

An isolated population of the southern scrub-robin (*Drymodes brunneopygia*) in the Great Victoria Desert

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Abstract. From 2013 to 2015 we recorded an isolated, highly fragmented and previously undocumented population of the southern scrub-robin within the arid shrublands of the Great Victoria Desert. In this region, the southern scrub-robin persists in scattered and intermittent areas of long-unburnt mulga (*Acacia* spp.) shrubland, with a dense shrubby understorey dominated by *Aluta maisonneuvei* and *Eremophila* shrubs. The Great Victoria Desert supports the only known desert population as the southern scrub-robin otherwise occurs in the temperate and semiarid shrublands of southern Australia and occurs in the desert at the arid extreme of its range. Fire is highlighted as a significant threatening process due to the species' restricted occurrence (less than 5% of the landscape in the region), low reproductive rate, limited dispersal capability and persistence within long-unburnt and fire-sensitive habitats. As forecast environmental changes are likely to render the arid extremes of the species' range unsuitable, this outlying, desert population is potentially declining and of conservation significance.

Additional keywords: climate change, distribution, ecology, fire, range extension, relic population.

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Introduction

The arid zone of Australia covers ~70% of the continent and is broadly defined as areas receiving an average of 250 mm or less of highly irregular rainfall. Within the arid zone, resource variations influence the distribution patterns of plants and animals as environments are shaped by flood, fire and drought (Whitford 2002; Bradstock *et al.* 2012; Nano *et al.* 2012; Woinarski *et al.* 2014). Arid bird assemblages are dynamic, containing a core guild of resident, specialist or persistent species, augmented by nomadic (opportunistic) species when conditions are favourable (Morton and Davies 1983; Tischler *et al.* 2013; Woinarski *et al.* 2014). Vegetation type is a key determinant of bird distributions and predictable avian patterns can be observed (e.g. within chenopod, mulga, eucalypt and riverine associations) (Cody 1994; Johnstone *et al.* 2000; Leavesley 2008; Pavey and Nano 2009; Burbidge *et al.* 2010; Reid and Gillen 2013).

However, across the arid zone, the distribution and occurrence of many birds has changed in response to anthropogenic disturbance, particularly land degradation, habitat alteration and fire, and striking patterns have emerged from several groups (Saunders and Curry 1990; Reid and Fleming 1992; Smith and Smith 1994; Woinarski and Recher 1997; James *et al.* 1999; Johnstone *et al.* 2000; Leavesley 2008; Woinarski *et al.* 2014). Water-dependent or mobile species – e.g. galah (*Eolophus roseicapilla*), crested pigeon (*Ocyphaps lophotes*), Australian magpie-lark (*Grallina cyanoleuca*) – have been favoured by the

creation of open landscapes and water sources associated with agriculture and mining (Reid and Fleming 1992; Read *et al.* 2000). Conversely, sedentary, ground-dwelling passerines have been adversely affected by changes in floristics and habitat structure with their limited mobility an important risk factor (Reid and Fleming 1992; Woinarski and Recher 1997).

The southern scrub-robin (*Drymodes brunneopygia*) is a sedentary, ground-dwelling passerine that inhabits dense shrublands and woodlands of southern, semiarid and temperate Australia (Brooker 2001; Johnstone and Storr 2004; Scoble 2012) (Fig. 1). It both feeds (for invertebrates, seeds and fruits) and nests at ground-level (Johnstone and Storr 2004) and, as a result, a fundamental habitat requirement is the presence of an intact and dense shrub layer (Scoble 2012). In Western Australia, the species inhabits dense shrublands (particularly of *Acacia*, *Melaleuca* and *Allocasuarina*) or mallee with a dense shrubby understorey, occurring in a broad band across the semiarid zone straddling the temperate south-west and arid interior (Johnstone and Storr 2004; Fox *et al.* 2016). The species has a low reproductive rate (lays a clutch of one egg: Johnstone and Storr 2004) and movements and dispersal appear limited (Brooker 2001; Johnstone and Storr 2004; Huggett *et al.* 2004). At the arid fringes of its range, the southern scrub-robin occurs in a few, small, isolated and poorly known populations (e.g. near Menzies, Davyhurst and Kalgoorlie: Fig. 1) (Johnstone and Storr 2004; J. Turpin, pers. obs.).

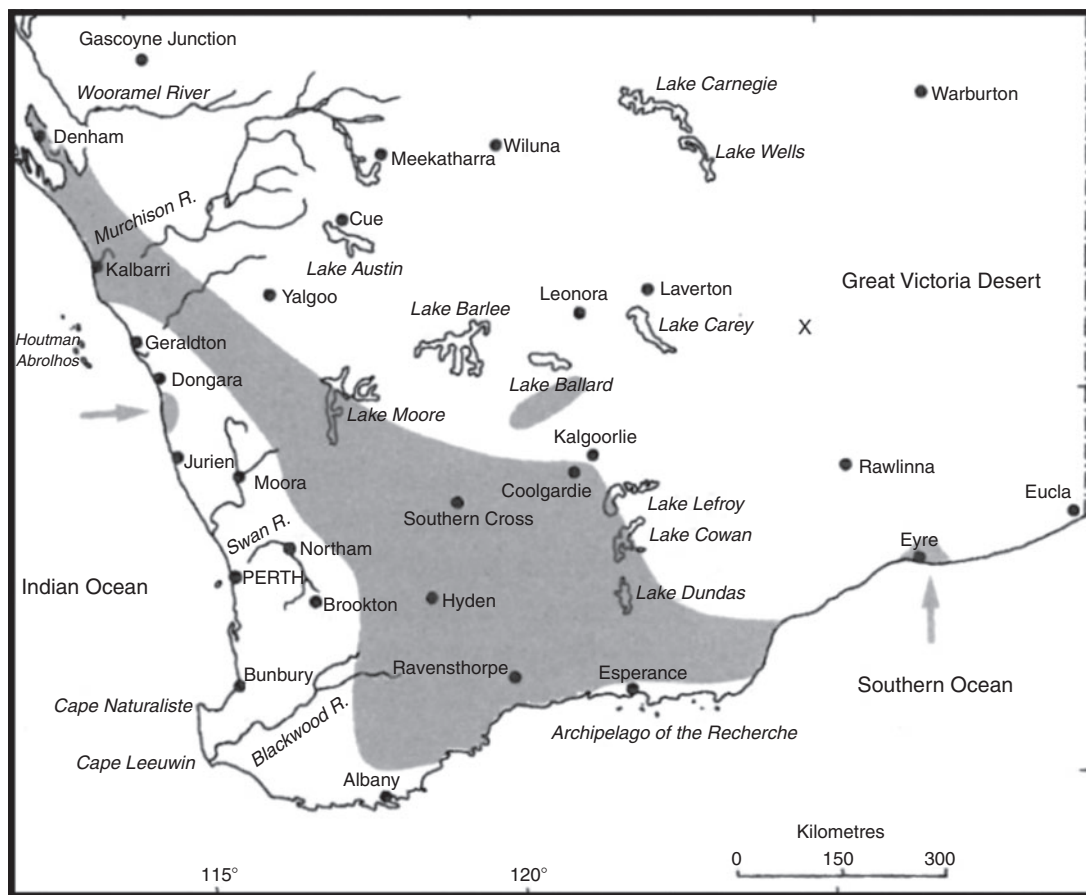


Fig. 1. Distribution of the southern scrub-robin in Western Australia as indicated in Johnstone and Storr (2004), extending from Peron Peninsula, south to the Stirling Range and east to Israelite Bay and Coolgardie. Note that Tropicana is marked with an X and other isolated populations occur south of Dongara (Cliff Head), Eyre and near Menzies.

Although the southern scrub-robin is classified under IUCN criteria as Least Concern (IUCN 2015), there is evidence of decline across its range (Saunders and Ingram 1995; Johnstone and Storr 2004; Huggett *et al.* 2004; Department of Environment and Natural Resources 2010; Garnett *et al.* 2011; Department of Environment and Heritage 2014; BirdLife Australia 2015a; BirdLife International 2015). This population decline has been attributed to habitat loss and degradation, increased predation (arising from exotic predators), grazing (pressures associated with exotic herbivores) and fire (Higgins and Peter 2002; Scoble 2012). In agricultural areas, the clearing and degradation of native vegetation has highly fragmented the species' habitat (and distribution) and some local extinctions have been noted (Johnstone and Storr 2004).

In October 2013, several southern scrub-robins were recorded by J. Turpin in the Great Victoria Desert over 300 km from the nearest known population (Fig. 1). While the region's bird assemblage had been documented across several surveys (e.g. Burbidge *et al.* 1976; Martinick and Associates 1986; Storr 1986; Johnstone and Storr 2004; *ecologia Environment* 2009a, 2009b, 2009c, 2009d; Ninox Wildlife Consulting 2009; Turpin 2014a, 2014b, 2015) the southern scrub-robin had not been previously recorded. This paper documents an

isolated and fragmented population of the southern scrub-robin at the arid extreme of the species' range. We discuss the species' occurrence, habitat and vulnerability in the Great Victoria Desert.

Methods

Surveys for the southern scrub-robin were carried out during five fauna surveys conducted near the Tropicana Gold Mine in the Great Victoria Desert (51J, 649448E, 6764924N) during October 2013, May 2014, September 2014, April 2015 and September 2015. Tropicana straddles the boundary of three biogeographic regions (IBRA Subregions: Great Victoria Desert 'Shield', Great Victoria Desert 'Central' and Nullarbor 'Carlisle': Department of the Environment 2014) and therefore the region contains a diverse range of vegetation types and habitats. Locally, the area is dominated by sand plain and sand dune fields supporting *Triodia* hummock grasslands and, to a lesser extent, open eucalypt woodland and mallee (e.g. *E. gongylocarpa*, *E. youngiana*, *E. concinna*, *E. trivalva* with *Callitris columellaris*). Undulating, stony and calcareous plains support open woodlands (such as *Casuarina*). Chenopod shrublands occur in association with saline soils, while rocky

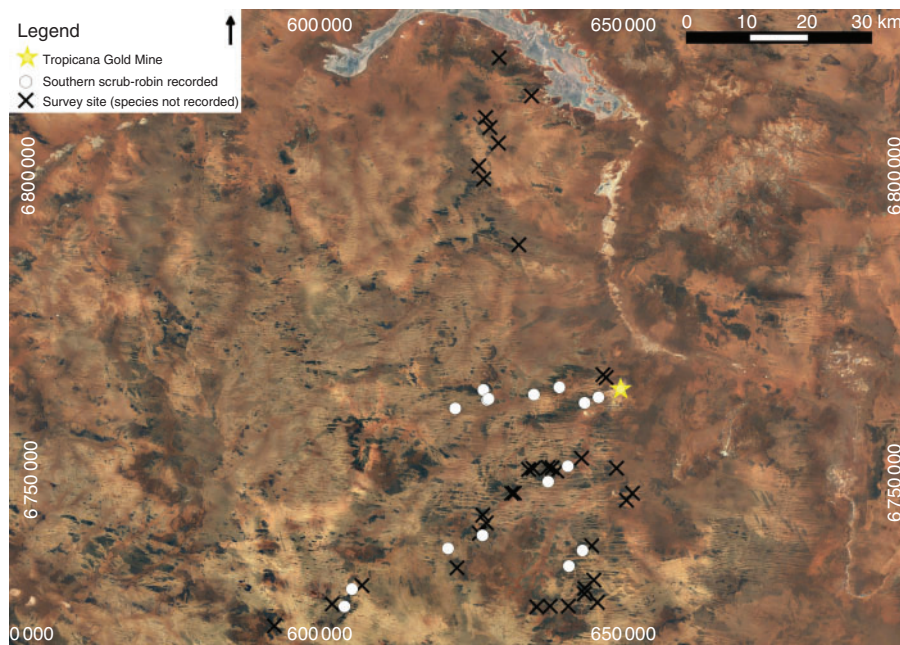


Fig. 2. Records of the southern scrub-robin from the Tropicana area, showing all the survey areas (blue indicates where the species was not detected, red indicates where the species was detected).

outcrops and hills are minimal. Dense, *Acacia*-dominated ('mulga') shrublands are uncommon and occur across a succession of age, composition and size classes (a reflection of the interaction of substrate, rainfall and fire history; Latz 1995; Walker and Hopkins 1998; Nano 2005; Nicholas 2007; Nano and Clarke 2008). Many occur as small, discrete and distinctive habitat patches scattered intermittently across the landscape (occurring on heavier red-earth soils, typically in areas providing some protection from fire, such as in the swales between sand-ridges, on lateritic gravelly slopes or rocky hills: Fig. 2).

The region's avian assemblage was sampled extensively via opportunistic and standardised census (2-ha, 20-min surveys: Turpin 2014a, 2014b) across all major vegetation types present. Once the southern scrub-robin was identified at Tropicana (during October 2013), target searches were subsequently conducted within areas of habitat deemed suitable to potentially support the species (dense shrublands; those accessible and within 80 km of Tropicana and larger than the minimum territory size recorded: Brooker 2001). Fifty-five patches of dense shrubland were selected using satellite imagery (readily visible as the landscape is dominated by open environments: see Fig. 2) and then surveyed for the birds' presence (Table 1, Fig. 2). The shrublands surveyed varied in age, fire history, composition and extent (ranging in size from 3 ha to almost 1000 ha: see Fig. 2). Most shrublands surveyed were dominated by *Acacia* (the main structural contributor to dense shrublands across the landscape) although two areas dominated by *Allocasuarina* were also sampled. To determine habitat preference, target searches extended beyond shrubland boundaries into adjacent habitats (often spinifex-dominated sandplain) and, as a result, all major habitats within the region were sampled for the presence of the southern scrub-robin.

To maximise the chance of detection, searches were conducted in the early morning and late afternoon (when birds are most active and vocal) and aided by the use of call-playback. The southern scrub-robin is highly social and territorial and adult pairs maintain permanent territories (mean of 4 ha: Brooker 2001). Males regularly defend the boundaries of their territories by song (Brooker 2001) and call throughout the year at dawn and dusk (J. Turpin, pers. obs.). However, birds can be difficult to detect during avian census as they are inconspicuous and elusive (especially in dense vegetation) and can remain silent for most of the day. Both sexes are detectable through call-playback as males readily respond (by call or investigation: J. Turpin, pers. obs.) and females move in close association.

To survey for the southern scrub-robin, two observers walked throughout each habitat patch searching for birds (observations or calls) and broadcasting prerecorded calls at regular intervals. Southern scrub-robin calls (recorded in the field and Bird Observers Club of Australia, 'Field Guide to Australian Bird-song CD8') were broadcast through a portable loud-speaker (Logitech X300) connected to an audio player (mobile phone, HTC One). Each sequence of calls was played three times and followed by 3 min of silence so any responding birds could be heard and located. If a southern scrub-robin was detected, the location, number of birds and habitat was recorded. If no birds were detected, call-playback was repeated and then the observers walked on. As the southern scrub-robin maintains territories several hundred metres across (Brooker 2001), call-playback was conducted at regular intervals to ensure calls were broadcast from multiple locations within any potential territory. In this way, searching was conducted from one side of a habitat patch to the other and then repeated on return via a parallel transect (200–500 m distant). Call-playback was also opportunistically conducted within a mulga patch if optimal habitat

Table 1. Southern scrub-robin (SSR) survey sites and records from Tropicana across five survey periods – October 2013 (1), May 2014 (2), September 2014 (3), April 2015 (4) and September 2015 (5)

Sites where calls were recorded (C) and genetic material collected by mist netting (G) are noted as are the number of individuals recorded in each survey period. Not all survey sites were accessed during each survey period and therefore many table cells remain blank where a site was not visited

Site	Easting	Northing	Vegetation	Patch size (ha)	SSR Recorded			Survey				
					Record (Yes/No)	C	G	1	2	3	4	5
Southern scrub-robin sites (UTM Zone 51)												
1	639291	6765222	Mixed <i>Acacia</i> shrubland	48	Y	Y		2	2	2		
2	627467	6763152	Mulga shrubland	50	Y			1	1			3
3	645694	6763579	Mulga, <i>E. forrestii</i> , <i>Aluta</i>	101	Y			2	1	0		
4	643427	6762667	Mulga, <i>E. forrestii</i> , <i>Aluta</i>	813	Y	Y			1	2	2	
5	635122	6764021	Mulga, <i>Eremophila</i> , <i>Aluta</i>	57	Y	Y		2		2		
6	626860	6764785	Mulga shrubland	472	Y			1				
7	640675	6752303	Mulga shrubland	100	Y	Y	Y			2		
8	621065	6738844	Mixed <i>Acacia</i> shrubland	104	Y (nest)	Y	Y			5		
9	605330	6732189	Mulga, <i>Eremophila</i> spp., <i>Aluta</i>	59	Y	Y				1		
10	604100	6729340	Mulga, <i>Eremophila</i> spp., <i>Aluta</i>	89	Y	Y	Y		2	5	2	
11	627704	6763332	Mulga, <i>Eremophila</i> shrubland	49	Y							3
12	626711	6740971	Mulga, <i>Eremophila</i> shrubland	673	Y							2
13	640853	6735950	<i>Acacia</i> , <i>Allocasuarina</i> shrubland	46	Y							2
14	637456	6749760	Mulga, <i>Eremophila</i> shrubland	265	Y							1
15	643079	6738502	Mulga, <i>Eremophila</i> shrubland	230	Y							2
16	622238	6761760	Mulga, <i>Eremophila</i> , <i>Aluta</i>	48	Y							2
Survey sites where the southern scrub-robin was not recorded (UTM Zone 51)												
A1	606967	6732773	Mulga shrubland	131	N					0	0	
PI1	635586	6729281	Mulga, <i>Eremophila</i> shrubland	95	N					0		0
PI2	637769	6729386	Mulga, <i>Eremophila</i> shrubland	136	N					0		0
PI3	640755	6729397	Mulga, <i>Eremophila</i> shrubland	14	N					0		0
PI4	645509	6729999	Mulga, <i>Eremophila</i> shrubland	60	N					0		0
PI1	626194	6741319	Mulga shrubland	530	N					0		
PI2	627323	6743024	Mulga shrubland	979	N					0		
PI3	626753	6744305	Mulga shrubland	157	N					0		
PI4	631479	6747866	Mulga shrubland	28	N					0		
PI5	631919	6747906	Mulga shrubland	340	N					0		
PI6	634261	6751754	Mulga shrubland	63	N					0		
PI7	634999	6751937	Mulga shrubland	105	N					0		
PI8	637447	6752078	Mulga shrubland	398	N					0		
PI9	638098	6752019	Mulga shrubland	150	N					0		
PI10	638871	6751499	Mulga, <i>Eremophila</i> , <i>Aluta</i>	238	N					0		
B1	626882	6799325	Mulga shrubland	152	N					0		
B2	629315	6805186	Mulga shrubland	113	N					0		
B3	627216	6809385	Mulga shrubland	90	N					0		
B4	627930	6807747	Mulga shrubland	115	N					0		
B5	634730	6812917	Mulga shrubland	118	N					0		
B6	629436	6819165	Mulga shrubland	58	N					0		
B7	626112	6801454	Mulga shrubland	22	N					0		
B8	632650	6788545	Mulga shrubland	202	N					0		
S1	588489	6699153	Mulga shrubland	302	N						0	0
S2	510407	6674965	Mixed <i>Acacia</i> shrubland	92	N						0	0
S3	510307	6675374	Mixed <i>Acacia</i> shrubland	89	N						0	0
A	646429	6767290	Mulga shrubland	240	N					0		0
B	646950	6766812	Mulga shrubland	33	N							0
C	642913	6753602	Mulga shrubland	128	N							0
D	648652	6751972	Mulga shrubland	108	N							0
E	592633	6726164	Mulga shrubland	926	N							0
F	602097	6729745	Mulga shrubland	3	N							0
A	644937	6733654	Mulga shrubland	3	N							0
B	651256	6747869	Mulga shrubland	73	N							0
C	650271	6746728	Mulga shrubland	68	N							0
D	622531	6735656	Mulga shrubland	9	N							0
E	644588	6739264	Mulga shrubland	217	N							0
F	643459	6732300	Mulga shrubland	850	N							0
G	643409	6731428	Mulga shrubland	52	N							0

(a dense shrubby understorey) was encountered outside of a previous search zone. A minimum of 20 min was spent surveying within a habitat patch; however, larger patches were searched for over 2 h so the entire patch could be traversed. Some habitat patches were also subject to repeat searches (Table 1).

When the southern scrub-robin was located, a detailed vegetation description was recorded. The dominant taxa present within both the shrubland canopy (overstorey, over 2 m tall) and understorey shrub layer (from ground height to 2 m) were noted within a 50-m radius. At four locations, mist nets were used to capture scrub-robins, undertake anatomical measurements and to obtain samples for genetic analysis (feathers). Also where possible, we recorded contact calls and songs on an Olympus LS 14 Linear PCM Recorder for comparison with birds in other areas.

The extent of habitat available to the southern scrub-robin was also estimated within ~80 km of Tropicana (Tropicana north to Lake Rason, south to the Plumridge Lakes Nature Reserve Access track, east to near Plumridge Lakes and west ~80 km). Areas of potential habitat (*Acacia*-dominated shrublands larger than 1 ha, to include the minimum territory sizes recorded by Brooker 2001 in the arid zone) were selected using satellite imagery (Google Maps™ ©2005 Google), the programs Canvas (ACD Systems) and QGIS (QGIS Development Team 2015) and their areas then calculated. The total area of potential habitat was then calculated and expressed as a percentage of the surrounding landscape.

Results

Over three years of study, the southern scrub-robin was recorded at 16 sites located between 5 km and 65 km south and west of Tropicana Gold Mine (Figs 2–6, Tables 1–3). Most observations were of breeding pairs, but up to five individuals were recorded at a single location (Table 1) and one southern scrub-robin nest was located at the base of an *Acacia* shrub (height: 50 mm; internal diameter: 58 mm; depth: 50 mm). Five birds were also

netted and measured, and feathers were collected for later genetic analysis (Table 3). The species was recorded at several sites on multiple occasions (Table 1, recorded during 10 of 11 known site revisits) and at three sites was recorded across three successive surveys (within metres of the previous records) highlighting the birds' sedentary nature.

While detectable, the southern scrub-robin was recorded rarely and intermittently across the landscape (Table 1, Fig. 2). Of the 55 shrubland sites sampled, only 16 (29%) were confirmed to support the species (Table 1, Fig. 2). The southern scrub-robin was recorded only from within dense *Acacia* shrublands (Figs 3–5) with a distinctive cohort of understorey shrubs (Table 2). Scrub-robins were recorded from mature mulga shrublands (*Acacia aneura* complex – mostly *A. caesaneura*, *A. incurvaneura* and *A. aneura* var. *intermedia*; 2–5 m tall) with a well developed and dense understorey (1–2 m) dominated by *Aluta maisonneuvei* subsp. *auriculata* and/or several



Fig. 3. The southern scrub-robin recorded near Tropicana (photograph: J. Turpin).



Fig. 4. