes
- WATER Rivers

Spatial domain:

Geographic extent name:

AUSTRALIAN CAPITAL TERRITORY,Australian Capital Territory,ACT - General

Geographic extent polygon:

148.5 -36, 149.5 -36, 149.5 -35, 148.5 -35, 148.5 -36

Note: The format for each Geographic extent name is: `Name - Identifier - Category - Jurisdiction` (as appropriate)

Geographic bounding box:
The bounding box encloses the maximum extents of the dataset. There may be voids or gaps within the bounding box, depending on the defined coverage of the dataset. Outer bounding rectangle as Latitude/Longitude coordinates based on the WGS84 datum (expressed as both Degrees Minutes Seconds and as decimal Degrees):

- **North bounding latitude:** 35 00 00.0 S (-35)
- **South bounding latitude:** 36 00 00.0 S (-36)
- **East bounding longitude:** 149 30 00.0 E (149.5)
- **West bounding longitude:** 148 30 00.0 E (148.5)

Data currency

Beginning date: 01 July 1995 (1995-07-01)

Ending date: Current

Dataset status

Progress: In Progress

Maintenance and update frequency: Continual

Access

Stored data format:

Digital Image, Text

Available format type:

Digital Database **Non-digital** Map **Digital** Spreadsheet **Non-digital** Text **Digital** Text

Access constraints:

Database access is unrestricted but retrieval is based on staff availability.

Data quality

Lineage:

Source data from DLWC Licencing Administration System and files, Dam Safety Committee, Sam Safety Unit (NSW and ACT), DLWC Asset Management, GIS-Remote Sensing.

Positional accuracy:

200m-5km depending on source (comment field available in database).

Attribute accuracy:

Accuracy dependent on LAS System and files; not verified.

Logical consistency:

Not tested.

Completeness:

Approximately 90% coverage but not verified.

Contact information

Contact organisation: Department of Land and Water Conservation (DLWC)

Contact position: Surface Water Planner

Postal address: GPO Box 39

Postal address: Sydney

Locality: Sydney

State: NSW

Country: Australia

Postcode: 2001

Telephone: 02 9228 6318

Facsimile: 02 9228 6140

Electronic mail address: mlonghurst@dlwc.nsw.gov.au

Metadata information

Metadata date: 26 February 2003 (2003-02-26)

Metadata Reference: http://canri.nsw.gov.au/nrdd/records/ANZNS0359000768.html

This dataset description **complies** with ANZLIC Core Metadata Guidelines Version 1 and XML DTD ANZMETA 1.1 (metadata validation date: 2003-03-03)

GEODATA TOPO-250K (Series 1) Topographic Data

ANZLIC unique identifier: ANZCW0702000024
Title: GEODATA TOPO-250K (Series 1) Topographic Data

Custodian

Custodian: Geoscience Australia
Jurisdiction: Australia

Description

Abstract:
Contains a medium scale vector representation of the topographic mapping features of Australia. The data include the following themes: Hydrography - drainage networks including watercourses, lakes, wetlands and offshore features; Infrastructure - systems for the transportation of goods and services, ie. roads, railways and associated structures, along with localities, built-up areas and aeronautical features so that these services may be located; and Relief - a series of spot elevations, chosen so as to give a representative picture of the terrain. The topographic map and data index gives coverage information.
ANZLIC search words:

- LAND Geography Mapping
- LAND Topography Mapping
- MARINE Coast Mapping

Geographic extent name: AUSTRALIA EXCLUDING EXTERNAL TERRITORIES - AUS - Australia - Australia
Note: The format for each Geographic extent name is: `Name - Identifier - Category - Jurisdiction` (as appropriate) See GEN Register

Geographic bounding box:

North bounding latitude: -9°

South bounding latitude: -44°

East bounding longitude: 154°

West bounding longitude: 112°

Data currency

Beginning date: Not Known
Ending date: 1994-01-01

Dataset status

Progress: Complete
Maintenance and update frequency: Irregular

Access

Stored data format:

Digital: Arc/Info

Digital: GINA

Digital: AS2482

Digital: DXF

Digital: MapInfo

Available format type:

Digital: Arc/Info

Digital: GINA

Digital: AS2482

Digital: DXF

Digital: MapInfo

Access constraints:
The data are subject to Commonwealth of Australia Copyright. A licence agreement is required and a licence fee is also applicable.

