WATERBIRD BREEDING COLONIES IN THE GULF PLAINS, 2009–2013

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ABSTRACT

We report the results of aerial surveys of breeding colonies of waterbirds (herons, ibises, cormorants and allies) in the central part of the Gulf Plains region, Queensland, conducted by the Carpentaria Land Council Aboriginal Corporation over five years (2009–2013). This was the first broad-scale, multi-year documentation of colonial waterbird breeding in the Gulf Plains; historically, about 10 colonies were known to science, all in estuaries. Coverage of the region was incomplete, but cumulatively 32 active colonies were recorded in our surveys, 28 of them described for the first time. Colonies were in tree or shrub habitats: 13 in estuarine mangrove and 19 in freshwater wetlands. Colonies were in each of the major river systems (up to five colonies per river) from the Leichhardt River to the Gilbert River, and up to 115 km from the coast. Eleven colonial-breeding species of waterbird were recorded, with some colonies including all, many colonies with most and a few colonies with just one or two of these species. Scale of waterbird breeding was mostly recorded in terms of colony dimensions, with informed estimates suggesting variations from in the order of hundreds to 10,000 breeding pairs. The most abundant species was the Intermediate Egret (*Ardea intermedia*), which was also among the most frequently detected breeding species, along with Australian White Ibis (*Threskiornis molucca*), Royal Spoonbill (*Platalea regia*), Nankeen Night Heron (*Nycticorax caledonicus*) and Little Black Cormorant (*Phalacrocorax sulcirostris*). At some sites, colonial breeding was not recorded in drier years; rainfall and river flow regimes are considered to be determinants of breeding activity. Threats presently recognisable include any process or development that reduces the flooding of colony sites or floodplain feeding areas or that threatens the health of nesting trees. Many of the individual colonies meet criteria for international importance. To sustain these assets perpetually, land managers will require further information on the numbers and ecological requirements of waterbirds that breed in colonies in the Gulf Plains region.

INTRODUCTION

Breeding colonies of waterbirds are dense aggregations at sites that meet the ecological requirements for breeding. In Australia, several species of herons,

ibises, cormorants and their allies breed in colonies. They commonly require inundated shrubs or trees that can support nests, near extensive and shallowly inundated habitat that will provide sufficient food for adults and their rapidly growing nestlings (Marchant & Higgins 1990; RJ personal observations). Colonies tend to be few and occupy relatively small areas in the landscape, generally less than 100 ha (Marchant & Higgins 1990; RJ personal observations); consequently they are vulnerable to direct or indirect loss or disturbance from human activities. Conservation planners and land managers therefore require comprehensive knowledge of the locations and characteristics of waterbird breeding colonies.

Information on waterbird breeding colonies in the Gulf Plains biogeographic region of tropical Queensland reveals that before 2000 only 10 or 11 colony sites were known to science: one each on tidal reaches of the Flinders, Bynoe, Gilbert, Staaten and Nassau Rivers; three in the Mitchell River delta; and two or three other colonies in coastal mangrove (Marchant & Higgins 1990; Taplin 1991; Driscoll 2001). These estuaries tend to be visited often by commercial fishermen and local residents and sometimes by ornithologists. However, no systematic survey of waterbird breeding colonies had been conducted across all major wetland systems, estuarine and freshwater, of the Gulf Plains before 2009. A major impediment had been the inability to access most of the region's wetlands during the wet season, when most colonial breeding occurs (Marchant & Higgins 1990). In the Top End of the Northern Territory, this impediment had been overcome by aerial surveying, which had proved effective in the discovery of many colonies during the wet season and demonstrated that many occur in freshwater wetlands (Chatto 2000).

An opportunity to fill some gaps in the knowledge of Gulf Plain colonies arose in 2008, when the Queensland Government approached Wetlands International (RJ) for advice on a target for biodiversity surveys by indigenous rangers during the wet season, when rangers were otherwise unable to access much of the country. Following successful trials using helicopters, start-up funding for systematic, broad-scale aerial surveys of colonies was secured and a survey program was implemented by the Land and Sea Rangers of the Carpentaria Land Council Aboriginal Corporation (CLCAC), based in Normanton. Surveys targeted the major river systems within the Kurtijar, Gkuthaarn and Kukatj tribal boundaries, which collectively extend from the Leichhardt River to the Staaten River and up to 150 km inland. The present article summarises results of CLCAC surveys of waterbird breeding colonies within this study area during wet seasons in the period 2009–2013, as fully documented in an unpublished internal report of

CLCAC (Jaensch 2013). Smaller programs of similar surveys by rangers at Burketown and Kowanyama mentioned in the CLCAC report are not reported here.

METHODS

Study area and target species

Surveys were conducted in the central near-coastal part of the Gulf Plains biogeographic region (Sattler & Williams 1999), between the Leichhardt River in the west and the Staaten River in the east (Figure 1). This area is characterised by alluvial plains that are crossed by abundant river channels and distributaries, which transform into complex estuarine systems (Sattler & Williams 1999). Rivers tend to run in summer–autumn, in and following the monsoonal wet season, often with vast areas of over-bank flooding, but water may be confined to deeper waterholes and relatively few off-river 'lagoons' in the winter–spring dry season (personal observations of RJ, PA & rangers).

