

## Status and habitat of the Carpentarian Grasswren (*Amytornis dorotheae*) in the Northern Territory

Justin Perry<sup>A,C</sup>, Alaric Fisher<sup>B</sup> and Carol Palmer<sup>B</sup>

<sup>A</sup>CSIRO Ecosystems Sciences, Australian Tropical Science Precinct, PMB PO Aitkenvale, QLD 4814, Australia.

<sup>B</sup>Biodiversity Conservation, Department of Natural Resources Environment and the Arts, PO Box 496, Palmerston, NT 0831, Australia.

<sup>C</sup>Corresponding author. Email: justin.perry@csiro.au

**Abstract.** Birds with restricted geographical distributions are particularly vulnerable to environmental change. In order to evaluate their conservation status it is necessary to have accurate records of their distribution and how that distribution has changed over time. The determinants of the distribution and abundance of the Carpentarian Grasswren (*Amytornis dorotheae*) are poorly known. In this study, we revisited eight locations in the Northern Territory where this species had been previously recorded. We examined the habitat and management characteristics of the sites where it was present or absent at both a local and landscape scale. Non-detection of Carpentarian Grasswrens at seven of the eight sites suggests that this species has undergone an extensive retraction in range since they were last surveyed in 1986. An increase in the frequency of large, late dry-season fires in northern Australia seems to have had a profound affect on the distribution of this species and suggests it is extremely vulnerable to environmental change.

**Additional keywords:** fire, Northern Australia, *Triodia*.

### Introduction

The Carpentarian Grasswren (*Amytornis dorotheae*) is a small passerine (Maluridae, Australo-Papuan wrens) restricted to plateaux and hills at the headwaters of the Gulf of Carpentaria of northern Australia (Schodde 1982). There are 10 recognised species of grasswren in Australia (Christidis and Boles 2008), all of which occupy a narrow range of habitats. This habitat specialisation is thought to be a function of limited dispersal ability, which makes them particularly vulnerable to changes in land management that may affect their preferred habitat configuration. Several small studies have identified clear and significant contractions in range in several species of grasswren (Schodde 1982; Brooker 2000; Garnett and Crowley 2000).