Data quality

Lineage:
The TOPO-250K product is primarily sourced from the 1:250 000 scale National Topographic Map Series (NTMS) and the Royal Australian Survey Corps' Joint Operation Graphics (JOG) map reproduction material (repromat). Additionally, digital information for Tasmania was provided by the Mapping Division of the Tasmanian Department of Environment and Planning and base mapping material for two map areas was provided by the Department of Land Administration, Western Australia. Where NTMS and JOG maps were published for the same area, the repromat used for the printing of the maps with the latest reliability date was used as the source. Where both map series were published with identical reliability dates, the NTMS material was used. A full description of the production method is provided in the TOPO-250K Data User Guide supplied with the data.

Positional accuracy:
TOPO-250K data complies with the following statement of horizontal accuracy: "The summation of errors from all sources results in data with a standard deviation of 100 metres for well defined features". Alternative and equal ways of expressing this error are: Not more than 10% of well-defined points are in error by more than 160 metres; and In the worst case, a well defined point is out of position by 300 metres. As the TOPO-250K data were digitised from existing map production material, some features may be subject to cartographic displacement. A full description of the features that may have been displaced and the range of displacement that may have occurred due to generalisation are provided in the TOPO-250K Data User Guide supplied with the data. The accuracy of the spot elevations in the relief theme varies with the type of source from which they were taken. Each of the following point determinations show the standard deviation of their Elevation and Horizontal accuracy respectively:

- **Spot height:** 5 metres, 50 metres
- **Point from 20m contour:** 10 metres, 50 metres
- **Point from 40m contour:** 20 metres, 50 metres
- **Waterline:** 25 metres, 100 metres

Attribute accuracy:

For the TOPO-250K product, attribute accuracy is a measure of the degree to which the attribute values of features agree with the information on the source material. The allowable error in attribute accuracy ranges from 0.5% to 5%, at a 99% confidence level. Where less than 1% of attribute errors are permissible the entire population is tested. Where a less stringent limit is set for allowable errors a random subset of the relevant features in the tile is generally tested. The sample size is determined from statistical tables using the known population size of the relevant feature. A full description of the checks on the data, the test sample size and the allowable error are provided in the TOPO-250K Data User Guide supplied with the data.

Logical Consistency:

For the TOPO-250K product, logical consistency is a measure of the degree to which data complies with the technical specifications. The data were tested using a mixture of UNIX scripts and ARC/INFO commands which were independent of the production system. Graphical tests were used to check such things as intersections, polygon closure, minimum size of polygons and topological relationships. A full description of the checks on the data, the test procedure, test sample size and the allowable error are provided in the TOPO-250K Data User Guide supplied with the data.

Completeness:

All instances of a feature and its attribute values that appear on the source material have been captured unless otherwise stated in the selection criteria for that feature provided in the TOPO-250K Data User Guide supplied with the data. The completeness was tested by overlaying symbolised plots of the data on the source material and carrying out a visual comparison.

Contact information

Contact organisation: Geoscience Australia - National Mapping Division

Contact position: Data Sales, Customer Support

Mail address: PO Box 2

Locality: BELCONNEN

State: ACT

Country: Australia

Postcode: 2616

Telephone: Australia Freecall 1800 800 173

Facsimile: +61 2 6201 4381

Electronic mail address: datasales@auslig.gov.au

Metadata information

Metadata date: 2001-02-15

Additional metadata

Metadata reference XHTML: http://www.auslig.gov.au/meta/meta18.htm
Metadata reference XML: http://www.auslig.gov.au/meta/meta18.xml

Attributes:

- Name
- Data quality
- Unique feature id
- State
- Perenniality
- Classification
- Facility type
- Formation
- Gauge
- Elevation
- Point determination
- State route number
- National route number
- Locality type
- Status
- Tracks
- Source