The CLCAC Land and Sea Rangers based at Normanton operate throughout the study area. Within the study area, nine river catchments were defined specifically for the purposes of the colony survey program, particularly to facilitate survey planning. From west to east these catchments were: Leichhardt River (includes Alexandra R.); catchments of M Creek, L Creek and Spring Creek (West); Flinders and Bynoe Rivers; Norman River; Walker Creek, Bayswater Creek and Brannigan Creek; Smithburne River and Fitzmaurice River; Duck Creek and Spring Creek (North); Gilbert River; and Staaten River (Figure 1).

Target species for the surveys were from four bird families: Ardeidae (herons and allies, including egrets); Threskiornithidae (ibises and spoonbills); Phalacrocoracidae (cormorants); and Anhingidae (darters) (taxonomy and names are based on Christidis & Boles 2008). Prior knowledge (Marchant & Higgins 1990; Chatto 2000; Jaensch 2009) indicated that many to most species would breed together and that breeding would often start and finish on different dates among species. Determining the optimal dates to conduct surveys – especially when only one survey per site was possible per season – and identifying all species and their breeding activity in a colony were thus substantial challenges for the survey program.

Timing of surveys

The timing of breeding by colonial waterbirds is influenced by availability of food for bringing the adults into condition for egg laying, sustaining adults sitting on nests and feeding of nestlings (Briggs & Thornton 1999). Food

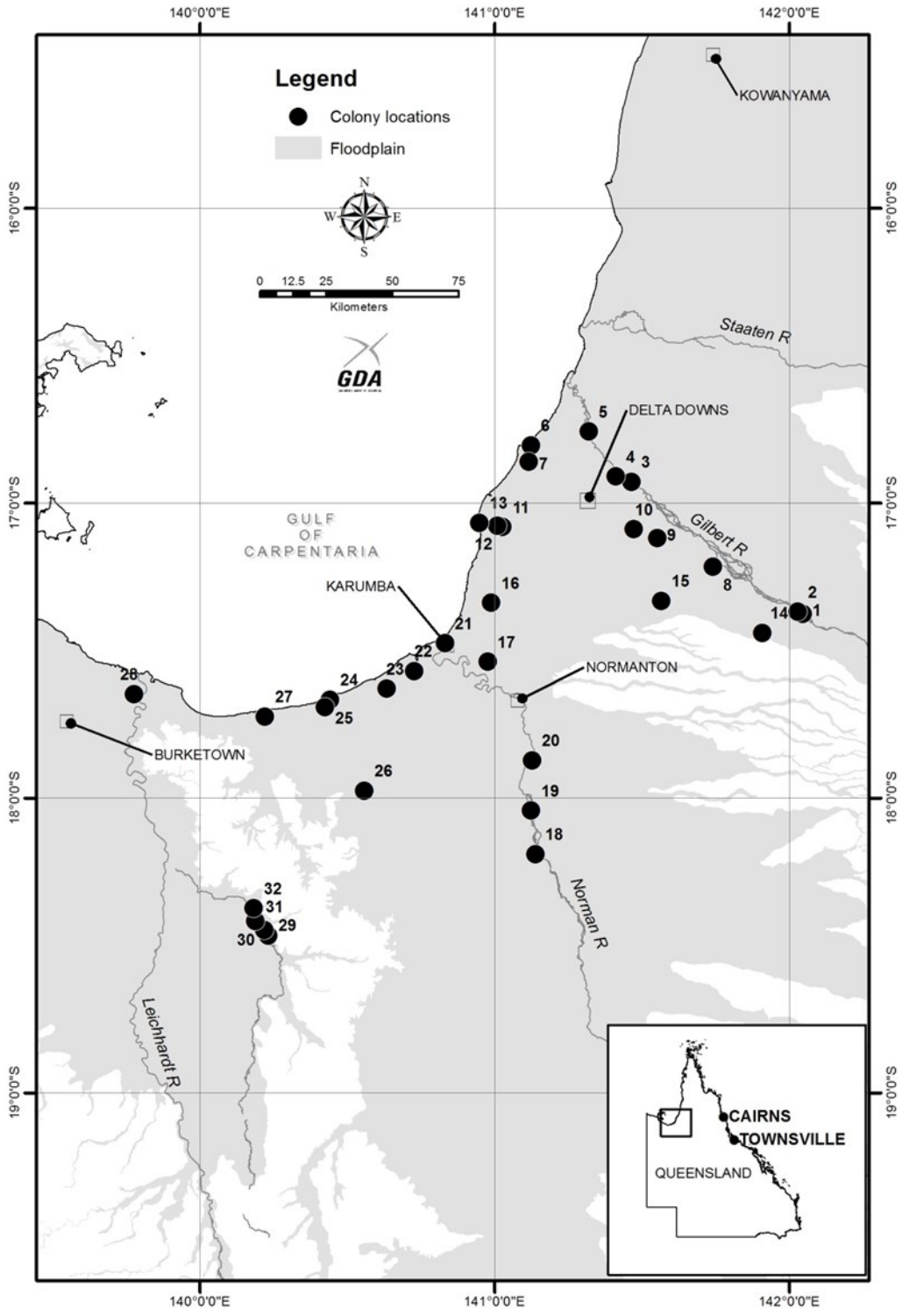

Figure 1. Location of waterbird breeding colonies recorded by the Normanton Land and Sea Rangers in the Gulf Plains region, 2009–2013.

