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DISTRIBUTION, STATUS AND OPTIONS FOR THE FUTURE MANAGEMENT OF THE GREY GRASSWREN *Amytornis barbatus barbatus* IN NEW SOUTH WALES

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This paper reviews the current and historic distribution of the Grey Grasswren *Amytornis barbatus barbatus* in New South Wales, its abundance and its prospects for survival in this State. None of its habitat is protected under conservation legislation and its remaining habitat suffers from continued degradation by grazing domestic stock. The options for habitat protection and future management are discussed and comment on the potential impact of climate change on the species' very specific habitat requirements is also raised.

INTRODUCTION

The Grey Grasswren *Amytornis barbatus* was first described from five specimens taken by N. J. Favaloro and W. Adams in the Caryapundy Swamp on the property, *Teurika*, in north-western New South Wales (NSW) on 7 July1967 (Favaloro and McEvey 1968). The precise location from which the type specimens were collected was not published, but simply described as "Teurika, north-west N.S.W" (Favaloro and McEvey 1968: p. 1). However, they later stated in the paper that the birds were taken from an "isolated section of Cane Grass in which clumps of Lignum were growing" (p.7) and all their observations of the species were from "four colonies over a distance of 25 miles (40 km) from *Teurika* to a point approximately five miles (8 km) over the border" (p. 8).

The Bulloorine subspecies of the Grey Grasswren *A. b. barbatus* is dependent on 'wetland' areas dominated by dense clumps of tall Lignum *Muehlenbeckia florulenta* (for refuge, feeding and nesting), also using Swamp Canegrass *Eragrostris australasica* (feeding and occasionally nesting in wet periods when Lignum habitat is inundated), Old Man Saltbush *Atriplex nummularia* (feeding) and samphire *Halosarcia* spp. (feeding) (Garnett and Crowley 2000; Hardy 2002; Higgins *et al*. 2001; McAllan and Cooper 1995; Schodde 1982). Lignum grows in the most flood-prone areas, Swamp Canegrass is dominant in irregularly flooded areas and saltbush occurs only where inundation is an infrequent event.

In 2000 a banding and observational study targeting the Grey Grasswren was commenced on *Narriearra*, a beef cattle grazing property that adjoins the eastern boundary of Sturt National Park about 40 kilometres east of Tibooburra NSW. The aim was to determine the species' current status and distribution in NSW and to undertake a study of the NSW population complementary to a similar study performed in south-western Queensland (Qld) (Hardy 2002).

The NSW population of this subspecies had been listed as *vulnerable* under the New South Wales Threatened Species Conservation Act, 1995 (NSW TSCAct). McAllan and Cooper (1995) recognised that the NSW populations of the species were found only to the north of the Bulloo Overflow and that management of feral animals and maintenance of the preferred habitats were of importance in conserving the species.

Garnett and Crowley (2000: p. 425) identified management actions required for the Grey Grasswren throughout its range as:

- "14.1 On the basis of surveys of population and habitat condition, assess conservation management requirements;
- 14.2 Develop a grazing regime that leaves core habitat lightly grazed, particularly during drought; and
- 14.3 Monitor population regularly."

A Draft Recovery Plan for the NSW population of the Grey Grasswren was published in 2003 (NSW NPWS 2003). The NSW Scientific Committee reviewed the species' status in 2004, upgraded their determination and relisted the bird as *endangered* (NSW Scientific Committee 2004). In 2008 the subspecies was listed as *vulnerable* under the Australian Government's Environment Protection and Biodiversity Conservation Act 1999 (Department of the Environment, Water, Heritage and the Arts 2009). Both of these determinations recognised that degradation and loss of habitat through cattle grazing was the most notable threat to the survival of the species.

STUDY SITES

Narriearra (presently 150 000 ha) was chosen as the primary study area as most observations of the species in NSW were on that property and the property owner was eager to assist a study of the species and provided unrestricted access. *Narriearra* now incorporates the former *Teurika* and adjoining *Connulpie* properties. Beef cattle productivity decline related to environmental degradation had made separate management of the three small properties unviable. The present *Narriearra* includes almost all of the NSW portion of the Caryapundy Swamp, extensive areas of sand dune and gibber plain and the north-west tip of the extensive low-lying clay pan known as the Bulloo Overflow (see Fig. 1).

Two separate sites were chosen, both of which were about ten hectares in area. The first was at Bartons Crossing and the second a few hundred metres to the south-east of Adelaide Gate (Photographs 1 and 2 respectively). Both sites featuring dense, tall Lignum with nearby Swamp Canegrass and saltbush, are approximately 10 kilometres apart and within a continuous area of Lignum covering many hundreds of hectares (Fig. 1).

Bartons Crossing, situated on the Adelaide Gate track, is a broad, shallow water channel some ten kilometres south of the Qld – NSW border and approximately 20 kilometres north of the now abandoned *Teurika* homestead (see Photograph 1). Initial overflow from Bulloo Lake flows south across the border (87m asl) a few hundred metres to the east of Adelaide Gate and disperses into swamplands to the south. Some of this water flows west through the Bartons Crossing channel (82m asl) into Caryapundy Swamp (see Fig. 1).