Size of dataset:

540 tiles, 3 themes per tile. An average of 3 to 9 mb file (all themes) depending on format

Scale/resolution:

1:250 000

Projection and datum:

Datum is AGD 66
2 projections available depending on format supplied:

- geographical - latitude and longitudes
- Australian Map Grid (AMG)

Price and access:

Product Price Lists

Restrictions on use:

None

Availability of sample data:

Available on web at http://www.auslig.gov.au/download/samples.htm

GEODATA 9 Second Digital Elevation Model (DEM-9S)

ANZLIC unique identifier: ANZCW0702000032
Title: GEODATA 9 Second Digital Elevation Model (DEM-9S)

Custodian

Custodian: Geoscience Australia
Jurisdiction: Australia

Description

Abstract:
The GEODATA 9 Second DEM Version 2 is a gridded digital elevation model computed from topographic information including point elevation data, elevation contours, stream lines and cliff lines. The grid spacing is 9 seconds in longitude and latitude (approximately 250 metres). 9 Second DEM is a cooperative effort of Geoscience Australia and Centre for Resource and Environmental Studies (CRES) at the Australian National University.
ANZLIC search words:

- LAND Topography Models

Geographic extent name: AUSTRALIA EXCLUDING EXTERNAL TERRITORIES - AUS - Australia - Australia
Note: The format for each Geographic extent name is: `Name - Identifier - Category - Jurisdiction` (as appropriate) See GEN Register

Geographic bounding box:

North bounding latitude: -9°

South bounding latitude: -44°

East bounding longitude: 154°

West bounding longitude: 112°

Data currency

Beginning date: 1998-07-01
Ending date: 2000-08-15

Dataset status

Progress: Complete
Maintenance and update frequency: Not Known

Access

Stored data format:

Digital: ASCII XYX

Digital: Arc/Info GRIDASCII

Available format type:

Digital: ASCII XYZ

Digital: Arc/Info GRIDASCII

Access constraints:
The data are subject to Commonwealth of Australia Copyright. A licence agreement is required and a licence fee is also applicable.

Data quality

Lineage:
The DEM was derived using the following Geoscience Australia data:

- Spot heights from GEODATA TOPO-250K Relief theme
- Linear watercourse features from the drainage layer of the GEODATA TOPO-250K Hydrography theme
- Coastline of Australia from GEODATA COAST-100K data and coastal inlets from the GEODATA TOPO-250K framework layer
- Radar altimeter point elevation data for Lake Eyre
- Trigonometric data points from the National Geodetic Data Base
- Spot heights (87 000), stream lines (11 000), sink point data (21 000), selected cliff lines and associated contour lines digitised from 1:100 000 scale mapping.

The DEM was created using the ANUDEM 5.0 algorithm developed by Dr Mike Hutchinson of the Centre for Resource and Environmental Studies (CRES) at the Australian National University.

Positional accuracy:
Not Documented

Attribute accuracy:
Not Relevant

Logical Consistency:
Not Relevant

Completeness:
Australia

Contact information

Contact organisation: Geoscience Australia - National Mapping Division

Contact position: Data Sales, Customer Support

Mail address: PO Box 2

Locality: BELCONNEN

State: ACT

Country: Australia

Postcode: 2616

Telephone: Australia Freecall 1800 800 173

Facsimile: +61 2 6201 4381

Electronic mail address: datasales@auslig.gov.au

Metadata information

Metadata date: 2001-03-15

Additional metadata

Metadata reference XHTML: http://www.auslig.gov.au/meta/meta15.htm
Metadata reference XML: http://www.auslig.gov.au/meta/meta15.xml

Price and access:

Product Price Lists

Attributes:

Elevation

Size of dataset:

37 1:1 million area tiles

Scale/resolution:

9 second grid

Projection and datum:

Datum is GDA 94
Projection is geographical - latitude and longitudes

Restrictions on use:

None

Availability of sample data:

