A Compendium of Ecological Information on Australia's Northern Tropical Rivers

REPORT 9

The waterbirds of Australian tropical rivers and wetlands

Donald C. Franklin[A]

[A]School for Environmental Research, Charles Darwin University, Darwin, Northern Territory 0909, Australia

national centre for tropical wetland research

Authors

D. Franklin - School for Environmental Research, Charles Darwin University, Darwin, Northern Territory 0909, Australia

This report should be cited as follows:

Franklin, D. C. 2008. Report 9: The waterbirds of Australian tropical rivers and wetlands. In G.P. Lukacs and C.M. Finlayson (eds) 2008. *A Compendium of Ecological Information on Australia's Northern Tropical Rivers. Sub-project 1 of Australia's Tropical Rivers – an integrated data assessment and analysis (DET18)*. A report to Land & Water Australia. National Centre for Tropical Wetland Research, Townsville, Queensland.

Contact information

NCTWR

C/ Australian Centre for Tropical Freshwater Research

James Cook University

Townsville 4811

Queensland Australia

Funding statement

This project was funded by the Natural Heritage Trust Phase 2 (NHT2) and Land & Water Australia (LWA) as part of the Tropical Rivers Inventory and Assessment Project (TRIAP).

Disclaimer

Acknowledgements

The Department of Environment and Heritage contacts for this project were Renee Bartolo, John Lowry and Rick van Dam. I am grateful for their encouragement and support. John Lowry provided GIS data assisted with setting up the GIS project. Maria Grazia Bellio answered my queries about earlier work on the project. Stephen Garnett and Roger Jaensch assisted with the identification and location of relevant literature. Christine Maas proofread a draft of this report.

TABLE OF CONTENTS

List of figures

List of tables

Executive Summary

1. As part of the Tropical Rivers Inventory and Assessment Project (TRIAP), a database of 94,148 waterbird records was assembled, comprising 82,596 records from the TRIAP area and 11,552 records from a surrounding 10 km buffer. These records were sourced from databases for Atlas1 and Atlas2 provided by Birds Australia, 99.1% of which are from the Historical Atlas (pre-1977), the first Field Atlas (1977-1981) or the second Field Atlas (1997-2002).

2. Waterbirds were defined to include species of freshwater and coastal wetlands including in-shore but not off-shore marine species. The TRIAP waterbird fauna comprises 145 species from twenty families, of which 112 species are represented in the database by more than ten records.

3. One TRIAP waterbird species – the Australian Painted Snipe – is listed as threatened under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBCA). Eighty-seven species are listed as "migratory" under the EPBCA, 44 species are listed under the Japan-Australia Migratory Bird Agreement and 53 species under the China-Australia Migratory Bird Agreement. The geographical characteristics of all listed species are summarised for the TRIAP area.

4. In the TRIAP area, the Australian Painted Snipe is an infrequent visitor or perhaps rare resident found more frequently in the more arid south. Its preferred habitat of ephemeral wetlands with a mix of mud-flats and dense low vegetation does not closely match habitats recorded for the species in the TRIAP area, which may reflect the marginal nature of its occurrence in this area. Breeding records in the TRIAP area have been in flooded grasslands.

5. A foraging guild classification based on a classification of foraging substrate, foraging methods and food types is presented. Twelve foraging guilds are recognised as occurring in the TRIAP area.

6. No waterbirds are endemic to the TRIAP area. However, the TRIAP area represents a major proportion of the range of the Chestnut Rail, and a major proportion of the Australian range of the Great-billed Heron.

7. A biogeographic classification of TRIAP waterbirds is developed based on breeding distributions. Four classes are recognised: a. species for whom TRIAP is a core breeding area; b. Australasian species for whom TRIAP is marginal to their main distribution; c. Palaearctic / Nearctic migrants – these do not breed in Australia; and d. Non-migratory species with a distribution centre in Asia, or Malesia including New Guinea. Few species other than vagrants have restricted ranges within the TRIAP area, but there is a weak declining gradient in species richness from east to west.

8. The distribution of waterbird families, foraging guilds and threatened species were compared qualitatively with a 1:250 000 classification of waterbodies into seven units. Although the results are "noisy", groups associated with deep water and saline habitats were clearly identifiable. A geomorphic classification of rivers provides only linear data and poor spatial correspondence with waterbird records. Neither classification provides a direct measure of the wetland features most relevant to most species, and whilst quantitative analysis could be pursued, it appears unlikely to identify many definitive habitat relationships.

1. INTRODUCTION

This report details the collation and interpretation of waterbird data and its relationship to digital habitat classification systems for the Tropical Rivers Inventory and Assessment Project (TRIAP). It has been prepared under contract between the Department of Environment & Heritage and Charles Darwin University. It includes specific consideration of species listed as threatened or migratory under the *Environment Protection and Biodiversity Conservation Act 1999* and/or listed under treaties between Australia and Japan (JAMBA) and Australia and China (CAMBA) relating to the protection of migratory species.

The TRIAP area formally contains 51 catchments (Fig. 1). It includes all Australian mainland catchments that empty into the Timor and Arafura Seas and the Gulf of Carpentaria and associated embayments from Broome in Western Australia to the tip of Cape York Peninsula in Queensland including the entire Kimberley, Northern Territory and Gulf coasts. It coincides broadly with that portion of Australia that is monsoonal tropical. Three focus catchments (Fig. 1) are the subject of particular attention in this report.

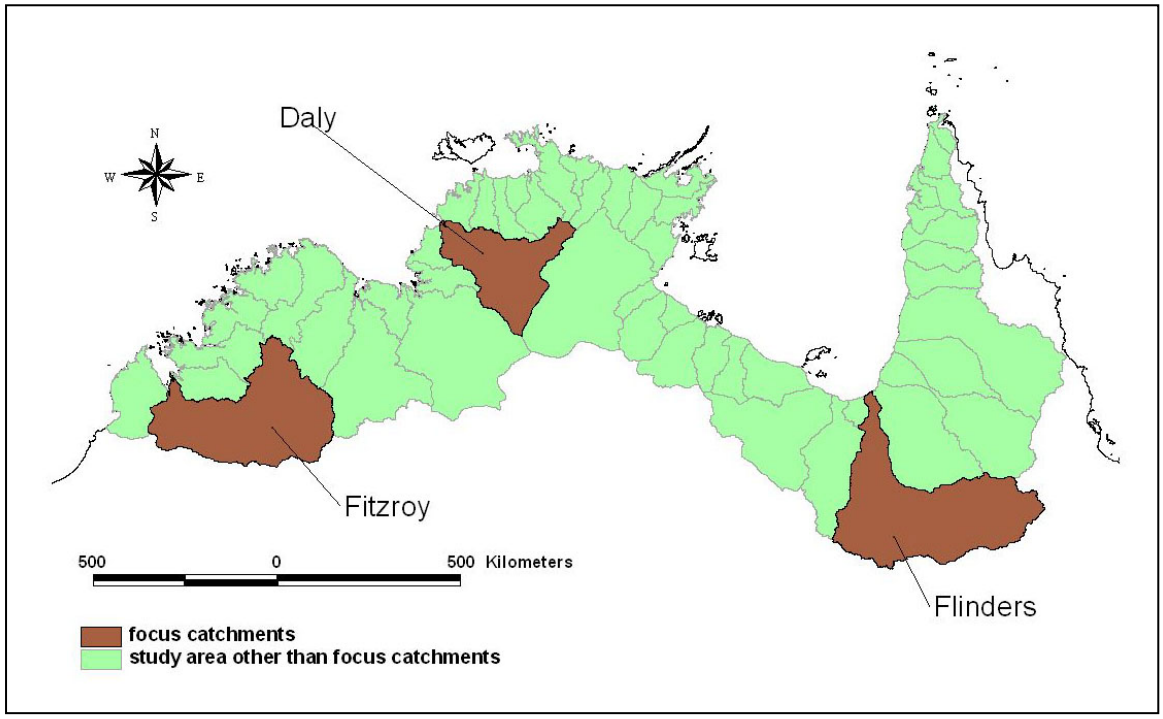


Figure 1. The TRIAP area and its 51 catchments, including the focus catchments.

The following agreed definition of waterbirds was provided by Bellio (unpublished):

> "In accordance with the Convention on Wetlands (www.ramsar.org) waterbirds are broadly defined as 'birds ecologically dependent on wetlands' and include traditionally recognized groups of birds known as wildfowl, waterfowl and shorebirds ..... families of waterbirds accepted under the Ramsar definition and included in the Asia-Pacific Migratory Waterbird Strategy (2001-2005) and found in the study area."

This definition is intended to include species associated with both freshwater and inland, coastal and in-shore saline habitats including waders, gulls and terns but excluding truly marine species such as boobies, jaegers, tropicbirds, frigatebirds and storm-petrels as these almost never use areas within TRIAP catchments.

Throughout this report, family and species names, taxonomic arrangements and checklist order follow Christidis & Boles (1994) with but one exception: the Australian population of the taxon previously known as the Painted Snipe *Rostratula benghalensis* has been elevated to full species status (see Lane & Rogers 2000 and references therein) and is listed as the Australian Painted Snipe *Rostratula australis*. This amendment is consistent with that adopted by the Department of Environment & Heritage (http://www.deh.gov.au/biodiversity/threatened/publications/painted-snipe.html).

2. THE WATERBIRD DATABASE

2.1. Database processing

The two source databases provided by the Commonwealth for this project were BA_ATLAS1.mdb and Bird Australia_97.mdb. These are the Atlas1 and Atlas2 datasets compiled by Birds Australia (Blakers *et al.* 1984, Barrett *et al.* 2003), although in both cases the datasets extend beyond the Field atlas data (section 2.2.).

Relevant fields were extracted from the source databases, merged and cropped to include only those in the TRIAP area and a surrounding 10 km buffer. The buffer records were retained because of location inaccuracies in the databases (discussed in section 2.2) and in particular that a substantial portion of coastal records and species would be lost without the buffer. Atlas1 records were vetted to exclude those coded as other than "normal" or "confirmed", i.e. the categories "doubtful" and "escapee" and several codes for which metadata are not available, although there it appears that records published by Blakers *et al.* (1984) have been vetted further. Atlas2 records had previously been vetted by Bellio (unpublished).

The resultant database is hereafter referred to as the master database (file: TRIAP_waterbirds_master.dbf). It contains 82,596 records for the TRIAP area and 11,552 records from the buffer, 94,148 in total. Study area and buffer records are distinguished in the database, as is the TRIAP catchment of each study area record. Metadata for the database and its derivate sub-set databases are provided in Appendix 3.

2.2. Sources of Atlas data

Atlas1 and Atlas2 records were obtained from a variety of sources, eleven of which are represented in the master database (Table 1). However, 99.1% of records were derived from three sources, the Historical Atlas and the Atlas1 and Atlas2 field atlases. The Historical Atlas is a more or less exhaustive databasing of published and unpublished records along with

specimen records from museum and private collections around the world - Blakers *et al.* (1984, p. xxv) describe it as "a comprehensive catalogue of the distribution of Australian birds from the time of European settlement". The two field atlases are extensive datasets for the periods 1977–1981 and April 1997 to April 2002 respectively, as reported by Blakers *et al.* (1984) and Barrett *et al.* (2003).

Table 1. Sources of waterbird records in the master database.

Source	Database Code	No. of records TRIAP	No. of records buffer
Atlas1			
Field atlas record	22	28,817	3,542
Historical atlas	23	8,737	1,619
Atlas2			
Field Atlas record form	1	43,289	6,052
Field Atlas electronic form	2	1,137	117
Nest Record Scheme	3	2	0
Literature	4	9	8
Pelagic	8	0	10
Parks & Wildlife Commission NT	10	229	0
QPWS – Wildnet	12	1	0
BirdInfo	13	384	204
Birds on Farms	14	27	0
Total Atlas1		37,554	5,161
Total Atlas2		45,042	6,391
Grand total		**82,596**	**11,552**

Metadata for other Atlas2 sources not been provided. The "Nest Record Scheme" refers to the Birds Australia project of that name (Marchant 1987-1989). "Parks & Wildlife Commission NT" records presumably refer to the Biological Records Scheme for which no metadata have evidently been published. "QPWS WildNet" refers to the Queensland Parks & Wildlife Service's wildlife database (e.g. Anon. 2002). "Birds on Farms" was a Birds Australia project, the methods for which are presented by Barrett (2000).

For current purposes, precision and accuracy are problematic. These datasets are all extensive in nature and individual search areas were often large (Table 2). For example, in the Atlas1 field survey, records were attributed to map grids of either 10' or 1º in area for which the coordinates were the centre of the grid cell. The two hectare searches of the Atlas2 field survey are by definition the most precise, with accuracy enhanced by the availability of Global Positioning Systems in recent times, but the alternate larger search areas are more generally applicable to the often-extensive wetlands of tropical areas. Thus, although the proportion of Atlas2 surveys that were 2 ha searches varied greatly between IBRA bioregions (Barrett *et al.* 2003, p729-730), these data are unlikely to be particularly relevant to waterbirds.

Table 2. Characteristics of the three main sources of waterbird records in the master database.

Source	% of records in master	Survey period	Precision	Accuracy	Notes
Historical atlas	11.0	pre-1977	variable, frequently very low	variable, frequently low, map-based	Records from literature and diaries, often with only very general locational information and with lists of species for large areas. Many records attributed to cells in excess of 100 x 100 km
Atlas1 field records	34.4	Jan. 1977 – Dec. 1981	1. 10' cells	map-based	Grid-based recording; cells vary with latitude, averaging *c.* 18.5 x 18 km in the TRIAP area
			2. 1º cells **	map-based	Grid-based recording; cells vary with latitude, averaging *c.* 110.5 x 107.5 km in the TRIAP area
Atlas2 field records	53.7	April 1997 – April 2002	1. 2 ha 2. 500 m radius 3. 5 km radius	GPS & map-based GPS & map-based GPS & map-based	Point-centred recording Point-centred recording Point-centred recording

2.3. Strengths and limitations of the master dataset

Given the remoteness of much of the TRIAP area, coverage is surprisingly substantial and well-dispersed (Figure 2). Nevertheless, there are major gaps and considerable unevenness. Coverage is particularly heavily concentrated in the Darwin-Kakadu-Katherine region of the Northern Territory and the Kununurra-Ord River region of Western Australia, along with other smaller foci such as Broome and Cloncurry-Mt Isa. In remoter areas, the path of main roads is clearly traceable in the record even at the coarse scale of Figure 2. The unevenness of coverage is related primarily to accessibility and proximity to major settlements. Furthermore, because a high proportion of records are contributed to visitors and access is limited during the wet season, seasonal coverage is both uneven and geographically biased. In the Atlas1 Field atlas, almost every degree cell received some coverage during "winter", but much of Cape York Peninsula, Arnhemland and the north Kimberley received no coverage at all during "summer" (illustrated by Blakers *et al*. 1984: pp. xxx – xxxi).

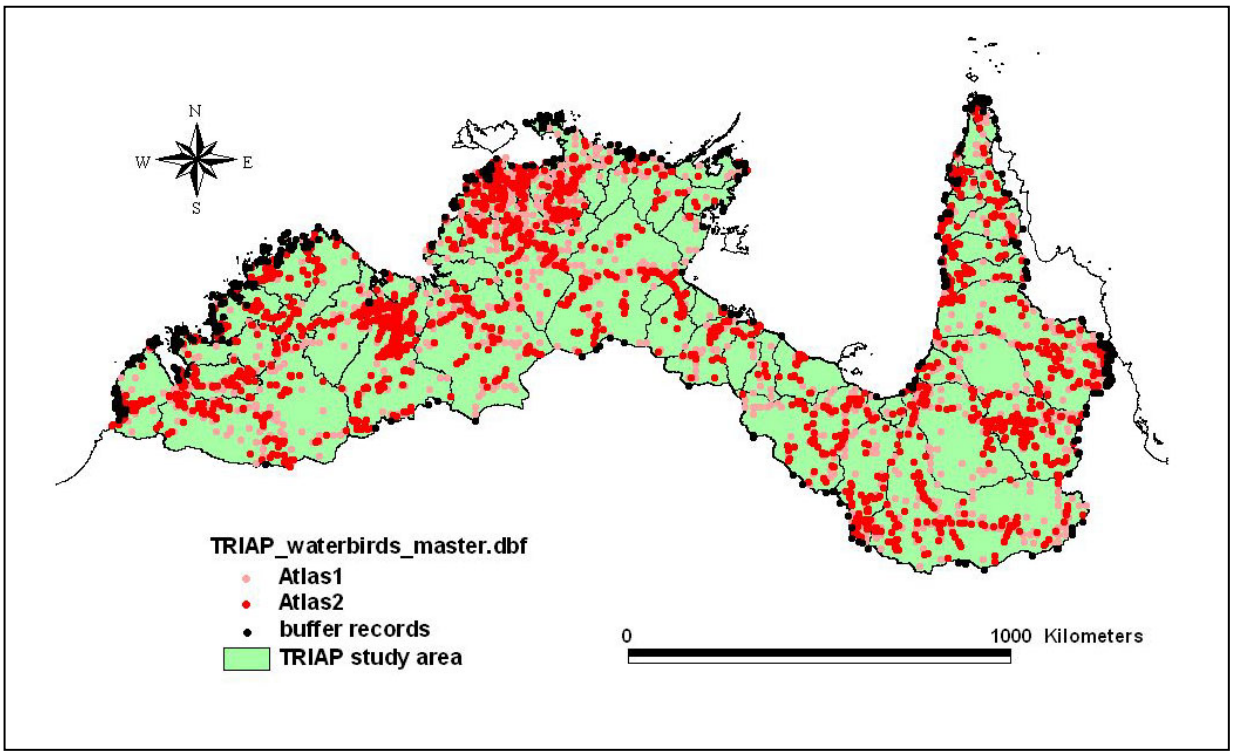


Figure 2. The TRIAP area with all waterbird records held in the master database.

Catchment totals varied by more than two orders of magnitude (Table 3). Whilst considerable unevenness can be attributed to variation in the size of catchments and in particular the area of wetlands they contain, coverage of less than 100 records (eight catchments) is by any definition very poor coverage. On the other hand, eighteen catchments are represented by more than 1,000 records and the three focus catchments each by more than 2,500 records.

Table 3. Number of records in the master database by catchment.

Catchment	State/Territory	Number of records
Adelaide River	NT	4,652
Archer River	Qld	547
Blyth River	NT	225
Buckingham River	NT	287
Calvert River	NT	61
Cape Leveque Coast	WA	8,450
Coleman River	Qld	591
Daly River	NT	2,517
Drysdale River	WA	451
Ducie River	Qld	111
East Alligator River	NT	3,530
Embley River	Qld	1,708
Finniss River	NT	6,921
Fitzmaurice River	NT	38
Fitzroy River	WA	5,159
Flinders River	Qld	2,844
Gilbert River	Qld	2,620
Goomadeer River	NT	307
Goyder River	NT	101
Holroyd River	Qld	71
Isdell River	WA	197
Jardine River	Qld	386
Keep River	WA, NT	499
King Edward River	WA	550
Koolatong River	NT	43
Leichhardt River	Qld	5,078
Lennard River	WA	612
Limmen Bight River	NT	195
Liverpool River	NT	74
Mary River	NT	1,198
Mitchell River	Qld	6,369
Morning Inlet	Qld	37
Moyle River	NT	183
McArthur River	NT	484
Nicholson River	Qld, NT	1,293
Norman River	Qld	3,614
Ord River	WA, NT	10,210
Pentecost River	WA	640
Prince Regent River	WA	336
Robinson River	NT	198
Roper River	NT	1,423
Rosie River	NT	107
Settlement Creek	Qld, NT	248
South Alligator River	NT	4,720
Staaten River	Qld	302
Towns River	NT	62
Victoria River	NT, WA	1,496
Walker River	NT	59
Watson River	Qld	274
Wenlock River	Qld	116
Wildman River	NT	402

Of more concern for the issues under consideration here are unevenness in coverage of habitats due to variation in accessibility. This effect varies greatly amongst catchments. For example, coasts of the TRIAP area are often remote, swampy and inaccessible, but this is markedly not the case in the Cape Leveque Coast (Broome) and Finniss River (Darwin) catchments. Even at quite local scales, the accessibility of habitats to observers can vary substantially – as an example, not the accessibility of sandstone watercourses in Litchfield National Park and the contrasting inaccessibility of floodplain wetlands in the nearby Reynolds River floodplain. Observers also tend to focus on landscape features such as lakes or rivers at the expense of floodplains and extensive swamps, and mangrove and saline coastal flats are particularly poorly sampled.