Photograph 1. *Typical Grey Grasswren habitat at Barton's Crossing site – September 2009.*

Photograph 2: *Typical Grey Grasswren habitat at Adelaide Gate site – September 2009.*

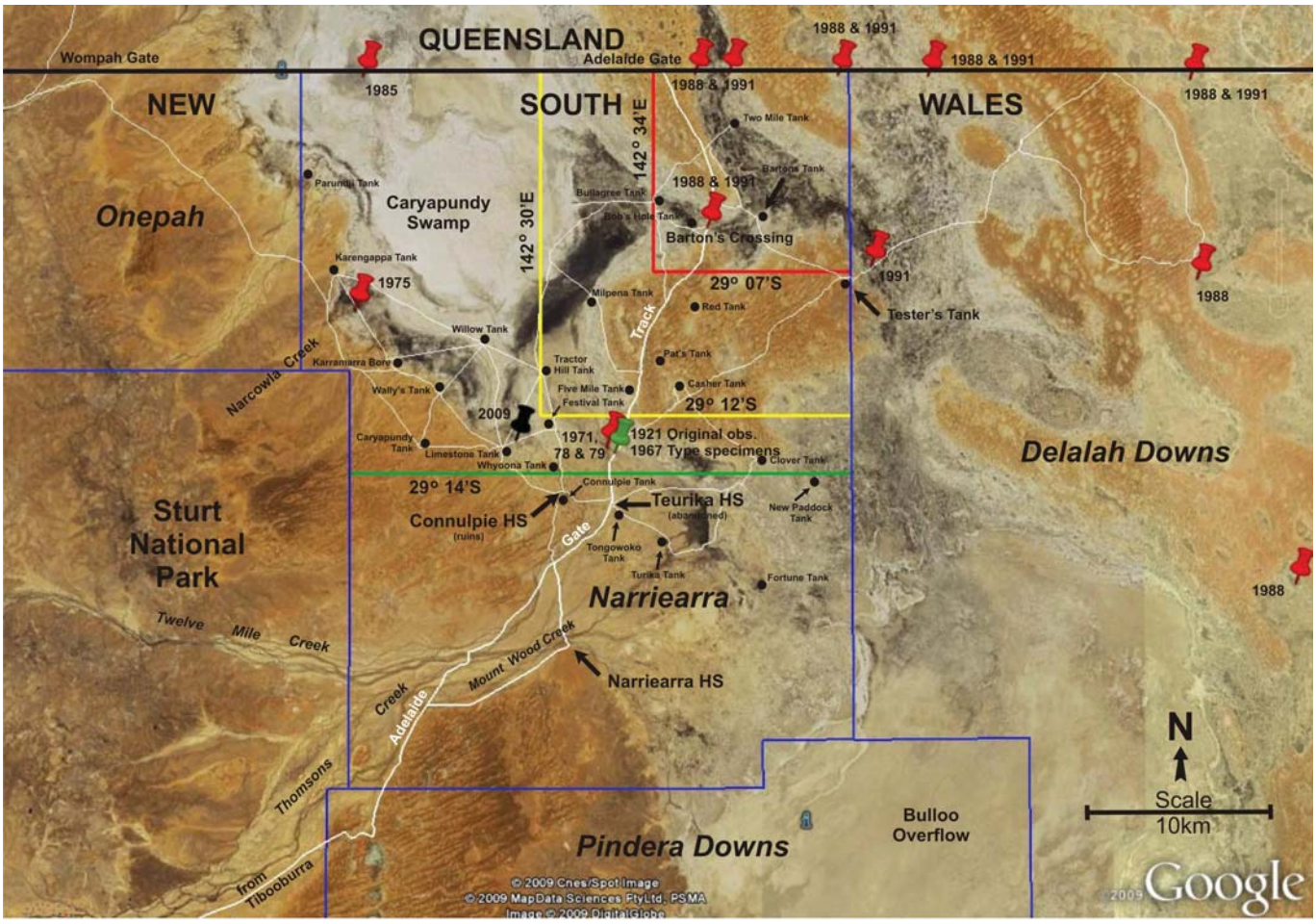

Figure 1: *Satellite image of Grey Grasswren distribution within NSW. Pinpoints show localities of sightings of Grey Grasswrens from 1967 to 2009. Major tracks traversed during the course of the study are shown. The parallels of latitude and meridians of longitude referred to in the text are also shown.* (Satellite image courtesy of Google Earth)

METHODS

Mist nets were used to capture birds using techniques described in Hardy (2002), i.e. basically, net lanes were swept of debris and nets were erected with the bottom shelf string resting on the ground. The netting intensity at both sites was similar to the efforts in Qld and jointly covered approximately twice the area of similar habitat that was netted in the 11 hectare Qld study site.

An extensive network of several hundred kilometres of tracks that are used to access ground water tanks, bores and water troughs and for stock management within *Narriearra* were all traversed by 4x4 vehicle between 2002 and 2009 to locate and map all potential Grey Grasswren habitat on the property and to search for birds. Extensive use was made of GPS equipment to accurately identify the coordinates of potentially suitable habitat and many of those areas were traversed on foot or bicycle in an attempt to locate grasswrens. A GPS was also used to identify all Grey Grasswren sightings. The general vicinity of most of the previously reported observation sites and similar habitat areas on the adjoining *Onepah* (north-west) and *Delalah Downs* (east) were also examined and searched (see Fig. 1).

Goodrick (1984) has an analysis of the wetland systems and some old photographs of the Overflow and inundated Lignum along the border fence. Considerable use was made of 1972 and 1973 aerial photography that was incorporated into the 1:100 000 orthophotomaps: Tibooburra (printed 1979), Tongowoko (printed 1978) and Thurloo Downs (printed 1978). Also, more current satellite imagery available over the Internet via Google Earth proved invaluable in predicting habitat availability and to map both current and probable past Grey Grasswren habitat. The property owner also provided helpful information on changes to the vegetation on the property over the past half-century and his knowledge of the former distribution of grasswrens was also important to the study.

RESULTS

All Grey Grasswrens and associated bird species observed and the numbers banded on *Narriearra* during the author's 36 days in the study area during eight visits over a nine-year period are summarised in Appendix 1. Those species that were captured in purely Lignum or associated Swamp Canegrass and saltbush habitat are noted as such. Other species were captured in adjoining *acacia* and *eucalyptus* habitat that may have harboured grasswrens during periods of flooding, but no grasswrens were observed in those areas.