items for herons, ibises, cormorants and allies and their nestlings are mainly small aquatic animals, notably fish, frogs and crustaceans (Marchant & Higgins 1990). Whereas these food items may be found in permanent

waterholes, lagoons and rivers and/or in intertidal habitats, local and regional flooding in the wet season causes a huge increase in abundance and availability of these foods; temporary (seasonal) wetlands are especially productive (Briggs *et al.* 1997; DPIPWE 2013). As the Intermediate Egret (*Ardea intermedia*) tends to be one of the most abundant of the target species in the Gulf Plains and northern Australia generally (Wetlands International 2013; Kingsford *et al.* 2012; RJ personal observations), its breeding activity may be a trigger for breeding by co-locating colonial waterbird species. Intermediate Egrets feed exclusively in shallow freshwater wetlands (Marchant & Higgins 1990; RJ personal observation) and thus can be expected to time their breeding in accordance with rainfall and flood events. Accordingly, major waterbird colonies in northern Australia are most likely to be supporting large numbers of nesting pairs and species in the mid-to-late wet season (March to May). Another timing consideration was, wherever possible, to avoid disturbance to large young in the nest and to avoid dates when many near-fledged young were present in colonies, as that would confuse our counting of the number of nesting pairs. Consequently, the optimal date for a single survey effort was considered to be mid-season (March), when all species were expected to be nesting, but with nests of most species still containing eggs or small young. In practice, surveys were conducted during March and/or April.

Transportation and routes for surveys

Helicopters were used for surveying for the following reasons. In March, the expected extent of floodwaters would create large areas to search for colonies and access to most known or likely colony sites was anticipated to be difficult or impossible on foot. Boat access was often impractical due to strong floodwater currents, vast areas of floodplain to navigate and the presence of saltwater crocodiles underneath colonies. Also, high aerial manoeuvrability was important to enable optimal viewing of colonies and minimise the duration of disturbance.

Based on the literature (Marchant & Higgins 1990; Taplin 1991; Chatto 2000; Driscoll 2001) and prior experience (RJ, PR and rangers), searching for colonies focussed on estuaries with mangroves and river reaches with wooded waterholes and associated wooded swamps. Surveys involved helicopter travel along river systems to locate waterbird colonies, and rapid collection of data (described below) when colonies were found. The number of observers on any one survey varied from one to three depending on the type of helicopter. The usual route involved helicopter travel along a river from its mouth to about the upper limit of its floodplain, crossover to the next river system

and following that downstream to the coast. Some efforts were confined to two rivers per survey date, owing to constraints of helicopter fuel range and observer fatigue. Known colony sites were included as first priority; the number of these increased year by year. In coastal areas, the major blocks of mangrove were checked, initially from at least 500 feet (150 m) altitude because white egrets tend to be highly conspicuous against green mangrove forest; based on RJ's experience of preferred colony sites, less attention was given to narrow fringing strips of mangrove. In freshwater riverine country, the tall and dense tree/shrub vegetation of major waterholes was checked wherever possible, accepting that it was not practical to cover all such waterholes on every flight. Off-channel habitats such as wooded swamps and inundated floodplain woodland were checked opportunistically, mainly where egrets were seen congregating. Some information on colony locations was provided to the CLCAC ranger coordinator by helicopter pilots, property managers and others in the community and was factored into planning of survey routes. Overall, the survey program was implemented according to available budget and rangers' other work commitments.

Type and constraints of data obtained

Data recorded were geographic position (coordinates), habitat type and impression of overall number of birds in the colony. During a second pass over the colony, species composition, improved assessment of scale of the colony (usually length, sometimes estimated numbers) and stages of breeding were recorded. In view of the inherent difficulties in counting birds and nests from a moving aircraft over just a few minutes and considering the fact that most colonies are linear, we recorded length of colony as an alternative measure of the size of breeding effort. Photographs and videos were obtained at some colonies; in several cases these enabled further refinement of size estimates and species composition. Overall, safety and other operational considerations greatly limited the time available to record data on breeding at any one colony.

Several assumptions, constraints and caveats apply to the survey data. As verification of nest contents was often impossible, a colony was considered as being active if at least several individuals of a target waterbird species were seen attending nests in suitable breeding habitat. This result also included situations where waterbirds seemed to be preparing to nest, or were acting as if breeding, or appeared to have recently finished nesting at the site. For example, breeding activity could be assumed with some confidence where groups of Pied Heron (*Ardea picata*) were flushed from inside the lower parts of an area of mangroves, because they are known to breed in

mangroves but otherwise spend most of their time in freshwater or dryland habitats (RJ personal observations). We also assumed that the total number of active nests (scale of breeding activity) in the colony matched the number of birds seen – whether estimated or counted accurately – in the colony. This assumption was reasonable where most of the birds in a colony were attending nests with eggs or small young, one adult per nest, while the other adult was elsewhere seeking food. Despite careful choice of survey date (see above), such conditions were not always applicable but it was beyond the scope of the survey program to address this limitation. An additional constraint was detectability. For example, Pied Herons tend to nest out of sight, in lower layers of the vegetation (RJ personal observation); with their dark steel-grey plumage they are far less conspicuous than the masses of eye -catching white waterbirds. Australasian Darters (*Anhinga novaehollandiae*) and sometimes other species often nest on the edges of colonies and so may have been missed because observers tended to focus on the core part of the colony. Egrets were moderately difficult to identify to species level in aerial surveys. There are no data for the early years, in regard to status of colonies that were found only in later years of the program, and some colonies found early on were not surveyed in every subsequent year.