Available on web at http://www.auslig.gov.au/download/samples.htm

Australia's River Basins 1997

ANZLIC unique identifier: ANZCW0702000012
Title: Australia's River Basins 1997

Custodian

Custodian: Geoscience Australia
Jurisdiction: Australia

Description

Abstract:
Australia's River Basins 1997 is the result of a joint State, Territory and Commonwealth Government project to create a national spatial database of major hydrological basins. It shows the boundaries of Australia's basins as defined by the Australian Water Resources Management Committee (WRMC).
Australia is divided into drainage divisions which are sub-divided into water regions which are in-turn sub-divided into river basins. The data includes the name and number of each of the 245 drainage basins, 77 regions, and 12 divisions.
ANZLIC search words:

- BOUNDARIES Mapping
- WATER Hydrology Mapping

Geographic extent name: AUSTRALIA EXCLUDING EXTERNAL TERRITORIES - AUS - Australia - Australia
Note: The format for each Geographic extent name is: `Name - Identifier - Category - Jurisdiction` (as appropriate) See GEN Register

Geographic bounding box:

North bounding latitude: -9°

South bounding latitude: -44°

East bounding longitude: 154°

West bounding longitude: 112°

Data currency

Beginning date: Not Known
Ending date: 1997-06-30

Dataset status

Progress: Complete
Maintenance and update frequency: Not Known

Access

Stored data format:

Digital: ArcInfo

Available format type:

Digital: ArcInfo Export

Digital: ArcView Shapefile

Digital: MapInfo mid/mif

Access constraints:
The data are subject to Copyright. Data files may be downloaded from Geoscience Australia's website at www.ga.gov.au/download/. A licence agreement is required.

Data quality

Lineage:
Data for basin boundaries have been captured by relevant State and Territory authorities from 1:10 000 and 1:250 000 scale source material. The balance of the data are from Geoscience Australia's GEODATA Coast 100K which includes coastlines and State and Territory borders.

Positional accuracy:
Variable - dependant on scale of source material.

Attribute accuracy:
Not Documented

Logical Consistency:
Australia's River Basin data complies with the following rules for topology:

- The data has a node/chain structure;
- Every line feature has a node at each end;
- Every line feature has a node at intersections;
- Every line feature has a node at the point where an attribute of the feature changes;
- There are no unnecessary pseudo nodes;
- Every polygon is closed;
- Every polygon contains a polygon label point;
- There are no coincident features;
- There are no undershoots, overshoots, broken lines or other artefacts;
- Divisions, Regions or Basins that are intersected by State borders have identical label point attributes each side of the State border; and
- Lines intersected by State borders, except for coastline, have identical attributes.

Completeness:
Complete for Australia

Contact information

Contact organisation: Geoscience Australia

Contact position: Data Sales

Mail address: GPO Box 378

Locality: CANBERRA

State: ACT

Country: Australia

Postcode: 2601

Telephone: Australia Freecall 1800 800 173

Facsimile: +61 2 6249 9955

Electronic mail address: datasales@ga.gov.au

Metadata information

Metadata date: 2003-04-02

Additional metadata

Metadata reference XHTML: http://www.auslig.gov.au/meta/meta5.htm
Metadata reference XML: http://www.auslig.gov.au/meta/meta5.xml

Size of dataset:

22.5 - 31.3 MB depending on the format.

Scale/resolution:

1:100 000 and 1:250 000

Projection/datum:

Geographical coordinates using the Australian Geodetic Datum 1966 (AGD66).

MAJOR WATER RESOURCES INFRASTRUCTURE (PART OF THE AUSTRALIAN WATER RESOURCES ASSESSMENT 2000 DATABASE)

DATASET

Unique Identifier
ANZCW1202000083

Custodian
Agriculture Fisheries and Forestry - Australia (AFFA)

Jurisdiction
Australia

DESCRIPTION

Abstract
Contains the spatial location of Water Availability Dams (storages) and their unique identifiers and names.
These locations and attributes were entered into a database by each State and Territory to define the location of dams and their total capacity for storage in the Surface Water Management Area (SWMA) in 1996/99 in ML.