Grey Grasswrens were not observed or captured on three of the eight visits to the study area. During the first visit, in April 2000, the primary habitat for grasswrens was deeply flooded by water from south-west Qld and the species could not be located in any of the accessible areas of the property. By October 2000 most of the flooding had subsided allowing access to most of the property. Lignum areas still contained isolated pools of water in April 2001 as remnants of the 2000 flood. In September 2004 similar water pools had developed in low-lying areas of Lignum following local inundation. All other years that the study sites were visited, the only surface water was in constructed ground tanks, Karramarra Bore (Fig. 1), or troughs supplied from that bore. In July 2007 and October 2009, which were both very dry periods, extensive searches were carried out but Grey Grasswrens were not located, even in the areas where they had been observed or captured on previous occasions.

All published records of sightings and the locality of the NSW Atlassers' sightings in 1988 and 1991 as were published in McAllan and Cooper (1995) are displayed on Figure 1. McAllan (pers. comm.) again recorded the species at Bartons Crossing in 2000. One sighting by the author in 2009 to the north-east of Limestone Tank is also shown on Figure 1.

Figure 2 shows the extent of known current habitat of Grey Grasswrens on *Narriearra* and *Delalah Downs*. All sightings of Grey Grasswrens during this study were within the areas shaded black in Figure 2. From examination of aerial photographs, discussions with the owner of *Narriearra* and personal observations, probable former (existing in 1967) distribution of Grey Grasswrens on that property, *Onepah* and the western portion of *Delalah Downs* is also shown. Current habitat that would support Grey Grasswrens covers approximately 7000 hectares on *Narriearra* and 1000 hectares on *Delalah Downs*.

With the exception of the most south-eastern locality, the author searched the vicinity of all of the recorded *Delalah Downs* observation localities in October 2009, but failed to locate any grasswrens.

DISCUSSION

Distribution

Dr Arthur Chenery, William and Ian Macgillivray made the first observation of the species on 25 August 1921, but were unable to take specimens. Chenery (1922) did not specifically identify the locality of the sighting. McAllan and Cooper (1995) reported they were told by Graham Chapman and the late Shane Parker that the original type specimens were assumed to have been taken at Bartons Crossing. However, McAllan later located a paper, Macgillivray (1923), which had been overlooked by several authors. In it Macgilivray identified the original observation as being "about 3 miles …" (5.4 km - from Connulpie homestead where they had camped) "... on a water channel by the road to Adelaide Gate" (McAllan 2000).

The property owner, Bill O'Connor (pers. comm.), informed the author that the 1967 type specimens were also taken from the vicinity of the original observation in an area which is only 3.3 kilometres north of the now abandoned *Teurika* homestead. (Figs 1 and 2).

The type specimen collection site was described in Favaloro and Evans (1968) as "dense Swamp Canegrass and large Lignum clumps" along the Adelaide Gate track. Chapman and Parker may have assumed Bartons Crossing as the original collection site on the basis of their observation of the only remaining suitable habitat for Grey Grasswrens was located there. This is some 20 kilometres north of the abandoned *Teurika* homestead. Bartons Crossing is, in fact, some 16.5 kilometres north of the original 1921 observation and 1967 type specimen collection locality.