Wetland conditions and survey coverage

Accumulated rainfall is an indicator of wetland condition; the intensity of rainfall is an additional indicator of the occurrence and size of floods. During the four Northern Wet Seasons (1 October of preceding year to 30 April of focus year) from 2009 to 2012, total rainfall across the Gulf Plains region was generally above average, whereas for the corresponding period in 2013, rainfall was below to well below average (Bureau of Meteorology 2013a). This is also reflected in the annual rainfall for Normanton Airport, near the centre of the study area, for the five calendar years 2009 to 2013: respectively 1338, 1183, 1292, 867 and (for nine months including the three that are typically the wettest) 470 mm, compared to the annual mean of 838 mm; results were similar for Miranda Downs station to the north-east, which has a much longer record of data (Bureau of Meteorology 2013b). Conditions for colonial breeding by waterbirds therefore are assumed to have been highly favourable in many parts of the Gulf Plains in 2009, 2010 and 2011, less favourable in 2012 and relatively poor in 2013. Wettest conditions were in 2009 and 2011 but the most severe floods (e.g. Norman River) were observed to be in 2009. Over such a large region, spanning more than 250 km of coastline and extending over 100 km inland, local and sub-regional variations within the overall annual pattern are to be expected.

Depending on funds available for helicopter charter and on rangers' commitments, survey coverage varied markedly as follows:

2009 (mid-March): extensive in the western and central catchments but nil in the northern catchments of the study area;
2010 (mid-April): limited, in central and northern catchments only;
2011 (mid-March to mid-April): extensive in all catchments except Duck and Spring Creeks;
2012: no surveys were conducted; and
2013 (mid-March): very limited, confined to the central catchments.

Collectively, over the five year period extensive coverage was achieved at least once in each of the nine catchments, including substantial parts of each river's estuary system. However, due to the complexity of the wetland systems and to operational constraints, there remained some unsurveyed areas, even within the well-surveyed freshwater channels and tidal estuaries.

RESULTS AND DISCUSSION

Location, distribution and habitats of colonies

Thirty-two waterbird breeding colonies were recorded by CLCAC during our Gulf Plains surveys from 2009 to 2013. Locations of the colonies are mapped in Figure 1. Tables 1 and 2 give the colony working (unofficial) names, river systems (catchments), coordinates, habitats and years in which colonies were recorded as active.

At least one colony was recorded in each catchment, except for Staaten River. Five catchments (the Gilbert, Smithburne, Walker, Norman, and Leichhardt catchments) each supported four to five colonies. At least one colony was recorded in each of the surveyed coastal estuaries, except for the Fitzmaurice estuary and Van Diemen Inlet. One colony was in mangroves on an island close to the mainland.

Many colonies (13) were in mangrove (intertidal) habitat, but the majority (19) were in freshwater wetlands in channels with riverine woodland/forest (especially *Melaleuca* trees and shrubs: Figure 2) (15) or in off-channel situations (on flat floodplain or in depression swamps; some colonies included riverine and off-channel habitats) (4).

Previous extensive surveys of waterbirds in the wider Gulf Plains region by Driscoll (2001), Taplin (1991) and others (Marchant & Higgins 1990) recorded some colonial breeding. Colonies of 100–200 Pied Cormorant (*Phalacrocorax varius*) along the coastline, one between Karumba and Pelican Island and another near Morning Inlet (Taplin 1991: undated records), were

Table 1. Names, catchments and coordinates of each colony recorded by the Normanton Land and Sea Rangers, 2009–2013.