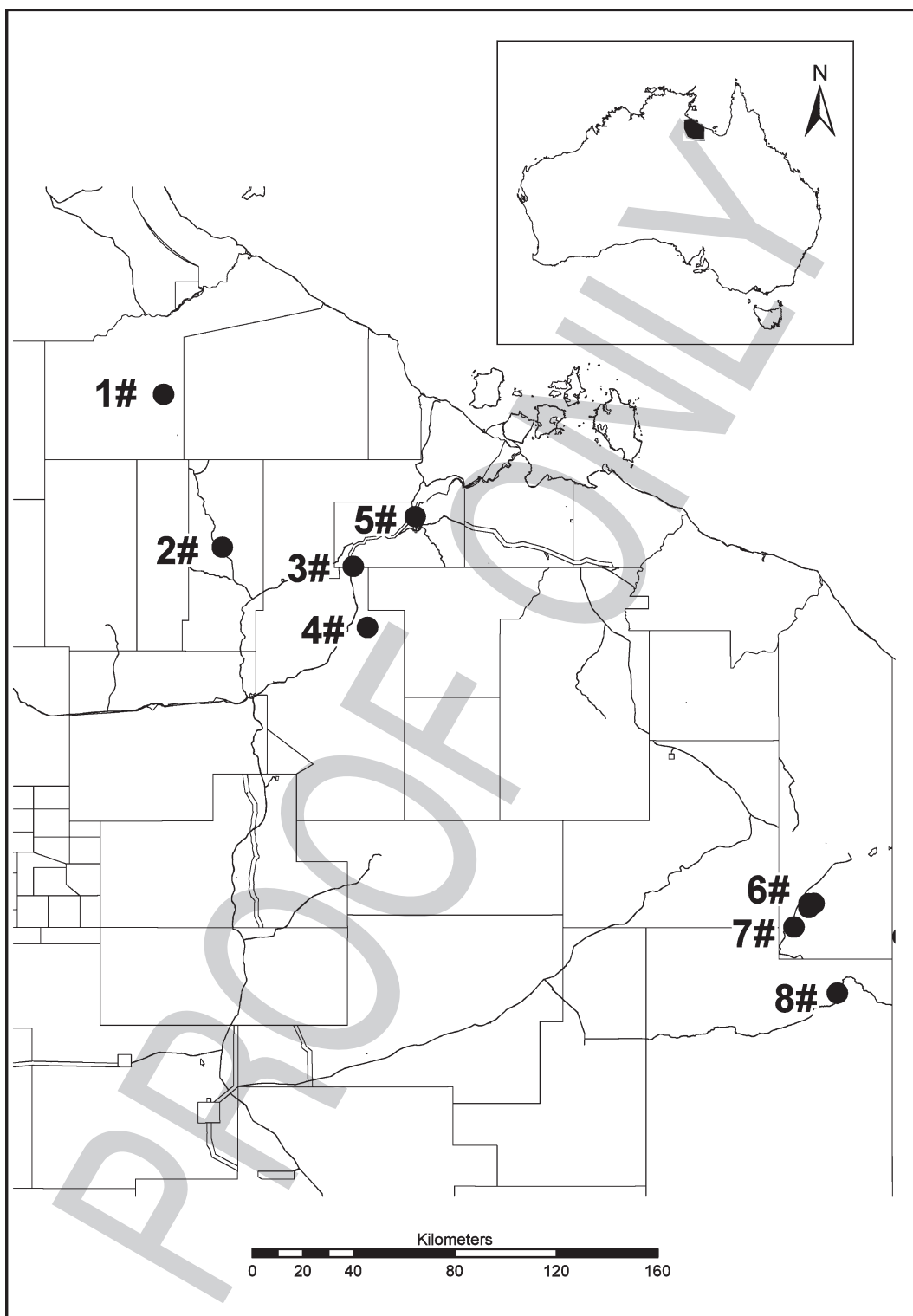
Before 1991, Carpentarian Grasswrens were known from only six sites within the southern Gulf of Carpentaria uplands in the Northern Territory (NT) (Martin and McKean 1986). Since 1991, Carpentarian Grasswrens have been observed in many locations near Mount Isa in north-western Queensland centred on a well-known site at McNamaras Road (Beruldsen 1992; Harris 1992; Harrington *et al.* 2009; Harris and Stewart 2009). The last published record of Carpentarian Grasswren in the NT was in 1991 (Chapman 1996), and the paucity of contemporary sightings has raised concerns about its status. There are suggestions that changed fire management has degraded Carpentarian Grasswren habitat, precipitating a decline in numbers (Schodde 1982; Harrington *et al.* 2009). This study aimed to clarify the status of the Carpentarian Grasswren in the NT by revisiting locations where the species has been previously reported, and recording

habitat and land-management characteristics of sites where it is still extant or apparently absent. Without this information, targeted action to recover populations of this restricted species will not be possible. More detailed information on the status of this species will also help to inform national listing under the Commonwealth *Environmental Protection and Biodiversity Conservation Act* 1999.

### Methods

#### *Study sites and surveys*

The known distribution of Carpentarian Grasswrens is in the Gulf of Carpentaria hinterland, between the Limmen River (NT) and Mount Isa (Queensland). Eight sites were selected for sampling based on previous observations (Martin and McKean 1986; Fig. 1). As Carpentarian Grasswrens are notoriously difficult to survey, being shy, cryptic and unreliable in their response to call-playback, we developed a search methodology to maximise success of recording the species at each site via reference to well-established search methods used at a grasswren site near Mount Isa. This site has been sampled consistently between 1998 and 2003 (B. F. Forsyth, unpubl. data). The following details shaped our final survey methodology: the average time for successful searches was 3.8 h; Carpentarian Grasswrens were observed throughout the day; the largest number of successful searches was between 1100 and 1300 hours; and success of searches was approximately consistent across the dry season months of May to September (compared with these months