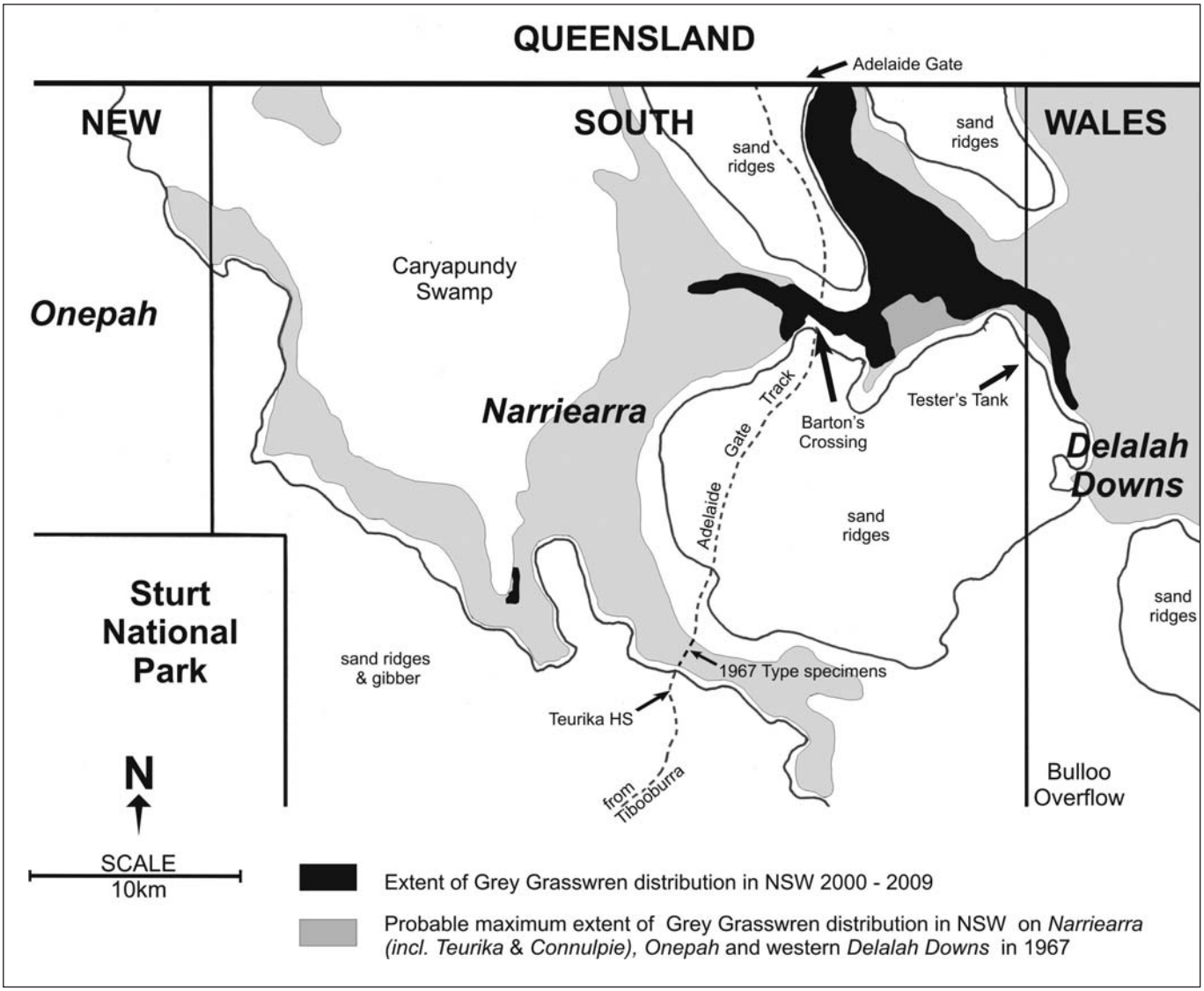

Figure 2: *2009 and presumed 1967 extent of Grey Grasswren distribution on* Narriearra*,* Onepah *and the western portion of* Delalah Downs.

The original observation and type specimen collection site is an unnamed wide shallow channel through which water flows west to east from Caryapundy Swamp into the Bulloo Overflow. The landholder advised the author that this channel once comprised dense Swamp Canegrass interspersed with large Lignum clumps that died back to a great extent after a prolonged flooding event in 1974/75. He also suggested the area has not revegetated to its former state because of a combination of lengthy dry periods and continuous heavy cattle grazing (see Photograph 3).

Published accounts of NSW Grey Grasswren observations were summarised by McAllan and Cooper (1995). Sightings were recorded in the vicinity of the original type specimen collection locality in 1971, 1978 and 1979 (Fig. 1) suggesting that the habitat of the original collection site had not significantly changed in the period 1967 to 1979. This also sheds doubt on the advice provided by the landowner that the grasswren habitat in this channel was destroyed by the 1974/75 flood.

Photograph 3: *Degraded habitat at the original 1921 observation locality and 1967 Type Specimen Collection Site – September 2009. Note cattle tracks in foreground.*

Observations recorded during 1975 and 1985 were approximately 19 kilometres and 29 kilometres to the north-west of earlier observations respectively (Fig. 1). The 1975 locality is still an extensive area of dense, tall Swamp Canegrass, but grasswrens could not be located in this area during this study nor in 1988 (Ian McAllan pers. comm.) (see Photograph 4). The 1985 observation was also in Swamp Canegrass in the vicinity of the state border, but this locality is now devoid of any habitat that could support grasswrens. Indeed, no potential grasswren habitat remains within five kilometres on either side of the border anywhere along its 23 kilometres traverse of Caryapundy Swamp. This may have also been the case in 1988 and 1991 (Ian McAllan pers. comm.).

Photograph 4: *1975 Narcowla Creek Swamp Canegrass observation locality – October 2009.*

With the exception of the records on *Delalah Downs* in 1988 and 1991 by NSW Bird Atlassers (McAllan and Cooper 1995) (Fig. 1), all the reliable sightings of Grey Grasswrens (well in excess of 100 sightings - including the original observation in 1921 and the 1967 collection of the type specimens, and 36 birds captured and banded and observations by the author and field research assistants since 2000) in NSW have been on *Narriearra* (black-shaded area in Fig. 2).

Except for the area of the Atlasers' sightings to the east of Tester's Tank near the western boundary of *Delalah Downs* (Fig. 1 – see Photograph 5), the habitat where the species had been recorded elsewhere on *Delalah Downs* in 1988 and 1991 (mostly Swamp Canegrass and saltbush) had by 2009 deteriorated to the extent that it is doubtful that suitable permanent habitat for the species still exists on this property (see Photograph 6). However, the Grey Grasswren, like many other arid zone bird species, survive through a population boom and bust existence depending on the prevailing climatic conditions. The population in the Qld study (Hardy 2002) attested to this. In any case, if the species does still exist in small numbers in the degraded Lignum, Swamp Canegrass and saltbush on the eastern claypans of *Delalah Downs*, the population may increase and even boom in wet years. Nevertheless, the disappearance of any connecting suitable habitat has isolated that population from the remaining grasswren habitat to the west. It is probable that connecting habitat would regenerate only in the event that cattle were removed from the Lignum channels in the northern reaches of the Bulloo Overflow.

McAllan and Cooper (1995) noted that the Bulloo Overflow (mostly to the south-east of *Narriearra* within the properties of *Delalah Downs* and *Pindera Downs*) fills by overflow from the Caryapundy Swamp and from the channels to the north and north-east of the Overflow, after Caryapundy Swamp fills to a depth exceeding three metres. This may be true in normal wet season flows as high water disperses from Bulloo Lake. During periods of widespread flooding in south-western Qld, however, water will flow south across the border though numerous claypans to the east of Adelaide Gate to eventually flow directly into the Overflow. Inundation of this area is so infrequent that ground moisture cannot support the vegetation types and density requirements for Grey Grasswens in a normal season.