As a result, it would be spurious and seriously misleading to assume that waterbird records represent a random sample of habitat. However, there is a simple solution which is generally robust when considering the habitat relationships of elements of the waterbird fauna separately – to use the distribution of all waterbird records as the baseline against which the distribution of sub-sets may be compared. This is a variation of the method employed by Franklin (1998) to characterise changes in abundance of granivorous bird species from Atlas and other historic data.

2.4. Other potential sources of waterbird records

There are major temporal and spatial gaps in the existing dataset. There are very few records for the period 1982 to early 1997, and none since 2002. There are also very few records from much of the coastline, major gaps being evident even at the coarse scale of Fig. 2. These include the coast from Kalumburu in the north Kimberley to the mouth of the Daly River in the Northern Territory, and from Blue Mud Bay in eastern Arnhemland to the central west coast of Cape York Peninsula.

There are a moderate number of publications describing substantial waterfowl surveys in the TRIAP area during the interval between the two field atlases. Many of these are listed in Appendix 4 . Some additional data may be held by government departments, but I do not believe these are likely to be extensive other than those of Ray Chatto. The surveys of Chatto (2000, 2001, 2003, unpubl.) are concentrated along the coast and in near-coastal saline and freshwater wetlands and are a very substantial and complementary addition to records in the master database, with access by aircraft largely overcoming problems of accessibility. Similar surveys by Garnett (1987) in Queensland and parts of the Northern Territory are also a substantial and complementary addition though confined to waders, much less detailed and specific about habitat, and not species-specific. Also in Queensland, a series of air surveys by Taplin (1991) may provide additional information, but my efforts to obtain a copy of this unpublished report have not been successful.

The *Atlas of Australian Birds* is ongoing and, whilst operating at a substantially lower level than for the period 1997 to 2002, is a likely source of a considerable number of additional waterbird records for the TRIAP area. For more information, go to http://www.birdsaustralia.com.au/atlas/index.html. Other on-going potential sources of data are databases held by state wildlife departments, of which the Northern Territory's Biological Records Scheme is perhaps the most well developed.

Regional studies such as that of Morton *et al.* (1990*a*,*b*; 1993*a*,*b*,*c*) for the Alligator River region, and species-specific geographical studies (e.g. Bayliss & Yeomans 1990) provide much additional information and finer-scale resolution of distribution and habitat relationships for TRIAP waterbirds. However, I do not consider the conclusions about distribution arising from them constitute "discrepancies" with the master database. Indeed, the only substantial discrepancy I am aware of is the information about coastal species available from Ray Chatto.

3. THE WATERBIRD FAUNA OF THE TRIAP AREA

3.1. Families and species

Twenty waterbird families have been reported in the study area (Table 4). Seven families are represented by a single species, whilst the Scolopacidae and Charadriidae (waders), Anatidae (ducks), Ardeidae (herons and allies) and Rallidae (rails and allies) are each represented by more than 10 species.

Table 4. Families of waterbirds found in the TRIAP area.

NB: Nomenclature and checklist order follows Christidis & Boles (1994). The numbers of species are those considered to be waterbirds (Appendix 1). The number of records are those contained in the master database created by the author from the databases provided by the Commonwealth as detailed elsewhere in this report.

Family	English Name	No. of species	No. of records	
			TRIAP	buffer
Anseranatidae	Magpie Goose	1	1,515	123
Anatidae	Swans, geese and ducks	19	11,239	1,031
Podicipedidae	Grebes	4	2,017	182
Anhingidae	Darters	1	2,816	209
Phalacrocoracidae	Cormorants	4	6,072	483
Pelecanidae	Pelicans	1	2,022	250
Ardeidae	Herons, egrets and bitterns	14	17,800	1,969
Threskiornithidae	Ibises and spoonbills	5	8,416	749
Ciconiidae	Storks	1	2,218	175
Gruidae	Cranes	2	2,728	159
Rallidae	Rails, crakes and coots	14	2,509	406
Scolopacidae	Snipe, curlews and sandpipers	36	6,820	2,510
Rostratulidae	Painted Snipe	1	34	0
Jacanidae	Jacanas	1	1,372	82
Burhinidae	stone-curlews	1	150	138
Haematopodidae	Oystercatchers	2	446	278
Recurvirostridae	Stilts and avocet	3	1,687	125
Charadriidae	Plovers	14	7,247	1,086
Glareolidae	Pratincoles	2	1,266	62
Laridae	Gulls, terns and skimmers	19	4,222	1,535
Total		**145**	**82,596**	**11,552**

A list of 145 species recorded in the TRIAP area is provided in Appendix 1. Of these, 33 are represented by ten or fewer records and may be regarded as vagrants, these being strongly concentrated in the Scolopacidae (11 species), Anatidae (7 species), Laridae (6 species) and Charadriidae (5 species). Four species in the database, each represented by a single record, are not recognised as part of the Australian fauna by Christidis & Boles (1994), these being the Eurasian Curlew *Numenius arquata*, Nordmann's Greenshank *Tringa guttifer*, Green Sandpiper *Tringa ochropus* and Eurasian Golden Plover *Pluvialis apricaria*. The Pin-tailed Snipe *Gallinago stenura* does not occur in the database, but is confirmed as an apparent vagrant to the TRIAP area by Jaensch (1989) and Higgins & Davies (1996). The Black-headed Gull *Larus ridibundus* was first recorded in the TRIAP area (Palliser 2004) since the completion of surveys included in the master database.

3.2. Species of special significance

One TRIAP waterbird species is listed as threatened and 87 species as migratory under the *Environment Protection and Biodiversity Conservation Act 1999* (Table 5). Forty-four and 53 TRIAP waterbird species are listed under the migratory bird treaties with Japan and China (JAMBA and CAMBA) respectively (Table 5). The combined list comprises 89 species, 61% of all TRIAP waterbird species, and is strongly concentrated in the predominantly migratory wader families Charadriidae and Scolopacidae and amongst migratory terns of the family Laridae. Most of these species are primarily associated with coastal and marine environments.

The listed threatened species is the Australian Painted Snipe *Rostratula australis*, its EPBCA status being Vulnerable. It is also listed as Vulnerable by Garnett & Crowley (2000), as an EPBCA migratory species, and under CAMBA. It was originally listed as the Painted Snipe *Rostratula benghalensis*, but the Australian population has now been elevated to full species status (Lane & Rogers 2000 and references therein) . The Australian population is not known to move beyond Australia apart from a single record in New Zealand (Harrison & Mulligan 1986 cited in Lane & Rogers 2000). Since listing as a threatened species is dependant on this elevation in taxonomic status, there is an incompatibility between its threatened status and its status as a migratory species and in particular under CAMBA.

Remarkably little is known about the Australian Painted Snipe. The available information has been summarised by Lane (1987, p44), Marchant & Higgins (1993, pp. 658-666), Lane & Rogers (2000), Oring *et al.* (2004) and at the DEH web-site http://www.deh.gov.au/biodiversity/threatened/publications/painted-snipe.html. The species is highly nomadic and prefers temporary fresh or brackish wetlands in inland Australia. The distribution of TRIAP records are discussed in section 3.4.4. and habitat preferences in the TRIAP area in section 4.

Table 5. Waterbird species that occur in the TRIAP area and are listed:

a. as threatened under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBCA).
http://www.deh.gov.au/biodiversity/threatened/index.html, 10 March 2006.

b. as migratory under the EPBCA.
http://www.deh.gov.au/biodiversity/migratory/list.html#a, 10 March 2006.
Note that some listings are for entire families without naming species.

c. under the Japan-Australia Migratory Bird Treaty (JAMBA).
http://www.austlii.edu.au/au/other/dfat/treaties/1981/6.html, 14 March 2006.

d. under the China-Australia Migratory Bird Treaty (CAMBA).
http://www.austlii.edu.au/au/other/dfat/treaties/1988/22.html, 14 March 2006.
* Indicates web-site nomenclature different to that used here.

[table on next page]

Table 5. Listed species. (Full caption on previous page)

Family / Species		**EPBCA threatened**	**EPBCA migratory**	**JAMBA**	**CAMBA**
Anatidae	Garganey *Anas querquedula*		X	X	X
	and all 18 other species (Appendix 1)		X		
Ardeidae	* Cattle Egret *Ardea ibis*			X	X
	Eastern Reef Egret *Egretta sacra*		X		X
	* Great Egret *Ardea alba*		X	X	X
Threskiornithidae	Glossy Ibis *Plegadis falcinellus*		X		X
Gruidae	Sarus Crane *Grus antigone*		X		X
	Brolga *Grus rubicunda*		X		
Rallidae	Red-legged Crake *Rallina fasciata*		X		X
Scolopacidae	* Latham's Snipe *Gallinago hardwickii*		X	X	X
	Pin-tailed Snipe *Gallinago stenura*		X		X
	* Swinhoe's Snipe *Gallinago megala*		X	X	X
	Black-tailed Godwit *Limosa limosa*		X	X	X
	Bar-tailed Godwit *Limosa lapponica*		X	X	X
	* Little Curlew *Numenius minutus*		X	X	X
	Whimbrel *Numenius phaeopus*		X	X	X
	Eastern Curlew *Numenius madagascariensis*		X	X	X
	Eurasian Curlew *Numenius arquata*		X		X
	* Common Redshank *Tringa totanus*		X		X
	* Marsh Sandpiper *Tringa stagnatilis*		X	X	X
	* Common Greenshank *Tringa nebularia*		X	X	X
	Wood Sandpiper *Tringa glareola*		X	X	X
	Terek Sandpiper *Xenus cinereus*		X	X	X
	* Common Sandpiper *Actitus hypoleucos*		X	X	X
	* Grey-tailed Tattler *Heteroscelus brevipes*		X	X	X
	* Wandering Tattler *Heteroscelus incanus*		X	X	
	Ruddy Turnstone *Arenaria interpres*		X	X	X
	Asian Dowitcher *Limnodromus semipalmatus*		X		X
	Great Knot *Calidris tenuirostris*		X	X	X
	Red Knot *Calidris canutus*		X	X	X
	Sanderling *Calidris alba*		X	X	X
	Red-necked Stint *Calidris ruficollis*		X	X	X
	Long-toed Stint *Calidris subminuta*		X	X	X
	Pectoral Sandpiper *Calidris melanotos*		X	X	
	Sharp-tailed Sandpiper *Calidris acuminata*		X	X	X
	Dunlin *Calidris alpina*		X		X
	Curlew Sandpiper *Calidris ferruginea*		X	X	X
	Buff-breasted Sandpiper *Tryngites subruficollis*		X	X	
	Broad-billed Sandpiper *Limicola falcinellus*		X	X	X
	Ruff *Philomachus pugnax*		X	X	X
	Red-necked Phalarope *Phalaropus lobatus*		X	X	X
	and all five other species (Appendix 1)		X		
Rostratulidae	Australian Painted Snipe *Rostratula australis*	X	X		X
Recuvirostridae	all 3 species		X		
Charadriidae	* Pacific Golden Plover *Pluvialis fulva*		X	X	X
	Grey Plover *Pluvialis squatarola*		X	X	X
	Ringed Plover *Charadrius hiaticula*		X	X	X
	Little Ringed Plover *Charadrius dubius*		X		X
	Lesser Sand Plover *Charadrius mongolus*		X	X	X
	Greater Sand Plover *Charadrius leschenaultii*		X	X	X
	Caspian Plover *Charadrius asiaticus*		X	X	X
	Oriental Plover *Charadrius veredus*		X		
	and all six other species (Appendix 1)		X		
Glareolidae	Oriental Pratincole *Glareola maldivarum*		X	X	X
Laridae	Caspian Tern *Sterna caspia*				X
	Lesser Crested Tern *Sterna bengalensis*		X		X
	Crested Tern *Sterna bergii*			X	
	Black-naped Tern *Sterna sumatrana*		X	X	X
	* Common Tern *Sterna hirundo*		X	X	X
	Little Tern *Sterna albifrons*		X	X	X
	Bridled Tern *Sterna anaethetus*		X	X	X
	* White-winged Black Tern *Chlidonias leucopterus*		X	X	X
	* Common Noddy *Anous stolidus*		X	X	X

3.3. Foraging guilds

As there appears to be no satisfactory *a priori* classification of waterbirds into foraging guilds, the following is proposed in which species are categorised according to their preferred or primary foraging substrate, foraging method and food types:

Foraging substrates:
T = terrestrial (mostly grasslands, often swampy)
F = freshwater including edge of water
S = saline areas including coast, inshore marine and saline inland areas.

Foraging methods:
W = wading (includes terrestrial)
A = aquatic (swimming, diving)

Food types:
H = herbivorous ± small or large fauna
I = smaller fauna, mostly invertebrates ("insectivores")
L = larger fauna - fish, frogs and large invertebrates such as crustaceans and grasshoppers (when terrestrial – "predators"; when aquatic - "fishers")

This classificatory system yields 12 foraging guilds amongst TRIAP species (Table 6). Individual classifications are given in Appendix 1.

Table 6. Foraging guilds of waterbirds recognised in this study.

Guild	Example(s)	No. of species	No. of records TRIAP	No. of records buffer
TWH	Plumed Whistling-Duck, Brolga	7	4,106	297
TWI	Masked Lapwing, Oriental Pratincole	10	5,175	487
TWL	Cattle Egret, Straw-necked Ibis	3	3,612	287
FWH	Wandering Whistling-Duck, Magpie Goose	4	4,652	408
FWI	Black-fronted Dotterel, Black-winged Stilt	15	8,623	865
FWL	Intermediate Egret, Royal Spoonbill	16	24,004	2,070
FAH	Green Pygmy-goose, Eurasian Coot	13	7,633	795
FAI	Pink-eared Duck, Australasian Grebe	5	2,205	205
FAL	Darter, Whiskered Tern, Australian Pelican	10	12,926	1,260
SWI	Greater Sand Plover, Eastern Curlew	42	6,141	2,927
SWL	Eastern Reef Egret, Beach Stone-curlew	6	2,035	1,122
SAL	Crested Tern, Little Tern	14	1,484	829
Total		**145**	**82,596**	**11,552**

3.4. Biogeography

3.4.1. *Endemism*

No waterbirds are endemic to the TRIAP area, and none has a breeding range restricted to it. The species most nearly restricted to it is the mangrove-dwelling Chestnut Rail *Eulabeornis castaneoventris*. Within Australia, the Chestnut Rail is rarely found outside the TRIAP area and adjacent off-shore islands, and beyond Australia is known only from the Aru Islands (Blakers *et al*. 1984, Marchant & Higgins 1993). The Great-billed Heron *Ardea sumatrana*, a species of major rivers and coastal mud-flats, occurs in tropical northern Australian, parts of the Indonesian archipelago and south-east Asia. Within Australia, it is most abundant in the TRIAP area, but is also sparingly recorded along the Pacific coast of Queensland.

3.4.2. *Biogeographic elements*

The waterbird fauna of the TRIAP area may be usefully understood as a melding of four "faunas" or biogeographic elements based on the breeding distributions of species. As with almost any ecological classification, this is of necessity somewhat arbitrary and a few species straddle the boundaries. An additional biogeographic perspective independent of that outlined in this sub-section is presented in the next sub-section (3.4.3.).

The biogeographic status of two TRIAP species – Little Tern *Sterna albifrons* and the Gull-billed Tern *Sterna nilotica* – is unclear and likely to involve multiple sub-populations with differing biogeographic patterns. The status of many Rallidae in the TRIAP area is unclear because nesting is cryptic and thus rarely reported. Robust biogeographic inference about at least two of these – Buff-banded Rail *Gallirallus philippensis* and the Bush-hen *Amaurornis olivaceus* – is not currently possible. The Red-legged Crake *Rallina fasciata* is a vagrant to Australia from Asia which does not readily fit into any grouping.

a. Species for whom TRIAP is a core breeding area within Australasia

Many waterbirds breed in substantial numbers in the TRIAP area at numerous locations and probably annually (Blakers *et al*. 1984, Barrett *et al.* 2003). In addition, a number of colonial-nesting waterbirds and seabirds for whom breeding in the TRIAP area was poorly documented have recently been shown to do so at numerous remote sites and often large numbers (Chatto 2000, 2001).

It is a general characteristic of such species that they are resident in the TRIAP area. The only species to breed frequently in TRIAP but which may routinely disperse elsewhere when not breeding is a population of the Little Tern *Sterna albifrons* (see discussion in Higgins & Davies 1996 and the numerous breeding records in Chatto 2001). A number of species disperse some distance inland beyond the TRIAP boundary following strong inland wet-season rains (Jaensch 2003*a*), but this may be for the purpose of breeding and is interpretable biogeographically as a temporary inland extension of the tropical waterbird network.

Many of these species are endemic to the Australasian region (often including Papua New Guinea and New Zealand), but a few range more widely into Asia and several – the Cattle Egret *Ardea ibis* and Striated Heron *Butorides striatus* are examples – occur much more widely.

Within group *a*, two moderately-distinct sub-groups may be recognised. The first are strongly associated with higher rainfall regions of the north ± the east and south-east of Australia. Examples include the Green Pygmy-goose *Nettapus pulchellus*, Pied Heron *Ardea picata*, Brolga *Grus rubicunda*, Comb-crested Jacana *Irediparra gallinacea* and Lesser Crested Tern

Sterna bengalensis. Species in this group that are primarily associated with freshwater tend quite markedly to be more numerous in the higher rainfall north of the TRIAP area such as the northern Top End and Cape York Peninsula (e.g. Fig. 3). The second group are widespread Australian species that often occur and even breed in the arid zone or around most or all of the Australian coast. Examples include the Australasian Grebe *Tachybaptus novaehollandiae*, Little Pied Cormorant *Phalacrocorax melanoleucos*, Pied Oystercatcher *Haematopus longirostris* and Silver Gull *Larus novaehollandiae*.

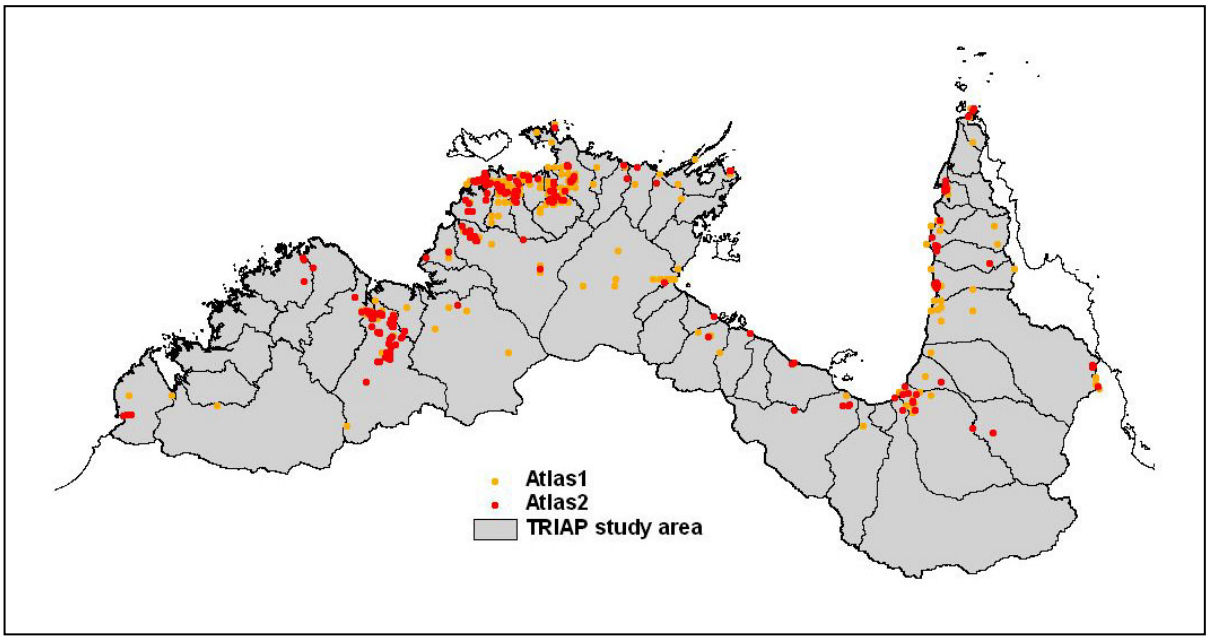


Figure 3. Records of the Pied Heron *Ardea picata* in the master database.

b. Australasian species for whom TRIAP is marginal to their main distribution

A large number of TRIAP waterbird species are Australasian and either do not breed in the TRIAP area, or do so relatively infrequently compared to other parts of their range. These species are typically non-breeding dry-season visitors to the TRIAP area. Some visit the TRIAP area on a more or less annual basis and in considerable numbers, whilst others are no more than vagrants. Their occurrence and especially any breeding in the TRIAP area is typically more frequent in the drier, southerly areas such as the Cape Leveque Coastal and Fitzroy River catchments in Western Australia and the gulf region of the Northern Territory and particularly Queensland (e.g. Fig. 4). Examples include the Black Swan *Cygnus atratus*, numerous ducks including the Australian Wood Duck *Chenonetta jubata*, Grey Teal *Anas gracilis* and Hardhead *Aythya australis*, Hoary-headed Grebe *Poliocephalus poliocephalus*, Australian Pelican *Pelecanus conspicullatus*, Yellow-billed Spoonbill *Platalea flavipes*, Purple Swamphen *Porphyrio porphyrio* and Whiskered Tern *Chlidonias hybridus*. The above examples are more or less widespread within extra-tropical Australia. Other sub-groups include arid-zone specialists such as the Pink-eared Duck *Malacorhynchus membranaceus* and Red-necked Avocet *Recurvisrostra novaehollandiae* and wet-tropic specialists such as the Red-necked Crake *Rallina tricolor*. However, boundaries between these sub-groups are frequently poorly defined.

