Threatened Species and Farming

Brolga:

Management of breeding wetlands in northern Victoria

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SUMMARY

This study was funded by the *Ecologically Sustainable Agriculture Initiative* (ESAI) of the Department of Primary Industries. It is one of seven case studies investigating management techniques for threatened species in the context of improvements in agricultural production that are ecologically sustainable over the long-term.

There are fewer than 1000 Brolgas remaining in south-eastern Australia. Their survival ultimately depends on the management of wetlands on farms. Brolga breeding wetlands (n=11) and control wetlands where no breeding had been recorded (n=5) were monitored over two years to investigate the effects of different wetland management regimes on Brolga breeding habitat. This work focussed on a distinct breeding sub-population in the Rutherglen – Yarrawonga – Katamatite – Tungamah – Dookie region, which consists of about 11 breeding pairs. These Brolgas make wide use of constructed and highly modified remnant wetlands used for the storage of irrigation water. Additional work took place across the entire Victorian and New South Wales Riverina.

Brolgas were only recorded nesting between June and January, with most records in September and October, in response to water associated with both rainfall and irrigation storage. Breeding almost exclusively occurred in wetlands where the majority of the wetland area was ephemeral (flooded for 2 - 6 months at a time up to 50 cm deep). The only other breeding records were in wetlands where the majority of the area had a semi-permanent water regime (flooded for 6 - 12 months at a time) with a smaller ephemeral area. Brolgas were never recorded breeding in wetlands where the majority of the area had a permanent water regime, which is typical of many constructed wetlands on farms. The ephemeral wetlands (and to a lesser extent the semi-permanent wetlands) typically had larger, healthier stands of waterplants, particularly *Eleocharis* species, the tubers of which are known to provide Brolgas with an important food source. All wetlands where Brolgas bred supported at least some level of grazing by sheep or cattle, although they tended to be ungrazed (or only very lightly grazed - <4 DSE/ha) when wet and not subject to set stocking rates. Relatively continuous high levels of grazing (>10 DSE/ha) around most of the control sites, coupled with a lack of shallow, ephemeral areas, resulted in these sites being devoid of wetland vegetation and of little value to Brolgas.

Breeding success was extremely low with an average of 0.28 birds fledging per nest. Large, non-breeding flocking sites revealed no recruitment after the drought in 2003 (0/123), whilst in 2004 there were only 5.2% (4/77) immature birds, reinforcing that this population may be suffering demographic malfunction. Improved wetland management and other conservation initiatives (e.g. fox baiting, constructing new wetlands) should see recruitment improve.

Many landholders and community organisations such as local Landcare groups have expressed interest in managing and creating wetland areas for Brolgas. Encouraging these people to maintain ephemeral shallows (up to 50 cm) that are flooded for 2 – 6 months at a time will benefit Brolgas and other wetland biota. There are numerous opportunities to modify exisiting created wetlands and construct others on farms to make the landscape more productive for Brolgas, other threatened species and biodiversity generally. Ideally, such wetlands could have the ephemeral shallows and mudflats, together with deep (50 – 140 cm), more permanent areas that are open, as well as other deep areas that support stands of dense vegetation like *Typha* or *Phragmites* species. There were several wetlands that had such diversity. These were all rich in birdlife, not only supporting breeding Brolgas but also other threatened species like the Australian Painted Snipe and Australasian Bittern, and migratory species like the Sharp-tailed Sandpiper. Indeed, there is great potential for significant biodiversity outcomes from small constructed wetlands (< 10 ha) on farms that use relatively small amounts of water, in many cases less than 20 ML per wetting-drying cycle.

1. INTRODUCTION

1.1 Ecologically Sustainable Agriculture Initiative (ESAI)

1 "Threatened Species and Farming" is a sub-project of the ESAI. This project will identify how agricultural practices might be modified to help conserve selected threatened species as part of working toward ecological sustainability. The project will document case studies of selected threatened species in four bioregions: the Victorian Riverina, Wimmera, Victorian Volcanic Plain and Gippsland Plain. The farms considered include examples from the meat, wool, dairy and grains industries. This case study focuses on the Brolga *Grus rubicunda* in the Victorian Riverina.

1.2 Wetland biodiversity conservation in agricultural landscapes

Wetlands often support high levels of biodiversity and are a common feature on many farms in Australia. Freshwater wetlands hold more than 40% of the world's species and 12% of all animal species (RAMSAR, date unknown), and approximately one quarter of Australia's bird species depend on wetlands. Birds are relatively easy to monitor compared to other groups and are often used as a surrogate for biodiversity. Even small wetlands on farms can support a high concentration of biodiversity, including threatened species like the Brolga. The management of both remnant and constructed wetlands on farms is strongly influenced by the needs of stock and water for irrigation. The conflict between irrigated agriculture and wildlife conservation has reached a critical point on a global scale, with a multitude of effects influencing migratory, nomadic and resident waterbirds worldwide (Lemly *et al.* 2000). Traditional forms of conservation, such as reserves and listing wetlands under international agreements, are not entirely effective (Kingsford 1998). Research for conservation and management should focus on determining the impact of water use associated with agriculture on wetland habitat availability, which is thought to be a primary cause of decline in threatened waterbirds like the Brolga, Australasian Bittern, Little Bittern, Black-necked Stork, Australian Painted Snipe, Magpie Goose and Lewin's Rail, and other wetland biota (Arnol *et al.* 1984, Marchant & Higgins 1993, Kingsford 1998, Garnett & Crowley 2000, Herring 2001). The shallow wetlands that most waterbirds favour have been the worst affected because they are the easiest to drain (Corrick 1981, 1982).

1.3 The Brolga

Brolgas are renowned for their 'dancing' and calling repertoire. Photo: David Webb.

Adult male with two-month old flightless chick feeding in irrigated Lucerne near Yarrawonga. Photo: MH

Distribution and conservation status

The Brolga (*Grus rubicunda*) is a large, charismatic wetland bird and one of the world's 15 species of crane, which are among the most appealing and most threatened bird groups on the planet (Meine & Archibald 1996). The Whooping Crane (*Grus americanus*) for example, suffered a severe population bottleneck but has become an international symbol for successful conservation, with recovery efforts in North America making imminent extinction unlikely by boosting numbers from a low of 14 individuals in 1938 to around 300 in 1999 (Bell & Merton 2002). The Brolga is an ideal animal for targeted threatened species conservation in agricultural landscapes, showing great potential as a flagship and umbrella species for wetland conservation on private land. Indeed, landholders hold 'their' Brolgas in high regard and respond very well to directed management actions for the species (Herring 2001).

The Brolga is listed as *Vulnerable* in Victoria, New South Wales and South Australia (Stanger *et al.* 1998), and although still considered secure nationally, the recent Birds Australia Atlas showed strong evidence for a nation-wide decline in the last 20 years (Barrett *et al.* 2003). Brolgas have declined dramatically in south-eastern Australia since European settlement, primarily from habitat loss, shooting, predation of young by the introduced fox and inappropriate wetland management. Declines are relatively well documented. For example, Brolgas were a common species on the coastal plains of East Gippsland until the 1920s, the plains around Melbourne and Port Phillip Bay until the early 1900s, and French Island and Western Port until 1919 (Arnol *et al.* 1984, White 1987). In the 1970s breeding was still being recorded near Corryong in the Upper Murray, close to the Alpine National Park (White 1987). They now appear extinct east of the Hume Highway from Sydney to Melbourne, with similar contractions in the west (e.g. Deniliquin and Kerang regions), and very few strongholds remain (Herring 2001). Two relatively distinct populations persist in Victoria: the northern, which includes southern New South Wales, and the south-western, which includes the far south-east of South Australia.