**Fig. 1.** Location of survey sites for Carpentarian Grasswrens, which represent all sites in the NT where they had been recorded historically. Sites: 1# Nathan River; 2# Tawallah Range; 3# Bukalara Range; 4# Glyde River; 5# Borroloola; 6# Moonlight Gorge; 7# Aquarium Springs; 8# Abandoned Tin Mine, China Wall.

there were relatively few searches in other months). This information suggested that it was unnecessary to target survey effort to a specific time of day (e.g. early morning) and birds were detected in all months during the dry season. Searching for a longer duration coupled with a wide search area per site was therefore the key element in reducing the possibility of a false-negative result.

For the surveys, each of the eight sites was divided into two subsites. One of the subsites encompassed the historical location of the Carpentarian Grasswren as precisely as possible, and the other was selected in the same or similar habitat within 5 km of the historical location. The search method involved walking three 1-km transects ~400 m apart. Transect locations were recorded using non-differential handheld GPS units. A Carpentarian Grasswren call (BOCA 2000) was broadcast using a portable compact disc player and a small portable speaker, for 30 s, at nine stops evenly spread along the transects. After the call was played, another minute was spent waiting for a return call.

The habitat characteristics of each site were recorded from a minimum of eighteen 0.25-ha quadrats spaced evenly along the search transects. Additional quadrats were recorded where Carpentarian Grasswrens were observed. Digital photographs were taken at each quadrat for future reference. The variables recorded were based on published and unpublished information pointing to the possible habitat requirements of this species (Schodde 1982; Martin and McKean 1986; Noske 1992). These included measures of rockiness, slope, past fire effect and severity, and vegetation structure. A full list of the habitat variables collected and associated methodology is provided in Accessory publication (Table A1) and a comprehensive description of the methods can be found in Perry (2005).

### Analysis

We examined variation in the habitat factors at sites where Carpentarian Grasswrens were present or absent at two scales: (1) at a local scale, using data from site 6 (the only site at which Carpentarian Grasswrens were recorded); and (2) at a landscape scale, comparing data from site 6 against all other sites (where no Grasswrens were recorded). We undertook these analyses to investigate whether there are key habitat characteristics that

define where Carpentarian Grasswrens were recorded at site 6, and to investigate if there were significant broader scale differences in the site where Carpentarian Grasswrens were present and those where they were absent. In the latter case, we treat all the site 6 quadrats as nominally 'present' sites, because we want to examine whether there are features of this site compared with the others that might help explain why Carpentarian Grasswrens were recorded only there. We used non-parametric Mann–Whitney rank tests to test for variation in the habitat factors between quadrats and sites where Carpentarian Grasswrens were present and those where absent. Data used in both analyses were at a quadrat scale. In the first test (i.e. within site 6 only) there were 5 present versus 16 absent quadrats. In the second test between sites there were 21 present quadrats and 128 absent quadrats.

It is likely that Carpentarian Grasswrens are limited by factors at a broader spatial and temporal scale than those measured in the site-scale analysis. To account for this, fire frequency, mean annual temperature, mean annual precipitation, geology and a derived topographic position index (Table 1) were compared against a randomly sampled pseudo-absence background of 10 000 unique points representing the potential known range of Carpentarian Grasswrens within 250 km of all occurrence points (Martin and McKean 1986; Harington, unpubl. data) using maximum entropy (Maxent) species habitat modelling with the program Maxent version 3.3.0 (see <http://www.cs.princeton.edu/~schapire/maxent/>, accessed 15 May 2011). Maxent is a presence-only probabilistic model that uses selected environmental variables to determine the most likely theoretical niche for each species. Maxent creates a uniform layer (x) that represents a probability distribution of entropy based on the set of environmental variables selected as the background that are compared with the occurrence values to determine which variables are most likely to be influencing species distributions using a logistic approach. Model accuracy was determined by comparing how distant the presence records are from the random background as measured by the area under the receiver operator curve (AUC). A model that is no better than random will have an AUC of ~0.5 whereas a very accurate model will have an AUC approaching 1 (Phillips *et al.* 2006).