The Cotton Pygmy-goose Nettapus coromandelianus is probably an east coast vicariant of the group a species the Green Pygmy-goose N. pulchellus, although their current distributions overlap extensively along the east coast of Queensland. The Double-banded Plover Charadrius bicinctus breeds in New Zealand and a portion of the population migrates to Australia in the non-breeding period, reaching the TRIAP area only as a vagrant.

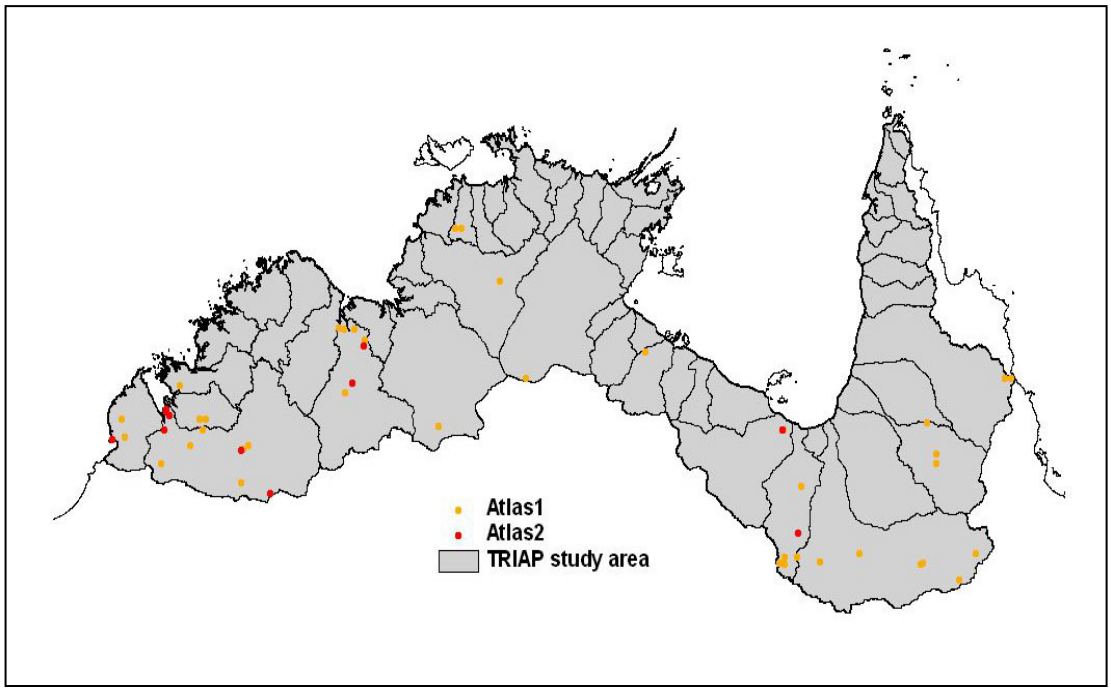


Figure 4. Records of the Black-tailed Native-hen *Gallinula ventralis* in the master database.

c. Palaearctic / Nearctic migrants.

This group of species breeds in the northern hemisphere and migrates southward annually for the northern winter. Some individuals remain in Australia throughout the year, but these do not breed in Australia. Most species are Palaearctic migrants (i.e. they breed in northern Asia ± northern Europe), but some also breeding in the Nearctic (far northern America), for example the Red-necked Phalarope *Phalaropus lobatus*. The Oriental Pratincole *Glareola maldivarum* is included here, although its breeding range is east and south Asia (Higgins & Davies 1996).

This group includes all Scolopacidae and the majority of the Charadriidae ("waders"). It also includes the Common Tern *Sterna hirundo*, White-winged Black Tern *Chlidonias leucopterus*, a population of the Gull-billed Tern *Sterna nilotica*, Black-headed Gull *Larus ridibundus*, Oriental Pratincole *Glareola maldivarum* and Garganey *Anas querquedula*.

Some species reach Australia and the TRIAP area only rarely, whilst others arrive annually and in huge numbers both in Australia generally (Lane 1987) and in the TRIAP area (Garnett 1987, Shurcliff 1993, Crawford 1997, Chatto 2003). Most of the latter, however, exhibit no marked preference for the TRIAP area over other parts of Australia, possible exceptions being the Oriental Plover *Charadrius veredus* and Oriental Pratincole *Glareola maldivarum*. Nevertheless, a number of sites in the TRIAP serve as key stop-over / launching grounds for migration, that at Roebuck Bay

near Broome being the largest and best-known. Lee Point near Darwin is also an important site for passage migrants (Shurcliff 1993). Lane (1987, pp. 156-158) provides a useful if somewhat dated summary of the importance of TRIAP area for migratory waders.

d. Non-migratory species with a distributional centre in Asia, Malesia or New Guinea

The few member of this group occur in the TRIAP area and Australia in only relatively small numbers, having core distributions to Australia's north. However, these species do not "over-winter" in Australia, are not migratory in the strict sense, and may or indeed do breed in northern Australia. It is possible that members of this group are potential group *a* species in the early stages of colonisation from the north, and it is perhaps noteworthy that the Australian occurrence of the two species concerned is concentrated in north Queensland.

The species concerned are the Brolga *Grus antigone* (see section 3.4.3) and the Spotted Whistling-Duck *Dendrocygna guttata*. The latter is a recent addition to the Australian fauna with a number of sightings and possible breeding near Weipa on Cape York Peninsula (Niland 1996, Beruldsen 2002).

An alternative approach to the classification of biogeographic groups could be based on endemicity to the Australasian region, in which case three groups might be recognised: *a.* species ± endemic to Australasia; *b.* tropical and pan-tropical species (these mostly or all breed in Australia); and *c.* Palaearctic / Nearctic migrants (do not breed in Australia).

3.4.3. *Species with restricted TRIAP ranges*

Most species with restricted occurrences within the TRIAP area are vagrants. The location of records of vagrants is more likely to be the product of chance and the distribution of observers than of any biogeographically meaningful trend. Some species are restricted to, or tend to be restricted to either the north or south of the TRIAP area, trends that are mostly the product of issues discussed in the previous section. The majority of waders of the families Scolopacidae and Charadriidae are strongly associated with the coast, a range restriction strongly and obviously related to habitat requirements..

However, an additional trend is of some biogeographic interest. A number of species occur within the TRIAP area only or primarily in the east, but there is no converse trend for species to occur only or primarily in the west. The western extent of their (primary) occurrence varies, yielding a weak declining gradient in species richness from east to west. The Red-necked Crake *Rallina tricolor* and Cotton Pygmy-goose *Nettapus coromandelianus* rarely occur beyond the far-eastern margin of the TRIAP area, whilst most TRIAP occurrences of the Australian Wood Duck *Chenonetta jubata* and Dusky Moorhen *Gallinula tenebrosa* are northward extensions of eastern Australian occurrences into Queensland and that of the Spotted Whistling-duck a southward extension from New Guinea (section 3.4.2.). Of more interest is the distribution of the Sarus Crane *Grus antigone* and Black-naped Tern *Sterna sumatrana*. The Sarus Crane is rarely recorded west of the Queensland border (Fig. 5) and all Australian breeding records have been in Queensland (Marchant & Higgins 1993, Barrett *et al.* 2003). The Black-naped Tern is an uncommon species of inshore waters in Queensland and in diminishing abundance west to about the mouth of the Daly River in the Northern Territory (Fig. 6), although Chatto (2001) has shown that breeding is widespread in the

Northern Territory portion of its range. The Radjah Shelduck *Tadorna radjah* and Green Pygmy-goose *Nettapus pulchellus* are markedly less frequent west of the Ord River catchment.

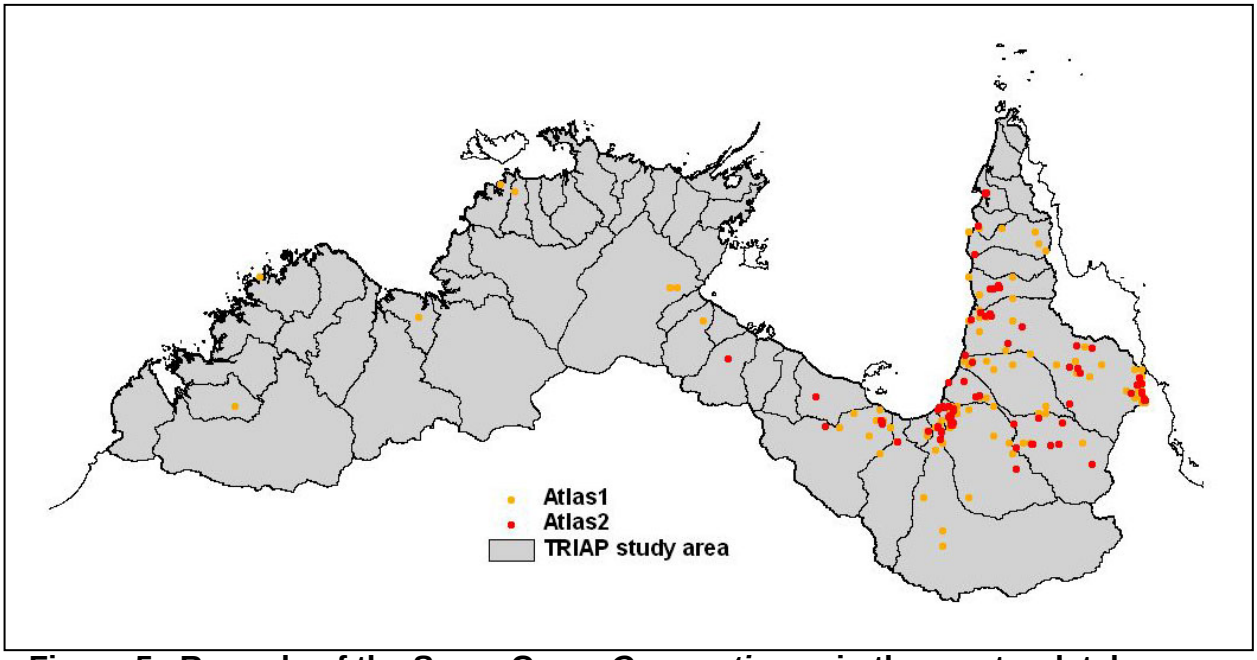


Figure 5. Records of the Sarus Crane *Grus antigone* in the master database.

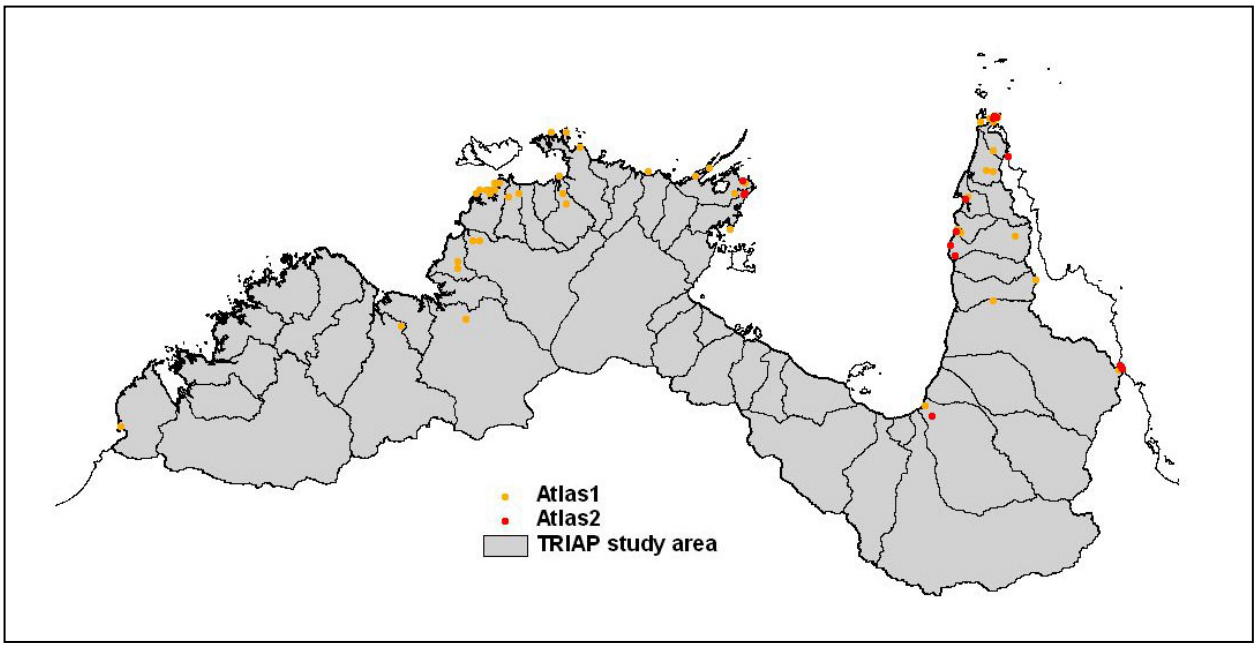


Figure 6. Records of the Black-naped Tern *Sterna striata* in the master database.

The Atlas1 records in the Ord (WA) and Victoria and Moyle River (NT) catchments were all rejected by Blakers *et al.* (1984). The records of Chatto (2001) fill much of the gap between records in north-eastern Arnhemland (NT) and the Queensland border.

No simple, universal explanation for this phenomenon is evident. However, it is correlated with and perhaps somewhat related to the seasonality of rainfall, which whilst marked

throughout the study area is more severe in the west. It also correlates with the most likely pathway for Asian species to colonise northern Australia – via New Guinea (section 3.4.2. group *d*).

3.4.4. *Listed species*

The 34 records of the Australian Painted Snipe *Rostratula australis* in the master database are concentrated in drier parts of the TRIAP area across its full east-west expanse (Fig. 7). Records not contained in the master database include one from the Victoria River catchment (Boekel 1980), a possible breeding record in the southern part of the Roper River catchment (Jaensch 2003*b*), and several from Western Australia (Jaensch 1989). In addition, Hassell & Rogers (2002) collated 26 records from seventeen sites in the Kimberley region of Western Australia. These were distributed through most months of the year and included a number of breeding records in the Broome and Derby areas. These lines of evidence and the cryptic nature of the species led them to suggest that a small population may be resident in the region.

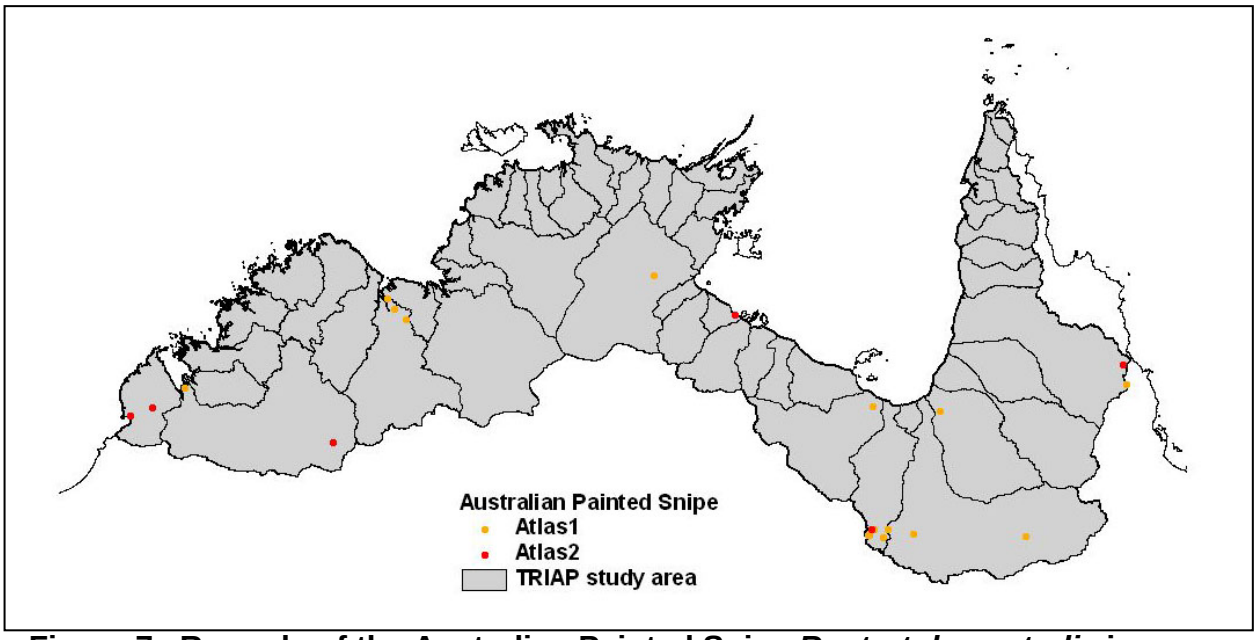


Figure 7. Records of the Australian Painted Snipe *Rostratula australis* in the master database.

The distributional features of all species listed under the *Environment Protection and Biodiversity Conservation Act 1999* including under CAMBA and JAMBA are summarised in Table 7.

Table 7. Distributional features of species listed under the EPBCA or JAMBA or CAMBA (from Table 5) within the TRIAP area.

No. of catchments: of 51 possible. Note that surveys in some catchments (Table 3) are grossly insufficient to represent the diversity that occurs within them.

Status codes: V = vagrant (10 or fewer TRIAP records in master database); U = uncommon (11–100 TRIAP records in master database); B = recorded breeding in the TRIAP area (information mostly from Blakers *et al.* 1984 and Barrett *et al.* 2003); a = TRIAP is a core breeding area; b = an Australasian species for whom TRIAP is ± marginal; c = Palaearctic/Nearctic migrant and thus non-breeding visitor the TRIAP area; d. = non-migratory species with a core distribution to Australia's north. See section 3.4.2. for explanation of codes a,b & c.

East-west occurrence codes: W = widespread; L = localised (see Notes). See section 3.4.3. for the significance of east-west distributional features.

North-south occurrence codes: W = widespread; N = northern (higher rainfall); S = southern (lower rainfall); C = occurs mostly on the coast (beaches, rocky shores, coastal and estuarine mud-flats); L = localised; See section 3.4.2. for the significance of north-south distributional features.

F/S codes: F = occurs mainly on freshwater; S = occurs mainly on saline waters.

Notes: "records" refers to master database records unless referenced to other sources.