Site code	Site name: (official, or created for the project)	River system (name of catchment)	Longitude (dec. deg. E)	Latitude (dec. deg. S)
GPWC-01	UPPER GILBERT - 1 (UPRIVER)	Gilbert River	142.0456	-17.3758
GPWC-02	UPPER GILBERT - 2	Gilbert River	142.0297	-17.3685
GPWC-03	MIDDLE GILBERT - 1 (UPRIVER)	Gilbert River	141.4647	-16.9279
GPWC-04	MIDDLE GILBERT - 2 (NEAR GRAHAM'S YARD)	Gilbert River	141.4125	-16.9092
GPWC-05	LOWER GILBERT	Gilbert River	141.3197	-16.7573
GPWC-06	KELSO POCKET (NORTH SPRING CK ESTUARY)	Spring Creek (North)	141.1237	-16.8041
GPWC-07	DUCK CREEK ESTUARY	Spring Creek (North)	141.1172	-16.8591
GPWC-08	UPPER SMITHBURNE	Smithburne River	141.7420	-17.2166
GPWC-09	BIRD WATERHOLE	Smithburne River	141.5520	-17.1185
GPWC-10	SMITHBURNE CENTRAL	Smithburne River	141.4730	-17.0888
GPWC-11	SMITHBURNE ESTUARY - 1 (UPRIVER)	Smithburne River	141.0269	-17.0813
GPWC-12	SMITHBURNE ESTUARY - 2 (DOWNRIVER)	Smithburne River	141.0107	-17.0760
GPWC-13	PELICAN ISLAND	coast	140.9495	-17.0666
GPWC-14	UPPER WALKER CREEK	Walker Creek	141.9084	-17.4398
GPWC-15	MAID'S LAGOON	Walker Creek (Bayswater Ck)	141.5669	-17.3317
GPWC-16	BRANNIGAN CREEK	Walker Creek (Brannigan Ck)	140.9892	-17.3379
GPWC-17	WILLS-WALKER SALTFLAT	Walker Creek	140.9769	-17.5381
GPWC-18	NORMAN 40 MILE	Norman River	141.1385	-18.1908
GPWC-19	CROCODILE WATERHOLE	Norman River	141.1239	-18.0429
GPWC-20	NORMAN WEIR	Norman River	141.1271	-17.8721
GPWC-21	KARUMBA (MOUTH)	Norman River	140.8320	-17.4750
GPWC-22	BYNOE (ESTUARY)	Flinders (Bynoe)	140.7270	-17.5693
GPWC-23	FLINDERS ESTUARY	Flinders (Bynoe)	140.6340	-17.6297
GPWC-24	WEST SPRING CREEK ESTUARY	Spring Creek (West)	140.4417	-17.6669
GPWC-25	LARGE SALTFLAT ISLAND (RUBBERVINE)	Spring Creek (West)	140.4249	-17.6922
GPWC-26	L CREEK	L Creek	140.5586	-17.9750
GPWC-27	MORNING INLET	M Creek	140.2207	-17.7239
GPWC-28	LEICHHARDT ESTUARY	Leichhardt River	139.7763	-17.6476
GPWC-29	ALEXANDRA - 1 (UPRIVER)	Alexandra River	140.2323	-18.4681
GPWC-30	ALEXANDRA - 2 (ORIGINAL COLONY)	Alexandra River	140.2200	-18.4490
GPWC-31	ALEXANDRA - 3	Alexandra River	140.1891	-18.4187
GPWC-32	ALEXANDRA - 4 (FLOODOUT, 12 MILE)	Alexandra River	140.1834	-18.3745

not noted in our surveys, probably because our focus was on river systems rather than coastline. Precise locations of historical colonies are not available in all cases but it seems that our surveys missed only one of the other historical colonies in our study area (Staaten estuary: Marchant & Higgins 1990) and discovered 28 new colonies. New colonies can be attributed to our wider coverage of freshwater wetlands, favourable dates of surveys and/or the overall level of colonial breeding activity in the year of survey.

Table 2. Principal habitat and scale of breeding recorded at each colony, 2009–2013. Blank cells mainly indicate that a colony was not surveyed in that year and do not necessarily mean that breeding did not occur.

Colony site code	Habitat at colony*	Scale in 2009 (birds)	Scale in 2010 (km)	Scale in 2011 (km)	Scale in 2013 (km)
GPWC-01	R			< 0.5 km	
GPWC-02	F			< 0.5 km	
GPWC-03	F		< 0.5 km		
GPWC-04	RF		3.5 - 4 km	4.5 - 5 km	
GPWC-05	S		< 0.5 km	< 0.5 km	
GPWC-06	M				< 0.5 km
GPWC-07	M				< 0.5 km
GPWC-08	RF			< 0.5 km	
GPWC-09	R	hundreds	< 0.5 km	0.5 - 1 km	
GPWC-10	R	thousands	1.5 - 2 km	2 - 2.5 km	0.5 - 1 km
GPWC-11	M		0.5 - 1 km	0.5 - 1 km	
GPWC-12	M			< 0.5 km	
GPWC-13	M		0.5 - 1 km	0.5 - 1 km	
GPWC-14	R			< 0.5 km	
GPWC-15	R	< 100	1 - 1.5 km	4.5 - 5 km	
GPWC-16	M			< 0.5 km	
GPWC-17	M			4.5 - 5 km	
GPWC-18	R	thousands		1 - 2 km	
GPWC-19	R			< 0.5 km	
GPWC-20	R	< 100			
GPWC-21	M	hundreds		1 - 1.5 km	
GPWC-22	M	< 100		0.5 - 1 km	
GPWC-23	M			1 - 1.5 km	
GPWC-24	M			0.5 - 1 km	
GPWC-25	S			< 0.5 km	
GPWC-26	R	hundreds		1 - 1.5 km	
GPWC-27	M			1 - 1.5 km	
GPWC-28	M			1.5 - 2 km	
GPWC-29	R			3.5 - 4 km	
GPWC-30	R	hundreds		< 0.5 km	
GPWC-31	R			1 - 1.5 km	
GPWC-32	R			< 0.5 km	

*Habitat at colony:
R = Riverine trees and/or shrubs (e.g. in or fringing waterholes)
S = Swamp trees and/or shrubs (in a basin or depression, not in a channel)
F = Floodplain trees and/or shrubs (on a flat subject to inundation)
M = Mangrove trees.

Timing and regularity of breeding effort

Systematic documentation of the stage of breeding occurred only in 2010 and 2011. In April 2010, eggs were recorded in some nests in most of the active colonies, and young were recorded at three colonies; in March-April 2011, eggs were recorded at all 28 surveyed colonies and young at 23 colonies. This confirms that March and/or April is a suitable time for

Figure 2. A riverine breeding colony of egrets in freshwater trees and shrubs, Gulf Plains. Photo: Normanton Land & Sea Rangers, CLCAC.

surveys, as it is not too late for nests to have eggs (see Methods), but caution is nevertheless required because it is not too early for nests to have young.