During the period 2000–2009 only approximately 7000 hectares and 1000 hectares of suitable habitat exist on *Narriearra* and *Delalah Downs* respectively. This compares with the probable area of habitat of some additional 38 000 hectares on *Narriearra* and *Onepah* and 45 000 hectares on *Delalah* Downs that apparently existed in 1967. However, the water flow regime and ground water dependent preferred habitat of tall, dense Lignum suggests that the majority of prime habitat in NSW always occurred on *Narriearra.* It is suggested that in the eastern areas of *Delalah Downs* the species would have occupied only marginal habitat in better years. If, as expected, climate change results in longer dry periods in the region and cattle grazing continues, it is most unlikely that

Photograph 5: *1991* Delalah Downs *(Tester's tank) observation locality – October 2009.*

Photograph 6: *1991 NE* Delalah Downs *Queensland border observation locality – October 2009.*

primary habitat will ever regenerate in the eastern claypans on *Delalah Downs.* The author did not detect any Grey Grasswren in this area, but even if there is an isolated boom/bust population still surviving in this area, it is likely to continue to decline and may disappear.

Comparison with Queensland Study

The Qld study was conducted over a period of 12 years at a site approximately 40 kilometres north-west of the present study. One hundred and ninety-three Grey Grasswrens were captured in the 11-hectare study site (Hardy 2002). However, over a similar number of netting days, using the same capture techniques and during similar dry climatic conditions as were experienced in the Qld study where 193 Grey Grasswrens were captured, only 36 were captured in the present study. Some birds were recaptured within two or three days of their banding, but only at the original banding location. No banded birds were recaptured in subsequent annual (or longer) visits to the two banding sites. This suggests that Grey Grasswrens may be nomadic within large areas of habitat.

In the Qld study, strong evidence existed to suggest that the relatively small study site of 11 hectares of tall, dense Lignum, with large expanses of nearby Swamp Canegrass and samphire was used by large numbers of grasswrens as a refuge area during periods of drought. That was not the case in NSW where the available habitat of tall, dense Lignum covered some 700 times the area studied in Qld and this study could not identify any specific areas that contained high concentrations of grasswrens.

The study site in Qld was seriously impacted by rabbits *Oryctolagus cuniculus* and feral pigs *Sus scrofa,* (Hardy 2002). These species were not present in sufficient numbers in NSW to cause substantial damage to much more extensive areas of Lignum than in the vicinity of the Qld study site. The main threat in NSW appears to be grazing by beef cattle (*Bos* spp.), but small numbers of rabbits occupy areas of Old Man Saltbush and feral pigs are present in the Lignum.

Abundance

The highest capture rates of Grey Grasswrens and other Maluridae (Variegated Fairy-wren *Malurus lamberti* and White-winged Fairy-wren *M. leucopterus*) were in the two years that the Lignum was flooded (2000 and 2001). In those very wet years, access to some Lignum habitat would have been severely limited to ground frequenting birds, and poorly flighted species, like the Maluridae, would congregate in remaining dense cover such as Swamp Canegrass and saltbush adjoining the inundated Lignum stands. The higher density of birds in limited habitat during those years would have been supported by a higher density of invertebrate food and seed than during dry years. Analysis of banding capture data and observations of the species in the banding sites and elsewhere during the dry years that the author visited the study area (2002, 2007 and 2009) suggests that, even in the 'prime' Lignum habitat, the Grey Grasswren population did not average more than one bird in about five hectares during those dry years.

This estimated density of 0.2 Grey Grasswrens per hectare is difficult to compare with other *Amytornis* spp. because data do not exist in most cases (Higgins *et al*. 2001) and secondly, the ten species in the genus are specialists within a variety of habitats. However, data for the two *Malurus* species that share the same habitat have been compared. Population density data for *M. lamberti* vary from less than 0.01 per hectare in coastal Qld to 0.4 and 0.66 per hectare in good habitat near Wollongong and Sydney and 0.55 per hectare during breeding seasons near Booligal, NSW (Higgins *et al.* 2001). Similarly, studies of *M. leucopterus* recorded densities ranging from 0.16 to 0.81 in Western Australia to 0.31 in South Australia (Higgins *et al*. 2001). Indicatively, the mean of data for the two species combined is 0.39 per hectare. In the present study we captured 36 Grey Grasswrens; 60 Variegated and 15 White-winged Fairywrens. Given that the combined number of fairy-wrens captured outnumbered the grasswrens by approximately 2 to 1 in capture rates and as the Grey Grasswren population density was estimated at 0.2 per hectare, the fairy-wren density of approximately 0.4 per hectare compares favourably with other studies.

Using the estimated Grey Grasswren density of 0.2 per hectare suggested above, the total population in NSW in the remaining good habitat of 8000 hectares is estimated to be in the region of 1600 birds and 1400 of these will be on *Narriearra.*

CONCLUSIONS

The habitat available to Grey Grasswrens in NSW appears to have contracted by approximately 90 per cent since the species' discovery some 43 years ago from a minimum of 800 square kilometres (80 000 hectares) in 1967 to not more than 80 square kilometres (8000 hectares) in 2009. There is little doubt that cattle grazing has been the cause of this habitat destruction. If the remaining habitat is not permanently protected from cattle grazing pressure within the next few years, the present rate of decline of available habitat will ensure that the nominate subspecies will become extinct over the next few decades. And this prediction does not take into consideration the likely adverse impacts of climate change.

To illustrate this, the most obvious and documented example of significant damage to former prime Grey Grasswren habitat is what occurred within the southern Caryapundy outflow channel, just north of the abandoned *Teurika* homestead, where the species was first observed in 1921 and collected in 1967. This channel now has no habitat that could support grasswrens. Indeed, there is no suitable habitat for the species within at least 10 kilometres of this site because young and regenerating Lignum and Swamp Canegrass is continually grazed.

Whether the habitat change in this area was caused by the long-lasting 1974–75 flood (as suggested by the property owner), or by overgrazing, is irrelevant. There is evidence that the area supported grasswrens until at least 1979, so regeneration of the natural habitat in this area and other substantial areas elsewhere on *Narriearra* may be possible if cattle are permanently removed. Further, it can be expected that the impacts of cattle grazing will increase if climate change results in longer drought periods because the cattle

will become more dependent on Lignum than at present and they will devastate the last remaining healthy stands of this primary habitat for the Grey Grasswren.