Family Species	**No. of catchments**	**Occurrence**				**Notes**
		Status	**E-W**	**N-S**	**F/S**	
Anatidae						
Plumed Whistling-Duck *Dendrocygna eytoni*	38	B,a/b	W	W	F	likely to occur in all catchments; breeding is perhaps more frequent in southerly areas
Wandering Whistling-Duck *Dendrocygna arcuata*	40	B,a	W	W	F	tends to be more common, and to breed more often, in the northern lowlands
Spotted Whistling-Duck *Dendrocygna guttata*	2	U,?B,d	L	L	F	recent records and possible breeding near Weipa, Cape York Peninsula (Niland 1996, Beruldsen 2002)
Blue-billed Duck *Oxyura australis*	1	V,b			F	records are near Mt Isa, Queensland
Musk Duck *Biziura lobata*	2	V,b			F	records are near Mt Isa, Queensland
Freckled Duck *Stictonetta naevosa*	4	V,b			F	records are widely scattered, mostly in southern areas
Black Swan *Cygnus atratus*	19	B,b	W	S/W	F/S	more records in southern areas; breeds only infrequently in the TRIAP area
Australian Shelduck *Tadorna tadornoides*	3	V,b			F	the five records are widely dispersed in southern areas
Radjah Shelduck *Tadorna radjah*	41	B,a	±W	N	F	most prevalent in northern lowlands, where it is a breeding resident; uncommon west of Ord River catchment
Australian Wood Duck *Chenonetta jubata*	14	b	L/W	S	F	majority of records are from Queensland south of 16º South; non-breeding or rarely-breeding visitor to TRIAP area
Cotton Pygmy-goose *Nettapus coromandelianus*	7	U,b	L	W	F	only recorded in Queensland; most records are on Wet Tropics edge of Mitchell river catchment; possibly a non-breeding visitor to TRIAP area

Table 7 continued

Family Species	No. of catchments	Occurrence Status	E-W	N-S	F/S	Notes
Anatidae continued						
Green Pygmy-goose *Nettapus pulchellus*	42	B,a	±W	±N	F	breeding resident in northern areas; tends to be less common in south and uncommon west of the Ord River catchment
Pacific Black Duck *Anas superciliosa*	48	B,a/b	W	W	F	likely to occur in all catchments
Australasian Shoveler *Anas rhynchotis*	8	V,b			F	infrequent visitor, likely to occur in any area but more frequently so in the east
Grey Teal *Anas gracilis*	41	B,b	W	W	F	likely to occur in all catchments, but mostly as a non-breeding visitor; breeding records are in the south
Chestnut Teal *Anas castanea*	4	V,b			S/F	the few records are widely dispersed
Garganey *Anas querquedula*	4	V,c			F	the few records are widely dispersed
Pink-eared Duck *Malacorhynchus membranaceus*	26	B,b	W	S/W	F	mostly a non-breeding visitor, breeding occasionally in the south
Hardhead *Aythya australis*	32	B,b	W	W	F	probably mostly a non-breeding visitor
Ardeidae						
Cattle Egret *Ardea ibis*	33	B,a	W	±N	F	major concentration of records in the Ord, Finniss, Adelaide, Mary, Wildman, South Alligator and East Alligator Rivers catchments; quite a few breeding rookeries in Northern Territory (Chatto 2000)
Eastern Reef Egret *Egretta sacra*	34	B,a	W	C	S	a strictly coastal species; the few inland records are almost certainly erroneous; likely to occur in all catchments
Great Egret *Ardea alba*	51	B,a	W	W	F	recorded in all catchments; numerous rookeries in coastal areas of the NT (Chatto 2000) and probably elsewhere in the TRIAP area
Threskiornithidae						
Glossy Ibis *Plegadis falcinellus*	42	B,a	W	±W	F	tends to be more common in northern areas; several breeding rookeries recorded (Blakers *et al.* 1984, Chatto 2000)
Gruidae						
Sarus Crane *Grus antigone*	20	B,d	L	N	F	rarely reported outside Queensland; more detail in section 3.4.2., including Fig. 3
Brolga *Grus rubicunda*	51	B,a	W	W	F	recorded in all catchments; breeding is widespread
Rallidae						
Red-legged Crake *Rallina fasciata*	1	V,?			F	recorded Cape Leveque Coastal; breeds in south Asia (Marchant & Higgins 1993)

Table 7 continued

Family Species	No. of catchments	Occurrence Status	E-W	N-S	F/S	Notes
Scolopacidae						
Latham's Snipe *Gallinago hardwickii*	17	c	W	W	F	*Gallinago* snipe are virtually inseparable in the field. Capture records suggest that most TRIAP records are Swinhoe's Snipe. Most records of Latham's Snipe are historical and probably incorrect, but both Latham's and Pin-tailed Snipe have been confirmed in the TRIAP area (Higgins & Davies 1996). *Gallinago* spp. are widely but sparingly dispersed in the TRIAP area; the Pin-tailed Snipe is probably a vagrant.
Pin-tailed Snipe *Gallinago stenura*	0					
Swinhoe's Snipe *Gallinago megala*	12					
Black-tailed Godwit *Limosa limosa*	27	c	W	C	S	mostly along coast; likely to occur in all catchments.
Bar-tailed Godwit *Limosa lapponica*	22	c	W	C	S	mostly along coast; likely to occur in all catchments.
Little Curlew *Numenius minutus*	31	c	W	?W	F/S	uses coast and near-coastal floodplains upon arrival, subsequently dispersing inland to grasslands, where it is probably under-recorded.
Whimbrel *Numenius phaeopus*	39	c	W	C	S	almost entirely on coast; likely to occur in all catchments.
Eastern Curlew *Numenius madagascariensis*	38	c	W	C	S	almost entirely on coast; likely to occur in all catchments.
Eurasian Curlew *Numenius arquata*	1	V,c			S	the sole record is from the Finniss River catchment.
Common Redshank *Tringa totanus*	2	U,c	W	C	S	infrequent visitor to widely-dispersed coastal locations (coastal buffer records increase catchment tally to four).
Marsh Sandpiper *Tringa stagnatilis*	29	c	W	±C	S/F	most records are on coast or sub-coastal, but can occur on inland waters; likely to occur in all catchments.
Common Greenshank *Tringa nebularia*	41	c	W	C/W	F/S	majority of records are on coast or sub-coastal, but often occurs on inland waters; likely to occur in all catchments.
Nordmann's Greenshank *Tringa guttifer*	1	V,c			S	the sole record is from the Finniss River catchment.
Wood Sandpiper *Tringa glareola*	22	c	W	W	F	prefers freshwater habitats and avoids the coast; could occur in any catchment.
Green Sandpiper *Tringa ochropus*	1	V,c			S	the sole record is from the South Alligator River catchment.
Terek Sandpiper *Xenus cinereus*	22	c	W	C	S	almost entirely on coast; could occur in any catchment.
Common Sandpiper *Actitus hypoleucos*	37	c	W	C&±N	S/F	widespread along the coast and on inland waters, but in the latter is more common in northern areas.
Grey-tailed Tattler *Heteroscelus brevipes*	20	c	W	C	S	almost entirely along the coast; could occur in any catchment.
Wandering Tattler *Heteroscelus incanus*	3	V,c			S	possibly under-recorded because difficult to distinguish from Grey-tailed Tattler; with buffer records, recorded from 6 catchments.
Ruddy Turnstone *Arenaria interpres*	16	c	W	C	S	almost entirely along the coast; could occur in any catchment.
Asian Dowitcher *Limnodromus semipalmatus*	3	U,c	V?	CV	S	with buffer records, recorded from 4 catchments and all states.
Great Knot *Calidris tenuirostris*	17	c	W	C	S	almost entirely along the coast; could occur in any catchment.

Table 7 continued

Family Species	No. of catchments	Occurrence Status	E-W	N-S	F/S	Notes
Scolopacidae continued						
Red Knot *Calidris canutus*	10	c	±W	C	S	almost entirely along the coast; recorded in all states.
Sanderling *Calidris alba*	12	c	±W	C	S	entirely coastal; recorded in all states.
Little Stint *Calidris minuta*	1	V,c			S	the sole record is from the Finniss River catchment.
Red-necked Stint *Calidris ruficollis*	35	c	W	±C	S	mostly along coast, but also on inland waters.
Long-toed Stint *Calidris subminuta*	5	U,c	±W	±W	S/F	uncommon visitor to coast and inland areas; recorded in all states but most records are from Western Australia and none are from Cape York Peninsula.
Pectoral Sandpiper *Calidris melanotos*	6	U,c	W	±C/V	S	the few records are from all states.
Sharp-tailed Sandpiper *Calidris acuminata*	35	c	W	±W	S/F	along coast and inland waters; could occur in all catchments.
Dunlin *Calidris alpina*	1	V,c			S	the one record is from the Cape Leveque Coastal catchment.
Curlew Sandpiper *Calidris ferruginea*	23	c	W	C/±W	S	mostly along coast; could occur in all catchments.
Stilt Sandpiper *Micropalama himantopus*	1	V,c			S	the one record is from the Finniss River catchment.
Buff-breasted Sandpiper *Tryngites subruficollis*	1	V,c			S	the one record is from the Finniss River catchment.
Broad-billed Sandpiper *Limicola falcinellus*	7	U,c	±W	C	S	the few records are nearly all coastal; recorded in all states.
Ruff *Philomachus pugnax*	5	U,c	±W	C	S	the few records are nearly all coastal and are in Western Australia and the Northern Territory; also reported from TRIAP Queensland coast (Higgins & Davies 1996).
Red-necked Phalarope *Phalaropus lobatus*	2	V,c			S	all records are from coastal areas of the Cape Leveque Coastal and Fitzroy River catchments; also reported from TRIAP areas of the Northern Territory and Queensland (Higgins & Davies 1996).
Rostratulidae						
Australian Painted Snipe *Rostratula australis*	11	U/B,b	W	S	F	see Figure 7 and text of this section.
Recuvirostridae						
Black-winged Stilt *Himantopus himantopus*	42	B,b	W	W	F/S	mostly a non-breeding visitor, but with some southern breeding records; see discussion in Chatto (2000)
Banded Stilt *Cladorhynchus leucocephalus*	2	V,b			S	the two records are from the Cape Leveque Coastal and Fitzroy River catchments; also reported as vagrant to TRIAP area in the Northern Territory; prefers brackish, non-marine waters (Higgins & Davies 1996)
Red-necked Avocet *Recurvirostra novaehollandiae*	15	U,b	W	±W	F/S	non-breeding visitor to the TRIAP area

Table 7 continued

Family Species	No. of catchments	Occurrence Status	E-W	N-S	F/S	Notes
Charadriidae						
Eurasian Golden Plover *Pluvialis apricaria*	1	V,c			S	the one record is from the Finniss River catchment.
Pacific Golden Plover *Pluvialis fulva*	27	c	W	±C	S	the majority of records are on or near the coast, but also recorded sparingly on inland waters ±throughout the TRIAP area.
Grey Plover *Pluvialis squatarola*	18	c	W	C	S	most records are on the coast and these are very widely dispersed across the TRIAP area.
Ringed Plover *Charadrius hiaticula*	1	V,c			S	the one record is from the Finniss River catchment.
Little Ringed Plover *Charadrius dubius*	3	V,c			S	recorded from the Fitzroy, Finniss and South Alligator River catchments.
Red-capped Plover *Charadrius ruficapillus*	36	B,a	W	±C	S	likely to occur along the coast in all catchments; also occurs on inland waters particularly if brackish or temporary with open margins; breeding reported at many coastal locations, but see Chatto (2000) for discussion of these and their relationship to movements.
Double-banded Plover *Charadrius bicinctus*	1	V,b			S	the sole record is from the Ducie River catchment; a non-breeding migrant to south-eastern Australia from New Zealand
Lesser Sand Plover *Charadrius mongolus*	23	c	W	C	S	almost all records are on the coast; could occur in all catchments.
Greater Sand Plover *Charadrius leschenaultii*	25	c	W	C	S	almost all records are on the coast; could occur in all catchments.
Caspian Plover *Charadrius asiaticus*	1	V,c			S	the sole record is from a non-coastal location in the Daly River catchment.
Oriental Plover *Charadrius veredus*	25	c	W	±W	F/S	uses the coast on arrival but disperses to inland grasslands, where it may be under-reported.
Black-fronted Dotterel *Elseyornis melanops*	40	B,a/b	W	W	F	likely to occur in all catchments on freshwater wetlands, but breeding is more frequent in southern areas
Red-kneed Dotterel *Erythrogonys cinctus*	30	B,b	W	W	F	fairly widespread on freshwater wetlands; the few breeding records are in southern areas
Masked Lapwing *Vanellus miles*	47	B,a	W	W	F	likely to occur and breed in all catchments
Glareolidae						
Oriental Pratincole *Glareola maldivarum*	22	±c	W	±W	F	non-breeding migrant from Asia; occupies open wetland margins and grasslands

Table 7 continued

Family Species	No. of catchments	Occurrence Status	 E-W	 N-S	 F/S	Notes
Laridae						
Caspian Tern *Sterna caspia*	36	B,a	W	±W	S	widespread along coast; also occurs inland, mainly on large, open waterbodies; scattered breeding records are mostly coastal
Lesser Crested Tern *Sterna bengalensis*	21	B,a	W	C	S	confined to the coast and likely to occur along all TRIAP catchment coasts; scattered breeding records
Crested Tern *Sterna bergii*	29	B,a	W	C	S	almost confined to the coast and likely to occur along all TRIAP catchment coasts; fairly numerous breeding records including a number of large rookeries (Chatto 2001)
Black-naped Tern *Sterna sumatrana*	18	U,B,a	L	C	S	mostly confined to the coast from the Daly River catchment east (Fig. 4); under-reported in Atlas data (*cf* Chatto 2001); breeding is widely dispersed, with numerous small colonies in the Northern Territory (Chatto 2001)
Common Tern *Sterna hirundo*	11	U,c	±W	C	S	records are widely dispersed along the coast.
Little Tern *Sterna albifrons*	25	B,?	W	C	S	mostly confined to the coast; breeding is widely dispersed along the coast in small colonies (see also Chatto 2001)
Bridled Tern *Sterna anaethetus*	10	U,B,a	±W	C	S	the few records are widely dispersed along the coast; probably under-reported (*cf* Chatto 2001); fairly numerous small breeding colonies in TRIAP area
White-winged Black Tern *Chlidonias leucopterus*	22	c	±W	C/N	F/S	mostly occurs along the coast and on sub-coastal floodplains; ±patchy occurrence along the coast probably reflects the availability of large floodplain complexes.
Common Noddy *Anous stolidus*	4	U(B),a/b		±C	S	inclusion of buffer records increases number of catchments to eight, three in Western Australia and five in Queensland; also reported from TRIAP coast of the Northern Territory (Higgins & Davies 1996); scattered breeding records on off-shore islets

4. HABITAT RELATIONSHIPS

4.1. The habitat classifications

Three habitat datasets were provided in digital form by the Commonwealth for this exercise, a 7-class geomorphic classification, a 10-class geomorphic classification and a classification of waterbodies (Table 8). The 7-class geomorphic classification was intended for use for the entire TRIAP area and the more detailed 10-class classification for the focus catchments only, and are based on the work of Erskine *et al.* (2005).

The geomorphic classifications provide relatively poor correspondence with records of most waterbird species and groups (e.g. Fig. 8). This is the product of two factors:

1. imprecision, and to a lesser extent inaccuracy in the location of records (section 2.2., Table 2)

2. the linear nature of the classifications provides poor correspondence with key waterbird habitat

The TRIA Program is by definition about rivers. However, relatively few TRIAP waterbird species occur with particular frequency or preference along rivers or on river banks, notably the Black Bittern *Ixobrychus flavicollis*, Great-billed Heron *Ardea sumatrana* and Common Sandpiper *Tringa nebularia*. Most waterbird species are more common in other habitats such as more open wetlands with expansive shallow margins.

Following discussion and in recognition of this problem, the Commonwealth provided a waterbodies classification as an alternative means of assessing habitat relationship. Although not necessarily overcoming the first of the above problems, its non-linear nature offers a substantially better match in dealing with the second problem (Fig. 9). After further discussion (with Rick van Dam and Renee Bartolo) it was agreed to use only the waterbodies classification.

The waterbody units are mostly intuitive and self-explanatory. The following features are summarised from notes provided by John Lowry (pers. comm.). Further information about the classification may be obtained from http://www.ga.gov.au/image_cache/GA2213.pdf.

Saline coastal flats / Mangroves. Although not explicitly stated in the definitions provided, saline coastal flats are presumed to differ from mangroves in being treeless. Saline coastal flats generally occur on higher ground than mangroves.

Land subject to inundation / Swamp. These appear to differ mainly in the length of time moisture is retained – longer in swamp. In contrast to **lake** and **watercourse**, both units are presumably vegetated, but there does not appear to be any discrimination between treed and treeless vegetation.

Watercourses / Lake. Only watercourses more than 250 m wide are mapped, with the result that many substantial watercourses are not shown. The lake unit includes "claypan, saltpan, waterhole, pool, billabong, pond and oxbow". Lakes may occur independently of watercourses but are often also embedded within them and are presumably then interpretable as deeper waterholes.

Table 8. Digital habitat classifications made available for this study.

NB: For the 10-class geomorphic classification, the focus catchments in which each unit occurs is listed.

Classificatory system / Classification units	
7-class continental-scale geomorphic classification of rivers	
bedrock channel	
bedrock confined	
level alluvial plain	
rolling alluvial plain	
undulating alluvial plain	
lake / swamp	
estuarine	
10-class geomorphic classification of rivers (focus catchments only)	
bedrock channel	Fitzroy, Daly, Flinders
bedrock confined	Fitzroy, Daly, Flinders
non-channelised	Daly, Flinders
anabranching	Fitzroy, Daly, Flinders
meandering	Fitzroy, Daly, Flinders
straight, low sinuosity	Fitzroy, Daly, Flinders
chain-of-ponds	Fitzroy, Daly
billabong / lake / swamp	Fitzroy, Daly
estuary	Fitzroy, Daly, Flinders
wandering	Flinders
1:250 000 waterbodies classification	
reservoirs	
lakes	
watercourses	
swamps	
land subject to inundation	
saline coastal flats	
mangroves	
(embedded non-waterbody areas such as islands)	

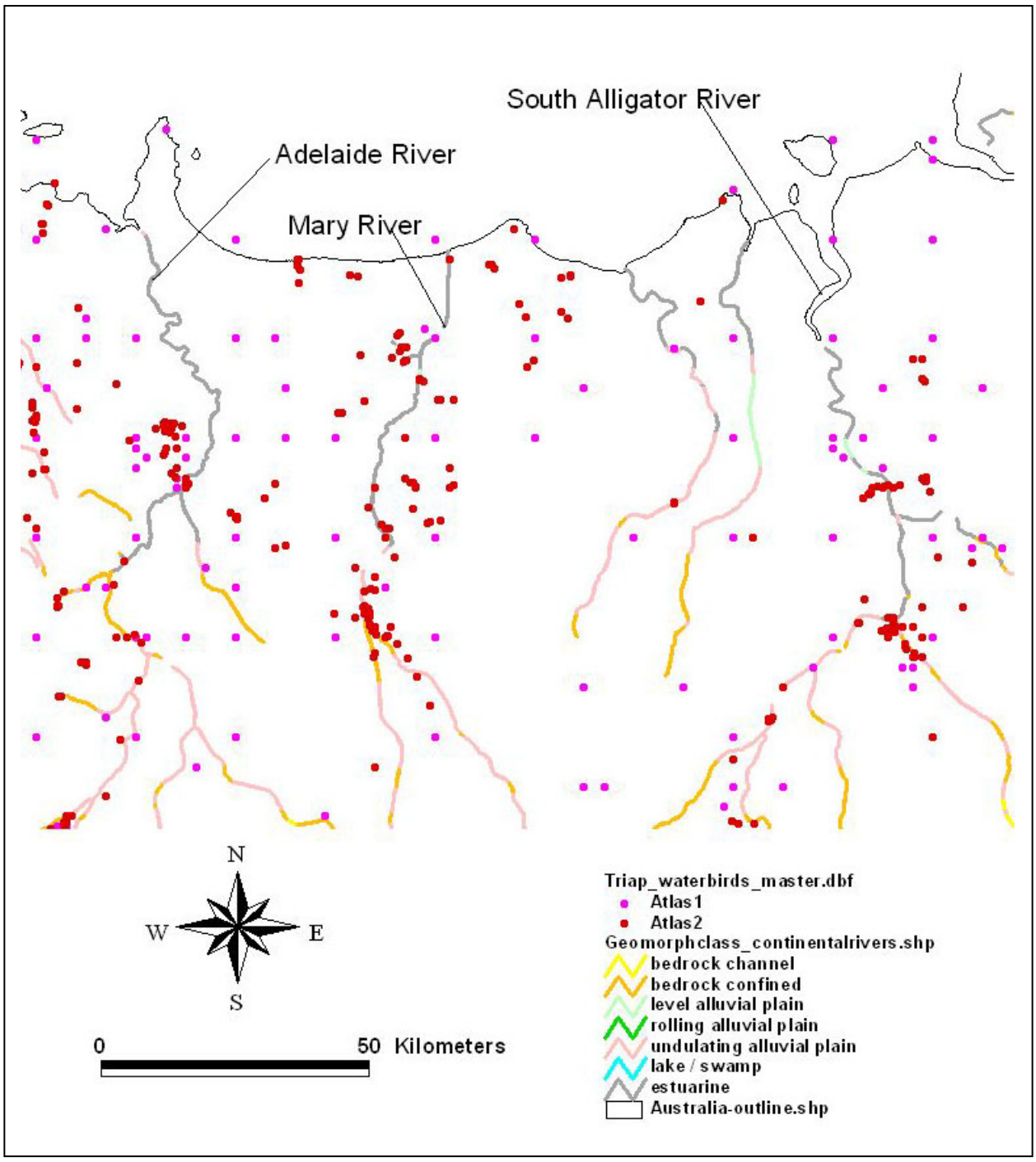


Figure 8. Overlay of waterbird records on the 7-class geomorphic classification for a portion of the north coast of the Northern Territory.

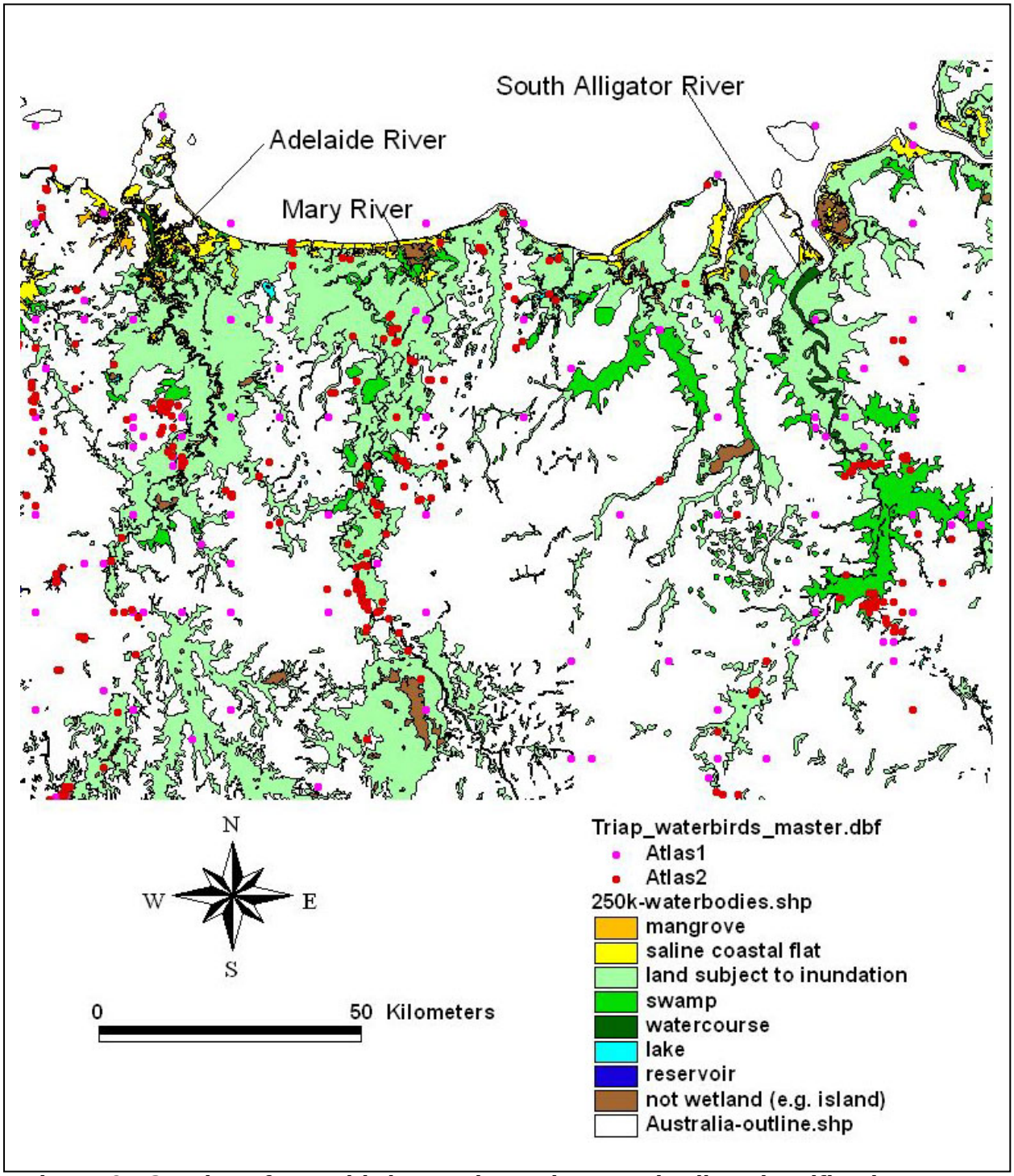


Figure 9. Overlay of waterbird records on the waterbodies classification for a portion of the north coast of the Northern Territory identical to that in Figure 8.

4.2. Methods

A GIS was prepared for the TRIAP area in which the following hierarchy could be superimposed:

1. Atlas1 records for the specified taxon or foraging guild
2. Atlas2 records for the specified taxon or foraging guild
3. all waterbird records
4. the waterbodies classification.

The distinction between Atlas1 and Atlas2 was maintained in recognition of the lower precision and accuracy associated with the latter (Table 2).

As the relevant datasets are extremely detailed, it was possibly only to consider a sample of the TRIAP area. For this purpose, the TRIAP area was divided into 17 compartments (Table 9). Because mangrove habitat occupies such a small portion of the TRIAP landscape and most mangrove areas were poorly surveyed for birds in the Atlas datasets, an additional two compartments featuring well-surveyed mangrove areas were identified and included (Table 9).

For each compartment, I zoomed in on one or more focus areas (usually two or three) containing records of the taxon or foraging guild or containing numerous records of waterbirds but notably lacking records of the taxon or foraging guild, and noted the waterbody units utilised along with any evidence of differential use of waterbody units. Records that were within a few kilometres of a waterbody unit were attributed to the nearest unit. The patterns noted in each compartment were aggregated across all compartments to provide a qualitative synthesis of the patterns of habitat use observed. I also noted evidence of habitat selection at the level of aggregations of units into coastal wetland complexes, major floodplains or river/billabong systems.

Since most statements about the waterbody units from which a taxon or guild was recorded are based on sampling, statements such as *was not recorded* should not be interpreted as absolute. Statements about positive or negative associations or lack of association with waterbody units are qualitatively equivalent to goodness-of-fit tests in which patterns of association with waterbody units of the taxon or guild are compared with that for all waterbirds.

For the focus catchments, I repeated the exercise, zooming in on a minimum of ten selections within each catchment.

Table 9. Compartments of the TRIAP area used for sampling of waterbird – waterbody classification relationships.

Purpose / Compartment (definition or main features)
TRIAP area coverage
1. Queensland, Cape York Peninsula north of 14º S
2. Queensland, Cape York Peninsula south of 14º S and north of 16º S
3. Queensland, Cape York Peninsula south of 16º S and north of 18º S
4. Queensland, east of 142º E, south of 18º S and north of 20º S
5. Queensland, east of 142º E, south of 20º S
6. Queensland, west of 142º E, north of 19º S
7. Queensland, west of 142º E, south of 19º S
8. Northern Territory, Gulf region south-east of the Roper River
9. Northern Territory, Arnhemland
10. Northern Territory, Kakadu National Park
11. Northern Territory, Darwin – Mary River region
12. Northern Territory, Sturt Plateau
13. Northern Territory, Victoria River district
14. Western Australia, lower Ord River valley
15. Western Australia, north Kimberley
16. Western Australia, upper Fitzroy and upper Ord River catchments
17. Western Australia, Cape Leveque and lower Fitzroy River catchments
Mangrove coverage
18. vicinity of Weipa, Queensland
19. vicinity of Darwin, Northern Territory

4.3. Family habitat relationships

Anseranatidae (magpie geese)

TRIAP: Although widely distributed throughout the TRIAP area, records were most numerous in major floodplain complexes. Recorded from all waterbody units, Anseranatidae were negatively associated with *mangroves*. There was some evidence of negative association with *watercourses* and *lakes*, but within floodplain complexes, records were often particularly numerous on or near deeper waterbodies (*swamp*, *watercourse*, *lake*).
Flinders River catchment: There are only three locations within this catchment, these being in the lower part corresponding to *anabranching* and *estuarine* units of the 10-class geomorphic classification.
Daly River catchment: Recorded from *land subject to inundation*, *watercourses*, *swamp* and *lake* units. There was no indication of associations amongst waterbody units, but compared to *all waterbirds*, records were concentrated in the northern portion of the catchment and in particular in the downstream floodplain.
Fitzroy River catchment: Recorded from *saline coastal flats*, *land subject to inundation*, *swamp*, *watercourse* and *lake*. The evident association was not with particular units but for the major floodplain complex in the centre and downstream portions of the catchment.

Anatidae (ducks, swan, pygmy-geese)

TRIAP: Anatidae occurred very widely through the TRIAP area, but there were noticeably fewer records relative to *all waterbirds* in the north Kimberley. Recorded from all waterbody units. The only suggestion of preference was weak negative association with *mangroves* and *saline coastal flats* and the coast. A notably high proportion of records were not associated with any waterbody unit, suggesting that Anatidae occur frequently on waterbodies too small to be mapped.
Flinders River catchment: Most waterbody records were on *watercourses*, additional noted being *land subject to inundation*, *lakes*, *reservoirs* and *saline coastal flats*. There was no evidence of association.
Daly River catchment: Recorded from *watercourses*, *land subject to inundation*, *swamp* and *lake*, with no evidence of association.
Fitzroy River catchment: Noted from all habitats except *mangrove* and *reservoir*, with no evident associations.

Podicipedidae (grebes)

TRIAP: Records are particularly sparse in the north Kimberley. Recorded from all waterbody units with a positive association with *lakes* and *reservoirs* and a negative association with *mangroves* and possibly *watercourses*.
Flinders River catchment: Recorded from *watercourses*, *reservoirs* and *land subject to inundation*, with an evident negative association with *land subject to inundation* and *swamp*.
Daly River catchment: There are surprisingly few records. Recorded from *land subject to inundation*, *swamp* and *watercourse*, with an evident negative association with *watercourse*.
Fitzroy River catchment: Recorded from all units except *mangroves*, with no obvious associations.

Anhingidae (darter)

TRIAP: Recorded from all waterbody units, but negatively associated with *mangroves* and *saline coastal flats* and positively associated with *lakes* and *reservoirs*. Within floodplain and swamp complexes, there was a positive association with *lakes* and a weaker positive association with *watercourses*.
Flinders River catchment: Most records are from *watercourses* and *reservoirs*. Correspondence with waterbody units was frequently poor, and there was insufficient evidence to suggest associations.

Daly River catchment: Most records were from *watercourses*, *swamps* and isolated patches of *land subject to inundation*. Inconsistent evidence of positive and negative association with of *watercourses* may be the product of a preference for deeper water.
Fitzroy River catchment: Recorded mostly from *watercourses* and *lakes* but also *swamp*, *land subject to inundation* and *saline coastal flat*. Within floodplain complexes, a positive association with *watercourses* and *lakes* was evident.

Phalacrocoracidae (cormorants)

TRIAP: Recorded from all units, with a fairly strong positive association with *lakes* and weak negative association with *mangroves*, *land subject to inundation* and in some areas *watercourses*. These patterns probably relate to the use of deeper and still waters for fishing by diving.
Flinders River catchment: Recorded from *watercourses*, *lakes* and *reservoirs*, with no obvious associations.
Daly River catchment: Recorded from *lakes*, *watercourses*, *land subject to inundation* and *swamp* with no obvious associations.
Fitzroy River catchment: Recorded from *lakes*, *watercourses*, *land subject to inundation* and *swamp*. Within the floodplain matrix there was a quite strong positive association with *watercourses* and *lakes* and negative association with *land subject to inundation*. In coastal areas, there was a weak negative association with *saline coastal flats*.

Pelecanidae (pelican)

TRIAP: Records tended to be aggregated along the coast independent of waterbody units and, within coastal and floodplain complexes, there was a positive association with *lakes* and *watercourses*. A positive association with *reservoirs* was also evident. Flinders River catchment: Recorded from *watercourses* and *reservoirs*, and on the coast, with no clear evidence of associations except that records were more likely to be on or near a recognised waterbody than were all waterbird records.
Daly River catchment: Recorded from *watercourses* and *land subject to inundation*, without clear evidence of associations.
Fitzroy River catchment: Recorded from *watercourses*, *lakes*, *swamp* and *land subject to inundation*, with no clear evidence of associations except that records were more likely to be on or near a recognised waterbody than were all waterbird records.

Ardeidae (herons, egrets and bitterns)

TRIAP: Recorded from all units with no evidence of associations.
Flinders River catchment: Recorded from *watercourses*, *lakes* and *reservoirs*, with no evidence of associations.
Daly River catchment: Recorded from *land subject to inundation*, *swamp*, *watercourse* and *lake*, with no evidence of associations.
Fitzroy River catchment: Recorded from all units except *reservoir*, with no evidence of associations.

Threskiornithidae (ibis and spoonbills)

TRIAP: Recorded from all units with no evidence of associations except for a weak, localised tendency for records to be more consistently on or near recognised waterbodies than all waterbird records.
Flinders River catchment: Recorded from *watercourses*, *lakes* and *reservoirs*, with no obvious associations.
Daly River catchment: Recorded from *land subject to inundation*, *swamp*, *watercourse* and *lake*, with no evidence of associations.
Fitzroy River catchment: Recorded from all units except *reservoirs* with no evidence of associations except for a weak tendency for records to be more consistently on or near recognised waterbodies than were all waterbird records.

Ciconiidae (stork)

TRIAP: Recorded from all units, with localised negative association with *mangrove* and *watercourse* units.
Flinders River catchment: Recorded from *watercourses*, *lakes* and *reservoirs*, with no obvious associations.
Daly River catchment: Recorded from *land subject to inundation*, *swamp*, *watercourse* and *lake*, with a weak tendency for records to be more consistently on or near recognised waterbodies than were all waterbird records.
Fitzroy River catchment: Recorded from all units except *mangroves* and *reservoirs* with a tendency for records to be more consistently on or near recognised waterbodies and along *watercourses* within floodplains than were all waterbird records.

Gruidae (cranes)

TRIAP: Recorded from all units with weak and/or localised negative association with *mangroves* and *watercourses* and a weak tendency to be more consistently associated with recognised waterbodies than all waterbird records.
Flinders River catchment: Recorded from *watercourses*, *lakes*, *reservoirs* and *land subject to inundation*, with no obvious associations.
Daly River catchment: Recorded from *land subject to inundation*, *swamp*, *watercourse* and *lake*, with no evidence of associations.
Fitzroy River catchment: Recorded from *lakes*, *watercourses*, *land subject to inundation*, *swamp* and *saline coastal flats*, with no obvious associations.

Rallidae (crakes, rails, moorhens)

TRIAP: Recorded from all units, with a positive association with *swamps* and *reservoirs* and some localised negative association with *watercourses*. Records along the coast and in *mangroves* and *saline coastal flats* are probably of the mangrove-specialist Chestnut Rail *Eulabeornis castaneoventris*.
Flinders River catchment: Recorded from *watercourses*, *lakes*, *reservoirs* and *land subject to inundation*, with no obvious associations.
Daly River catchment: Recorded from *land subject to inundation*, *swamp*, *watercourse* and *lake*, with no evidence of associations.
Fitzroy River catchment: Recorded from *lakes*, *watercourses*, *land subject to inundation*, *swamp* and *saline coastal flats*, but negatively associated with *watercourses*.

Scolopacidae (snipe, curlews and sandpipers)

TRIAP: Recorded from all waterbody units. This family is notable for its abundance along the coast. It displays a positive association with *mangroves* and *saline coastal flats*. In that other units are more frequent inland where records of Scolopacidae are *relatively* less frequent, a negative association with all other units exists. However, within non-coastal areas, the only noticeable associations was a weak positive association with *lakes* and a weak negative association with *watercourses*.
Flinders River catchment: Recorded from *watercourses*, *lakes* and *reservoirs*. There are noticeably very few Atlas2 records, these being confined to the vicinity of the river mouth and Corella Dam.
Daly River catchment: Recorded from *land subject to inundation*, *watercourse* and *lake*, with perhaps a weak positive association with *watercourse* evident in the lower catchment.
Fitzroy River catchment: Recorded from all units except *reservoirs*. The greatest concentration of records is close to the coast, with a positive association with *mangroves* and *saline coastal flats*.

Rostratulidae (Australian Painted Snipe)

TRIAP: the 24 locations are distributed as follows:

saline coastal flat	4

land subject to inundation	1
watercourse	4
lake	4
reservoir	7
no unit attributable	4

Flinders River catchment: The eleven locations are distributed as follows: *reservoir* - 6, *lake* - 2, *watercourse* - 1, no unit attributable - 2. The reservoirs concerned are: Lake Moondarra – 4 location records; and Lake Mary Kathleen – 2 location records.
Daly River catchment: There are no records from this catchment.
Fitzroy River catchment: The two location records are one each from *watercourse* and *saline coastal flat*.

Jacanidae (jacana)

TRIAP: Records are more frequent in northern areas and in major floodplain complexes. Although recorded from all units except *mangrove*, there was a strong positive association with *lakes*, a strong negative association with *mangroves* and weak negative associations with *saline coastal flats* and *watercourses*.
Flinders River catchment: There are only seven locations recorded in this catchment: three were on *reservoirs* and one each associated with *land subject to inundation*, *watercourse*, *lake* and no unit attributable.
Daly River catchment: Most records are in the lower catchment, on or in the vicinity of floodplains. Recorded from *land subject to inundation*, *swamp*, *watercourse* and *lake*, with no evident associations.
Fitzroy River catchment: The eight location records in this catchment are distributed: *saline coastal flat* – 2, *land subject to inundation* – 1, *swamp* – 2; *lake* – 2 and no unit attributable – 1. There is a possible weak negative association with *land subject to inundation* and *watercourse*.

Burhinidae (stone-curlew)

TRIAP: The sole waterbird member of this family in the TRIAP area is the Beach Stone-curlew *Esacus neglectus*. As its name suggests, it is very strongly associated with the coast and estuaries, and the few inland records are probably erroneous. In coastal areas, the considerable majority of records were not associated with any waterbody units, but those that were exhibited a striking positive association with *watercourses*, reflecting the preference of the species for open estuarine (and coastal) habitats. Recorded from all units except *swamp* and *reservoir*.
Flinders River catchment: There are no records for this catchment.
Daly River catchment: The one credible location record in this catchment is on *land subject to inundation* near the river mouth.
Fitzroy River catchment: The one location record in this catchment is on *saline coastal flat*.

Haematopodidae (oystercatchers)

TRIAP: More or less exclusively coastal, the few inland records of this species are probably doubtful. Most records are associated with the coast rather than waterbody units, but with records from all units except *swamp* and *reservoir*. In immediate-coastal areas, there was a weak positive association with *watercourses* and a negative association with *land subject to inundation* and *swamp*.
Flinders River catchment: On of two location records is coastal and not associated with a waterbody unit, and the other with *watercourse*.
Daly River catchment: There are no records from this catchment.
Fitzroy River catchment: The sole location record is in the vicinity of *saline coastal flat*.

Recurvirostridae (stilts and avocet)

TRIAP: Recorded from all waterbody units, with a weak positive association with *reservoirs* and a weak negative association with *mangroves* and *watercourses*, the latter away from the coast.
Flinders River catchment: Recorded from *watercourses* and *reservoirs*, with a possible weak negative association with *lake*.
Daly River catchment: Recorded from *land subject to inundation* and *watercourse*, with a possible negative association with *watercourse*.
Fitzroy River catchment: Recorded from all waterbody units except *mangrove* and *reservoir*, with no obvious associations.

Charadriidae (plovers)

TRIAP: Recorded in all waterbody units with no obvious associations except a possible weak negative association with *land subject to inundation*.
Flinders River catchment: Recorded from *watercourses*, *lake* and *reservoir*, with no obvious associations.
Daly River catchment: Recorded from *land subject to inundation*, *swamp*, *watercourse* and *lake*, with no obvious associations.
Fitzroy River catchment: Recorded from all waterbody units except *reservoir*, with no obvious associations.

Glareolidae (pratincoles)

TRIAP: Recorded from all units except *mangroves*. The Glareolidae are negatively associated with *mangroves* and there is a localised negative association with *watercourses*.
Flinders River catchment: Few of the records in this catchment are in or near any waterbody unit; there are records from *land subject to inundation*, *watercourse* and *lake*.
Daly River catchment: Records are mostly from *land subject to inundation*, with some from *watercourses*, there being a weak negative association with *watercourses*.
Fitzroy River catchment: Recorded from all waterbody units except *mangrove* and *reservoir*. There is a negative association with *watercourse*.

Laridae (gulls and terns)

TRIAP: The Laridae are particularly associated with the coast and major floodplain complexes. They were reported from all waterbody units with positive associations with *lakes* and *reservoirs* and localised negative associations with *watercourses*.
Flinders River catchment: Recorded from *land subject to inundation*, *watercourse*, *lake* and *reservoir*, with no obvious associations.
Daly River catchment: The eight location records were from *land subject to inundation* - 4, *watercourse* – 3 and no unit attributable – 3.
Fitzroy River catchment: Recorded from all waterbody units except *reservoir*, with no obvious associations.

4.4. Foraging guild habitat relationships

See Table 6, section 3.3. for an explanation of foraging guilds. Note that "herbivore" includes the possibility of also being extensively insectivorous, whereas "insectivore" implies that herbivory is not a major component of the diet.

TWH (terrestrial wading herbivore)

TRIAP: Recorded from all waterbody units, with weak evidence of a positive association with *land subject to inundation*, negative association with *mangroves*, and localised negative association with *watercourses*.
Flinders River catchment: Recorded from *watercourse*, *lake* and *reservoir*, with no evidence of preferential associations.

Daly River catchment: Recorded from *land subject to inundation*, *swamp*, *watercourse* and *lake*, with no obvious associations.
Fitzroy River catchment: Recorded from all waterbody units except *mangrove* and *reservoir*, with a suggestion of a negative association with *mangrove*

TWI (terrestrial wading insectivore)

TRIAP: Recorded from all waterbody units with no evidence of associations.
Flinders River catchment: Recorded from *watercourse*, *reservoir* and *saline coastal flat*, with no evidence of association.
Daly River catchment: Recorded from *land subject to inundation*, *swamp*, *watercourse* and *lake*, with a possible weak positive association with *watercourse*.
Fitzroy River catchment: Recorded from all waterbody units except *reservoir*, with weak evidence of a positive association with *land subject to inundation* and a negative association with *watercourse*.

TWL (terrestrial wading predator or fisher)

TRIAP: Recorded from all waterbody units with a fairly strong positive association with *lakes*, a weak positive association with *reservoir* and *swamp*, negative associations with *mangrove* and *saline coastal flat* and localised negative associations with *watercourse*.
Flinders River catchment: Recorded from *watercourse*, *land subject to inundation*, *lake* and *reservoir*, with no evidence of any associations.
Daly River catchment: Recorded from *land subject to inundation*, *watercourse* and *lake*, with no obvious association.
Fitzroy River catchment: Recorded from all waterbody units except *mangrove* and *reservoir*, with a possible weak negative association with *mangrove*.

FWH (freshwater wading herbivore)

TRIAP: This foraging guild was most prevalent in coastal floodplains. It was quite strongly positively associated with *lakes* and *reservoirs*, displayed a localised but at times strong negative association with *watercourses*, and a weak negative association with *mangroves*.
Flinders River catchment: Recorded from *lakes*, *watercourses*, *land subject to inundation* and *reservoirs*, with no evidence of associations.
Daly River catchment: Recorded from *land subject to inundation*, *swamp*, *watercourse* and *lake*, with no obvious association.
Fitzroy River catchment: Recorded from *land subject to inundation*, *swamp* and *saline coastal flat*, with a quite marked negative association with *watercourse* and a weak negative association with *mangrove*.

FWI (freshwater wading insectivore)

TRIAP: Recorded from all waterbody units, with weak tendencies to positive association with *saline coastal flats*, *lakes* and *reservoirs* and localised negative association with *watercourse*.
Flinders River catchment: Recorded from *lakes*, *watercourses*, *land subject to inundation* and *reservoirs*, with no evidence of associations.
Daly River catchment: Recorded from *land subject to inundation*, *swamp*, *watercourse* and *lake*, with no obvious association.
Fitzroy River catchment: Recorded from all waterbody units with no obvious associations.

FWL (freshwater wading predator or fisher)

TRIAP: This abundant foraging guild was recorded from all waterbody units with no evidence of associations.
Flinders River catchment: Recorded from *watercourse*, *lake* and *reservoir*, with no evidence of associations.

Daly River catchment: Recorded from *land subject to inundation*, *swamp*, *watercourse* and *lake*, with no obvious association.
Fitzroy River catchment: Recorded from all waterbody units except *reservoir*, with no evidence of association.

FAH (freshwater aquatic herbivore)

TRIAP: Recorded from all waterbody units. There was a quite strong negative association with *watercourses*, and weaker negative associations with *mangroves*, and *land subject to inundation*. These trends reflect a preference for deep, permanent, still freshwater.
Flinders River catchment: Recorded from *watercourse*, *lake* and *reservoir*. Contrary to the trend for the TRIAP area as a whole, there was a positive association with *watercourses*.
Daly River catchment: Recorded from *land subject to inundation*, *swamp*, *watercourse* and *lake*, with a fairly strong negative association with *watercourse*.
Fitzroy River catchment: Recorded from all waterbody units except *mangrove* and *reservoir*, FAH was negatively associated with *watercourse* and *mangrove*.

FAI (freshwater aquatic insectivore)

TRIAP: FAI tended be concentrated on major floodplains both in the north and south of the TRIAP area, with particularly few records from the north Kimberley. Recorded from all waterbody units, there were weak positive associations with *swamp*, *lake* and *reservoir* and a strong negative association with *watercourse*.
Flinders River catchment: Recorded from *watercourse*, *lake*, *land subject to inundation* and *reservoir*, with a quite marked negative association with *watercourse*.
Daly River catchment: Recorded from *land subject to inundation*, *swamp* and *watercourse*, FAI exhibited a negative association with *watercourse*.
Fitzroy River catchment: Recorded from all waterbody units except *mangrove* and *reservoir*, FAH was strongly negatively associated with *watercourse* and weakly negatively associated with *mangrove*.

FAL (freshwater aquatic predator or fisher)

TRIAP: Recorded from all waterbody units, within floodplain complexes there was a trend towards positive association with deeper waterbodies – *lakes*, *watercourses* – and away from *land subject to inundation*. However, in other settings there were localised negative associations with *watercourse*.
Flinders River catchment: Recorded from all units except *mangroves* and *saline coastal flats*, there was a weak positive association with *watercourse*.
Daly River catchment: Recorded from *land subject to inundation*, *swamp*, *watercourse* and *lake*, there was no evidence of any association.
Fitzroy River catchment: Recorded from all waterbody units except *reservoir*, there was a quite strong positive association with *watercourse*.

SWI (saline wading insectivore)

TRIAP: Records of this foraging guild were most numerous in coastal areas. Notwithstanding that many coastal records were on the coast and did not fall within a waterbody unit, there was a strong positive association with *mangrove* and *saline coastal flat*. Away from the coast, a variety of waterbody units were occupied but with a quite strong negative association with *watercourse*.
Flinders River catchment: The few records in this catchment were associated with the coast and with *land subject to inundation, watercourse, lake* and *reservoir* without obvious associations.
Daly River catchment: Records for this catchment were mostly from *land subject to inundation*, with some from *watercourse*, but there were too few records to infer any associations.

Fitzroy River catchment: Recorded from all waterbody units except *reservoir*, there was a clear positive association with *mangrove* and *saline coastal flat*.

SWL (saline wading predator or fisher)

TRIAP: The relatively few records of this guild are strongly though not entirely concentrated in coastal areas. In coastal areas, many records were associated with the coast independently of any waterbody unit, but there was also a strong positive association with *mangroves*, a weak negative association with *saline coastal flats* and *land subject to inundation* and a tendency for records to be clustered around *watercourses* (i.e. estuaries). The sparse record away from the coast was positively associated with *watercourses*, *lakes* and *reservoirs* and negatively associated with *land subject to inundation*.

Flinders River catchment: Eight of the twelve location records were from *reservoir*, the remaining being distributed one each on *watercourse*, *lake*, the coast independent of waterbody units and not attributable to a unit.

Daly River catchment: Five of ten location records were from *watercourse*, three from *land subject to inundation*, one from *lake* and one could not be attributed to a waterbody unit.

Fitzroy River catchment: Seventeen of nineteen locations records were within 150 m of the coast, 10 being in *saline coastal flat*, four in *mangrove*, three in *swamp* and one could not be attributed to a unit, with a clear positive association with *saline coastal flat* and perhaps also with *mangrove*. The two non-coastal records could not be attributed to a waterbody unit.

SAL (saline aquatic predator or fisher)

TRIAP: Records were strongly associated with coast areas but secondarily with major floodplains. In coastal areas, the considerable majority of records were on the coast independent of any waterbody units, and there was no clear associations within those records that were associated with waterbody units. The sparse record away from coastal areas was strongly positively associated with *reservoirs*.

Flinders River catchment: Eight of the twenty-four location records were on *watercourse*, seven were on *reservoir* one on *lake*, one on the coast independent of waterbody units and seven could not be attributed to a unit. However, the spatial aggregation of records on one *reservoir* and a few *watercourses* precludes any conclusion about association.

Daly River catchment: Three of six location were records were on *land subject to inundation*, two were on *watercourse* and one could not be attributed to a waterbody unit.

Fitzroy River catchment: Eight of fifteen location records were on *land subject to inundation*, four were on *watercourse*, one was on *swamp* and two could not be attributed to a waterbody unit.

4.5. Discussion

4.5.1. *Methodological issues*

This analysis is both qualitative and broad-brush. For a number of reasons, it cannot be expected to produce strong or definitive results.

The first reason is that there is a fundamental and often severe mismatch of scales between the waterbody and waterbird data. Waterbird surveys are rarely point surveys, often of necessity. Wetlands frequently comprise a mosaic of habitats even at the large scale measurable by remote sensing. Thus, general waterbird surveys such as Atlas data frequently do not discriminate between elements of the mosaic which the waterbody classification does. Indeed, the precision of much Atlas data is often measured in kilometres rather than metres.

Secondly, the waterbody classification is not specifically designed to reflect features of relevance to waterbirds. For example, there appears to be no discrimination between treed and treeless floodplain vegetation nor between brackish and freshwater lakes. Relevant features may also be at a scale far too fine to be measured by remote sensing, for example in the structure of wetland margins. Relevant wetland characteristics may also change over time, for example in degrees of salinity or the state of margin vegetation.

Thirdly, the habitat requirements of a species are not necessarily unitary. Optimal habitat may change from the breeding to non-breeding season, and a species may utilise several sets of habitat characteristics more or less simultaneously, for example alternately for foraging and nesting.

Finally, habitat requirements are most characteristic of species, whereas these analyses are pitched at families and foraging guilds. This may be particularly problematic in families where divergence has occurred though gross habitat specialisation, as for instance is particularly the case within the Ardeidae. It may thus be anticipated that families with only one or a few species within the TRIAP area will show greater habitat definition than speciose families, and this was often the case. Furthermore, foraging guilds may show clearer habitat definition than families because the classification is in itself a partial description of habitat requirements, and this also was often the case.

There are particular problems with both the waterbodies and geomorphic datasets. A major problem with the waterbodies dataset is that it does not indicate watercourses less than 250 m wide, a problem avoided by the geomorphic datasets. The entirely linear nature of the geomorphic datasets is problematic, though this could be overcome by incorporating buffers into the GIS or attributing all records to the geomorphic unit in nearest proximity. There are therefore, possibilities for further and more quantitative analysis of these datasets. However, given the series of constraints detailed in the above paragraphs, it is not envisaged that such analyses will offer great enhancement to the definition of waterbird / habitat relationships.

4.5.2. *The Australian Painted Snipe*

The only listed threatened waterbird species to occur in the TRIAP area is also the only member of the family Rostratulidae in the TRIAP area; information about its occurrence in relation to waterbodies is summarised under the family heading in section 4.3. The waterbody units recorded as used in this analysis were diverse (5 of 7 possible), with insufficient evidence to suggest associations. At least 11 of the 20 locations attributable to a waterbody unit were probably permanent waterbodies (*watercourse*, *reservoir*), an anomaly that calls for brief explanation given that the species is characteristically associated with shallow, ephemeral freshwater or brackish wetlands (Marchant & Higgins 1993, Lane &

Rogers 2000). This may be partially explicable in terms of the apparent unusual habitat requirements of the species – shallow, ephemeral wetlands that contain *both* bare mudflats and dense vegetative cover (Marchant & Higgins 1993; see also Oring *et al.* 2004). Whilst watercourses and reservoirs may be permanent, their margins may provide a suitable combination of habitat including receding water. Furthermore, at least some TRIAP sites may serve as drought refuges rather than prime habitat for the species.

Breeding records in the TRIAP area have been in flooded grasslands (Hassell & Rogers 2002, Jaensch 2003*b*).

4.5.3. *Patterns of habitat use*

Notwithstanding my assessment of methodological problems (section 4.5.1.) and that most families were recorded from all waterbody units, some patterns are evident that are consistent with field observations.

A set of families and guilds that are primarily associated with deep, permanent water were variously identified as positively associated with *lake* and/or *reservoir* in particular or negatively associated with shallow, temporary wetlands such as *saline coastal flat* and/or *land subject to inundation*. These include the grebes (Podicipedidae), darter (Anhingidae), cormorants (Phalacrocoracidae), pelican (Pelecanidae), jacana (Jacanidae), gulls and terns (Laridae) and the three freshwater aquatic guilds (FAH, FAI and FAL). However, the converse was only rarely the case (magpie geese - Anseranatidae), evidently because wading species frequently use margins of deeper waterbodies, and because the distribution of wading species was strongly confounded by preferences for either freshwater or saline habitats.

Preferences for saline habitats were clearly evident in the form of coastal records and/or association with *mangroves* and *saline coastal flats* amongst "wader" families (most families in the order Charadriiformes, namely Scolopacidae, Burhinidae, Haematopodidae, Charadriidae) and gulls and terns (Laridae) and, of course, amongst saline-foraging guilds (S~). The converse was also evident as negative associations with *mangroves* and *saline coastal flats* in magpie geese (Anseranatidae), ducks and relatives (Anatidae), darter (Anhingidae), cormorants (Phalacrocoracidae), stork (Ciconiidae), cranes (Gruidae), jacana (Jacanidae), stilts and avocet (Recurvirostridae) and pratincoles (Glareolidae). Two of three terrestrial foraging guilds (TWH, TWL) exhibited similar negative associations. However, amongst the freshwater guilds (F~) where the strongest negative associations with saline habitats might be anticipated, results were equivocal and varied, with no association with *mangrove* and/or *saline coastal flat* identified for three guilds (FWL, FAI, FAL), negative associations for two guilds (FWH, FAH) and a positive association for one (FWI). These anomalies emphasize the at-times arbitrary nature of the guild classification and are probably also the product of scalar mismatches between waterbird and waterbody data in coastal habitat mosaics.

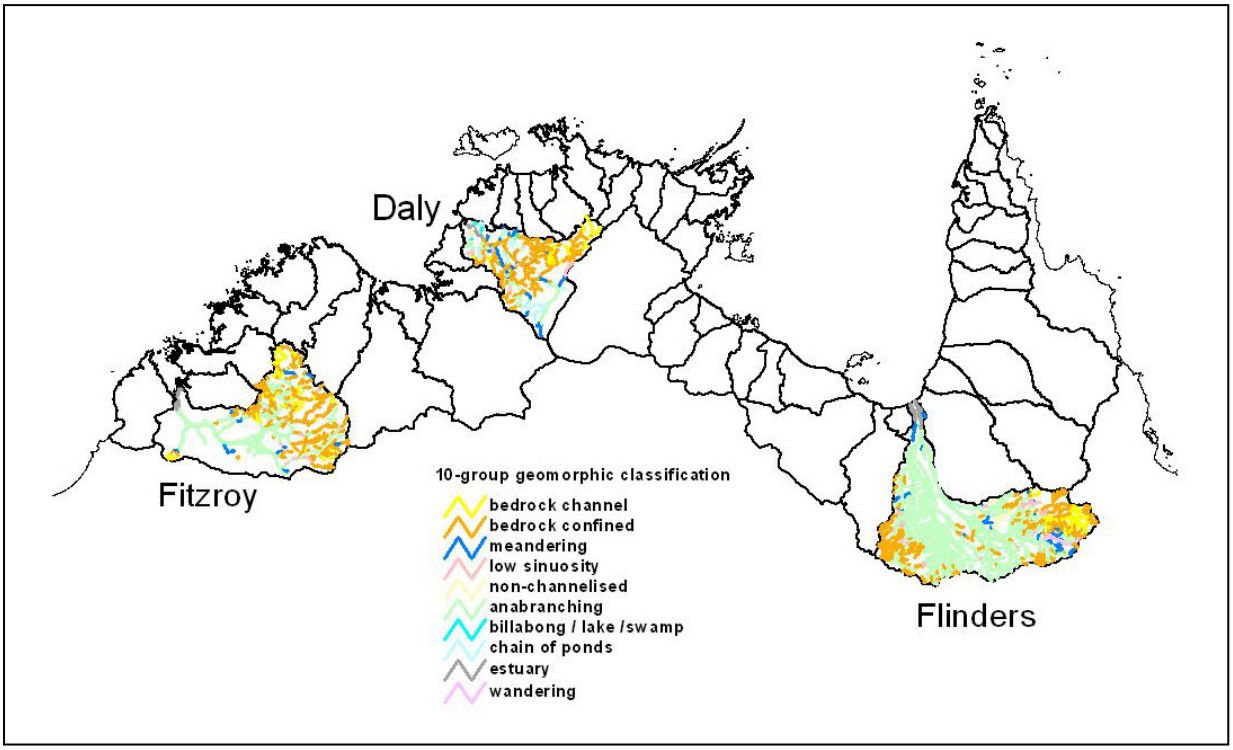
4.5.4. *Focus catchments*

Though at near-opposite ends of the TRIAP area, the Fitzroy and Flinders River catchments share a position of relative aridity with rocky uplands and extensive mid-system lowland anabranching (Fig. 10). In contrast, the Daly River catchment has a higher rainfall, an extensive coastal floodplain with embedded wetlands, and a more complex geomorphology (Fig. 10). None of the focus catchments has an extensive coast and only that of the Fitzroy River catchment is accessible (vicinity of Derby) and well-surveyed for waterbirds.

Given the "noisiness" of the waterbody/waterbird relationship, the smaller number of records associated with individual catchments was often insufficient to identify habitat associations.

The list of waterbodies used by a family or guild with a catchment was frequently identical to those present or frequent within the catchment.

Figure 10. Gross characterisation of the focus catchments by geomorphic river classes.



5. LITERATURE CITED

Anonymous (2002). Introduction to Environmental Management Systems in Agriculture. Biodiversity Resource Guide. Queensland. http://www.daff.gov.au/corporate_docs/publications/word/nrm/ems/ems_biodiversity_qld.doc

Barrett G. 2000. Birds on Farms, ecological management for agricultural sustainability. *Wingspan* 10(4): Supplement

Barrett G, Silcocks A, Barry S, Cunningham R, Poulter R. 2003. *The new atlas of Australian birds*. Hawthorn East: Royal Australasian Ornithologists Union

Bayliss P, Yeomans KM. 1990. Seasonal distribution and abundance of Magpie Geese, *Anseranas semipalmata* Latham in the Northern Territory, and their relationship to habitat, 1983 - 1986. *Australian Wildlife Research* 17: 15-38

Bellio, M-G (unpublished). BIRDS COLLATION SUMMARY.doc. Computer file provided by Department of Environment and Heritage.

Beruldsen GR. 2002. Spotted Whistling-Duck *Dendrocygna guttata* - probable breeding in Australia. *Australian Bird Watcher* 19: 143-6

Blakers M, Davies SJJF, Reilly PN. 1984. *The Atlas of Australian Birds*. Carlton: Melbourne University Press. 738 pp.

Boekel C. 1980. Birds of Victoria River Downs Station and of Yarralin, Northern Territory. Part 1. *Australian Bird Watcher* 8: 171-93

Chatto R. 2000. *Waterbird breeding colonies in the Top End of the Northern Territory*. Palmerston: Parks and Wildlife Commission of the Northern Territory

Chatto R. 2001. *The distribution and status of colonial breeding seabirds in the Northern Territory*. Palmerston: Parks and Wildlife Commission of the Northern Territory. 206 pp.

Chatto R. 2003. *The distribution and status of shorebirds around the coast and coastal wetlands of the Northern Territory*. Darwin: Parks and Wildlife Commission of the Northern Territory

Chatto R. unpublished. *The distribution and status of waterbirds around the coast and coastal wetlands of the Northern Territory [draft]*. Darwin: Parks and Wildlife Commission of the Northern Territory

Christidis L, Boles WE. 1994. *The Taxonomy and Species of Birds of Australia and its Territories*. Hawthorn East: Royal Australasian Ornithologists Union. 112 pp.

Crawford DN. 1997. Wader census from Darwin, Northern Territory, Australia, 1970 to 1972. *Stilt* 30: 32-4

Erskine WD, Saynor MJ, Erskine L, Evans KG & Moliere DR 2005. A preliminary typology of Australian tropical rivers and implications for fish community ecology. *Marine and Freshwater Research* 56: 253–267.

Franklin DC. 1999. Evidence of disarray amongst granivorous bird assemblages in the savannas of northern Australia, a region of sparse human settlement. *Biological*

Conservation 90: 53-68

Garnett ST. 1987. Aerial surveys of waders (Aves: Charadriiformes) along the coast of north-eastern Australia. *Australian Wildlife Research* 14: 521-8

Garnett ST, Crowley GM. 2000. *The Action Plan for Australian birds 2000*. Canberra: Environment Australia

Harrison KC & Mulligan S. 1986. Painted Snipe (*Rostratula benghalensis*) at Lake Ellesmere. *Notornis* 34: 78-79.

Hassell CJ, Rogers DI. 2002. Painted Snipe nesting at Taylor's Lagoon near Broome, north-western Australia. *Stilt* 41: 14-21

Higgins PJ, Davies SJJF, eds. 1996. *Handbook of Australian, New Zealand & Antarctic Birds. Volume 3. Snipe to Pigeons*. Melbourne: Oxford University Press

Jaensch R. 2003*a*. Records of northern waterbirds in the Barkly wetlands, Northern Territory, 1993-2002. *Northern Territory Naturalist* 17: 20-30

Jaensch R. 2003*b*. Recent records and breeding of Painted Snipe *Rostratula benghalensis* in the Mitchell Grass Downs and Sturt Plateau, Northern Territory. *Northern Territory Naturalist* 17: 31-7

Jaensch RP. 1989. *Birds of wetlands and grasslands in the Kimberley division, Western Australia : some records of interest, 1981-88*. Canning Bridge, Western Australia: Royal Australasian Ornithologists Union

Lane BA. 1987. *Shorebirds in Australia*. Melbourne: Nelson

Lane BA, Rogers DI. 2000. The Australian Painted Snipe *Rostratula (benghalensis) australis*: an endangered species? *Stilt* 36: 26-34

Marchant S. 1987-1989. Stephen Marchant on Nest Record Schemes. Parts 1-5. *RAOU Newsletter* 74: 8-9; 75: 10-1; 77: 4; 79: 10; 82: 9

Morton SR, Brennan KG, Armstrong MD. 1990*a*. Distribution and abundance of magpie geese, *Anseranas semipalmata*, in the Alligator Rivers Region, Northern Territory. *Australian Journal of Ecology* 15: 307-20

Morton SR, Brennan KG, Armstrong MD. 1990*b*. Distribution and abundance of ducks in the Alligator Rivers region, Northern Territory. *Australian Wildlife Research* 17: 573 – 90

Morton SR, Brennan KG, Armstrong MD. 1993*a*. Distribution and abundance of herons, egrets, ibises and spoonbills in the Alligator Rivers Region, Northern Territory. *Wildlife Research* 20: 23-43

Morton SR, Brennan KG, Armstrong MD. 1993*b*. Distribution and abundance of grebes, pelicans, darters, cormorants, rails and terns in the Alligator Rivers Region, Northern Territory. *Wildlife Research* 20: 203-17

Morton SR, Brennan KG, Armstrong MD. 1993*c*. Distribution and abundance of Brolgas and Black-necked Storks in the Alligator Rivers Region, Northern Territory. *Emu* 93: 88-92

Marchant S, Higgins PJ, eds. 1993. *Handbook of Australian, New Zealand & Antarctic Birds. Volume 2. Raptors to lapwings*. Melbourne: Oxford University Press

Niland DC. 1996. First record of Spotted Whistling-Ducks in Australia. *Sunbird* 26: 39-41

Oring LW, Rogers D, Oring KE, Tzaros C. 2004. Snipes in peril. *Wingspan* 14(4): 10-5

Palliser T 2004. Rare birds in 2003. *Wingspan* 14(3): 38-39.

Shurcliff KS. 1993. Seasonal patterns of wader populations in Darwin, Northern Territory, 1974-1987. *Northern Territory Naturalist* 14: 10-8

Taplin A. 1991. *Distribution and abundance of selected waterbird species in the Gulf Plains and Western Cape York during 1990*: Unpublished report to Queensland National Parks & Wildlife Service

Thackway R, Cresswell ID, eds. 1995. *An interim biogeographic regionalisation for Australia: a framework for setting priorities in the national reserves system cooperative program. Version 4.0*. Canberra: Australian Nature Conservation Agency

Appendix 1. Waterbird species recorded in the study area.

NB: Checklist order and nomenclature follows Christidis & Boles (1994) except for the Australian Painted Snipe (see Lane & Rogers 2000). See Table 6 for explanation of guild codes. The number of records refers to the master database supplied by the author.

Family / Species	**Guild**	**No. of records** TRIAP	buffer
Anseranatidae			
Magpie Goose *Anseranas semipalmata*	FWH	1,515	123
Anatidae			
Plumed Whistling-Duck *Dendrocygna eytoni*	TWH	908	104
Wandering Whistling-Duck *Dendrocygna arcuata*	FWH	1,118	98
Spotted Whistling-Duck *Dendrocygna guttata*	TWH	34	0
Blue-billed Duck *Oxyura australis*	FAH	2	0
Musk Duck *Biziura lobata*	FAI	3	0
Freckled Duck *Stictonetta naevosa*	FAH	9	1
Black Swan *Cygnus atratus*	FAH	323	36
Australian Shelduck *Tadorna tadornoides*	TWH	5	0
Radjah Shelduck *Tadorna radjah*	FWI	1,705	124
Australian Wood Duck *Chenonetta jubata*	TWH	356	33
Cotton Pygmy-goose *Nettapus coromandelianus*	FAH	48	18
Green Pygmy-goose *Nettapus pulchellus*	FAH	1,379	60
Pacific Black Duck *Anas superciliosa*	FAH	2,647	279
Australasian Shoveler *Anas rhynchotis*	FAH	10	3
Grey Teal *Anas gracilis*	FAH	1,304	134
Chestnut Teal *Anas castanea*	FAH	5	3
Garganey *Anas querquedula*	FAH	6	0
Pink-eared Duck *Malacorhynchus membranaceus*	FAI	318	37
Hardhead *Aythya australis*	FAH	1,059	101
Podicipedidae			
Australasian Grebe *Tachybaptus novaehollandiae*	FAI	1,698	159
Eurasian Little Grebe *Tachybaptus ruficollis*	FAI	1	0
Hoary-headed Grebe *Poliocephalus poliocephalus*	FAI	185	9
Great Crested Grebe *Podiceps cristatus*	FAL	133	14
Anhingidae			
Darter *Anhinga melanogaster*	FAI	2,816	209
Phalacrocoracidae			
Little Pied Cormorant *Phalacrocorax melanoleucos*	FAL	3,002	202
Pied Cormorant *Phalacrocorax varius*	FAL	677	100
Little Black Cormorant *Phalacrocorax sulcirostris*	FAL	1,964	139
Great Cormorant *Phalacrocorax carbo*	FAL	429	42
Pelecanidae			
Australian Pelican *Pelecanus conspicullatus*	FAL	2,022	250

Ardeidae			
White-faced Heron *Egretta novaehollandiae*	FWL	3.056	273
Little Egret *Egretta garzetta*	FWL	1,767	231
Eastern Reef Egret *Egretta sacra*	SWL	402	307
White-necked Heron *Ardea pacifica*	FWL	2,383	127
Great-billed Heron *Ardea sumatrana*	FWL	289	60
Pied Heron *Ardea picata*	FWL	1,096	73
Great Egret *Ardea alba*	FWL	3,241	302
Intermediate Egret *Ardea intermedia*	FWL	2,127	161
Cattle Egret *Ardea ibis*	TWL	681	33
Striated Heron *Butorides striatus*	SWL	549	245
Nankeen Night Heron *Nycticorax caledonicus*	FWL	1,687	116
Little Bittern *Ixobrychus minutus*	FWL	13	2
Black Bittern *Ixobrychus flavicollis*	FWL	496	39
Australasian Bittern *Botaurus poiciloptilus*	FWL	13	0
Threskiornithidae			
Glossy Ibis *Plegadis falcinellus*	FWL	1,215	72
Australian White Ibis *Threskiornis molucca*	FWL	2,357	296
Straw-necked Ibis *Threskiornis spinicollis*	TWL	2,798	238
Royal Spoonbill *Platalea regia*	FWL	1,595	118
Yellow-billed Spoonbill *Platalea flavipes*	FWL	451	25
Ciconiidae			
Black-necked Stork *Ephippiorhynchus asiaticus*	FWL	2,218	175
Gruidae			
Sarus Crane *Grus antigone*	TWH	261	35
Brolga *Grus rubicunda*	TWH	2,452	124
unidentified Crane *Grus sp.*	TWH	15	0
Rallidae			
Red-necked Crake *Rallina tricolor*	TWL	133	16
Red-legged Crake *Rallina fasciata*	TWI	1	0
Buff-banded Rail *Gallirallus philippensis*	FWI	253	52
Lewin's Rail *Rallus pectoralis*	FWI	3	1
Bush-hen *Amaurornis olivaceus*	TWI	95	17
Baillon's Crake *Porzana pusilla*	FWI	85	0
Australian Spotted Crake *Porzana fluminea*	FWI	38	0
Spotless Crake *Porzana tabuensis*	FWI	35	7
White-browed Crake *Porzana cinerea*	FWI	224	17
Chestnut Rail *Eulabeornis castaneoventris*	SWL	79	30
Purple Swamphen *Porphyrio porphyrio*	FWH	647	105
Dusky Moorhen *Gallinula tenebrosa*	FAH	191	67
Black-tailed Native-hen *Gallinula ventralis*	TWH	75	1
Eurasian Coot *Fulica atra*	FAH	650	93

Scolopacidae			
Latham's Snipe *Gallinago hardwickii*	TWI	45	15
Pin-tailed Snipe *Gallinago stenura*	TWI	0	0
Swinhoe's Snipe *Gallinago megala*	TWI	38	2
unidentified Snipe *Gallinago* sp.	TWI	19	2
Black-tailed Godwit *Limosa limosa*	SWI	199	68
Bar-tailed Godwit *Limosa lapponica*	SWI	281	192
Little Curlew *Numenius minutus*	TWI	329	40
Whimbrel *Numenius phaeopus*	SWI	569	337
Eastern Curlew *Numenius madagascariensis*	SWI	398	248
Eurasian Curlew *Numenius arquata*	SWI	1	0
Common Redshank *Tringa totanus*	SWI	12	19
Marsh Sandpiper *Tringa stagnatilis*	SWI	421	48
Common Greenshank *Tringa nebularia*	FWI	823	186
Nordmann's Greenshank *Tringa guttifer*	SWI	1	0
Wood Sandpiper *Tringa glareola*	FWI	332	7
Green Sandpiper *Tringa ochropus*	SWI	1	0
Terek Sandpiper *Xenus cinereus*	SWI	178	105
Common Sandpiper *Actitus hypoleucos*	FWI	916	259
Grey-tailed Tattler *Heteroscelus brevipes*	SWI	281	201
Wandering Tattler *Heteroscelus incanus*	SWI	7	3
unidentified Tattler *Heteroscelus* sp.	SWI	7	10
Ruddy Turnstone *Arenaria interpres*	SWI	299	148
Asian Dowitcher *Limnodromus semipalmatus*	SWI	18	21
Great Knot *Calidris tenuirostris*	SWI	211	144
Red Knot *Calidris canutus*	SWI	125	94
Sanderling *Calidris alba*	SWI	127	38
Little Stint *Calidris minuta*	SWI	3	0
Red-necked Stint *Calidris ruficollis*	SWI	393	171
Long-toed Stint *Calidris subminuta*	SWI	54	3
Pectoral Sandpiper *Calidris melanotos*	FWI	18	1
Sharp-tailed Sandpiper *Calidris acuminata*	SWI	424	55
Dunlin *Calidris alpina*	SWI	1	0
Curlew Sandpiper *Calidris ferruginea*	SWI	233	76
Stilt Sandpiper *Micropalama himantopus*	SWI	1	0
Buff-breasted Sandpiper *Tryngites subruficollis*	SWI	1	0
Broad-billed Sandpiper *Limicola falcinellus*	SWI	30	16
Ruff *Philomachus pugnax*	SWI	18	1
Red-necked Phalarope *Phalaropus lobatus*	SWI	6	0
Rostratulidae			
Australian Painted Snipe *Rostratula australis*	FWI	34	0
Jacanidae			
Comb-crested Jacana *Irediparra gallinacea*	FWH	1,372	82
Burhinidae			
Beach Stone-curlew *Esacus neglectus*	SWL	150	138
Haematopodidae			
Pied Oystercatcher *Haematopus longirostris*	SWI	335	196
Sooty Oystercatcher *Haematopus fuliginosus*	SWI	111	82
Recurvirostridae			
Black-winged Stilt *Himantopus himantopus*	FWI	1610	119
Banded Stilt *Cladorhynchus leucocephalus*	SWI	2	0
Red-necked Avocet *Recurvirostra novaehollandiae*	SWI	75	6

Charadriidae			
Eurasian Golden Plover *Pluvialis apricaria*	SWI	1	0
Pacific Golden Plover *Pluvialis fulva*	SWI	225	99
Grey Plover *Pluvialis squatarola*	SWI	178	98
Ringed Plover *Charadrius hiaticula*	SWI	1	0
Little Ringed Plover *Charadrius dubius*	SWI	9	0
Red-capped Plover *Charadrius ruficapillus*	SWI	465	168
Double-banded Plover *Charadrius bicinctus*	SWI	1	0
Lesser Sand Plover *Charadrius mongolus*	SWI	155	94
Greater Sand Plover *Charadrius leschenaultii*	SWI	282	186
Caspian Plover *Charadrius asiaticus*	SWI	1	0
Oriental Plover *Charadrius veredus*	TWI	137	16
Black-fronted Dotterel *Elseyornis melanops*	FWI	2,104	79
Red-kneed Dotterel *Erythrogonys cinctus*	FWI	443	13
Masked Lapwing *Vanellus miles*	TWI	3,245	333
Glareolidae			
Oriental Pratincole *Glareola maldivarum*	TWI	134	6
Australian Pratincole *Stiltia isabella*	TWI	1,132	56
Laridae			
Silver Gull *Larus novaehollandiae*	SWL	855	402
Black-headed Gull *Larus ridibundus*	SWL	0	0
Gull-billed Tern *Sterna nilotica*	FAL	688	179
Caspian Tern *Sterna caspia*	SAL	637	157
Lesser Crested Tern *Sterna bengalensis*	SAL	204	157
Crested Tern *Sterna bergii*	SAL	336	249
Roseate Tern *Sterna dougallii*	SAL	25	34
White-fronted Tern *Sterna striata*	SAL	3	0
Black-naped Tern *Sterna sumatrana*	SAL	41	46
Common Tern *Sterna hirundo*	SAL	53	42
Little Tern *Sterna albifrons*	SAL	148	106
Fairy Tern *Sterna nereis*	SAL	4	0
Bridled Tern *Sterna anaethetus*	SAL	13	21
Sooty Tern *Sterna fuscata*	SAL	6	6
Whiskered Tern *Chlidonias hybridus*	FAL	978	90
White-winged Black Tern *Chlidonias leucopterus*	FAL	217	35
Common Noddy *Anous stolidus*	SAL	11	10
Black Noddy *Anous minutus*	SAL	2	1
Lesser Noddy *Anous tenuirostris*	SAL	1	0

Appendix 2. List of databases provided by the author.

All databases are dBase IV .dbf files. These should be ready for use in ARCVIEW and related GIS programs, and should be readily imported into Excel and other spreadsheet programs. Metadata for these files are provided in Appendix 3.

Note that all "triap" file contains both TRIAP and buffer records. Note also that a small number of files contain no records – because there are no records for the relevant combination.

The only threatened species – the Australian Painted Snipe – is the sole TRIAP member of the family Rostratulidae and is databased under that name.

Master files

triap_waterbirds_master. Also: daly~, fitzroy~, flinders~

Family files (See Table 4 for summary and common names of families)

triap_family_anatidae. Also: daly~, fitzroy~, flinders~
triap_family_anhingidae. Also: daly~, fitzroy~, flinders~
triap_family_anseranatidae. Also: daly~, fitzroy~, flinders~
triap_family_ardeidae. Also: daly~, fitzroy~, flinders~
triap_family_burhinidae. Also: daly~, fitzroy~, flinders~
triap_family_charadriidae. Also: daly~, fitzroy~, flinders~
triap_family_ciconiidae. Also: daly~, fitzroy~, flinders~
triap_family_glareolidae. Also: daly~, fitzroy~, flinders~
triap_family_gruidae. Also: daly~, fitzroy~, flinders~
triap_family_haematopodidae. Also: daly~, fitzroy~, flinders~
triap_family_jacanidae. Also: daly~, fitzroy~, flinders~
triap_family_laridae. Also: daly~, fitzroy~, flinders~
triap_family_pelecanidae. Also: daly~, fitzroy~, flinders~
triap_family_phalacrocoracidae. Also: daly~, fitzroy~, flinders~
triap_family_podicipedidae. Also: daly~, fitzroy~, flinders~
triap_family_rallidae. Also: daly~, fitzroy~, flinders~
triap_family_recurvirostridae. Also: daly~, fitzroy~, flinders~
triap_family_rostratulidae. Also: daly~, fitzroy~, flinders~
triap_family_scolopacidae. Also: daly~, fitzroy~, flinders~
triap_family_threskiornithidae. Also: daly~, fitzroy~, flinders~

The foraging guilds (see Table 6 and section 3.3. for details of the classification)

triap_guild_fah. Also: daly~, fitzroy~, flinders~
triap_guild_fai. Also: daly~, fitzroy~, flinders~
triap_guild_fal. Also: daly~, fitzroy~, flinders~
triap_guild_fwh. Also: daly~, fitzroy~, flinders~
triap_guild_fwi. Also: daly~, fitzroy~, flinders~
triap_guild_fwl. Also: daly~, fitzroy~, flinders~
triap_guild_sal. Also: daly~, fitzroy~, flinders~
triap_guild_swi. Also: daly~, fitzroy~, flinders~
triap_guild_swl. Also: daly~, fitzroy~, flinders~
triap_guild_twh. Also: daly~, fitzroy~, flinders~
triap_guild_twi. Also: daly~, fitzroy~, flinders~
triap_guild_twl. Also: daly~, fitzroy~, flinders~

Appendix 3. Metadata for databases provided by the author.

Field name	dbase structure	Explanation / terms / codes *
commonname	character, 25	Common names following Christidis & Boles (1994). C
sci_name	character, 30	Scientific names following Christidis & Boles (1994). C
family	character, 20	Family names following Christidis & Boles (1994). C
for_guild	character, 3	Foraging guild; codes as per Table 6 and section 3.3. C
catchment	character, 20	TRIAP catchment, determined by GIS intersection. These are spelt out in full as per Table 3. Buffer-zone records have been ascribed a catchment of "xxx". C
latitude	numeric, 9,5	Latitude, in decimal degrees. The datum is apparently unknown. C
longitude	numeric, 9,5	Longitude, in decimal degrees. The datum is apparently unknown. C
source	numeric, 2	The source of the record; codes as in Table 1. C
location1	character, 26	Description of location of record. O
location2	character, 17	Nearest town or feature. O
state	character, 3	NT = Northern Territory, Qld = Queensland, WA = Western Australia. C
ibra	character, 3	Interim Biogeographic Region, following Thackway & Cresswell (1995). O
rec_form	numeric, 8	Atlas record form number. O
spec_code	numeric, 3	Birds Australia species code. C
start_date	date	date of observation or start date of observation period. O
atlas	character, 1	a = Atlas1; b = Atlas2. C

* C = compulsory entry; i.e. there should be an entry for each record;
O = optional entry; data often missing.

Appendix 4. References to waterbirds in the TRIAP area.

NB: See also Appendix 5. This list is *not* comprehensive.

Barnes T. 1997. Finally found: the missing link between the egg and the adult stage of the Chestnut Rail - *Eulabeornis castaneoventris*. In *Zoos: Evolution or Extinction?*, ed. G Hunt, L Slater, pp. 219-21. Healesville: Healesville Sanctuary

Barnes TA, Franklin DC. 1997. Notes on nests of the Chestnut Rail. *Northern Territory Naturalist* 15: 6-11

Bayliss P, Yeomans KM. 1990. Seasonal distribution and abundance of Magpie Geese, *Anseranas semipalmata* Latham in the Northern Territory, and their relationship to habitat, 1983 - 1986. *Australian Wildlife Research* 17: 15-38

Bellio MG, Bayliss P, Finlayson M, Dostine P. 2004. *Framework for assessing the values of waterbirds in the Alligator Rivers Region, northern Australia*. Darwin: Supervising Scientist Internal Report 479

Beruldsen GR. 2002. Spotted Whistling-Duck *Dendrocygna guttata* - probable breeding in Australia. *Australian Bird Watcher* 19: 143-6

Boekel C. 1980. Birds of Victoria River Downs Station and of Yarralin, Northern Territory. Part 1. *Australian Bird Watcher* 8: 171-93

Braithwaite RW, Estbergs JA. 1982. Discovery of a Rufous Night Heron rookery in the Northern Territory. *Northern Territory Naturalist* 5: 20

Brook BW, Whitehead PJ. 2005. Sustainable harvest regimes for magpie geese (*Anseranas semipalmata*) under spatial and temporal heterogeneity. *Wildlife Research* 32: 459–64

Brook BW, Whitehead PJ. 2005. Plausible bounds for maximum rate of increase in magpie geese (*Anseranas semipalmata*): implications for harvest. *Wildlife Research* 32: 465–71

Campbell J. 1990. Waders of the Parry Lagoons, Kimberley region, W.A,. *Stilt* 16: 58

Chatto R. 2000. *Waterbird breeding colonies in the Top End of the Northern Territory*. Palmerston: Parks and Wildlife Commission of the Northern Territory

Chatto R. 2001. *The distribution and status of colonial breeding seabirds in the Northern Territory*. Palmerston: Parks and Wildlife Commission of the Northern Territory. 206 pp.

Chatto R. 2003. Seabirds and shorebirds of the Darwin Harbour Regional Plan of Management area. In *Proceedings: Darwin Harbour Region: Current Knowledge and Future Needs*, ed. WGftDHA Committee, pp. 231-5. Darwin: Department of Infrastructure, Planning and Environment

Chatto R. 2003. *The distribution and status of shorebirds around the coast and coastal wetlands of the Northern Territory*. Darwin: Parks and Wildlife Commission of the Northern Territory

Chatto R. 2003. Waterbirds of the Darwin Harbour Regional Plan of Management area. In *Proceedings: Darwin Harbour Region: Current Knowledge and Future Needs*, ed.

WGftDHA Committee, pp. 236-9. Darwin: Department of Infrastructure, Planning and Environment

Chatto R. unpublished. *The distribution and status of waterbirds around the coast and coastal wetlands of the Northern Territory [draft]*. Darwin: Parks and Wildlife Commission of the Northern Territory

Claridge G, Johnson R. 1988. Possible unusual movement of Red-necked Avocets into northern Australia. *Stilt* 12: 53

Claridge G, Johnson R, Dalliston C. 1988. An undescribed Gulf Plains wetland in Queensland. *Stilt* 12: 53-4

Collins P, Boyle A, Minton c, Jessop R. 2001. The importance of inland claypans for waders in Roebuck Bay, Broome, NW Australia. *Stilt* 38: 4-8

Collins P, Jessop R. 1997. Little Tern *Sterna albifrons* in the west Kimberley division of Western Australia. *Stilt* 30: 26-31

Crawford DN. 1979. Waterbirds: indices and fluctuations in dry-season refuge areas, Northern Territory. *Australian Wildlife Research* 6: 97-103

Crawford DN. 1997. Wader census from Darwin, Northern Territory, Australia, 1970 to 1972. *Stilt* 30: 32-4

Dawson TJ, Whitehead PJ, McLean A, Fanning FD, Dawson WR. 2000. Digestive function in the Magpie Goose (Anseranas semipalmata). *Australian Journal of Zoology* 48: 265-79

Dorfman E. 2002. Stalking the stork. *Nature Australia* Autumn 2002: 44-51

Dorfman EJ, Lamont A, Dickman CR. 2001. Foraging behaviour and success of Black-necked Storks (*Ephippiorhynchus asiaticus*) in Australia: implications for management. *Emu* 101: 145-9

Dostine PL, Morton SR. 2000. Seasonal abundance and diet of the Comb-crested Jacana *Irediparra gallinacea* in the tropical Northern Territory. *Emu* 100: 299-311

Evans SM, Bougher AR. 1987. The abundance of estrildid finches at waterholes in the Kimberley (WA). *Emu* 87: 124-7

Frith HJ. 1977. Band recoveries of the Magpie Goose *Anseranas semipalmata*. *Australian Wildlife Research* 4: 81-4

Frith HJ, Davies SJJF. 1961. Ecology of the Magpie Goose, *Anseranas semipalmata* Latham (Anatidae). *CSIRO Wildlife Research* 6: 91-141

Frith HJ, Davies SJJF. 1961. Breeding seasons of birds in subcoastal Northern Territory. *Emu* 61: 97-111

Garnett S. 1985. Heronries of the Mitchell River delta. *Sunbird* 15: 1-4

Garnett S. 1989. *Wading bird abundance and distribution - south-eastern coast of the Gulf of Carpentaria*. Moonee Ponds, Victoria: Royal Australasian Ornithologists Union report no. 58

Garnett S, Minton C. 1985. Notes on the movements and distribution of Little Curlew *Numenius minutus* in northern Australia. *Australian Bird Watcher* 11: 69-73

Garnett ST. 1987. Aerial surveys of waders (Aves: Charadriiformes) along the coast of north-eastern Australia. *Australian Wildlife Research* 14: 521-8

Garnett ST, Shephard S. 1997. Cape York Peninsula, Australia, as a stopver site for Latham's Snipe *Gallinago hardwickii*. *Stilt* 30: 54-5

Gole M. 2005. Birds of Lake Nongra and surrounding bushland, Northern Territory. *Northern Territory Naturalist* 18: 54-60

Halse SA, Pearson GB, Kay WR. 1998. Arid zone networks in time and space: waterbird use of Lake Gregory in north-western Australia. *International Journal of Ecology and Environmental Sciences* 24: 207-22

Hassell CJ, Rogers DI. 2002. Painted Snipe nesting at Taylor's Lagoon near Broome, north-western Australia. *Stilt* 41: 14-21

Heuman GA. 1926. Birds in the Northern Territory and the new finch. *Emu* 25: 134-6

Houston WA, Duivenvoorden LJ. 2002. Replacement of littoral native vegetation with the ponded pasture grass Hymenachne amplexicaulis: effects on plant, macroinvertebrate and fish biodiversity of backwaters in the Fitzroy River, Central Queensland, Australia. *Marine and Freshwater Research* 53: 1235-44

Jaensch R. 1994. Internationally significant numbers of Oriental Plover and Oriental Pratincole at ephemeral inland wetlands of the Northern Territory, Australia. *Stilt* 24: 12-3

Jaensch R. 1994. *An inventory of wetlands of the sub-humid tropics of the Northern Territory*. Darwin: Conservation Commission of the Northern Territory

Jaensch R. 1994. Lake Finniss: an internationally significant site for Little Curlew. *Stilt* 25: 21

Jaensch R. 2003. Records of northern waterbirds in the Barkly wetlands, Northern Territory, 1993-2002. *Northern Territory Naturalist* 17: 20-30

Jaensch R. 2003. Recent records and breeding of Painted Snipe *Rostratula benghalensis* in the Mitchell Grass Downs and Sturt Plateau, Northern Territory. *Northern Territory Naturalist* 17: 31-7

Jaensch R. 2003. Breeding by Freckled Duck *Stictonetta naevosa*, and a review of recent records, in the Barkly wetlands, Northern Territory. *Northern Territory Naturalist* 17: 38-42

Jaensch RP. 1988. Little Bitterns breeding in northern Australia. *Australian Bird Watcher* 12: 217-21

Jaensch RP. 1989. *Birds of wetlands and grasslands in the Kimberley division, Western Australia : some records of interest, 1981-88*. Canning Bridge, Western Australia: Royal Australasian Ornithologists Union

Jaensch RP, Vervest RM. 1990. *Waterbirds at remote wetlands in Western Australia, 1986-8. Part One: Lake Argyle and Lake Gregory*. Perth: Royal Australasian Ornithologists Union

Martin P, Hancock GJ, Johnston A, Murray AS. 1998. Natural-series radionuclides in traditional North Australian aboriginal foods. *Journal of Environmental Radioactivity* 40: 37-58

McCrie N. 1987. Recent N.T. record of Red-necked Phalarope. *Northern Territory Naturalist* 10: 17

McKean JL. 1980. Oceanic ornithological survey between Derby, W.A. and Darwin, N.T. *Northern Territory Naturalist* 3: 8-13

McKean JL. 1983. Lewin's Rail *Rallus pectoralis*, a new addition to the avifauna of the Northern Territory. *Australian Bird Watcher* 10: 137

McKean JL. 1983. Some notes on the occurrence of the Great Reed Warbler *Acrocephalus arundinaceus* in the Northern Territory. *Northern Territory Naturalist* 6: 3-8

McKean JL, Dampney AR. 1984. First sighting of the Spotted Redshank *Tringa erythropus* in Australia. *Northern Territory Naturalist* 7: 8-9

McKean JL, Hertog AL. 1981. Some further records of uncommon migrant waders near Darwin, N.T. *Northern Territory Naturalist* 4: 10-3

McKean JL, Hertog AL, Marr N. 1982. An Australian record of the Stilt Sandpiper *Micropalama himantopus*. *Northern Territory Naturalist* 5: 22-3

McKean JL, Thompson HAF. 1983. Subspecific identification of an Australian specimen of the Little Ringed Plover (*Charadrius dubius*). *Northern Territory Naturalist* 6: 14-5

Morton SR, Brennan KG, Armstrong MD. 1990. Distribution and abundance of magpie geese, *Anseranas semipalmata*, in the Alligator Rivers Region, Northern Territory. *Australian Journal of Ecology* 15: 307-20

Morton SR, Brennan KG, Armstrong MD. 1990. Distribution and abundance of ducks in the Alligator Rivers region, Northern Territory. *Australian Wildlife Research* 17: 573 – 90

Morton SR, Brennan KG, Armstrong MD. 1993. Distribution and abundance of herons, egrets, ibises and spoonbills in the Alligator Rivers Region, Northern Territory. *Wildlife Research* 20: 23-43

Morton SR, Brennan KG, Armstrong MD. 1993. Distribution and abundance of grebes, pelicans, darters, cormorants, rails and terns in the Alligator Rivers Region, Northern Territory. *Wildlife Research* 20: 203-17

Morton SR, Brennan KG, Armstrong MD. 1993. Distribution and abundance of Brolgas and Black-necked Storks in the Alligator Rivers Region, Northern Territory. *Emu* 93: 88-92

Munksgaard NC, Brazier JA, Moir CM, Parry DL. 2003. The use of lead isotopes in monitoring environmental impacts of uranium and lead mining in Northern Australia. *Australian Journal of Chemistry* 56: 233-8

Niland DC. 1996. First record of Spotted Whistling-Ducks in Australia. *Sunbird* 26: 39-41

Noske R, van Gessel F. 1987. First record of the Blue-billed Duck for the Northern Territory. *Northern Territory Naturalist* 10: 13

Nye ER, Dickman CR. 2005. Activity budgets and habitat use of the Green Pygmy-goose (*Nettapus pulchellus*) on dry-season refuges in Kakadu National Park, Northern Territory. *Emu* 105: 217-22

Parks and Wildlife Commission of the Northern Territory. 2003. *Management program for the Magpie Goose (Anseranas semipalmata) in the Northern Territory of Australia 2003-2007*: Parks and Wildlife Commission of the Northern Territory

Percival D. 1984. Streaked Shearwater *Calonectris leucomelas* in the Northern Territory. *Northern Territory Naturalist* 7: 10-1

Shurcliff KS. 1993. Seasonal patterns of wader populations in Darwin, Northern Territory, 1974-1987. *Northern Territory Naturalist* 14: 10-8

Taplin A. 1991. *Distribution and abundance of selected waterbird species in the Gulf Plains and Western Cape York during 1990*: Unpublished report to Queensland National Parks & Wildlife Service

Tulloch D, Cellier KM, Hertog AL. 1988. The distribution of the nests of the Magpie Goose (*Anseranas semipalmata* Latham) at Kapalga, NT - a 4-year study. *Australian Wildlife Research* 15: 211-21

Walker T. 1991. *The Wellesley Islands, Gulf of Carpentaria*. Unpublished report

Ward MJ, Smith JG. 2003. Brown Goshawk *Accipiter fasciatus* attacking a Green Pygmy-goose *Nettapus pulchellus* over and in water. *Australian Field Ornithology* 20: 105-6

Whitehead P, Dawson T. 2000. Let them eat grass! *Nature Australia* 26: 46-55

Whitehead PJ. 1997. *Dynamics of habitat use by the Magpie Goose Anseranas semipalmata: implications for conservation management*. Darwin: PhD thesis, Northern Territory University

Whitehead PJ. 1998. Boofheads with deep voices: sexual dimorphism in the Magpie Goose *Anseranas semipalmata*. *Wildfowl* 49: 72-91

Whitehead PJ. 1999. Aspects of the nesting biology of the Magpie Goose *Anseranas semipalmata*: Incubation period, hatching synchrony and patterns of nest attendance and defence. *Emu* 99: 121-34

Whitehead PJ, Bayliss P, Fox RE. 1988. Recreational waterfowl hunting activity and harvests in Northern Territory, Australia. *Australian Wildlife Research* 15: 625-31

Whitehead PJ, Freeland WJ, Tschirner K. 1990. Early growth in the magpie goose *Anseranas semipalmata*: sex differences and influence of egg size. *Australian Journal of Zoology* 38: 249-62

Whitehead PJ, Saalfeld K. 2000. Nesting phenology of magpie geese (*Anseranas semipalmata*) in monsoonal northern Australia: responses to antecedent rainfall.

Journal of Zoology, London 251: 494-508

Whitehead PJ, Tschirner K. 1990. Eggs and hatchlings of the Magpie Goose *Anseranas semipalmata*. *Emu* 90: 154-60

Whitehead PJ, Tschirner K. 1990. Magpie Goose *Anseranas semipalmata* nesting on the Mary River floodplain: extent and frequency of flooding losses. *Australian Wildlife Research* 17: 147-57

Whitehead PJ, Tschirner K. 1991. Lead shot ingestion and lead poisoning in magpie goose *Anseranas semipalmata* foraging in a northern Australian hunting reserve. *Biological Conservation* 58: 98-112

Whitehead PJ, Tschirner K. 1991. Patterns of egg laying and variation in egg size in the Magpie Goose *Anseranas semipalmata*: evidence for intra-specific nest parastism. *Emu* 91: 26-31

Whitehead PJ, Tschirner K. 1992. Sex and age-related variation in foraging strategies of the Magpie Goose *Anseranas semipalmata*. *Emu* 92: 28-32

Whitehead PJ, Turner S. 1998. Using the presence and condition of eggshells to determine nest success in the magpie goose, *Anseranas semipalmata*. *Wildlife Research* 25: 603-9

Woinarski JCZ, Fisher A, Brennan K, Morris I, Willan RC, Chatto R. 1998. The Chestnut Rail *Eulabeornis castaneoventris* on the Wessel and English Company Islands: notes on unusual habitat and use of anvils. *Emu* 98: 74-8

Appendix 5. General references that contain useful information about waterbirds in the TRIAP area.

NB: References may have a broad geographic or taxonomic scope than those listed in Appendix 4. This list is *not* comprehensive.

Barrett G, Silcocks A, Barry S, Cunningham R, Poulter R. 2003. *The new atlas of Australian birds*. Hawthorn East: Royal Australasian Ornithologists Union

Blakers M, Davies SJJF, Reilly PN. 1984. *The Atlas of Australian Birds*. Carlton: Melbourne University Press.

Braithwaite LW. 1975. Waterfowl on a dry continent. *Natural History* 64: 60-9

Bridgewater PB. 1987. The present Australian environment - terrestrial and freshwater. In *Fauna of Australia*, pp. 69-100. Canberra: Australian Government Publishing Service

Cowling SJ. 1972. *Bibliography on waterbird research and management in Australia*. Canberra: A.F.A.C. Secretariat

Dingle H. 2004. The Australo-Papuan bird migration system: another consequence of Wallace's Line. *Emu* 104: 95-108

Frith HJ. 1982. *Waterfowl in Australia*. Sydney: Angus & Robertson

Higgins PJ, Davies SJJF, eds. 1996. *Handbook of Australian, New Zealand & Antarctic Birds. Volume 3. Snipe to Pigeons*. Melbourne: Oxford University Press

Kingsford RT, Norman FI. 2002. Australian waterbirds - products of the continent's ecology. *Emu* 102: 47-69

Lane BA. 1987. *Shorebirds in Australia*. Melbourne: Nelson

Marchant S, Higgins PJ, eds. 1990. *Handbook of Australian, New Zealand & Antarctic Birds. Volume 1. Ratites to Ducks*. Melbourne: Oxford University Press

Marchant S, Higgins PJ, eds. 1993. *Handbook of Australian, New Zealand & Antarctic Birds. Volume 2. Raptors to lapwings*. Melbourne: Oxford University Press

McKilligan N. 2005. *Herons, egrets and bitterns. Their biology and conservation in Australia*. Collingwood: CSIRO.

Olsen P, Weston M. 2004. *The state of Australia's birds 2004. Water, wetlands and birds*. Hawthorn East: Birds Australia

Pringle JD, Lindsey TR. 1985. *The Waterbirds of Australia*. North Ryde: Angus & Robertson. 331 pp.

Roshier DA, Robertson AI, Kingsford RT, Green DG. 2001. Continental-scale interactions with temporary resources may explain the paradox of large populations of desert waterbirds in Australia. *Landscape Ecology* 16: 547-56