**Table 1. Environmental variables used in Maxent species distribution modelling**

Variable	Source and description	Range
Fire frequency (number of times burnt during 1997–2009)	North Australian Fire Information (available at <a href="http://www.firenorth.org.au/nafi/app/init.jsp">http://www.firenorth.org.au/nafi/app/init.jsp</a> , accessed 3 September 2010)	0 = no fire 12 = annual fire
Mean annual temperature	Derived using Anuclim 5.1 software (McMahon <i>et al.</i> 1995) and a ~250-m resolution DEM (GEODATA 9 s DEM Version 2: Geoscience Australia, <a href="http://www.ga.gov.au/meta/ANZCW0703005624.html">http://www.ga.gov.au/meta/ANZCW0703005624.html</a> , accessed 16 May 2011)	18–30
Topographic position index	Derived using a filled 9 arc-second Digital Elevation Model using TPI tool in ArcMap (Jenness 2006)	Values close to 0 indicate a flat landscape; increasing negative values tend towards gullies and ravines; increasing positive values tend towards hilltops or ridges
Lithology	Lithology Type 1 : 1 000 000 National Geology Map (Raymond and Retter 2010)	1–644

## Results

A total of 170 km of transects was walked and 138 h spent searching for Carpentarian Grasswrens at the eight sites. It took an average of 8.6 h (s.d. 1.93) to complete surveys at each subsite. The average total length of transects per subsite was 10.6 km (s.d. 5.86). Call broadcasting was used 117 times and was successful three times. Carpentarian Grasswrens were observed at only one of the eight sites surveyed, consisting of a total of eight individuals seen across five quadrats.

There was significant variation in the habitat factors at the two scales. Within site 6, fire damage, percentage of quadrat area burnt and canopy cover (%) were all significantly higher in quadrats from which Carpentarian Grasswrens were absent (and conversely lower in the presence quadrats), and distance to the nearest track or road, time since fire, percentage cover of big rocks and percentage cover of *Triodia* in the 40–60-cm range was higher in the quadrats in which Carpentarian Grasswrens were present (Table 2). In the site 6 versus all remaining site comparisons, current water, fire damage, percentage cover of pebbles, and canopy cover (%) were all significantly higher in quadrats in which Carpentarian Grasswrens were absent (and conversely lower in the presence quadrats) and distance to track or road, time since fire, the number of deep broad gullies and sedge cover (%) was higher in the sites where Carpentarian Grasswrens were present (Table 2).

Species distribution models using broad-scale remotely sensed environmental variables were influenced primarily by lithology (31.4%), fire frequency (27.2%), annual precipitation (20.8%) and distance to hills (18.5%). Mean annual temperature (1.5%) and topographic position index (0.5%) did not greatly influence the model. Model outputs indicate a habitat preference

for sandstone and conglomerate lithology and an annual rainfall of ~800 mm (Fig. 2). Models predicted that Grasswrens were more likely to be found <1 km from a ridge or hilltop. Although the model was not influenced greatly by mean annual temperature and topographic position index, the response curves indicated a preference for areas with a mean annual temperature >25°C within structurally diverse areas (ridges or gullies rather than flatter areas) (Fig. 2). Models were accurate within the northern range of the Carpentarian Grasswren (mean AUC 0.92) after bootstrapping 20 times, but did not predict well into the known southern range of the species near Mount Isa, Queensland.