The inconsistent coverage of sites from year to year (see Methods) and sparseness of information on sites surveyed but found to be inactive, preclude drawing strong conclusions on regularity of colonial breeding in the Gulf Plains from the results of our surveys. We consider that some active colonies may have been missed in 2009 and 2010 due to gaps in coverage of catchments. However, we are aware that some sites were first detected as supporting active colonies in 2011, a year with conditions that were wetter than average, and that some colonies were inactive in the relatively dry year 2013. Twelve particular colonies were active in at least two years and it seems that at least some colonies (e.g. Smithburne Central, Maid's Lagoon) may be active in most years (Table 2). In drier years, rainfall may be sufficient to generate small floods that inundate some floodplain in some of the middle reaches of the river systems, but floods probably do not reach the saline coastal zone, other than as in-channel flow. We therefore expect that some of the mangrove colonies will be inactive in drier years because saline flats and marshes will not have been inundated by rain and/or floods. At such times, some waterbirds – notably the Intermediate Egret – may not have enough optimal feeding habitat close to the colony sites.

Scale of breeding effort (colony size)

Table 2 illustrates the scale of breeding recorded in the various survey years, at each colony that was surveyed and found to be active. Some colonies were less than 500 m long and/or held fewer than 100 birds; others were several kilometres long and/or held thousands of birds. Without documentation of the density of birds (high, low, continuous, or patchy), it is not possible to assign an estimate of bird or nest numbers to colonies, based on colony length. However, from prior field experience and examination of photos and videos taken of some colonies, we estimate that most of the colonies that were at least 1 km long contained thousands of birds. This scale was recorded in at least one year at each of 12 colonies, and in two or more years at four colonies: Middle Gilbert 2, Smithburne Central, Maid's Lagoon and Norman 40 Mile. The largest colonies, each 4.5–5 km long in at least one year, were Middle Gilbert 2, Maid's Lagoon and Wills-Walker Saltflat. From prior field experience we estimate that each of these held several thousand birds, if not in the order of 10,000 birds in some years. We think these numbers, albeit coarse estimates, probably reflect the number of breeding pairs. As the surveys were only snapshots, it is possible that there were also undetected late or early breeders and some repeat nests at some colonies over the course of the breeding season.

With the exception of Wills-Walker Saltflat, the largest colonies were all in freshwater/inland locations, although the mangrove-based Leichhardt Estuary and Karumba colonies were moderately large. This result is not necessarily typical in northern Queensland: a colony in mangroves on the South Mitchell River estuary, north of the study area, near Kowanyama is sometimes very large, supporting in the order of 10,000 breeding pairs (RJ personal observations).

Data were inadequate for comprehensive inter-annual comparisons of scale of breeding effort but they showed variation at some colonies, such as the colony in mangroves opposite Karumba (probably an order of magnitude larger in 2011 than in 2009), whereas the size of some other colonies was consistent through time (Table 2). Rangers postulated that some increases may have been due to return of the previous year's young to breed in their birthplace colony, while in other cases, newly detected colonies may have been due to previous year's young needing to find alternative places to breed. As these waterbirds are highly mobile it is also possible that in wetter years, some – originating in other regions of northern Australia – visit the Gulf Plains to breed, whereas they may not visit in drier years.

Results by waterbird species (distribution and scale of breeding)

Table 3 shows the distribution of the 11 waterbird species recorded breeding in Gulf Plains colonies, among the 32 colonies surveyed from 2009 to 2013, based on aggregated data across all surveys. The highest number of species (11) was at Norman 40 Mile colony, followed by Maid's Lagoon (10) and five other sites each with 9 species. Ten colonies each had fewer than three species recorded breeding. The most widespread breeding species was the Australian White Ibis (*Threskiornis molucca*) (26 colonies), followed by the Royal Spoonbill (*Platalea regia*) (20) and the Nankeen Night-Heron (*Nycticorax caledonicus*), Intermediate Egret and Little Black Cormorant (*Phalacrocorax sulcirostris*) (18 each). No Cattle Egrets (*Ardea ibis*) were detected in the colonies in our surveys or in earlier coastal surveys by Taplin (1991) despite increasing range and numbers in Australia and small numbers on Karumba Plain (Marchant & Higgins 1990; Wetlands International 2013; RJ personal observations). Some egrets and black and white cormorants may not have been correctly identified in a few instances due to the short time available for surveying at each colony. Direct comparison between historical records and our data is possible for the combined Flinders and Bynoe estuarine colonies: species composition was similar (*cf.* Taplin 1991 citing earlier data from S. Garnett).

The scale of breeding effort by each species cannot be described adequately at present. However, the general impression, reinforced by RJ's observations elsewhere (e.g. South Mitchell River) and some other reports (Top End: Chatto 2000) is that the Intermediate Egret is the most abundant breeding species in the largest Gulf Plain colonies. Taplin (1991) concluded that the Little Egret (*Egretta garzetta*) was the most abundant breeding egret in a 1990 survey that focussed on estuarine parts of the study area (favoured habitat for Little Egret more so than Intermediate Egret: RJ personal observations) but the 1990 wet season was a failure and was compounded by ongoing drought (Taplin 1991); this may have inhibited breeding at inland sites (favoured by Intermediate Egret). The Australian White Ibis, Little Black Cormorant and Royal Spoonbill each also seem to comprise a substantial proportion of the overall total breeding effort in the region, based on our observations and on the number of colonies at which they occur.