OPTIONS FOR FUTURE MANAGEMENT

There appear to be several options for the future management and preservation of Grey Grasswren habitat in NSW.

The first option and most desirable outcome for Grey Grasswrens would be that the whole of the property *Narriearra* be acquired by NSW National Parks and Wildlife Service (Department of Environment and Climate Change) for addition to the adjoining Sturt National Park, or declaration as a Nature Reserve, specifically for the protection of the unique Grey Grasswren habitat and study of the species in the future.

This action is most desirable because removal of domestic stock from the whole of the property will remove the greatest threat to regeneration of Lignum and Swamp Canegrass over an estimated area of over 35 000 hectares, thus potentially increasing by five fold the area currently available to the species that presently occupies approximately only 7000 hectares. (It should be noted that cattle don't eat the saltbush, which occurs throughout the property, but is an important foraging habitat for Grey Grasswrens when it adjoins the preferred habitat of Lignum and Swamp Canegrass.)

Acquisition of the whole property by the NSW State government would also:

- preserve almost all of the present Grey Grasswren habitat and range within NSW;
- protect the primary south flowing channel (a few hundred metres to the east of Adelaide Gate) from the Bulloo River/Lake in Qld;
- protect almost the whole of Caryapundy Swamp and the Bartons Crossing channel upon which the Carryapundy Swamp is significantly dependent;
- protect the remainder of the east-flowing Twelve Mile, Thomsons and Mount Wood Creek systems (Fig. 1) which add water from Sturt NP to the south of Caryapundy Swamp and to the Bulloo Overflow.

The second option could be acquisition of part of the property to protect the historic distribution of Grey Grasswrens on *Narriearra*. This would involve the acquisition of approximately 87 500 hectares (58 %) being that part of *Narriearra* north of 29°14' S (an east-west line a little to the north of abandoned *Teurika* HS) (shown by a green line in Fig. 1). This option would preserve the majority of the wetland area and allow for regeneration of a substantial proportion of former grasswen habitat. However, from the author's discussions, it appears that this option is not likely to be supported by the property owner because the most valuable grazing land is north of this line. Commercial cattle grazing on the remainder of the property would probably not be viable.

Two additional potential management initiatives were raised as basic ideas in discussions with officers of the Western Catchment Management Authority (WCMA). The WCMA is a NSW State Government agency that was established to ensure the local community has a significant say in how natural resources (land, vegetation, rivers, groundwater and biodiversity), are managed. The WCMA in some situations may provide some financial assistance or compensation to landholders whose livelihood is affected by agreed biodiversity conservation initiatives. However, the extent of the areas suggested by the WCMA for exclusion of cattle grazing to protect Grey Grasswren habitat was made in consideration of the author's data.

The first suggestion made by the WCMA was that portion of *Narriearra* north of 29°07'S and east of 142°34'E (shown by red lines in Fig. 1) might be acquired and fenced to exclude cattle and managed for the preservation of the Grey Grasswren in its remaining prime habitat in NSW. This proposal would excise approximately 16 500 hectares from the property and about 26 kilometres of fencing would be involved. This area contains most sightings of the species since 1988 and would be the most direct fence line with minimal construction within areas that get inundated by floodwaters. However, this would effectively be an acknowledgement that cattle will continue to limit regeneration of former habitat and prevent expansion of the remaining population to its former range. This would also be an acceptance that the species will always remain vulnerable to catastrophic loss of all or most of its remaining habitat and population in NSW by alterations brought about by climate change, fire or feral animals (pigs, rabbits, foxes and feral cats).

WCMA officers also suggested that it may be feasible by agreement with the landholder to close all constructed stock watering points north of 29°12'S (Casher and Five Mile Tanks and all those north thereof) and east of 142°30'E (Milpena and Bullagree Tanks and all those east thereof) (shown by yellow lines in Fig. 1). It is the author's understanding that stock will not walk more than about 10 kilometres from grazing areas to water, so this proposal may be feasible. Closure of artificial watering points might exclude most stock from the remaining prime grasswren habitat in dry periods when the habitat is most vulnerable to destruction by overgrazing. This alternative would effectively excise about 43 000 hectares from beef cattle production during dry periods. However, the comments raised with respect to the previous suggestion would still apply and from the author's discussions with the landholder, it seems doubtful that agreement could be reached to close these ground water tanks.

Failing implementation of any of the above options, Biodiversity Banking might be an alternative for conservation management of *Narriearra.* Biodiversity Banking is an option available to landholders, government agencies and catchment management authorities which was legislated for under the NSW *Threatened Species Conservation Amendment (Biodiversity Banking) Act 2006* (DECC 2007; Banyon *et al*. 2008). Biodiversity Banking could allow the landholder to benefit economically from the biodiversity asset that he is currently managing. However, cattle grazing of the unique environment on *Narriearra* is inappropriate for conservation of the remaining viable Grey Grasswren habitat and any form of restriction on grazing is probably uneconomical.

If none of the above suggested management options for the remnant Grey Grasswren habitat can be implemented immediately, the very least that the conservation agency must do is to immediately place a caveat on the Western Lands Lease for *Narriearra* to ensure that it can pass from the present landholder, upon his termination of direct personal management of the property, only to the NSW NPWS, so that acquisition of the whole of the property is eventually realised.