A single day count at flocking sites, accounting for birds remaining at breeding sites, yielded an estimate of 600 – 650 for the south-western Victorian population, including the far south-east of South Australia (Arnol *et al.* 1984). Although Bool Lagoon, near Naracoorte in S.A, can support up to a third of the south-western Victorian population during the flocking season (Arnol *et al.* 1984), south-eastern S.A now only supports 10 – 20 breeding pairs (Bransbury 1991). White (1987) suggested that there could be as few as 50 – 100 Brolgas remaining in northern Victoria, whilst Du Guesclin & Goldstraw (2003) reported the population as static from 1981-1996 with 60-70 birds. It is now known that about 100 (80 – 120) Brolgas remain in northern Victoria. This contrasts strongly with historical abundance, including local concentrations in the Corop region of 200 – 300 in the early 1900s (Herring 2001) and in the Barmah forest Brolgas were common in the 1890s (Leslie 1995), still with hundreds and regular breeding there in the 1920s (Chesterfield *et al.* 1984, Loyn *et al.* 2002). The northern Victorian Brolga population consists of three distinct sub-populations or groups; Corop, Kerang/Dingee/Echuca and the broader Yarrawonga region (Herring 2001).

The Yarrawonga region group, which was the focus of this study, consists of approximately 11 breeding pairs and is roughly bounded by Rutherglen in the east, Benalla in the south, Katamatite in the west, and the Murray River in the north. However, in contrast to the other two northern Victorian groups, this group can not be considered largely isolated from the Brolgas of southern New South Wales because just across the border there is a large flocking site, near Barooga, which is almost certainly used by birds from the Yarrawonga region group, and regular breeding still occurs in the Balldale and Savernake regions just north of the Murray River. Extremely low densities of Brolgas throughout central New South Wales largely isolate the southern population in Victoria, south-east South Australia and southern New South Wales from their northern counterparts (Barrett *et al.* 2003, Cooper & McAllan 1995, Herring 2001).

Wetland management

Brolgas are closely associated with privately-owned wetlands in lowland agricultural areas. Directions for future management of both remnant and created breeding habitat are now considered critical steps in the recovery of this species in south-eastern Australia. However, very little attention and no adequate prescriptions have been identified to manage breeding wetlands appropriately (Arnol *et al.* 1984, White 1987, Marchant & Higgins 1993, McIntyre 1995, Herring 2001).

The effects of different wetland management regimes on the Brolga and many other threatened waterbirds remain largely unknown. Brolga breeding sites in the New South Wales and Victorian Riverina in 2000 typically had emergent vegetation around 90 cm in height, with an aerial cover of about 25% in water depths around 30 cm (Herring 2001). This level of emergent vegetation growth appears to maintain a panoramic view of the surrounds, which adult Brolgas appear to require, whilst still providing and supporting adequate food resources, as well as sufficient cover for young chicks when parents are feeding.

In addition to resource availability, breeding habitat selection in birds is often a function of predator avoidance, highlighted by studies showing raptors nesting on the ground on predator-free islands (Newton 1998). Only rarely will Brolgas nest on dry land (White 1987). Nest site selection in Brolgas may have originally evolved because of native ground-dwelling predators like Quolls (*Dasyurus* spp.), Dingoes (*Canis lupus dingo*) and the Tasmanian Tiger (*Thylacinus cynocephalus*). Red Foxes (*Canis vulpes*) pose little threat to adults but are likely to be the most significant predator of chicks. Young Brolgas are particularly susceptible because a long fledging period (c. 100 days) exacerbates the risk of predation and chicks leave the safety of the nest site soon after hatching, reputedly within 48 hours.

Popular opinion suggests shooting and 1080 baiting for Foxes is required to maintain southern Brolga populations. However, reducing predation through directed habitat management for waterbirds can be more effective than direct predator control in increasing breeding success (Weller 1999). Indeed, adequate water levels (~ 30 cm) and sufficient cover at Brolga breeding sites may help to reduce fox predation and increase the likelihood of a chick fledging.

Water regimes, especially the flooding dynamics and depths, are a major factor in determining wetland bird assemblages and opportunities for them to breed. A recent trial of environmental flows at 11 privately-owned shallow wetland sites in south-western NSW proved to be highly successful, with positive responses from a diverse array of waterbirds, including the Latham's Snipe, Red-kneed Dotterel and Nankeen Night Heron (Nias *et al.* 2002), and more recently, the Brolga (T. Alexander, pers comm.). Irrespective of rainfall, many of the study sites in the Yarrawonga region are flooded each year because of existing management regimes associated with irrigation practices. These controlled water regimes vary dramatically and are likely to have significant effects on breeding habitat availability for Brolgas.

1.4 Objectives

The current study had four main objectives:

- To monitor Brolga activity at breeding (and associated flocking) sites across the Victorian Riverina, specifically the broader Yarrawonga region but also incorporating southern New South Wales.
- To examine and clarify management issues associated with Brolga breeding wetlands.
- To identify the effects of and relationships between different wetland management regimes and Brolga breeding habitat availability.
- To determine practical management guidelines for maintaining, enhancing and creating Brolga breeding habitat.

2.0 METHODS

2.1 Site selection and monitoring of Brolga activity

A total of 16 focal wetland sites were chosen for study in the broader Yarrawonga region, 11 of which had been used by Brolgas for breeding since 1998. This region is roughly bounded by the Murray River in the north, Rutherglen in the east, Katamatite in the west and Benalla in the south (Figure 2.1). The number of sites was limited by the number of breeding pairs remaining in the focal study area. Additional breeding wetlands were incorporated across a broader study area – the Victorian and New South Wales Riverina.

The development and management of an observer network, particularly the owners of the focal study sites and key observers living in the study area, was an integral part of this study (see acknowledgements). The observer network was used as an aid to determine the level of habitat use (e.g. only a night-roost site, breeding activity or frequency of use as a feeding area) and breeding success at each site, as well as assistance to quantify management regimes. Observers were kept in touch with the progressive results of breeding and flocking each year by email, telephone and in-person contact. This helped maintain enthusiasm and provided a platform for data exchange.