Search Word	Qualifier
WATER Surface	Monitoring
WATER Surface	Resources

Bounding Coordinates
North: -9
South: -44
East: 154
West: 112

DATA CURRENCY
Beginning Date

01-Jun-2001
Ending Date
29-Jul-2001

DATASET STATUS

Progress
Complete

Maintenance & Update Frequency
As Required

ACCESS

Stored Data Format

DIGITAL - ArcInfo 8 Point Coverage

Access Constraints
The data are subject to Commonwealth of Australia Copyright. A licence agreement is required.

DATA QUALITY

Lineage
Latitude and longitude Water Availability Dam (storages) locations were entered into an Access Database for the NLWRA Theme 1 Water Availability reporting by the States and Territories. This information was extracted from the database and the final spatial data generated is based on the following methodology;
* nationally 1417 records were extracted,
* of these 1417, 165 of these records had a zero latitude and / or longitude, hence these records were deleted,
* of the 1252 records remaining, 819 records did not specify a datum, datum assumptions were made for each of these dams either based on the surrounding points, or if there was a datum entry that was incorrect they were calculated to AGD66.
* Once the spatial data was generated and projected into GDA94, the dams were intersected with SWMAs and State boundaries. There were 15 dams that were not within Australia hence these were deleted.
* The total final Dams (storages) spatial records are 1237, which are all stored in an SDE layer of the Audit Atlas called geo_wa_dams.
* The Dams spatial coverage is associated with the attribute table also supplied from the States and Territories. This table is stored in the Atlas database (tblswma_storages) and it contains 1417 records.

Positional Accuracy
Unknown

Attribute Accuracy

The attributes associated with the Water Availability Dams (Storages) are the dam number and name, the datum used for projection and the one supplied, the state code, the SWMA number supplied (i.e. rawswma_no) and the SWMA number determined from the intersection with the SWMA boundaries, the dam type, and the dam capacity.
Descriptions of Infrastructure/Dam Type codes are as follows:-
10 Channel
12 Pipeline
14 Prescribed Dam (NSW DAM Safety Committee)
15 Storage
16 Irrigation Storage
17 Town Water Supply Storage
25 Weir
26 Regulation Weir/Structure
27 Waterhole
30 Pump Station
35 Pipehead
36 Hydro Power Station
40 Hydro Dam
45 Lock
50 Hydro Power Station Storage
55 Hydro Storage
60 Barrage
The accuracy of the attribute information is considered 99%; States and Territories have supplied these names and numbers.

Logical Consistency
ArcInfo was used to undertake a topological consistency check to detect flaws in the spatial data structure and to flag them as errors for correction. This check ensures that all points are labelled uniquely with their Dam number.

Completeness
National Coverage, 87% of all are included in this coverage (refer to Lineage above).

CONTACT INFORMATION

National Land and Water Resources Audit (NLWRA)
Technical Director
GPO 2182
Canberra
ACT
Australia
2601

Telephone
02 6257 3067
Facsimile
02 6257 9518
Electronic Mail Address
atlas@nlwra.gov.au

METADATA DATE
20 July 2001

MEAN ANNUAL AND MONTHLY RAINFALL (MM)