As mentioned above, the present NSW population of Grey Grasswrens occupies only 8000 hectares and 7000 of these are on *Narriearra*. Information is also included in this paper suggesting that the primary Lignum and Swamp Canegrass habitat for Grey Grasswrens could increase by 35 000 hectares if that vegetation was permitted to expand to at least its 1967 extent. If cattle are not removed, any regeneration of the primary habitat vegetation species following infrequent rainfall, or inundation by flooding, is immediately negated by cattle grazing on the new shoots. If cattle are removed it would appear that through a series of wet years, there would be no barrier to expansion of the preferred habitat to at least the extent that existed in 1967. If this regenerated habitat were to then be recolonised by Grey Grasswrens, as it undoubtedly would because it is a population boom/bust species, the total population on *Narriearra* alone, at the current estimated population density, would increase from the present estimate of 1400 to in excess of 8000 birds in dry years. This would probably provide sufficient justification to remove the species from the *Endangered* list under the *NSW TSC Act*.

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Banded group of Grey Grasswrens prior to release.

APPENDIX 1

All avian fauna observed (•) and banded (3) on *Narriearra* during eight visits to the property from 2000 to 2009.

SPECIES		Number Banded	Species caught only in lignum and saltbush association	24-26/4/00 (Flooded)	5-8/10/00 (Flooded)	11-19/4/01 (Wet)	29/6-4/7/02 (Dry)	16-20/9/04 (Wet)	20-21/7/07 (Dry)	7-11/9/09 (Dry)	2-3/10/09 (Dry)
Emu	*Dromaius novaehollandiae*						•	•	•	•	•
Black Swan	*Cygnus atratus*				•						
Australian Wood Duck	*Chenonetta jubata*			•	•					•	•
Pink-eared Duck	*Malacorhynchus membranaceus*			•	•		•	•			•
Grey Teal	*Anas gracilis*			•	•	•	•				•
Pacific Black Duck	*A. superciliosa*			•	•	•				•	•
Hardhead	*Aythya australis*			•	•			•			
Australasian Grebe	*Tachybaptus novaehollandiae*			•	•	•		•		•	•
Hoary-headed Grebe	*Poliocephalus poliocephalus*				•	•	•	•		•	•
Common Bronzewing	*Phaps chalcoptera*			•				•			
Crested Pigeon	*Ocyphaps lophotes*			•		•	•	•	•	•	•
Diamond Dove	*Geopelia cuneata*	3			2		1	•	•	•	•
Peaceful Dove	*G. striata*	1		1	•		•		•		•
Australasian Darter	*Anhinga melanogaster*				•						
Great Cormorant	*Phalacrocorax carbo*				•						
Little Black Cormorant	*P. sulcirostris*				•						•
Australian Pelican	*Pelecanus conspicillatus*				•	•					
White-necked Heron	*Ardea pacifica*			•	•	•				•	
Eastern Great Egret	*A. modesta*			•	•	•					
Intermediate Egret	*A. intermedia*				•						
White-faced Heron	*Egretta novaehollandiae*			•	•		•				
Nankeen Night-Heron	*Nycticorax caledonicus*			•	•						
Glossy Ibis	*Plegadis falcinellus*				•						
Australian White Ibis	*Threskiornis molucca*				•	•					
Straw-necked Ibis	*T. spinicollis*				•						
Royal Spoonbill	*Platalea regia*			•	•						
Yellow-billed Spoonbill	*P. flavipes*			•	•						
Whistling Kite	*Haliastur sphenurus*			•	•			•			•
Black Kite	*Milvus migrans*			•	•	•	•	•			•
Brown Goshawk	*Accipiter fasciatus*			•				•			•
Collared Sparrowhawk	*A. cirrhocephalus*			•							•
Spotted Harrier	*Circus assimilis*			•			•				
Swamp Harrier	*C. approximans*			•		•		•			
Wedge-tailed Eagle	*Aquila audax*			•	•		•	•	•	•	•
Little Eagle	*Hieraaetus morphnoides*			•				•			
Nankeen Kestrel	*Falco cenchroides*			•		•	•	•	•	•	•
Brown Falcon	*F. berigora*			•	•	•	•	•	•	•	•
Australian Hobby	*F. longipennis*			•				•			
Grey Falcon	*F. hypoleucos*			•							
Black Falcon	*F. subniger*			•				•			
Black-tailed Native-hen	*Tribonyx ventralis*	3	♦	•	•			3			

APPENDIX 1 (Continued)

SPECIES		Number Banded	Species caught only in lignum and saltbush association	24-26/4/00 (Flooded)	5-8/10/00 (Flooded)	11-19/4/01 (Wet)	29/6-4/7/02 (Dry)	16-20/9/04 (Wet)	20-21/7/07 (Dry)	7-11/9/09 (Dry)	2-3/10/09 (Dry)
Eurasian Coot	*Fulica atra*						•				
Australian Bustard	*Ardeotis australis*							•	•		
Black-winged Stilt	*Himantopus himantopus*				•			•			•
Red-necked Avocet	*Recurvirostra novaehollandiae*				•						•
Inland Dotterel	*Charadrius australis*			•			•				
Black-fronted Dotterel	*Elseyornis melanops*			•	•		•	•		•	•
Red-kneed Dotterel	*Erythrogonys cinctus*	1	♦	•	1			•		•	•
Banded Lapwing	*Vanellus tricolor*			•				•			
Masked Lapwing	*V. miles*			•	•	•	•	•		•	•
Marsh Sandpiper	*Tringa stagnatilis*				•						•
Little Button-quail	*Turnix velox*	1	♦	•				1			
Australian Pratincole	*Stiltia isabella*				•			•			•
Gull-billed Tern	*Gelochelidon nilotica*				•						
Caspian Tern	*Hydroprogne caspia*				•						
Whiskered Tern	*Chlidonias hybridus*				•						
Silver Gull	*Larus novaehollandiae*				•						
Major Mitchell's Cockatoo	*Lophochroa leadbeateri*					•					
Galah	*Eolophus roseicapilla*			•	•	•	•	•	•	•	•
Little Corella	*Cacatua sanguinea*					•	•	•	•		
Cockatiel	*Nymphicus hollandicus*			•	•	•		•	•	•	•
Blue Bonnet	*Northiella haematogaster*	1		1	•	•	•	•	•	•	•
Budgerigar	*Melopsittacus undulatus*			•	•	•		•		•	•
Blue-winged Parrot *	*Neophema chrysostoma*					•	•	•	•	•	
Horsfield's Bronze-Cuckoo	*Chalcites basalis*	1		•	1			•			
Black-eared Cuckoo	*C. osculans*			•		•		•			
Pallid Cuckoo	*Cacomantis pallidus*							•		•	
Southern Boobook	*Ninox novaeseelandiae*			•			•				
Red-backed Kingfisher	*Todiramphus pyrrhopygia*			•	•			•			•
Rainbow Bee-eater	*Merops ornatus*	2		•	•			2		•	•
White-winged Fairy-wren	*Malurus leucopterus*	15	♦	•	4	4	1	1	•	5	•
Variegated Fairy-wren	*M. lamberti*	60	♦	3	29	5	8	6	•	9	•
Grey Grasswren	*Amytornis barbatus*	36	♦		•	4	16	14		2	
Redthroat	*Pyrrholaemus brunneus*	47	♦		6	5	11	15	•	10	•
Weebill	*Smicrornis brevirostris*			•			•				
Southern Whiteface	*Aphelocephala leucopsis*								•	•	•
Red-browed Pardalote	*Pardalotus rubricatus*			•				•		•	•
Striated Pardalote	*P. striatus*							•			
Pied Honeyeater	*Certhionyx variegatus*	8	♦					4		4	•
Singing Honeyeater	*Lichenostomus virescens*	36	♦	•	9	1	•	4	•	22	•
White-plumed Honeyeater	*L. penicillatus*	26		23	1			2			
White-fronted Honeyeater	*Phylidonyris albifrons*	1	♦							1	
Yellow-throated Miner	*Manorina flavigula*	5	♦	1			•			4	•
Spiny-cheeked Honeyeater	*Acanthagenys rufogularis*	3	♦	2			•	1			•

APPENDIX 1 (Continued)

SPECIES		Number Banded	Species caught only in lignum and saltbush association	24-26/4/00 (Flooded)	5-8/10/00 (Flooded)	11-19/4/01 (Wet)	29/6-4/7/02 (Dry)	16-20/9/04 (Wet)	20-21/7/07 (Dry)	7-11/9/09 (Dry)	2-3/10/09 (Dry)
Crimson Chat	*Epthianura tricolor*	9	♦	•	•			9			•
Orange Chat	*E. aurifrons*	9	♦	1	•	•		8			•
Black Honeyeater	*Sugomel niger*									•	
White-browed Babbler	*Pomatostomus superciliosus*									•	•
Chestnut-crowned Babbler	*P. ruficeps*			•			•	•		•	•
Cinnamon Quail-thrush	*Cinclosoma cinnamomeum*									•	
Chirruping Wedgebill	*Psophodes cristatus*	16	♦	•	2	•	5	3		6	•
Ground Cuckoo-shrike	*Coracina maxima*			•							
Black-faced Cuckoo-shrike	*C. novaehollandiae*	3		3			•	•	•	•	•
White-winged Triller	*Lalage sueurii*						•	•		•	
Rufous Whistler	*Pachycephala rufiventris*	1					•	1			•
Grey Shrike-thrush	*Colluricincla harmonica*			•			•				
White-breasted Woodswallow	*Artamus leucorynchus*			•	•			•			•
Masked Woodswallow	*A. personatus*										•
White-browed Woodswallow	*A. superciliosus*					•					•
Black-faced Woodswallow	*A. cinereus*			•	•	•	•				•
Grey Butcherbird	*Cracticus torquatus*			•							
Pied Butcherbird	*C. nigrogularis*			•			•	•	•	•	•
Australian Magpie	*Gymnorhina tibicen*			•	•	•	•	•	•	•	•
Grey Fantail	*Rhipidura fuliginosa*			•			•				
Willie Wagtail	*R. leucophrys*	6		3	•	2	1	•		•	•
Australian Raven	*Corvus coronoides*			•	•	•	•	•	•	•	•
Little Crow	*C. bennetti*					•	•		•	•	•
Restless Flycatcher	*Myiagra inquieta*			•			•				•
Magpie-lark	*Grallina cyanoleuca*	3		3	•	•	•	•	•	•	•
White-winged Chough	*Corcorax melanorhamphos*			•						•	•
Jacky Winter	*Microeca fascinans*							•		•	•
Red-capped Robin	*Petroica goodenovii*	3		•	1	1	•	1			•
Australian Reed-Warbler	*Acrocephalus australis*	3	♦		1			2			
Little Grassbird	*Megalurua gramineus*	3	♦		3	•		•		•	•
Rufous Songlark	*Cincloramphus mathewsi*							•			•
Brown Songlark	*C. cruralis*							•			•
White-backed Swallow	*Cheramoeca leucosternus*			•	•	•	•	•		•	•
Welcome Swallow	*Hirundo neoxena*	1		1		•	•	•			
Fairy Martin	*Petrochelidon ariel*			•			•	•		•	•
Tree Martin	*P. nigricans*					•		•			•
Mistletoebird	*Dicaeum hirundinaceum*	1		1		•	•			•	•
Zebra Finch	*Taeniopygia guttata*	34	♦	5	7	18	1	1	•	2	•
House Sparrow	*Passer domesticus*						•			•	•
Australian Pipit	*Anthus novaeseelandiae*			•	•		•				•

* During the course of this study, flocks of Blue-winged Parrots *Neophema chrysostoma* were regularly observed feeding on Lignum seed, both on the stems and on the ground surrounding Lignum clumps. This species migrates north from breeding grounds in Victoria and South Australia to forage during autumn and winter months and this food source has previously not been documented (Higgins 1999). Lignum seed may be an important winter food resource for this species.