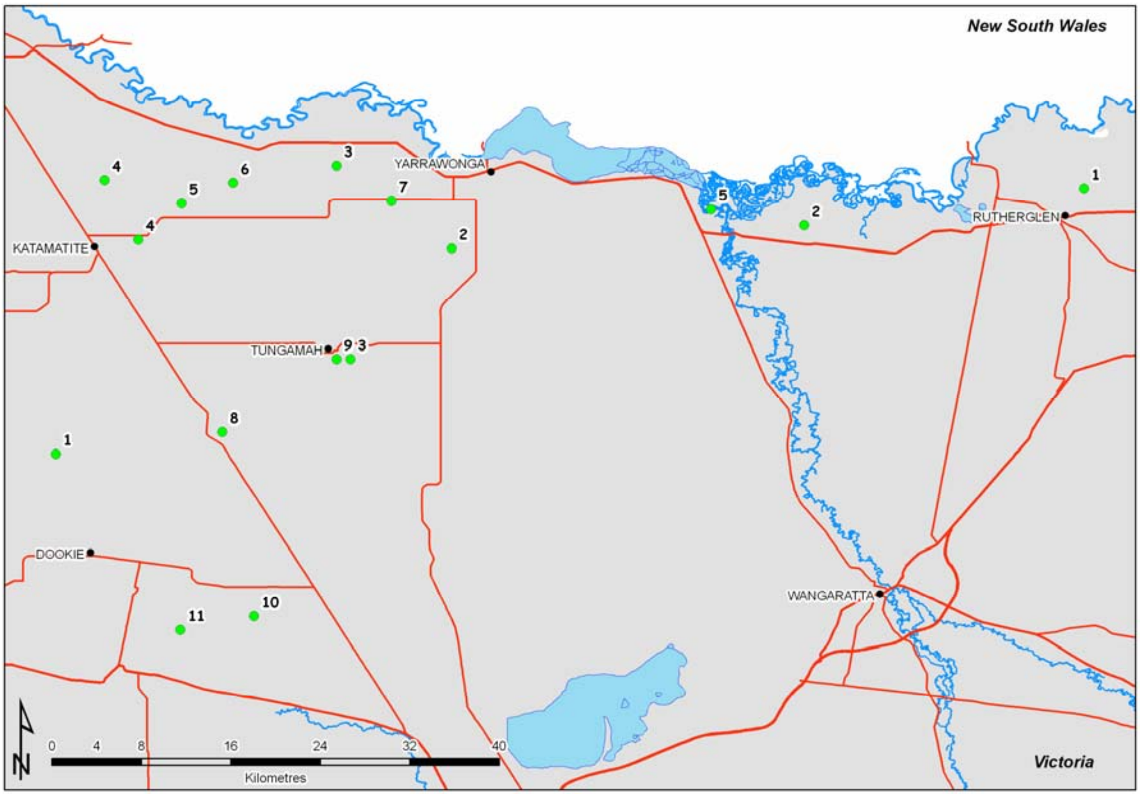

Figure 2.1 Map of focal study sites

2.2 Breeding habitat

The focal wetlands were surveyed once when they were dry and every 3-6 weeks when wet.

Vegetation

Vegetation was measured at four randomly placed 1 m^2 quadrats covering the edge and interior of the wetland area at each site. The aerial cover, height and floristics were recorded. Photo points were also used to help ascertain changes in vegetation.

Water Regimes

The period and extent of inundation was monitored during the field work with estimates using GPS mapping, photopoints and through the observer network. The water regimes, particularly flooding dynamics and depths, were quantified and include those associated with irrigation practices. Landholders helped ascertain the timing and quantities of water entering each system. Water depths were measured at the four quadrats used for vegetation survey and a mean taken for each sampling period.

The amount of water (ML - Megalitre) present in each wetland when full was measured using mean depth and area calculations (i.e. 1 ML = 10 cm over 1 ha). This did not account for seepage, evaporation and 'top-ups', so when calculating the total amount of water used per wetting-drying cycle (or per annum for semi-permanent and permanent wetlands) this figure was increased by 50%, somewhat arbitrarily. It was extremely difficult to differentiate the volumes of irrigation water from natural precipitation and runoff.

Grazing

The DSE (Dry Sheep Equivalent), based on a 50 kg wether being equal to 1, was used to standardize the varying grazing levels of both sheep and cattle and various levels of reproduction across the sites. This was determined through landholder information and the number and type of stock seen in the paddock/s containing the wetland when taking vegetation and water regime measurements. Measurements of pugging and manure levels were severely confounded by inadequate detection in water so were deemed unreliable and not used.

2.3 Flocking ecology and recruitment

The simplest, most effective way to monitor the health of Brolga populations is to measure recruitment annually. Improvements in wetland management and breeding success should be reflected by increased recruitment over time. Non-breeding flocks were located through the observer network, especially those observers associated with regularly used sites. Flocks were counted by the author, except for the Pyramid Hill count that was made by experienced birdwatcher Simon Starr, from between 100 m and 800 m several times with binoculars and/or a spotting scope. The surrounding landscape within approximately 5 km of the flock was searched for additional birds, as flocks sometimes disperse into two or more groups during the day. Only when the same figure was revealed at least three consecutive times was it accepted. The number of immatures in each flock was determined by head colouration (i.e. the presence/absence of a red caruncle) and checked at least four times so no birds were missed. Distribution and habitat use of flocks (e.g. what they were feeding on, where they roosted) was also recorded.

3.0 RESULTS

3.1 BREEDING BIOLOGY

Brolgas were only recorded nesting as isolated pairs on discrete wetlands. No dry land nesting was recorded. There were 24 nesting records from 18 wetlands. During the 2003 and 2004 breeding seasons Brolgas were recorded nesting from June to January, with most records in September and October (Figure 3.11). The 2003 season was the most productive for Brolgas in northern Victoria and southern New South Wales since 2000, representing 18 of the 24 nesting records for the study.

From the 24 nesting records, 18 were monitored adequately to determine the following: 32 eggs were produced (mean clutch size of 1.78), of which only 13 chicks (41%) survived the first week after hatching. Only five of these 13 chicks were known to have fledged, so the mean number of young fledged per nest was 0.28 and only 15.6% of eggs were successful in producing a fledged young. Chicks were highly mobile and often difficult to monitor (Figure 3.12) but the primary cause of mortality was presumably predation, although starvation, disease and other causes cannot be ruled out. The only confirmed predation event was of a four-day old chick at study site 7 in 2003 that was taken by a Whistling Kite, which was also breeding in this wetland, when the parents were separated from the chick by a fence.

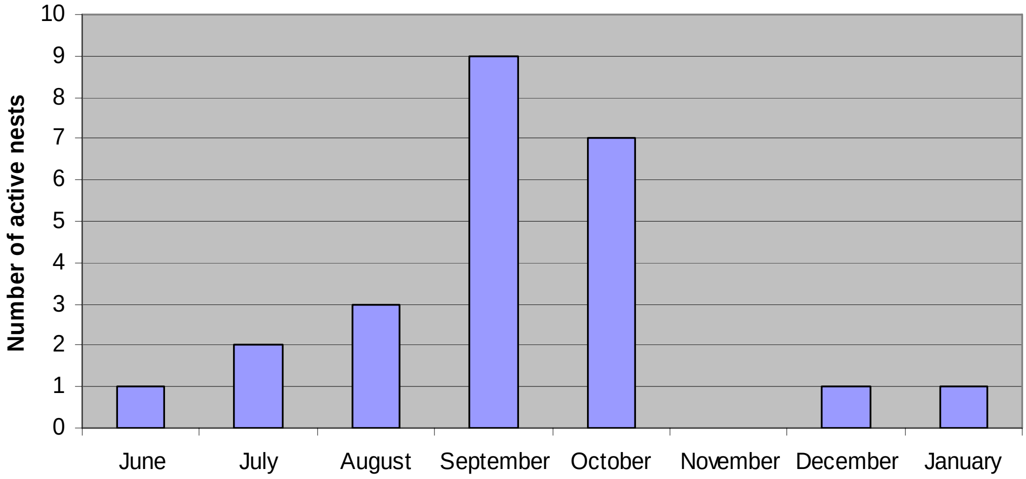

Figure 3.11 Temporal distribution of active Brolga nest records from the Victorian and New South Wales Riverina in 2003 and 2004 (n=24). Note: nests are only active during incubation so these data represent the commencement of breeding.

Brolgas were recorded at all 11 breeding sites but only seven of these were used for breeding during the study period. Not all breeding sites supported regular feeding and roosting. No Brolga activity was recorded at control sites (Table 3.11)

Table 3.11 Brolga activity at the 16 wetland study sites from 2002-2004

Site category and no.	Brolgas present	Regular night-time roost	Regular feeding	Breeding recorded
Breeding sites				
1	*	*	*	*
2	*	*	*	*
3	*			
4	*	*	*	*
5	*	*		*
6	*			
7	*	*	*	*
8	*	*	*	
9	*	*		*
10	*			
11	*	*	*	*
Control sites				
1				
2				
3				
4				
5				

Figure 3.12 Brolga pair with approximately five-day-old chick at breeding site near Jerilderie, NSW in 2004. Photo: David Webb.

3.11 Adult and fledgling mortality from collisions with powerlines

A total of 4 Brolgas were recorded to have died as a result of collisions with powerlines during the study (1 adult and 1 fledgling at Rutherglen, 1 adult near Urana and 1 adult at Brimin). An additional two birds (both adults, 1 near Durham Ox and 1 at Tootool, near The Rock) were either killed from collisions with powerlines or vehicles. The two birds from Urana and Tootool were collected with full data and have been stored at the Charles Sturt University Ecology Laboratory in Albury and await taxidermy by Dr David Watson. Stomach contents will be analysed and they will be used for education purposes and/or lodged at the Museum of Victoria.

On two occasions (Durham Ox and Rutherglen) the adults that were killed were nesting. The remaining bird at Rutherglen aborted within a few days of its partner’s death, whilst the remaining Durham Ox bird continued to incubate and the chick survived for at least 10 weeks and may have fledged. The remaining adult from the Brimin site either repartnered only months later or another pair began to use the site.

3.2 BREEDING HABITAT

3.21 Vegetation

Brolga breeding sites in the focal study area were typically *Eleocharis*-dominated or co-dominated wetlands with little or no tree cover (Figure 3.21, Table 3.21). These *Eleocharis* wetands did not include *E. sphacelata*, which is the largest Riverina species and has disappeared from many wetlands, and appeared to primarily comprise *E. acuta* with some *E. plana* and *E. pallens*. The sites where Brolgas did not breed, including ‘old’ breeding sites and control sites were either largely devoid of wetland vegetation (< 5% cover) or were dominated by tall, robust waterplants like *Typha* species, which are associated with deeper and more permanent water regimes (Table 3.21). Following flooding the most obvious change in vegetation was a replacement of either bare ground/litter or terrestrial grasses (mostly exotic annuals) with waterplants, particularly *Eleocharis acuta*.

Table 3.21 Vegetation characteristics for the 16 focal study sites. E = *Eleocharis* sp., C = Canegrass (*Eragrostis ausralasica*, *E. infecunda*), J = *Juncus* sp., W = Water Couch (*Paspalum* sp.), T = *Typha*, A = *Amphibromus* sp., P = *Phalaris* sp. B = Breeding recorded study period.

Site (B indicates Breeding)	Dominant species (> 5% cover) when flooded	Mean height (cm) when flooded	Mean cover % for entire wetland when flooded	% Tree cover for entire wetland basin
1 (B)	J / E	18	27	< 5%
2 (B)	C / E / A	62	22	< 5%
3	E	39	6	0
4 (B)	T / E	53	8	< 5%
5 (B)	E / T	41	11	0
6	J / P	67	16	0
7 (B)	W / J / T / E	48	37	0
8	C (dry)	93 (dry)	85 (dry)	< 5%
9 (B)	E	87	49	10
10	E	77	51	< 5%
11 (B)	E	45	56	0
Control 1	< 5%	N/A	< 5 %	< 5%
Control 2	< 5%	N/A	< 5 %	0
Control 3	< 5%	N/A	< 5 %	0
Control 4	< 5%	N/A	< 5 %	0
Control 5	T	140	48	0

Figure 3.21 Typical *Eleocharis*-dominated Brolga breeding site near Katamatite in 2003. Photo: MH

3.22 Water regimes

The 11 Brolga breeding sites were primarily ephemeral wetlands but most contained a storage dam that was semi-permanent or permanent (Table 3.22, Figure 3.23). The mean depth when flooded ranged from 24-72 cm for the breeding sites, whereas most control sites were over 1 m. Water volume at breeding sites varied from 8.4-383 ML and was typically larger than that found at control sites.

During this study breeding was only recorded in five ephemeral wetlands and two semi-permanent wetlands that contained a smaller ephemeral area (Figure 3.23). A total of approximately 30 other breeding attempts in the broader study area during the study period were almost exclusively from ephemeral wetlands. Brolgas typically began nesting on ephemeral wetlands 20-60 days after they filled. On two separate occasions at two different sites, Brolgas nested at recently flooded ephemeral wetlands that were within 2 km of their 'normal' breeding wetland that had become either semi-permanent or permanent. During the course of the study two breeding sites were 'lost' when the Muckatah depression was channeled to improve water efficiency, resulting in the ephemeral areas no longer receiving water.

Table 3.22 Water regime characteristics for the 16 focal wetland sites.

Site	Mean depth (cm) when flooded	Estimated volume when filled (ML)	Permanent (semi-permanent)-Ephemeral ratio
1	27	27	3:2
2	36	32.4	1:42
3	24	10.1	ALL EPHEMERAL
4	72	19.4	5:4
5	41	12.3	1:3
6	28	8.4	8:5
7	32	12.5	1:4
8	0	N/A	N/A
9	39	11.7	3:2
10	34	383	1:135
11	26	19.5	ALL EPHEMERAL
Control 1	100 +	1.3	4:1
Control 2	82	3.6	1:5
Control 3	100 +	1.8	6:1
Control 4	100 +	7.9	3:4
Control 5	100 +	11.7	5:1

Figure 3.22: Brolga nest site near Yarrawonga – a 2.6 ha constructed wetland used for irrigation storage – illustrates the potential benefits from relatively small amounts of water (<20 ML). Photo: MH

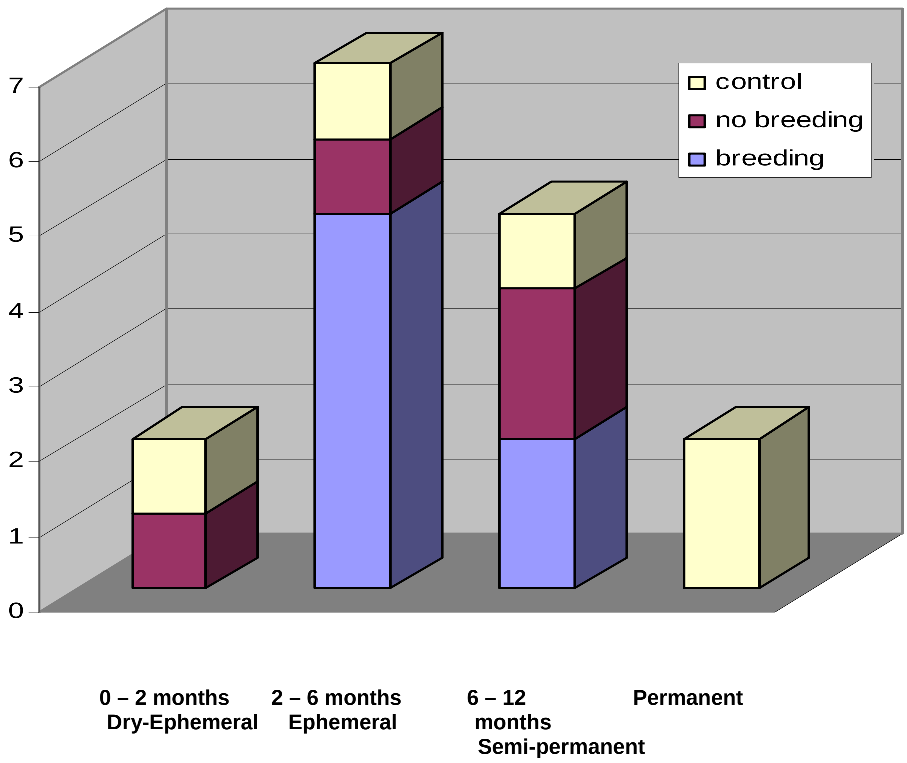

Figure 3.23 Mean period of inundation for majority of basin (>50%) when flooded for 2003 and 2004 at breeding, past breeding and control sites for the 16 focal wetland sites. Note: 'Breeding Sites' are those wetlands where Brolgas nested during the study period and 'Old Breeding Sites' are those where Brolgas had bred prior to study but since 1998.

3.23 Grazing

All wetland sites used in this study had a highly variable history of grazing over at least the last 100 years. All 16 focal study sites, except the only public land site (Moodies Swamp), were also subject to some level of grazing by sheep or cattle during the study period, including all the wetlands where Brolgas were recorded breeding during the study period (Table 3.23). Grazing levels and regimes varied enormously at and between the sites, making it difficult to determine the precise effects of different grazing practices. The highest stocking rate was 52 DSE/ha during a crash-grazing event.

One consistent theme emerged: sites where breeding occurred were regularly rested and generally ungrazed (or only very lightly grazed - <5 DSE/ha) when they were wet, and crash-grazed only when they were dry, whereas most control sites were subject to relatively set stocking rates (5-30 DSE/ha) irrespective of the flooding level.

Table 3.23 Grazing characteristics for the 16 focal study sites.

Site No.	Subject to set stocking rates	Ungrazed for 2-8 months each year	Typically grazed when wet
1		*	
2		*	
3			*
4		*	
5		*	
6	*		*
7		*	
8		*	
9		*	
10		*	
11		*	
Control 1	*		*
Control 2	*		*
Control 3	*		*
Control 4		*	*
Control 5	*		*

3.3 Flocking and recruitment

No flocking (>6 birds) was recorded in the focal study area. The approximately 11 breeding pairs in the focal study area presumably used the Barooga flocking site in 2004. All flocks located persisted for between 2 and 4 months between October and July, although usually between February and June following the Winter/Spring breeding season and Summer breeding dispersal. As a result of the severe drought, the 2003 flocking season consisted of an unprecedented concentration (in recent times) of Brolgas for southern New South Wales and northern Victoria. The Tuckerbil Swamp area near Leeton was found to support 123 birds (Table 3.31). The only other flocking recorded in the NSW Riverina at the time was at Wanganella, north of Deniliquin. Brolgas from the Kerang-Dingee-Echuca region and the Corop region were found to be independent, still flocking at their traditional sites in comparable numbers to previous years, whereas many of the birds in the focal study area around Yarrawonga (that probably usually use the Barooga site) were unaccounted for elsewhere. In addition to the flocks detailed in Table 3.31, flocks of 20+ occurred near Corop, Dingee and Wanganella during the study period.

The proportion of immature birds in flocks was extremely low, including a record low of 0% (0/123) in 2003 following the drought (Table 3.31).

Brolga flocks fed primarily in paddocks and crops within 3 km of their wetland roosting sites. Brolga flocks were recorded feeding in rice, corn, wheat and barley crops, all usually after harvest where they were taking the remaining grain. All flocks appeared to roost overnight exclusively on open wetlands with shallow water that were not subject to high levels of human disturbance.

Table 3.31: Proportion of immature Brolgas at non-breeding flocking sites in the Victorian and NSW Riverina at peak times during 2003 and 2004.
Note: the NSW sites were likely to be utilised (Barooga) or possibly utilised (Leeton) by Victorian Brolgas from the focal study area (Yarrawonga-Rutherglen-Tungamah-Dookie-Katamatite region) during the study period, whereas the Pyramid Hill site supported a discrete group that breeds locally in the Kerang-Dingee-Echuca region.

Site & Date	Total No. of birds	No. of immature birds	Proportion of immature birds
Tukerbil Swamp, Leeton 9th July 2003	123	0	0.0%
Total 2003	**123**	**0**	**0.0%**
Tuckerbil and Fivebough Swamps, Leeton 3rd July 2004	28 (23 + 5)	1	3.6%
Caramar Rd, Barooga 9th July 2004	29	2	6.9%
Pyramid Hill April - May 2004	20	1	5.0%
Total 2004	**77**	**4**	**5.2%**
Total 2003 & 2004	**200**	**4**	**2.0%**

3.4 Community Engagement

Through the use of in-person contact with the author, email updates, telephone conversations, media (primarily local newspapers and newsletters) and public events, we were able to actively engage the community. Table 3.41 details the four public events held during the study. The impact of this community engagement on wetland conservation on farms is difficult to measure but is likely to have wide-ranging positive benefits for the Brolga and other wetland biota.

Table 3.41 Details of seminars/field days held during project

Field Day location	Date	No. of Attendees	Duration of event
Burramine	June 25th 2003	50+	2.5 hours
Rutherglen	September 10th 2004	50+	2.5 hours
Dookie	September 15th 2004	26	3 hours
Durham Ox	September 22nd 2004	~75	3 hours

4.0 DISCUSSION

4.1 Breeding biology

The poor breeding success recorded during this study, coupled with the low number of individuals, is a cause for concern and supports the current threatened status of the Brolga in Victoria and New South Wales. Fox control trials would be useful in determining if fox predation is significantly reducing breeding success. Additionally, supplemental feeding experiments could be used to determine the role that chick starvation/malnutrition plays. Commencement of breeding and the level of activity at wetlands known to have supported breeding Brolgas prior to this study were highly variable suggesting the birds are responding to habitat availability.

After the study period, on approximately 23rd February 2005 the Brolga pair at study site 7 attempted to breed following extensive runoff associated with heavy summer rain. This attempt failed two weeks later but exemplifies the ability of Brolgas to respond to rising water levels following heavy rainfall (or inflows associated with irrigation) outside of the normal breeding season (July-December). In habitat partitioning experiments *E. acuta* showed no seasonal dormancy, suggesting it is able to respond positively to flooding at any time of year (Bell & Clarke 2004).

4.12 Adult and fledgling mortality from collisions with powerlines

A visual deterrent project has been initiated in the Rutherglen area as a result of this study. Indigo Shire and Tru Energy (formerly TXU), together with the author will install colourful buoys (like those often used to alert pilots to powerlines) in areas where Brolgas regularly fly, notably the two sites where deaths occurred during this study.

4.2 Breeding habitat

Vegetation, water regimes, grazing and fire

This study has shown that Brolga breeding sites are clearly associated with ephemeral water regimes and shallow wetlands, and the subsequent extent, structure and composition of wetland vegetation.

Contrary to most Brolga breeding sites in southern New South Wales and northern Victoria, most of the focal study sites were relatively small, constructed (or highly modified) wetlands in intensive irrigation areas (e.g. mean breeding wetland area in Herring (2001) was 115.2 ha, n = 32). These created or highly modified wetlands have the potential to deliver significant biodiversity outcomes from relatively small amounts of water, often less than 20 ML per site per year. In a landscape context this is minimal compared to some agricultural crops like rice and tomatoes that use between 7 and 11 ML per ha per year.

An estimated 35% of Murray River wetlands have water levels that are kept artificially high for irrigation, leading to the deterioration of floodplain vegetation (Lemly *et al*. 2000). On at least six separate occasions over the last five years landholders in the NSW and Victorian Riverina trying to manage Brolga wetlands positively by maintaining high water levels or ‘topping-up’ a drying wetland have actually reduced the quality of Brolga breeding habitat. There have been noticeable changes in the vegetation at these wetlands with a loss of species associated with ephemeral water regimes (e.g. *Eleocharis acuta*, *Marsilea drummondii*) and an increase in those associated with more permanent water regimes (e.g. *Typha domingensis*, *Azolla filiculoides*) that can soon become dominant. Receding water levels in ephemeral wetlands may enable Brolgas to access the tubers more readily. Encouraging landholders and other people responsible for managing wetlands to maintain ephemeral shallows, appreciate the value of receding water levels and a drying phase will be critical for the conservation of these wetlands. Additionally, we need to be conscious not to employ the same regime each year, as the dynamic nature of wetlands is major factor in their ability to support such high levels of biodiversity. This highlights the need for conservation planning in the broad landscape, as well as on individual properties.

The pipe-lining, channeling and alteration of existing water regimes along natural drainage lines (specifically the Muckatah depression and the Boosey Creek) to improve water use efficiency emerged as a threat to Brolga breeding habitat during this study. This creates an interesting paradox where restoring highly modified waterways and/or reinstating natural flows may come at the expense of threatened species that have come to rely on manipulated water regimes associated with agriculture. The Muckatah depression, in between Yarrawonga and Katamatite, produces the highest concentration of Brolga breeding records in the Yarrawonga region and one of the highest in northern Victoria. There is potential to flood strategically located wetlands along the channel, either in existing wetlands that will no longer fill or in newly constructed ones, on an intermittent pattern to provide different breeding sites in different years.

Wetlands that initially fill early in the season (June onwards) probably have a greater likelihood of producing successful breeding, as enough time needs to be allowed for nesting material (waterplants) and food resources (tubers, frogs, yabbies) to accumulate, and if the first attempt fails there is still time for a second breeding attempt.

Brolgas were only recorded utilising *Eucalyptus camaldulensis* wetlands that had a canopy cover of 10% or below, typically lower than 5%, with large mature, well-spaced trees and shallow, open areas with emergent vegetation. Several naturally-open remnant wetlands in the broader study area have been planted with dense stands of young *E. camaldulensis*, making them unsuitable for Brolgas. In the extensive Barmah-Millewa forest, where Brolgas appear to be extinct, *E. camaldulensis* has invaded open wetland areas, because altered river hydrology for irrigation has reduced the depth and duration of flooding in winter-spring, and increased summertime flooding, favouring mass-germination of this species (Chesterfield 1986, Bren 1992). During this study, Brolgas were absent from the *E. camaldulensis* State Forests along the Murray River, which are mostly highly modified dense stands with inappropriate flooding regimes.

Eleocharis species are relatively palatable to stock whereas Canegrass (*Eragrostis australasica* and *E. infecunda*) is rarely eaten unless there are fresh succulent shoots available. For these reasons, *Eleocharis* wetlands are regularly grazed and Canegrass wetlands are often burnt to promote grazing value, or otherwise prevented from forming rank growth (Cunningham *et al.* 1981, Herring 2001, Herring in prep.).

The most ecologically significant study site, Moodie Swamp, is the largest individual wetland on the entire Broken Creek floodplain, and known to attract several threatened waterbird species including Australasian Bittern, Australian Painted Snipe and Freckled Duck (Hull 1996). In the mid-late 1980s, strategic burning was undertaken to facilitate the use of Moodie Swamp by two Brolga breeding pairs. This was temporarily achieved through the retention of old fire-age vegetation in the centre on this large wetland, dividing the site into two sections (R. Weber pers. comm.). Apart from this trial, no work on the effect of different fire regimes on Brolga breeding habitat has ever been undertaken. Moodie Swamp, together with other significant Canegrass wetlands across northern Victoria (e.g. One Tree and Two Tree Swamps, Corop) and southern New South Wales (e.g. Lake Cullival, Urana, Nulla Nulla Swamp, Corowa) will benefit from a new project with the NSW Murray Wetlands Working Group focused on management regimes in these habitats.

Some of the different habitats surrounding Brolga breeding wetlands (e.g. irrigated vs. non-irrigated pasture, crop type) may provide important feeding habitat and also have an overall effect on breeding habitat selection. Brolgas are known to forage extensively in crop stubble during the flocking season, preferentially selecting corn within a 5 km radius of their wetland roosting site (Herring 2001). Certain land uses, in addition to wetland management, may now be important for the conservation of Brolgas in agricultural landscapes and require further investigation.

4.3 Wetland construction and modification

It is pleasing that the Brolga – one of southern Australia's most threatened waterbirds – is able to breed in relatively small (often less than 10 ha), constructed wetlands in an intensive irrigation landscape. These breeding sites are not typical of most on-farm storage dams, which usually lack sufficient habitat and support few waterbirds. The Australian Wood Duck is a rare example of a waterbird to actually benefit from the proliferation of farm dams (Kingsford 1992). During excessively dry periods, many landholders undertake earthworks to desilt and re-dig their farm dams to make them more efficient. During this time there is a great opportunity to dramatically increase the habitat value for Brolgas and biodiversity generally at the dam by creating ephemeral shallows. Stock can be excluded from the majority of the wetland (so they still have access) or entirely excluded with water pumped out to a trough. This has the added benefit of reducing the risk of Liver Fluke, Johnes disease and other threats to stock associated with self-contaminated water. Constructing entirely new wetlands for biodiversity conservation purposes is rare in Australia but shows great promise. Figures 5.1 and 5.2 show simple conceptual designs for modifying existing created wetlands and constructing others.

4.4 Flocking and recruitment

The flocking data presented here reveal that Brolgas are highly dynamic during the non-breeding season, with the number of birds varying enormously between sites and years. The need Brolgas have for an open wetland for roosting during flocking season illustrates the importance of having some permanent wetlands and a range of water regimes across the landscape. Models based on those developed by Sheldon (2004) for south-western Victoria could be used to predict Brolga flocks each year. However, flocking habitat is highly variable and important factors influencing Brolga use each year are not obvious (Sheldon 2004). Annual wetland flooding data, especially for regularly used sites, and surrounding habitat data, especially favoured crops like corn, would be useful. Indeed, encouraging farmers to grow corn adjacent to wetlands that are known to act as roosting sites for non-breeding flocks may benefit Brolgas in their subsequent breeding season. In the Platte River Valley, Nebraska, U.S.A, non-breeding flocks of more than 300 000 Sandhill Cranes (Grus canadensis) obtain over 90% of their energy requirements from abundant corn stubble, whilst sources of protein (from invertebrates) are from native grasslands (Krapu *et al.* 1984, Reinecke & Krapu 1986, Sparling & Krapu 1994).

Recruitment, as a measure of the population's health, is the simplest and most effective means of monitoring the success of future conservation efforts (e.g. altered wetland management, fox control efforts). The low levels of recruitment found during this study (0% in 2003, 5.2% in 2004, and 2% for these years combined) are a cause for concern. The only large-scale count ever undertaken prior to this study in the broader study area of southern NSW and northern Victoria yielded 4.4% (6/137) in 2000 (Herring 2001). These figures contrast strongly with those from Brolga flocks in northern Australia, which often constitute more than 10% immatures (Herring 2001). Brolgas are recognisable as immature for their first two flocking seasons so annual recruitment is approximately half of the figures presented here. An annual recruitment of 2% may be adequate for Riverina Brolgas, if average breeding life is about 50 years. Krajewski & Wood (1995) employed a more realistic recruitment rate of 15% and a 12.5 year generation time for the Brolga at a total population size of 20 000 when assessing mitochondrial DNA relationships within the *Grus* genus. The majority of dead Brolgas found in Queensland are the young of the year (Johnsgard 1983); suggesting fledgling mortality could also be high. Fluctuation in recruitment for cranes has been documented overseas. In Mexico, from 1986-1990, Greater Sandhill Crane (*Grus Canadensis tabida*) annual recruitment ranged from 8.2-15.8%, with an average 10.1%, whilst in Lesser Sandhill Cranes (*G. c. canadensis*) it ranged from 2.9-10.4%, with an average of 6.5% (Drewien *et al.* 1996).

4.5 Wetland conservation for Brolgas in context of other biodiversity

Targeting conservation efforts at individual species can be dangerous because management actions may disadvantage many other species, have few positive outcomes for biodiversity generally and waste precious time and money. Some species however, like the Brolga, are closely associated with sites of higher overall species richness within their group (i.e. waterbirds, Herring 2001) and sites that are a priority for conservation generally. Additionally, the use of iconic, charismatic species like the Brolga is one of the most effective ways to engage people and promote biodiversity conservation.

The importance of flooding on a previously dry wetland basin (and more broadly the need for a drying phase) has also been shown for duck, cormorant, ibis, heron and grebe breeding (Crome 1988). Indeed, one could easily surmise that these and other species breeding inland have evolved to be stimulated by the cue of a recently filled wetland. Still, there is the need for permanent wetlands that may act as drought refuges and support Brolgas and other mobile biota during non-breeding seasons. More permanent wetlands may also provide suitable breeding habitat in drier than average years when most of the more ephemeral wetlands remain dry, thus enabling some breeding to occur in dry years.

Brolga breeding wetlands in northern Victoria (e.g. One Tree and Two Tree Swamps, Corop) and southern New South Wales (e.g. Native Dog Swamp, Savernake; Lake Cullival, Urana) regularly support the world’s most threatened bittern – the Australasian Bittern – which was recorded at more than a third of 32 Brolga breeding sites in northern Victoria and southern New South Wales in 2000 (Herring 2001). The Australasian Bittern regularly utilises Canegrass wetlands but breeding in these habitats may be limited because current management regimes result in a lack of older, taller, thicker stands that have sufficient cover for nest sites (Herring, in prep.). Other cover-dependent species, such as the Little Bittern, Latham’s Snipe, Australian Painted Snipe, Baillon’s Crake and Australian Spotted Crake have also been recorded at Brolga breeding sites in the Victorian and New South Wales Riverina (Herring 2001).

Of particular note, the Australian Painted Snipe, Australia’s most threatened breeding waterbird, is also known to breed almost exclusively in ephemeral wetlands, especially those with receding water levels that have a combination of very shallow water, exposed mud and dense low cover (Rogers *et al*. 2005b). Australian Painted Snipe have been found at a minimum of 6 sites in the Victorian and New South Wales Riverina since 2000 that are also regularly used by Brolgas. Like Brolgas, they avoid large stands of tall, dense vegetation like those dominated by *Phragmites australis* or *Typha* species. Wetland management targeted for Australian Painted Snipe (as proposed for Hird Swamp, Cohuna, Rogers *et al.* 2005) is unlikely to disadvantage Brolgas.

Fivebough Swamp, near Leeton, is regularly used by non-breeding Brolgas and is well known for its significance for shorebirds (e.g. it has been RAMSAR listed, has supported over 4000 Sharp-tailed Sandpipers in recent years and is regularly used by Australian Painted Snipe). In recognition of its biodiversity value, initial conservation efforts in 1997 saw cattle grazing cease (FTWMT 2002). This resulted in the rapid regeneration of *Typha* species and Water Couch (*Paspalum disticum*), which favoured many cryptic waterbirds (e.g. Little and Australasian Bittern, Clamorous Reed Warbler) but reduced the amount of mudflats available to migratory shorebirds and other birds that avoid tall, dense vegetation. Grazing has since been returned to parts of the swamp and appropriate regimes and mosaics are being determined through various trials (FTWMT 2002, Mike Schultz pers. comm.). In Iowa, United States of America, wetlands with a cover: water ratio of 50:50 up to 30:70 supported the highest species richness of birds, and the abundance of even those species that favoured robust emergents was highest at these levels (Weller 1999). Indeed, the balance between too much cover and not enough is at the heart of the challenge of managing wetlands for open mudflat species and those associated with tall, dense vegetation, together with other successional stages between these extremes.

The importance of ephemeral wetlands has also been shown for macroinvertebrates in floodplain wetlands of the Murray River because of the marked differences in species assemblages between permanent and temporary water regimes (Hillman & Quinn 2002). At wetlands on the Murrumbidgee floodplain, frog species richness declined with increasing grazing levels as a result of reduced wetland habitat quality (Jansen and Healey 2003).

Figure 4.1 Constructed ephemeral wetland used for irrigation storage near Jerilderie, NSW – a 30 ha, 200 ML Brolga breeding site that was ungrazed for 5 years, also supports Australian Painted Snipe, Australasian Bittern and 10 migratory shorebird species. Note the structural diversity of mudflat, Canegrass, Nardoo, *Eleocharis* Spike-rushes, Cumbungi and deep open water. Photo: MH

5. CONCLUSIONS

Management options, including some of the following suggestions, are to be developed jointly with DPI Agriculture staff, land-holders and other key stakeholders in the final phase of the project.

The Brolga is in a dire situation in the Victorian and New South Wales Riverina, with critically low numbers, poor breeding success and a lack of recruitment into the breeding population. Improved wetland management, coupled with fox control and other conservation initiatives, should see this situation improve. Raising awareness amongst wetland managers, particularly farmers, of the importance of ephemeral water regimes and shallow wetland areas for the Brolga, other threatened waterbirds and wetland biota generally would have a positive effect on agricultural sustainability across the landscape. Both natural and constructed wetlands can be managed or modified in such a way as to increase their 'carrying capacity' for biodiversity. Striking the balance between not enough wetland vegetation cover and too much is at the heart of the challenge of managing wetlands on farms for a maximum number of breeding species.

These and other important wetland management prescriptions could be disseminated through a colour A4 booklet.

5.1 Suggested wetland designs and modifications to existing created wetlands to provide Brolga breeding habitat and general improvements for wetland biota

The following wetland designs for creating wetlands or modifying existing created wetlands are based on the results from this study, together with Herring (2001) and Arnol *et al.* (1984).

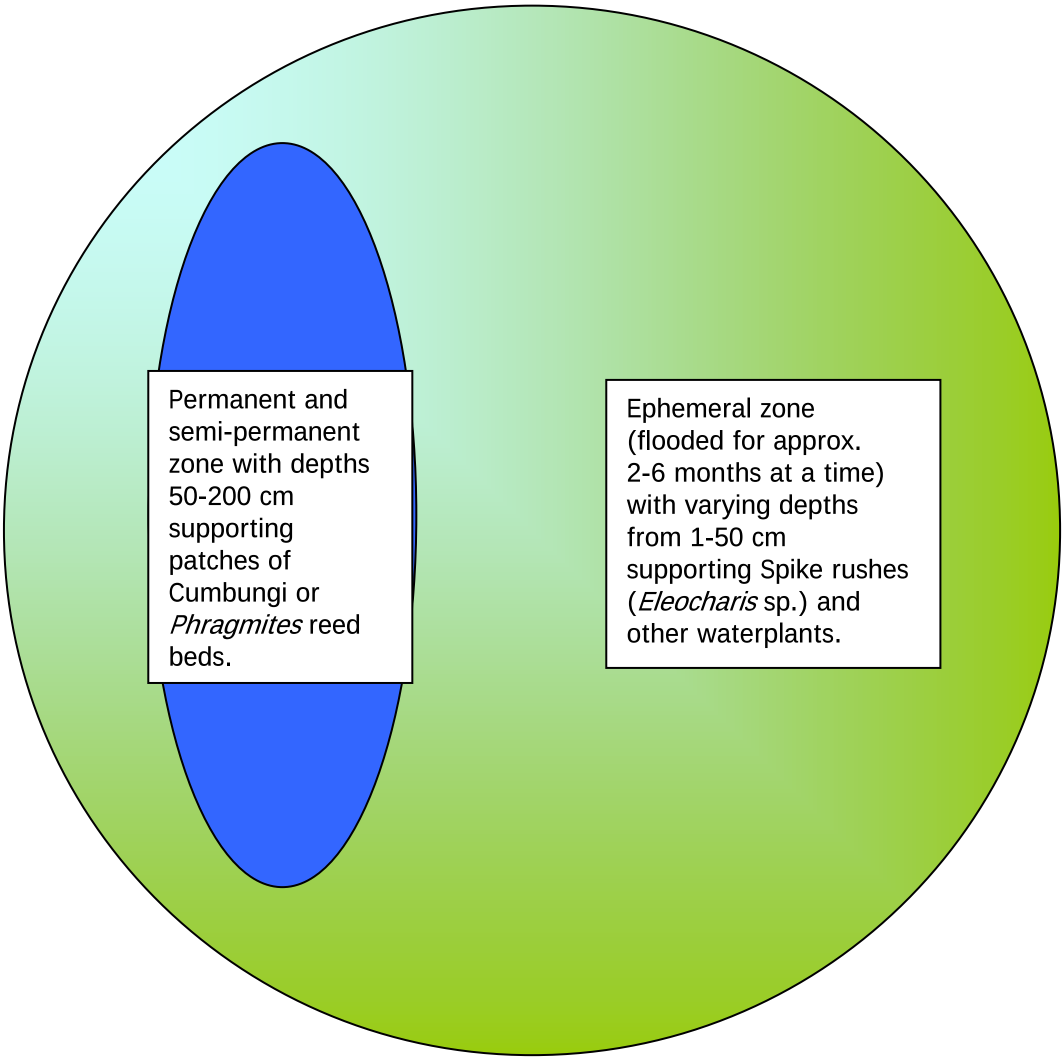

Figure 5.1 Basic conceptual design to construct a wetland for Brolgas, other threatened waterbirds and biodiversity generally.

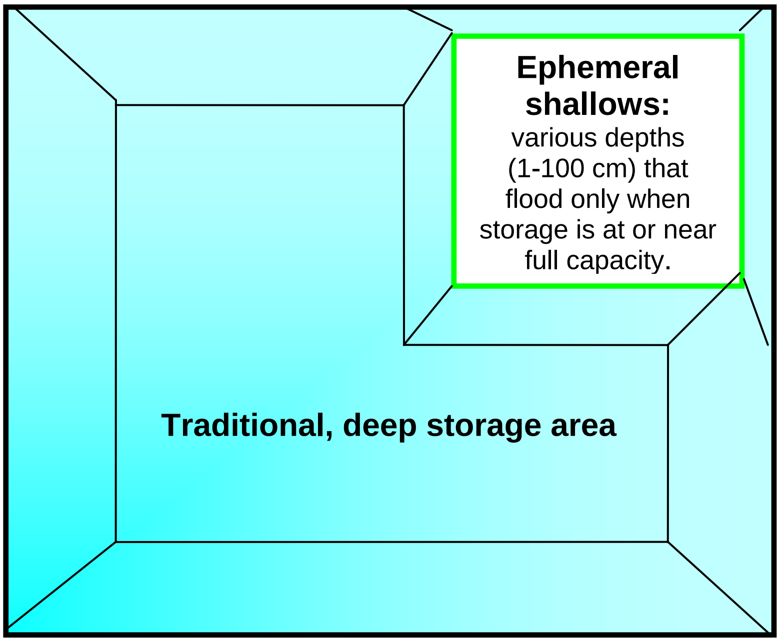

Figure 5.2 Basic conceptual design to enhance a typical storage dam for Brolgas, other threatened waterbirds and biodiversity generally.

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