DATASET

Unique Identifier
ANZCW1202000117

Custodian
CSIRO, Land and Water

Jurisdiction
Australia

DESCRIPTION

Abstract
Definition: Mean annual (00) and monthly (01...12) rainfall (mm) for the period 1980-1999.
Interpretation: The spatial distribution of rainfall across the continent is strongly nonuniform. About one third of the continent is classed as arid (receiving less than 250 mm average annual rainfall) and another third as semi-arid (250 mm to 500 mm). The rainfall distribution also changes dramatically through the annual cycle, so that the seasonal cycle of rainfall is quite different in different climatic regions. In the northern parts of the continent, rainfall is dominated by a humid, monsoonal wet season (October to March) followed by a hot, dry season (April-September). In the southwestern parts the pattern is Mediterranean with hot, dry summers and cool, wet winters, watered by frontal rain from the Southern Ocean. In southeastern parts the rainfall is more uniformly distributed through the year, under the combined influences of winter rain from the Southern Ocean and summer rain from the Pacific Ocean, brought by weather systems from the northeast. The combined effect is that the seasonal pattern of Australian rainfall has a "flip-flop" character, being wet in the tropics and dry in the south during the (southern) summer, and the reverse in the southern winter.
Notes: These surfaces are derived from Bureau of Meteorology(BoM) data, interpolated to daily time step and a spatial grid of 0.05 degrees by the Queensland Department of Natural Resources (QDNR).
Rain.00, Rain.01 ... Rain.12 - Mean annual and monthly rainfall (mm)
Data is in geographics and GDA94.

Search Word	Qualifier
CLIMATE AND WEATHER Rainfall	Maps
CLIMATE AND WEATHER Rainfall	Models

Bounding Coordinates

North: -9
South: -44
East: 154
West: 112

DATA CURRENCY
Beginning Date

01-Jan-1980

Ending Date
31-Dec-1999

DATASET STATUS
Progress
In Progress

Maintenance & Update Frequency
As Required

ACCESS
Stored Data Format
Arcview binary grid format, single precision

Access Constraints
The data are subject to Commonwealth of Australia Copyright. A licence agreement is required

DATA QUALITY
Lineage
Monthly and annual meteorological surfaces are temporal averages of 20 years (1980-1999) of daily gridded data at 0.05 degree spatial resolution supplied by QDNR in May 2000. Before temporal averaging, the original 0.05 degree data were regridded with a 0.025 degree shift to match the model analysis grid, using linear-weighted averages of the 4 surrounding cells.

Positional Accuracy
Refer to lineage and metadata for QDNR Data Drill surfaces at http://www.silo.growzone.com.au/datadrill_readme.html and Jeffrey SJ, Carter JO, Moodie KB, Beswick AR. 2001. Using spatial interpolation to construct a comprehensive archive of Australian climate data. Environmental Modelling & Software 16:309-330.

Attribute Accuracy
Refer to lineage and metadata for QDNR Data Drill surfaces at http://www.silo.growzone.com.au/datadrill_readme.html and Jeffrey SJ, Carter JO, Moodie KB, Beswick AR. 2001. Using spatial interpolation to construct a comprehensive archive of Australian climate data. Environmental Modelling & Software 16:309-330.

Logical Consistency
All gridded input data (meteorology and land surface characteristics) were compared to the analysis landmask for consistency at the coastlines in a two step process. 1) All input data occurring on non-land cells were discarded. 2) Land cells having no input data were assigned the value of the nearest input datum determined by a clockwise spiralling-outward search starting with the cell immediately to the east of the empty cell.

Completeness

Daily source data are temporally complete from January 1, 1980 to December 31, 1999. Data are spatially complete with respect to the 0.05 degree land mask used in the analysis, derived from an Arcview vector-to-grid conversion of the Auslig Topo2.5m coastline.

CONTACT INFORMATION

CSIRO, Land and Water
Theme 5.4a Data Manager
GPO Box 1666
Canberra
ACT
Australia
2601

Telephone
02 6246 5554
Facsimile
02 6246 5560
Electronic Mail Address
peter.briggs@cbr.clw.csiro.au

METADATA DATE

30 August 2001

ADDITIONAL METADATA

Jeffrey SJ, Carter JO, Moodie KB, Beswick AR. 2001. Using spatial interpolation to construct a comprehensive archive of Australian climate data.

Appendix 2

Accuracy Assessment Results

Assessment area	Overall Accuracy (%)	Kappa[a]	n
Inland NSW	85.79	0.76	401
North Coast NSW	85.42	0.80	96
South Coast NSW	90.46	0.87	1142
Richmond catchment TM imagery	79.70	0.66	2926
Richmond catchment MSS imagery	65.01	0.33	1146

[a]The Kappa statistic is a measure of agreement based upon the difference between the actual agreement in the error matrix and the chance agreement (Congalton and Green 1999).