Gaps in coverage

There are significant gaps in our survey coverage, which could be targets for future surveys in order to obtain a comprehensive understanding of colonial

Table 3. Occurrence of waterbird species among the surveyed colonies, 2009–2013.

Colony	Australasian Darter	Australian White Ibis	Eastern Great Egret*	Intermediate Egret	Little Black Cormorant	Little Egret	Little Pied Cormorant**	Nankeen Night-Heron	Pied Cormorant	Pied Heron	Royal Spoonbill	Totals
GPWC-01		X							X			**2**
GPWC-02		X			X							**2**
GPWC-03												**0**
GPWC-04		X	X	X	X	X		X			X	**7**
GPWC-05		X			X						X	**3**
GPWC-06										X		**1**
GPWC-07										X		**1**
GPWC-08											X	**1**
GPWC-09		X	X	X	X	X	X	X	X		X	**9**
GPWC-10		X	X	X	X	X	X	X		X	X	**9**
GPWC-11		X	X	X		X	X	X			X	**7**
GPWC-12		X										**1**
GPWC-13		X		X	X	X		X			X	**6**
GPWC-14		X			X						X	**3**
GPWC-15	X	X	X	X	X	X	X	X	X		X	**10**
GPWC-16		X										**1**
GPWC-17		X						X		X	X	**4**
GPWC-18	X	X	X	X	X	X	X	X	X	X	X	**11**
GPWC-19		X	X	X	X	X						**5**
GPWC-20	X			X								**2**
GPWC-21		X	X	X	X	X		X	X	X	X	**9**
GPWC-22		X	X	X	X	X		X		X	X	**8**
GPWC-23		X	X	X	X	X		X	X		X	**8**
GPWC-24		X	X	X		X		X		X	X	**7**
GPWC-25		X										**1**
GPWC-26		X	X	X	X	X		X	X	X	X	**9**
GPWC-27			X	X		X		X		X		**5**
GPWC-28		X	X	X		X		X		X	X	**7**
GPWC-29		X	X	X	X	X			X		X	**7**
GPWC-30		X	X	X	X	X		X	X	X	X	**9**
GPWC-31		X			X			X				**3**
GPWC-32		X			X			X			X	**4**
Totals	**3**	**26**	**16**	**18**	**18**	**17**	**5**	**18**	**9**	**12**	**20**	

* Eastern Great Egret *Ardea modesta*
** Little Pied Cormorant *Microcarbo melanoleucos*

breeding in the Gulf Plains. Within the study area, geographical gaps include Van Diemen Inlet, Fitzmaurice River and the lower-middle reaches of the Flinders-Bynoe and Leichhardt Rivers. Observers should be alert to possible additional colonies in channels or bends outside the paths previously flown. Elsewhere in the Gulf Plains, and especially in years of average to above-average rainfall, surveys to find colonies should be conducted outside the study area to the west, between the Leichhardt River and Northern Territory border, and to the north, in western Cape York. Furthermore, additional species may be detected breeding in specific colonies, other than those recorded in our 2009–2013 surveys, including species that are less abundant or less conspicuous (e.g. Pied Heron), or that nest underneath the upper canopy layers (e.g. Nankeen Night-Heron). The Normanton Land and Sea Rangers hope to fill gaps in coverage wherever possible; surveys over at least 10 years would be desirable in order to fully document the diversity and variability of colonies.

MANAGEMENT AND CONSERVATION

Ecological requirements of colonial waterbirds

A comprehensive understanding of the ecological components and processes that trigger and sustain waterbird breeding within colonies should be developed to inform surveillance/monitoring and the management of these natural assets. These ecological requirements remain poorly known and many will be specific to the geography and habitats of the Gulf Plains region. It is recommended that a program of ground-level surveys be undertaken by the CLCAC rangers at several accessible colonies on several dates over at least one complete breeding season. Data to procure at each colony should include: vegetation used for supporting nests; changes in water depth and extent; a full list of species breeding; estimates of relative abundance and total numbers of species; dates of laying, eggs hatching and young departing; and measures of breeding success. Aerial surveys of these sites should be conducted using previous methods, so that ground-to-aerial extrapolations can be attempted on the data, thereby enabling greater use of existing and future information from aerial surveys. Information on diets of the colonial nesting waterbirds would also be instructive for management, but would require highly sophisticated research.

Site management and conservation issues

During the 2009–2013 surveys, no immediate major threats to the viability of waterbird breeding colonies in the Gulf Plains were identified. In some riverine colonies, rubber vine (*Cryptostegia grandiflora*) may destroy trees in which

the birds nest but it is conceivable that, although rubber vine is a widespread weed, in some cases the birds could relocate and successfully breed at other sites. Fishing and other boat activity in estuaries, even at Karumba port, is most likely not a present threat because colonies tend to be well inside the dense mangrove forest. Commercial grazing of cattle is conducted over most of the Gulf Plains landscape and on present evidence this does not seem to pose an obvious direct threat to colonies. However, severe soil erosion in catchments of northern Australia does cause waterholes to be filled with waterborne sand/silt (Brooks *et al.* 2011), affecting the health of waterhole shrubs/trees; we consider this impact thereby may potentially alter the suitability of such waterholes for colonial breeding.

The greatest potential threat to long-term sustainability of colonies may be any process or development that reduces the flooding of colony sites or floodplain feeding areas, or threatens the health of essential nesting trees. Changes to river flow and flooding in the region (through construction upriver of large reservoirs or irrigation schemes), such as in the Flinders and Gilbert River catchments therefore pose possible future threats to colonies. Such changes may make conditions for widespread breeding by waterbirds far less favourable, especially in years of average to below-average rainfall. Dams may stop small flows that are common early in the wet season; even in wetter years, downstream wetland habitats and floodplains are primed by small early flows and this increases the spread and environmental benefits of later flood pulses (Kingsford 2000).

Importance of the Gulf Plains region for colonial breeding waterbirds

Criteria adopted by the Ramsar Convention on Wetlands, to which Australia is a signatory, are the most widely used indicators of international importance of a wetland. Several of these criteria relate to waterbirds (Ramsar Convention 2013):

Criterion 4: A wetland should be considered internationally important if it supports plant and/or animal species at a critical stage in their life cycles, or provides refuge during adverse conditions.

Criterion 5: A wetland should be considered internationally important if it regularly supports 20,000 or more waterbirds.

Criterion 6: A wetland should be considered internationally important if it regularly supports 1% of the individuals in a population of one species or subspecies of waterbird.

In our opinion, each colony identified in our surveys meets Ramsar Criterion 4 because breeding, especially colonial breeding, may be considered a critical stage in the life cycle of a waterbird. We also consider

that several of the larger colonies probably meet Criterion 5 because the number of breeding pairs likely exceeds 10,000 and thus the site supports at least 20,000 waterbirds. Furthermore, it is our view that Criterion 6 is probably met at some colonies. An estimate of total population size, endorsed by the Ramsar Convention (Wetlands International 2013), exists for each of the waterbirds breeding in the Gulf Plains colonies that we documented. Accordingly, for the Little Black Cormorant, Intermediate Egret, Nankeen Night-Heron and Australian White Ibis the 1% threshold is 10,000 birds and for each of the other seven species (e.g. Royal Spoonbill), the 1% threshold is 1000 birds (Wetlands International 2013). Despite the absence of comprehensive counts of species from all of the colonies that we surveyed, we consider that larger colonies, such as Smithburne Central and Maid's Waterhole, would each meet Criterion 6 for more than one species and that some smaller colonies may also meet Criterion 6 for at least one species. As only one criterion needs to be met, we conclude that most, if not all, of the Gulf Plains colonies are internationally important in terms of globally accepted criteria.

In northern Australia, the only other known aggregation of colonies of similar scale and species composition is in coastal floodplains of the Northern Territory, east and west of Darwin (Chatto 2000). These Top End colonies lie along about 450 km of coastal and sub-coastal wetlands, whereas those in the Gulf Plains region span about 250 km. Direct comparisons between the two regions may be possible in the future if we succeed in obtaining comprehensive details on numbers of birds breeding in the Gulf Plains. Furthermore, whereas our surveys have provided a major addition to the knowledge of where colonies are located in northern Queensland, more colonies will possibly be detected in less well known or unsurveyed reaches of rivers draining to the Gulf of Carpentaria in coming years. We are aware of suitable habitat in other catchments and several colonies have been identified in western Cape York (Marchant & Higgins 1990; Taplin 1991; RJ personal observations) but the scale, composition and timing of all colonies remain inadequately documented.

We consider several environmental factors to be important for understanding why so many colonies and waterbirds occur in the Gulf Plains region and to plan for their conservation. Firstly, the landscape is relatively flat and has many river and estuary systems, with multiple and complex networks of channels, associated floodplains and off-river depressions. In many years, relatively high and often intense seasonal rainfall and over-bank flooding fills these wetlands, producing abundant food

resources for feeding by waterbirds. Additionally, the landscape presently has high integrity because the rivers and associated land systems are mostly unaffected by water regulation, disconnection of flows, removal of tree cover by clearing and development for cropping or industry. However, changes to any of these factors may impact the viability of the colonies.

Connections to other waterbird regions

Management of habitats, sites and species is more complex where substantial numbers of the key species move, annually or irregularly, to sites outside the region of interest. There is some evidence (Marchant & Higgins 1990) that some waterbird species, including many of those that have been recorded in the Gulf Plains colonies, migrate between northern Australia and southern New Guinea, and/or eastern Indonesia, during the dry season. For example, large numbers of egrets have been recorded in southern New Guinea (Halse *et al.* 1996) when they seem less abundant in drier parts of northern Australia; however, some egrets and Pied Herons apparently travel north only as far as northern Cape York (Taplin 1991; Driscoll 2001). Movements seem to reflect regional differences in seasonal dryness and thus availability of wetland feeding habitat. These likely connections between waterbird breeding colonies in the Gulf Plains region and other regions of Australia or overseas, indicate interdependence of wetland sites by showing that one cannot function without the ecosystem services provided by the other.

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Some places along the Norman River where waterbird breeding colonies were recorded, have been identified as Culturally Significant sites to the Kukatj people. These places were used for trading and ceremonies and burial sites are situated in the area. Similar values are likely to exist in regard to other rivers and their colonies.

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