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THE HABITAT DISTRIBUTION AND POPULATION SIZE OF THE BLACK-NECKED STORK *Ephippiorhynchus asiaticus australis* IN NEW SOUTH WALES

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Knowledge of habitat distribution and population size is important for the conservation management of species. The Black-necked Stork (Ciconiidae: *Ephippiorhynchus asiaticus australis*) is listed as an *endangered* species under the New South Wales (NSW) *Threatened Species Conservation Act 1995* and there is ongoing debate on its population size in the State. In this study, the habitat of the Black-necked Stork in NSW was mapped in detail for the first time using 5632 collated records and vegetation, wetland and geomorphological information. The approximate location of known and potential territories was mapped using nest location data, observational records, movement estimates and the distribution of apparently suitable habitat. We estimated a breeding population size in NSW of approximately 75 pairs. We suggest that a greater conservation effort is needed to protect and rehabilitate the wetlands of the major north coast floodplains and we also identify the need for further fieldwork to more accurately determine the numbers and extent of territories.

INTRODUCTION

The Black-necked Stork *Ephippiorhynchus asiaticus australis* is rare in New South Wales (NSW) and has been listed as e*ndangered* under the NSW *Threatened Species Conservation Act 1995*. Fundamental to the conservation and management of endangered species is a sound knowledge of their habitat distribution and population size. Important regional and local habitats of a species can be identified and quantified from a reliable habitat distribution map. It provides a focus for conservation activities and minimises the chances of misdirecting scarce conservation resources. A good habitat distribution map is also a very useful tool when estimating population size.

The Black-necked Stork is a conspicuous species that is often reported by birdwatchers. It was clear that the large number (thousands) of records available for collation would form the cornerstone of a habitat-mapping project. It appeared quite likely that the distribution pattern of Black-necked Stork habitat in many areas might be able to be inferred largely from the pattern of records themselves. Consequently, a major effort was expended in maximising the number of records collated.

In contrast to the focus on records of the current study, the only previous attempt to map the distribution of the Black-necked Stork habitat in north-east NSW was based on only 32 records. This was carried out by the NSW National Parks and Wildlife Service (NPWS) in 1998 using statistical habitat modelling techniques (NPWS 1999a). The model used 37 biophysical predictors to produce a presence-only Generalised Additive Model (Brown *et al.* 2000; NPWS 1998, 1999a). Being based on so few records, the resultant model was inevitably extremely coarse, although the two main predictors (Minimum Temperature of the Coldest Month (positively related) and Ruggedness Index (negatively related)) reflected the warm, flat habitat preferred by the Black-necked Stork. The NPWS model did therefore provide a reasonable depiction of Black-necked Stork habitat distribution at the very broad scale of the whole of north-east NSW. However, it was inadequate when examined in detail. Many areas of clearly inappropriate habitat were depicted as important and other areas of known high quality habitat given a very low value. These inaccuracies become highly problematic when the model is uncritically used for conservation planning. Developing a more accurate depiction of Black-necked Stork habitat has therefore become a key task for underpinning conservation and management decisions for the species.

Quantitative predictors still do not exist that would enable a fine-scale habitat map to be obtained from statistical modelling. Many of the predictor variables that are available do not cover the entire study area, or do not cover the entire area at a consistent level of accuracy. Another problem for statistical modelling is caused by the biases in the location of Black-necked Stork records that lead to inaccurate predictions at a fine scale. These biases include: many more records near accessible sites close to populated areas compared with inaccessible sites distant from population centres, many records of flying birds that are most conspicuous when crossing towns or major roads, and the difficulty in distinguishing in-flight records from others (such as foraging records). An alternative approach to statistical modelling was needed that could use the records without becoming distorted by their inherent biases.

In this study we used the records of the Black-necked Stork and personal knowledge (GPC) as a guide, and mapped habitat distribution using GIS coverages that reflect important features of Black-necked Stork habitat. These included wetland mapping (important for stork foraging), floodplain mapping (identified as important general habitat for the species), vegetation mapping (important for helping to identify suitable areas such as appropriate wetlands and avoiding, for example, dense paperbark swamps) and geomorphological mapping (also useful for identifying wetlands, particularly those not mapped by other coverages). The habitat-mapping component of this study largely comprised the combining of these coverages, guided by the records and personal knowledge, into a single habitat map.

The distribution of potential Black-necked Stork habitat was mapped from the Queensland border along the east coast as far south as Windsor, as well as an isolated patch near Moree. From collated nesting information, this is the extent of the historical breeding range of the species in NSW (while there was a historical breeding attempt on the south coast, it was apparently not successful). Recently, breeding has not been confirmed south of Bulahdelah. Since the actual range may well change in the future if the species spreads farther south, expands into other inland locations or contracts, the distribution map will need to be periodically updated.

At least four estimates have been made of the population size of the Black-necked Stork in NSW, namely: 37 to 43 birds (Salmon 1965), about 36 birds (Morris 1976), as few as 30 pairs (Dodkin, n.d.), and at least 11 breeding pairs in the state in 2000 (Morris 2002).

These estimates were based primarily on anecdotal information and not the result of thorough surveys. We considered that they were generally under-estimating the population size, and with the recent increase in knowledge of the species in NSW, thought that it was an appropriate time to generate a revised estimate.

The size of the breeding population of a species is of particular importance, especially for a territorial species, where the breeding population numbers are directly related to the amount of habitat that is suitable to form viable territories. Territories in turn are related to the distribution of nest trees. We strongly believed that reliable nest tree data would provide the most reliable foundation for estimating the breeding population size. Consequently, major effort was expended in maximising the number of nest tree locations collated.

Using nest tree data and the mapped habitat distribution as a guide, we mapped territories within the historical breeding range of the Black-necked Stork in New South Wales. The method we used, while admittedly far from precise, bases the estimate of the breeding population on an explicit set of rules that will facilitate future refinement.

METHODS

Collation of records

Observational and nest records of Black-necked Storks were collated from a number of sources. These were:

- three years of fieldwork and thirty years of incidental observations by GPC,
- direct contact with professional and lay members of the ornithological community,
- interrogating the *Atlas of NSW Wildlife* held by the NSW Department of Environment, Climate Change and Water, and
- obtaining additional records provided by Birds Australia and the NSW Bird Atlassers.

The accuracy and reliability of the records were validated where practicable; particularly those records occurring in new or unusual locations. Additional validation of nest records was carried out and many of the observers were contacted by GPC, who also visited many of the nests.

Mapping habitat distribution

The mapping was undertaken by combining three separate GIS coverages into a final map of habitat considered to be suitable for the Black-necked Stork, guided by records and personal knowledge.

Firstly, mapping of coastal and floodplain wetlands of significance were selected directly from Department of Environment, Climate Change and Water (DECCW) wetland and vegetation coverages and Department of Primary Industries, Mineral Resources (DMR) coastal quaternary geology mapping (Troedson *et al.* 2004). The coastal quaternary geology mapping enabled the fine-scale identification of habitat features such as different types of wetland and floodplain palaeochannels, which are known to be used by Black-necked Storks. This coverage only extends along the coast and floodplains north of the Hunter River. South of the Hunter River and away from the coast, only the DECCW wetland mapping was available. The DECCW mapping is a compilation of existing wetland mapping (Hunter Central Rivers CMA 2006; Kingsford *et al.* 2003, 2004), and vegetation mapping (Griffith *et al.* 2003; McCauley 2006; NPWS 1999b) as well as direct editing from Spot5 imagery. With the current limitations in data and predictors over the entire study area, it was clear that it would not have been possible to statistically model habitat to the same level of resolution.

Personal knowledge, records (including nest tree records), vegetation mapping, aerial photography and Spot 5 imagery were used to subjectively categorise the wetlands into three classes of habitat quality. Habitat Quality 1 contained the wetlands considered to be most significant, Habitat Quality 2 contained moderately significant wetlands and Habitat Quality 3 contained the least significant. Densely vegetated wetlands and deep open water were excluded where this information was available as these areas are avoided by foraging storks.

The second coverage used was coastal floodplain mapping. The coastal floodplain is of high significance to the Black-necked Stork and all areas mapped as floodplain by the NSW Department of Primary Industries (other than those wetlands already mapped as Habitat Quality 1, 2 or 3) were assigned Habitat Quality 4. These areas contain minor unmapped wetlands potentially used by storks for foraging and scattered trees used for nesting, roosting and perching.

Finally, the NPWS Black-necked Stork statistical model was also used. This provides a reasonably good representation of the broad general distribution of the Black-necked Stork in north-east NSW. All modelled areas with a probability value of 50 or greater (Values 50–95 from CRA model), other than those already mapped as Habitat Quality 1, 2, 3 or 4, were assigned Habitat Quality 5. These areas also contain minor unmapped wetlands potentially used by storks for foraging and are the areas traversed by storks when accessing foraging, nesting or roosting sites.

Territory mapping

The ruleset below was used to guide the delineation of territories. The rules are based on the observations of GPC over many years in Coutts Crossing and the lower Clarence River.

1. Daily movements were generally a maximum of about six kilometres from the nest, although in linear habitats this could be up to about 10 kilometres.

2. The average distance between the centres of eight adjacent and simultaneously active nests in the well-studied prime habitat of the lower Clarence River was about eight km. This rough estimate of spacing was used as a benchmark, in conjunction with the distribution and spacing of the nest records available from the fieldwork and data collation.

3. The size of the territories in the prime habitat of Coutts Crossing and the lower Clarence River (12 territories of approximately 6000 ha each) was used as a benchmark.

4. Proximity to extensive wetlands. The well-studied territories all contained extensive wetlands. Wherever possible, potentially important wetlands were included in predicted territories to replicate this pattern.

Black-necked Stork observational and nest records were superimposed on the habitat distribution map and the ruleset above used to estimate territories, thereby extrapolating the territory pattern estimated in well-studied sites across the region. Any known nesting history was also useful where known. Although breeding and non-breeding territories could not be distinguished, all territories mapped were considered likely to be potential breeding territories. Caution was taken not to misinterpret observations of flying storks that were over towns and roads, so that the territories were mapped over areas of suitable habitat omitting larger areas of forest and urban development. Clusters of records suggesting a probable territory would, most likely, have contained occasional records of storks from adjacent or overlapping territories or transient, unattached, birds but were considered to mostly comprise records of the territorial birds. This was based on many years of observation by GPC.

Territories were mapped over all of the historical breeding range in New South Wales.

RESULTS

A total of 5632 observational records and 91 nest records were collated.

Figure 1 shows the map of Black-necked Stork habitat in NSW, categorised into Habitat Quality classes from 1 to 5. There is no mapped habitat west of the Moree area, where Storks are virtually absent and occur only as very rare vagrants.

Figure 2 shows the results of the territory mapping in NSW. A total of 81 provisional territories were mapped across the historical breeding range from the Queensland border to Windsor (south) and Moree (west). No territories were mapped south of Sydney, as there has been no known breeding there for the past 30 years, and no historical evidence of successful breeding. Territory boundaries are somewhat arbitrary as there appears to be some overlap of territories where they meet.

The known history of the provisional territories, and their approximate areas, are included in Appendix 1. Mean territory size was 8900 hectares (with a standard deviation of 4550 ha) and mean area of wetland per territory was 1640 hectares.

Of the 81 provisional territories mapped, 32 have been confirmed to be currently occupied by a breeding pair (see Appendix 1). An additional 17 territories currently contain frequently observed pairs that are probably breeding, but nests were not located. Recent (2000–2006) records were obtained for 30 of the remaining 32 territories. In many of these, there have been regular observations of Black-necked Storks and we would expect confirmation of breeding in some of them in the future. However, in the six territories mapped at the southern end of the breeding range (from Myall Lakes to Windsor), breeding has not been confirmed recently. Therefore, after excluding the six southern territories, we estimate that 75 provisional territories could be expected to currently contain a breeding pair. Consequently, our estimate of the breeding population of Black-necked Storks in NSW is 75 pairs.

Figure 3 shows an example of the detailed habitat mapping in the Grafton area, together with records of occurrence and the mapped territories. This area is particularly well known from close observation by GPC over many years.

DISCUSSION

The habitat mapping developed in this study is built on the foundation of the enormous increase in the number of records obtained from data collation, with 5632 records now available (compared with the 32 in 1998). In places, the distribution could be partly inferred from the pattern of records themselves.

It is essential that a habitat map such as this remains an evolving work, where significant problems are rectified over time. Indeed, a key advantage of this type of mapping is that it can be readily updated as new information becomes available. For example, the vegetation mapping used is still very broad in many areas and this leads to a number of suitable and unsuitable habitats being contained within single broad polygons. This is typified by the very broad 'coastal complex' category mapped in many areas along the coast. In these areas, there was not a direct correspondence between vegetation category and habitat quality and further refinement will be required when new vegetation mapping is completed.

Some areas of wetland that are too dense to be quality Black-necked Stork habitat are still likely to be wrongly classified and will also need to be further refined. These occurred when vegetation mapping, aerial photo images and local knowledge

were all insufficient to satisfactorily estimate the habitat value of the wetland. New wetland layers south of the Hunter River would also improve the habitat mapping.

The current estimated size of the breeding population, based on provisional territories, is 75 pairs (150 individuals). This study confirmed that 32 of the provisional territories were currently occupied. An additional 49 provisional territories were based on recent (2000–2006) records and the habitat mapping. Breeding has not been confirmed recently for the six provisional territories mapped at the southern end of the range (from Myall Lakes to Windsor) so these were not included in the estimate of the current breeding population. The size of the non-breeding population, comprising unattached adult, juvenile and immature birds, is not known. At least sixty-nine young storks fledged in the state between 2003 and 2006 (Clancy 2008) and it would be expected that the majority of these would survive to maturity. If 75 per cent of these survived to the end of 2006 there would have been a population of at least 202 birds in the state at that time, ignoring older unattached adults. The state population is therefore likely to be around 200–220 birds. Despite a healthy recruitment rate of 1.6 young per successful nest (Clancy 2008) the breeding population in the state appears to remain static. This would suggest a high mortality rate or emigration to areas north of New South Wales, or both.

In many of the provisional territories there have been regular observations of Black-necked Storks, so it is likely that

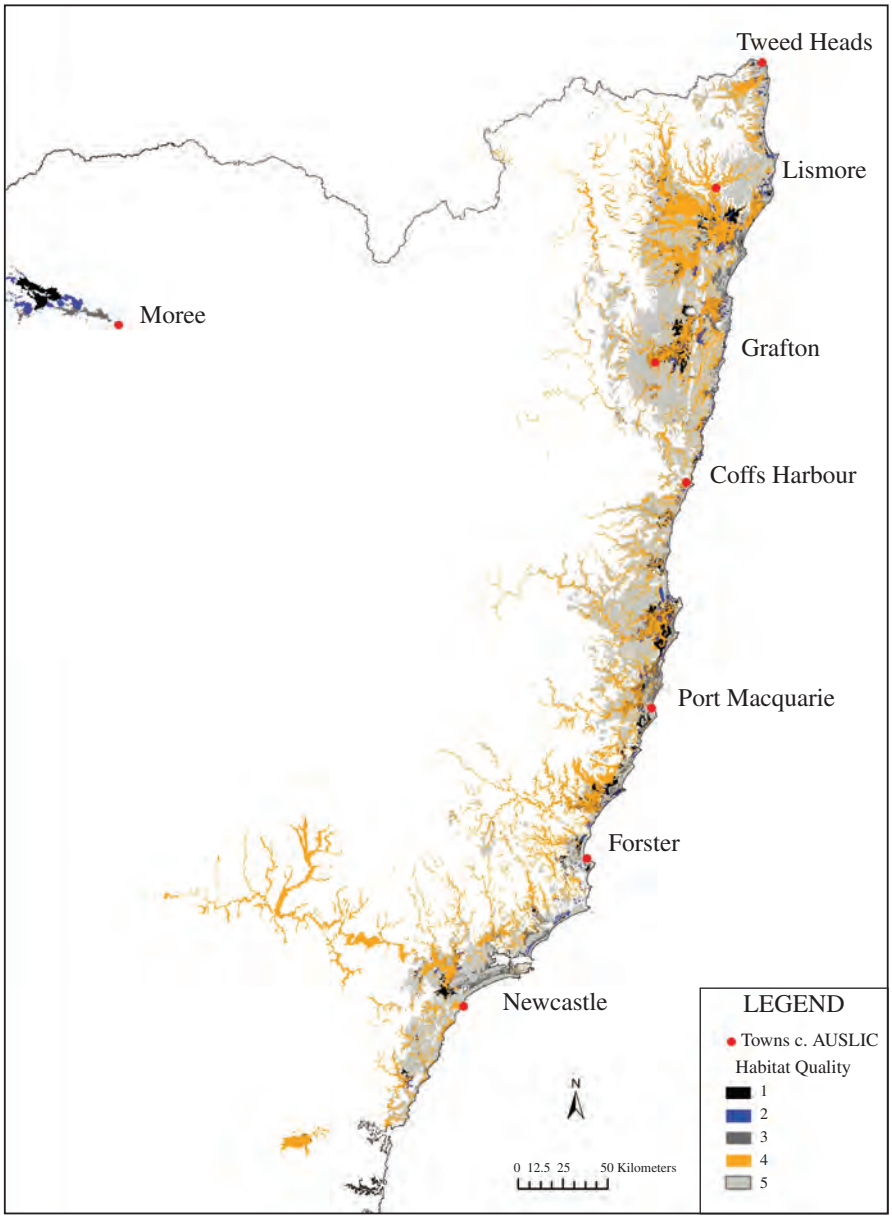

Figure 1. *Predicted habitat of the Black-necked Stork across its recent breeding range in New South Wales. (Note that the Gingham Wetland habitat near Moree is mapped using less detailed information that is not entirely consistent with the scale of the coastal mapping.)*

breeding will be confirmed in a number of them in the future. The provisional territories averaged 8900 hectares in size. This compared with an average size of 6300 hectares in 11 well-studied territories in the lower Clarence River. The larger overall provisional territory size could be explained by the higher quality of the lower Clarence River habitats and the need for the animals to range more widely in poorer quality habitat, although it may also represent a paucity of data. More intensive study of movement patterns and habitat use in these potentially poorer habitats is warranted.

Approximately 388 530 hectares of the provisional territories (54% of the total area) were mapped as floodplain, indicating the importance of the major river valleys for the Black-necked Stork. Unfortunately, only 6.2 per cent (54 100 ha) of the floodplain in north-east NSW is protected in the formal reserve system. Most of the floodplain, particularly the crucial floodplain wetlands, remains subject to numerous threats and susceptible to ongoing degradation. We believe that the location of some of the well-known Black-necked Stork nests and key foraging sites need to be taken into account when areas on the floodplain are considered for reservation or other forms of protection.

The sandplain habitats of the coastal zone were the most significant non-floodplain areas containing territories. Most are situated in reserves and are in better condition than the floodplains. Other areas are poorly known, including parts of the lower Hunter Valley and upper reaches of some of the major river valleys. No

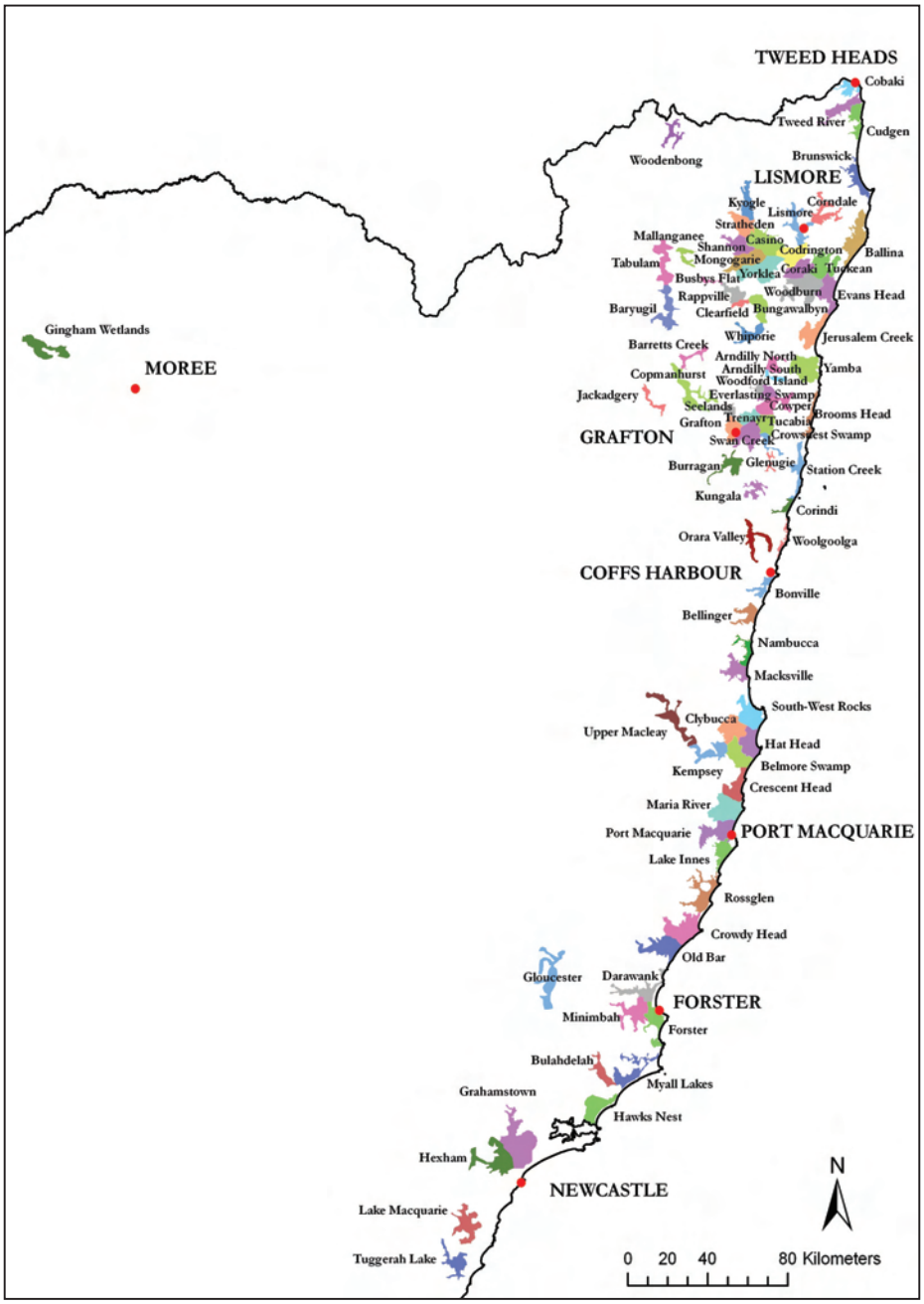

Figure 2. *Predicted territories of the Black-necked Stork across its recent breeding range in New South Wales.*

territories were identified in the extensive area of low quality habitat in the upper Hunter River Valley or between Stockton and Nelson Bay due to a lack of reliable records in these areas.

Further fieldwork is needed in poorly known areas to improve the precision of the habitat map and to better estimate the number of territories. A broad educational and publicity program would encourage a greater reporting of sightings and in particular should assist with the reporting of nest locations. Detailed studies of the local movement of territorial pairs, and a search for nests, would help to consolidate the mapped boundaries of the provisional territories. These studies would also help to determine if some large predicted territories, in fact, comprise more than one, or a number of small predicted territories actually comprise one larger territory.

The mapped results suggest that there is limited potential for additional territories within the current breeding range along the coast, and virtually no potential for additional floodplain territories of high quality. The movement of a banded juvenile from Bulahdelah to Casino (over 400 kilometres) in 2004 and its poor condition (GPC, pers. obs.) adds some anecdotal evidence in support of this idea as the bird might otherwise have been expected to settle closer to its natal territory. Therefore, the breeding population could be close to its maximum size, despite the relatively low number of birds in the state.

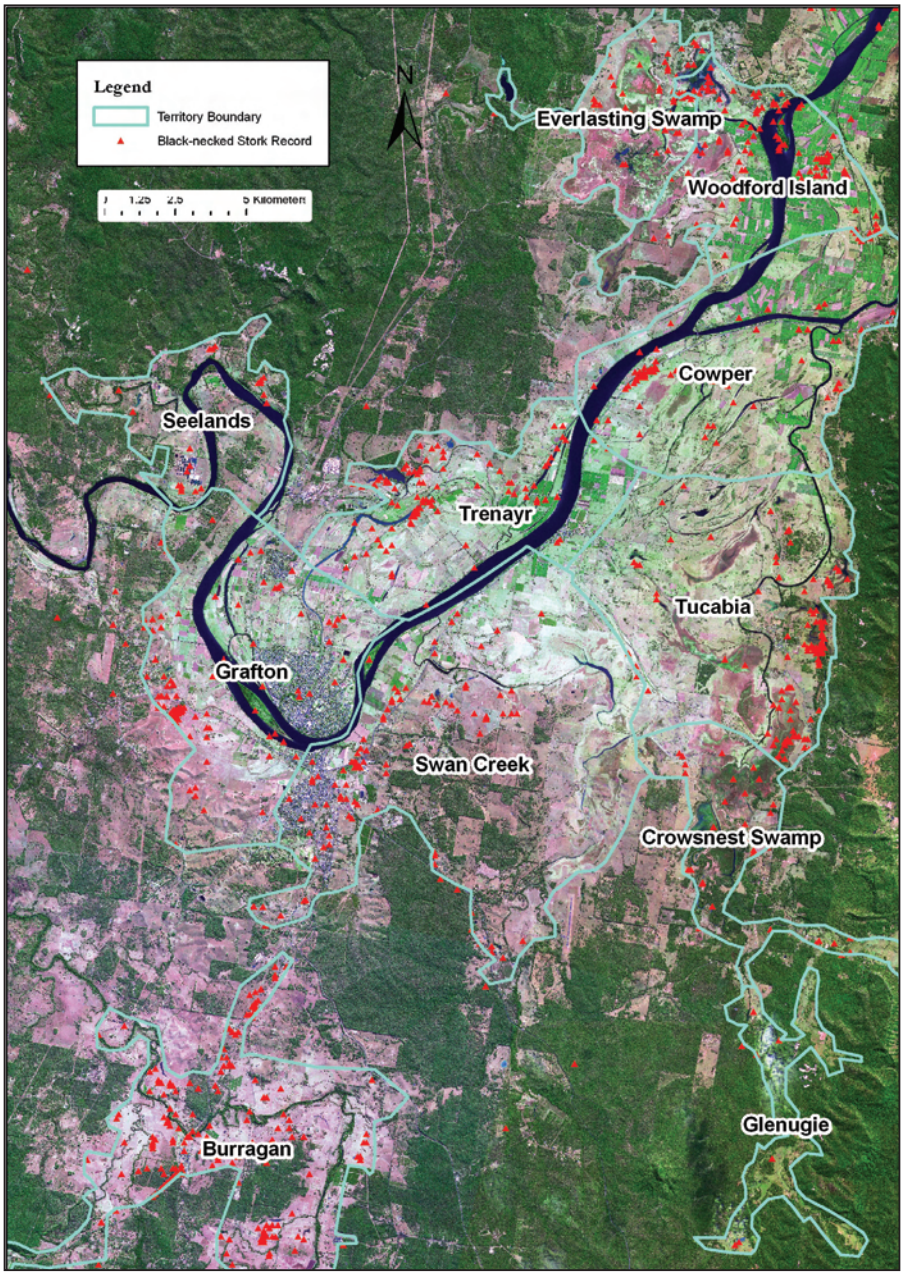

Figure 3: *Detail of predicted territories of the Black-necked Stork on the Clarence River floodplain near Grafton. Collated records are overlain.*

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APPENDIX 1

History of provisional territories of Black-necked Storks in NSW.

Territory	River Valley	Size (ha)	Confirmed nesting 2000-2006	Previous nesting	Records Pre-2000	Records 2000+	Wetland area (ha)	Floodplain area (ha)
Cobaki	Tweed	4730	Yes	No	11	27	956	1066
	Pair nested at Piggabeen in 2005, young on nest, fate not known.							
Tweed River	Tweed	7870	No	Yes	7	6	606	6969
	Pair nested on Stotts Island c. 1985, birds still seen in area (2003, 2004, 2005).							
Cudgen	Tweed	6590	No	No	1	13	1109	693
	Records in recent years (2001, 2004, 2005, 2006).							
Brunswick	Brunswick	7610	No	Yes	12	5	2645	2260
	Former nest reported at Brunswick Heads. Pair regularly present in area. Numerous reports at Byron Sewage Treatment Works (2001, 2002, 2003, 2004, 2005).							
Woodenbong	Richmond	4940	No	No	1	3	195	0
	Birds regularly observed in area, likely to constitute a territory. Personally observed in 2001.							

APPENDIX 1 (Continued)

History of provisional territories of Black-necked Storks in NSW.

Territory	River Valley	Size (ha)	Confirmed nesting 2000-2006	Previous nesting	Records Pre-2000	Records 2000+	Wetland area (ha)	Floodplain area (ha)
Kyogle	Richmond	7820	No	Yes	6	3	97	5263
	Formerly nested at Cedar Point (1987-1993); birds still observed in area (2004).							
Corndale	Richmond	8210	No	Yes	4	1	0	4238
	Formerly nested (late 1970s-early 1980s), possibly other pairs in area.							
Lismore	Richmond	9100	No	No	11	14	40	7205
	Adult pair with juv-imm. at Lismore Lake 2003. Regular reports (2001, 2003, 2004).							
Stratheden	Richmond	8640	Yes	No	8	6	266	5767
	Nested successfully during study.							
Ballina	Richmond	14 530	No	Yes	25	21	3481	6470
	Reported to have nested on North Creek (1984). Birds regularly seen in area (2002, 2003, 2004, 2005, 2006).							
Shannon	Richmond	8280	No	Yes	4	7	127	3563
	Nested prior to survey (2000). Birds still observed in area (2005).							
Casino	Richmond	14 520	No	Yes	27	23	389	12 268
	Formerly nested E and N of City (1986-1990). Adult pair regularly observed in area (2003, 2004, 2005, 2006).							
Yorklea	Richmond	16 770	No	No	0	1	38	10 653
	Nest reported during survey with birds observed south of Casino.							
Codrington	Richmond	10 510	Yes	Yes	7	13	953	8823
	Active, but unsuccessful, nest during study.							
Mongogarie	Richmond	11 540	Yes	Yes	10	11	233	8005
	Long history of nesting using four different nests over time.							
Coraki	Richmond	8800	Yes	Yes	7	8	1661	7451
	Active nest during study.							
Tuckean	Richmond	12 450	No	No	8	7	5263	9983
	Regular reports of birds (2005).							
Woodburn	Richmond	17 470	Yes	No	10	21	3323	15 667
	Active nest during study at Bungawalbin Creek.							
Evans Head	Richmond	10 470	No	No	23	5	5225	3207
	Birds regularly seen in area (2001, 2003).							
Busbys Flat	Richmond	1350	No	No	4	6	115	515
	Adult pair regularly recorded (2003, 2004). Nest site not known.							
Rappville	Richmond	6180	Yes	Yes	2	3	155	3733
	Active nest during survey.							
Clearfield	Richmond	2080	No	Yes	1	3	98	1532
	Former nest site. Adults present during study near suitable nest. Nest claimed to be that of Wedge-tailed Eagle but possibly used by both species at different times.							
Bungawalbin	Richmond	8050	Yes	Yes	5	11	413	6907
	Active nest at Main Camp during study.							
Whiporie	Richmond	6630	Yes	Yes	3	5	554	3195
	Adult female and recently fledged juvenile present at Main Camp (South) during study, presumably from this territory. Recorded in area in 2003, 2005, 2006.							

APPENDIX 1 (Continued)

History of provisional territories of Black-necked Storks in NSW.

Territory	River Valley	Size (ha)	Confirmed nesting 2000-2006	Previous nesting	Records Pre-2000	Records 2000+	Wetland area (ha)	Floodplain area (ha)
Jerusalem Creek	Richmond	10 920	No	Yes	12	0	4801	231
	Former nest site. Pair likely to be still present but much of area inaccessible. Birds seen to north and west of site (1980s-1990s).							
Mallanganee	Clarence	3470	No	Yes	0	3	53	1178
	Reported nesting prior to study. Adult pair present during study.							
Tabulam	Clarence	10 810	No	Yes	10	5	96	3732
	Reported nesting prior to study. Adult pair observed in area (2003, 2006).							
Baryulgil	Clarence	10 360	No	Yes	1	2	28	2248
	Former nesting reported circa 1983.							
Barretts Creek	Clarence	3790	Yes	No	0	5	68	884
	Reported nesting during study, young produced. One adult reportedly shot during 2006.							
Arndilly North	Clarence	4220	Yes	Yes	4	39	925	833
	Successfully nested during study.							
Arndilly South	Clarence	2200	Yes	Yes	20	58	759	1555
	Successfully nested during study.							
Yamba	Clarence	14 880	No	Yes	42	24	2915	9308
	Nested at Romiaka Island prior to study (2000) and earlier on Palmers Island. Adult pair observed in area (2005, 2006), nest in disarray.							
Everlasting Swamp	Clarence	2480	Yes	Yes	14	24	1556	2005
	Adults at nest during study, outcome not known.							
Woodford Island	Clarence	4100	Yes	Yes	45	80	1313	3892
	Successfully nested during study.							
Copmanhurst	Clarence	13 050	No	Yes	4	6	139	3783
	Reported nesting in circa 1983. Birds seen in area (1998, 2003, 2006).							
Jackadgery	Clarence	3420	No	Yes	7	2	10	1087
	Nested at Diggers Creek prior to study. Single birds regularly observed including in 2005. Pair reported at Cangai in 2007.							
Cowper	Clarence	9860	Yes	Yes	30	39	3088	9475
	Successfully nested at Tyndale during study.							
Brooms Head	Clarence	4300	No	No	14	5	1184	949
	Adult pair with juveniles recorded at Sandon prior to study, nest site not known. Recorded 2002, 2003, 2004.							
Seelands	Clarence	3110	No	No	6	16	102	1495
	Adult pair regularly observed in area during study.							
Trenayr	Clarence	4916	Yes	Yes	36	55	549	4642
	Successfully nested at Bunyip Creek during study.							
Tucabia	Clarence	7320	Yes	Yes	60	54	2275	6595
	Successfully nested at Chaffin Creek and Gilletts Ridge during study.							
Swan Creek	Clarence	11 160	Yes	Yes	41	56	2078	6200
	Successfully nested during study.							
Grafton	Clarence	6800	No	Yes	51	40	427	5356
	Nested regularly at Waterview Heights until 2001. Adult pair still in area. No nesting recorded during study.							

APPENDIX 1 (Continued)

History of provisional territories of Black-necked Storks in NSW.

Territory	River Valley	Size (ha)	Confirmed nesting 2000-2006	Previous nesting	Records Pre-2000	Records 2000+	Wetland area (ha)	Floodplain area (ha)
Crowsnest Swamp	Clarence	2950	Yes	Yes	18	16	1206	2229
	Successfully nested during study.							
Glenugie	Clarence	1670	No	Yes	6	1	55	844
	Nesting prior to study (1988, 1990, 1991). Different pair to Crowsnest as both nested in 1990.							
Station Creek	Clarence	6680	No	Yes	17	9	2338	1677
	Adults with young recorded on Wooli River. Nest site not known (1980s-1990s, 2002, 2003).							
Burragan	Clarence	6950	Yes	Yes	91	106	388	3159
	Formerly nested at Lower Kangaroo Creek. Successfully nested at Coutts Crossing during study.							
Kungala	Clarence	4650	No	No	3	6	100	1294
	An adult pair observed in the Kungala and Lanitza area is presumed to constitute a breeding pair (2002, 2003).							
Orara Valley	Clarence	7200	No	No	12	10	48	3466
	Adult pair observed in area (2002, 2003, 2004, 2005). Nest site not known.							
Corindi	Coffs - Nambucca	2460	Yes	Yes	13	11	632	1417
	Reported nesting during study. Regular nesting prior to study.							
Woolgoolga	Coffs - Nambucca	2530	No	No	11	15	999	1120
	Birds regularly reported (2002, 2003, 2004, 2005).							
Bonville	Coffs - Nambucca	4710	No	No	12	19	686	2130
	Pair regularly observed (2003, 2004, 2005).							
Bellinger	Coffs - Nambucca	6370	Yes	Yes	18	39	1362	4543
	Successfully nested during study at Urunga.							
Nambucca	Coffs - Nambucca	4370	No	Yes	12	12	701	1547
	Birds regularly observed (1999-2000, 2003), former nesting reported.							
Macksville	Coffs - Nambucca	7690	Yes	Yes	11	12	1754	4755
	Successfully nested at Gumma during study.							
South West Rocks	Macleay	12 940	Yes	No	6	23	4872	6522
	Adult pair regularly recorded (2000, 2001, 2002, 2003, 2004, 2005, 2006, 2007). Nest site recently reported.							
Clybucca	Macleay	12 140	No	Yes	3	9	2872	10 474
	Reported nesting at Collombatti prior to study. Birds still recorded in surrounding area (2003, 2004, 2005).							
Hat Head	Macleay	9950	No	Yes	2	3	4314	8104
	Recorded nesting prior to study. Nesting known in area since at least 1974 (Rogers 1975). Adult pair present in area during study (2003).							
Belmore Swamp	Macleay	10 510	Yes	No	7	15	3537	8764
	Birds present for many years (2002, 2003, 2005). Nest located in 2006 when they successfully bred.							
Kempsey	Macleay	8850	No	No	13	10	829	5614
	Birds regularly observed in area (2000, 2002, 2003, 2004, 2005, 2006).							
Upper Macleay	Macleay	12 200	No	No	0	9	119	5731
	Regular records of birds (2001, 2002, 2003, 2004, 2006).							
Crescent Head	Macleay	9290	No	No	3	14	4412	6425
	Regular records in area (2003, 2004, 2005, 2006).							
Maria River	Hastings	15 290	Yes	No	4	9	5932	8977
	Successfully nested during study.							

APPENDIX 1 (Continued)

History of provisional territories of Black-necked Storks in NSW.

Territory	River Valley	Size (ha)	Confirmed nesting 2000-2006	Previous nesting	Records Pre-2000	Records 2000+	Wetland area (ha)	Floodplain area (ha)
Port Macquarie	Hastings	12 900	No	No	17	13	2701	7223
	Birds regularly seen between Wauchope and Port Macquarie (2000, 2003, 2004, 2005).							
Lake Innes	Hastings	6920	Yes	No	9	12	2693	3232
	Regular reports and successfully nested during study (2001, 2002, 2003, 2004, 2005, 2006). Nest site not known.							
Rossglen	Hastings	12 270	No	No	8	15	3513	5908
	Adult pair present, local nesting suspected. Adult carrying nesting material near Hannam Vale in 1981 (Lindsey 1982).							
Crowdy Head	Manning	16 740	Yes	Yes	17	28	6319	9519
	Known to nest for many years in Crowdy Bay National Park north of Harrington, including during study. Precise location of nest site not known.							
Old Bar	Manning	13 950	No	Yes	7	15	1663	11 253
	Former nest site on Oxley Island (circa 1972). Birds still present in area (2001, 2002, 2003, 2004, 2005, 2006).							
Gloucester	Manning	15 380	No	No	6	8	176	3943
	Concentration of records in suitable habitat (2001, 2002, 2003, 2007).							
Darawank	Great Lakes	9964	No	No	4	12	2185	4144
	Birds regularly observed at Darawank Swamp and other sites (2001, 2003, 2004, 2006).							
Minimbah	Great Lakes	12 090	No	Yes	3	13	2574	3806
	Reported nesting at Coolongolook in 1999. Adult pair regularly observed in area (2002, 2003, 2004, 2005, 2006).							
Forster	Great Lakes	9650	No	Yes	16	6	1879	603
	Nested in late 1960s to early 1970s at Green Point. Birds still recorded locally (2001, 2003, 2004, 2006). Current nest location not known.							
Myall Lakes	Great Lakes	10 660	No	Yes	3	0	2080	1256
	Nested in 1970s. No recent records but site very secluded.							
Bulahdelah	Great Lakes	6010	Yes	Yes	8	8	1392	2739
	Nested at site for a number of years. Successfully nested in 2003, but not since. Adults still recorded locally.							
Hawks Nest	Great Lakes	11 820	No	No	6	3	4230	2620
	Suspected nesting prior to study. Observed in area in 2003.							
Grahamstown	Hunter	26 620	No	No	25	16	4467	9451
	Adult pair regularly observed at Williamtown and Grahamstown Reservoir (2000, 2001, 2002, 2003, 2004).							
Hexham	Hunter	16 320	No	No	20	29	4217	8181
	Adult pair regularly seen at Ash Island, Hexham Swamps, Pambalong NR and Shortland (Wetland Centre) (2000, 2001, 2002, 2003, 2004, 2005).							
Lake Macquarie	Hunter	12 390	No	No	12	0	324	3411
	Suitable habitat present and history of records, although none in 2000-2006 period.							
Tuggerah Lake	Wyong	8660	No	?	29	2	1403	4663
	Breeding suspected between 1991 and 1993. Bird recorded in 2002.							
Windsor	Hawkesbury	10 850	No	Yes	13	0	216	5375
	Bred at Castlereagh in 1959, and also possibly in 1957. A few recent Sydney area records but territory not permanently occupied.							
Moree	Gingham	52 567	Yes	No	4	2	10 500	11 531
	Pair nested in 2005, young disappeared from nest. Adults observed in 2006.							