## Discussion

### Status

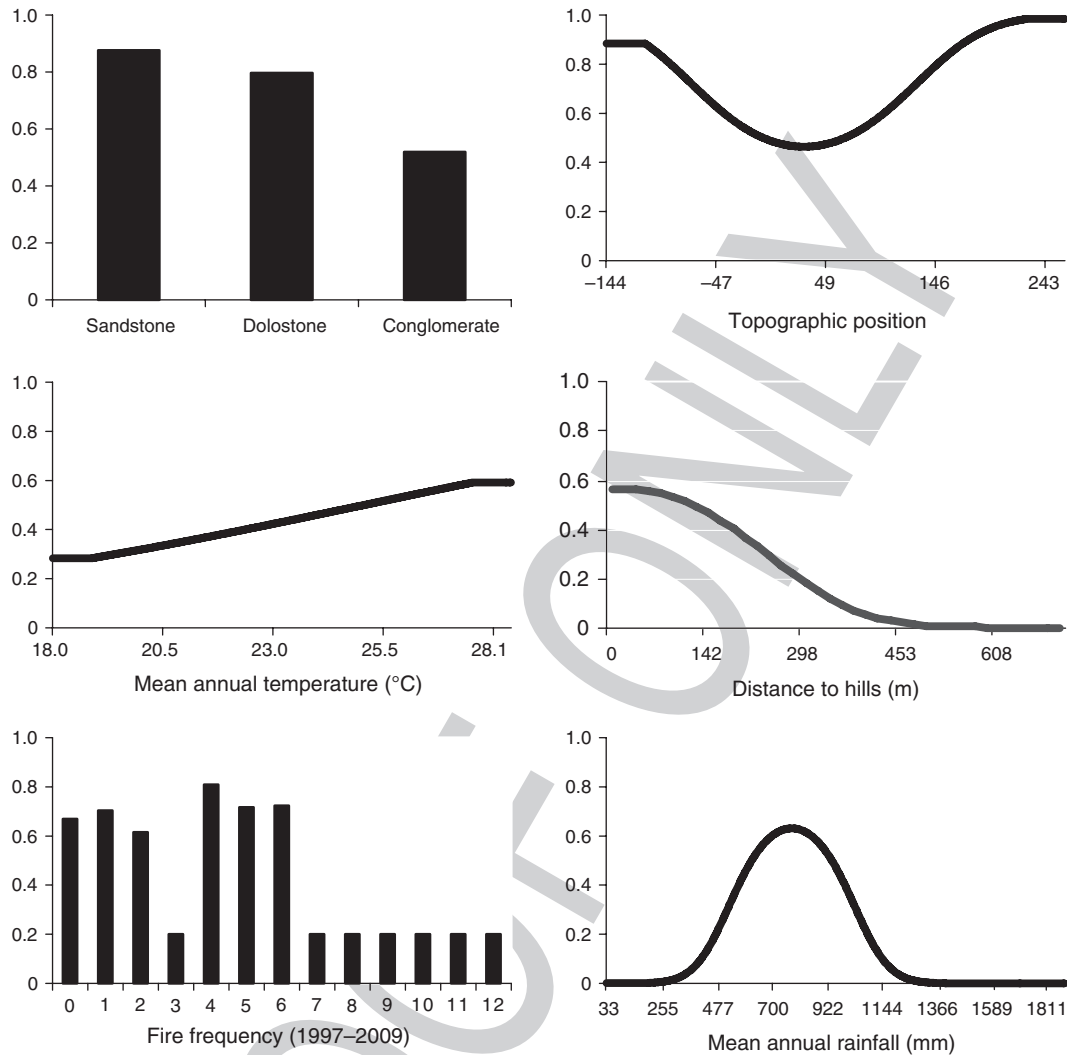
Carpentarian Grasswrens were observed at only one of eight sites and in five of 117 quadrats in this study, a result of great concern. Although this species is notoriously cryptic, it is unlikely, given the search effort, that Carpentarian Grasswrens were missed at all seven sites where they were not recorded. The results of this study, subsequent surveys by Harrington *et al.* (2009), and the absence of anecdotal sightings of Carpentarian Grasswrens in the NT since the late 1990s suggest this species might be in severe decline and of significant conservation concern. It also strongly supports the current listing as endangered under the *Territory Parks and Wildlife Conservation Act 2000* (NT), and there may be a case to revise the classification to critically endangered, using the IUCN (2001) criteria of a population reduction of >80%, which has occurred in the NT since 1986, and a known extant population occurring in an area <100 km<sup>2</sup>. Recent surveys of the entire range of Carpentarian Grasswrens indicate that the

**Table 2.** Variation in habitat scores analysed at two scales, using the non-parametric Mann–Whitney rank test

The first comparison is between presence and absence quadrats at site 6, and the second between site 6 (the only site where Grasswrens were recorded) and the remaining sites. Tabulated data are the mean ± standard error; values in bold represent the highest mean score; *n* is the number of quadrats in that comparison; *Z* is the Mann–Whitney test statistic; and *P* is the significance level. A full list of the habitat variables and associated methodology is provided in Accessory publication (Table A1)

Scale and variable	Carpentarian Grasswren		<i>Z</i>	<i>P</i>
	Absent	Present		
Local (within site 6)	<i>n</i> = 16	<i>n</i> = 5		
Distance to road or track (m)	1338.6 ± 101.1	<b>3826.0 ± 322.9</b>	−3.13	0.002
Fire damage (index 0–5) <sup>A</sup>	<b>2.5 ± 0.1</b>	1.0 ± 0.5	2.40	0.015
Time since fire (years)	3.5 ± 0.1	<b>4.8 ± 0.2</b>	−2.72	0.006
Percentage burnt	<b>45.5 ± 2.4</b>	16.0 ± 12.2	2.37	0.017
Big rocks (60 cm–2 m wide)	14.5 ± 1.1	<b>25.2 ± 6.2</b>	−1.70	<0.1
Hummock 40–60 cm tall	6.9 ± 0.6	<b>17.4 ± 5.0</b>	−2.26	0.023
Canopy cover (%)	<b>8.0 ± 0.6</b>	3.4 ± 0.0.5	1.69	<0.1
Landscape (across sites)	<i>n</i> = 128	<i>n</i> = 21		
Distance to current water (m)	<b>392.3 ± 13.6</b>	309.7 ± 39.7	2.15	0.038
Distance to road or track (m)	949.2 ± 52.0	<b>4151.8 ± 121.4</b>	−7.47	<0.001
Fire damage (index 0–5) <sup>A</sup>	<b>2.6 ± 0.1</b>	1.8 ± 0.3	2.07	0.039
Time since fire (years)	3.4 ± 0.1	<b>4.2 ± 0.1</b>	−3.62	<0.001
Pebbles (<0.6 cm wide)	<b>3.2 ± 0.7</b>	0.5 ± 0.1	2.05	0.038
Percentage of site described as				
Deep Gully Broad	0.5 ± 0.3	<b>4.7 ± 3.1</b>	−2.49	0.012
Sedge (proportion of 100-m transect)	0.2 ± 0.1	<b>0.5 ± 0.2</b>	−4.67	<0.001
Canopy cover (%)	<b>8.5 ± 0.6</b>	3.9 ± 0.4	3.27	0.001

<sup>A</sup>Fire damage relative score: 0, no visible effect from fire; to 5, significant effect from fire.



**Fig. 2.** Maxent species distribution model response curves and histograms. Environmental variable values are presented on the x-axis and include: lithology (only the top three lithographic groups presented), topographic position index (values close to 0 are flatter, increasing positive values represent hills and ridges, increasing negative values represent gullies and ravines), mean annual temperature (°C), distance to hills (m), fire frequency (between 1997 and 2009) and mean annual rainfall (mm); y-axis values represent likelihood value between 0 and 1.

Queensland populations are stable in areas that do not experience frequent fire (Harrington *et al.* 2009).

#### Habitat

The northern population of Carpentarian Grasswrens has highly specialised habitat preferences at both landscape and site scales. The historical sites were restricted to dissected, topographically complex, sandstone and conglomerate hills and plateaux. This is in contrast to the southern population (near Mount Isa, Queensland), which is spread across a diverse range of habitat types, ranging from hills to alluvial plains (J. Perry and G. Harrington, unpubl. data). Although annual rainfall was an important predictor for this species at a landscape scale the known distribution of Carpentarian Grasswrens indicates that they have a far broader climatic range than the model suggests.

We found that Carpentarian Grasswrens occurred in areas that afforded some protection from fire and predation provided by rockiness and topography of habitat. The sites where Carpentarian Grasswrens were absent in this study were far more susceptible to fire and some areas experienced biennial fire in the past 12 years. In contrast, the site where Carpentarian Grasswrens were observed was burnt only twice in the past 12 years (North Australian Fire Information, see <http://www.firenorth.org.au/nafi/app/init.jsp>, accessed 12 September 2010). However, as fire frequencies were derived using fairly coarse imagery (1.1-km<sup>2</sup> pixel resolution), the heterogeneity of fires at a finer scale will not be evident using these data (Yates *et al.* 2008). Analysis of the site-scale data showed that, on average, sites that were affected by fire retained ~50% unburnt vegetation.

The sites of historical and contemporary records of Carpentarian Grasswrens tended to be dominated by large rocks

embedded in broader dissected sandstone plateaux. Price *et al.* (2003) found that rocky terrain (40–50% of the area comprising rock) protects vegetation from fire, and in this study we observed remnant pockets of mature *Triodia* in rocky, fire-affected areas. More homogenous landscapes were more likely to be affected by fire because, in the absence of physical barriers, large areas were equally susceptible. Without alternative shelter, the loss of *Triodia* in these less-topographically diverse areas is likely to increase the probability of predation on Grasswrens.

### Threats

Changed fire regimes have been postulated to be the greatest threat to the Carpentarian Grasswren in the NT (Schodde 1982; Martin and McKean 1986; Chapman 1996; Garnett and Crowley 2000; Harrington *et al.* 2009). Frequent fire could affect Carpentarian Grasswrens by reducing the availability of mature *Triodia* for shelter, nutrition and nesting sites and by direct mortality to nestlings and adults (Martin and McKean 1986). Historical descriptions of the Gulf of Carpentaria uplands portray a landscape dominated by mature *Triodia*. Barnard (1913) described the area as containing ‘great masses of ‘old man’ spinifex’. Furthermore, Officer (1972) indicated that *Triodia* was abundant in the area around the Glyde River and was up to ‘six feet’ tall (~182 cm) in some places. This is incongruent with the average height of *Triodia* in this study, which was only 40 cm. *Triodia* can take up to 5 years to reach maturity (Felderhof and Gillieson 2006) and based on the fire-frequency data, at least some of the northern habitat has the potential to burn every 2 years. Given the reliance of Carpentarian Grasswrens on mature *Triodia*, for nesting and shelter, this frequency of fire is potentially catastrophic and may explain their absence at these sites (compared with the seemingly stable populations further south where fires are infrequent).

### Conclusion

In this survey, Carpentarian Grasswrens were located in only one of eight sites in the NT where the species was previously known to occur. Coupled with the scarcity of anecdotal records in the past 15 years, there is clearly cause for concern over the status of this species in the NT. The sparse evidence available suggests that the cause of the decline is most likely to be related to frequent fire altering the structure of *Triodia* hummock grasslands on rugged hills and plateaux in the Gulf of Carpentaria, NT. The northern population of Carpentarian Grasswrens is far more restricted in use of habitat type than the southern population. This is most likely a response to the higher frequency of fire in the northern part of their range forcing them to select areas that have natural barriers to fire.

The current listing of endangered under the *Territory Parks and Wildlife Conservation Act* recognises the parlous state of the populations and affords it some protection. However, the significant range reductions since the late 1980s provide a compelling case for reclassification as critically endangered. Comparisons between the habitat of northern (NT) and southern (Queensland) populations of the Carpentarian Grasswren are currently underway (J. Perry and G. Harrington, unpubl. data) and these data will

provide a far better understanding of the habitat requirements and status of this species across its entire range.

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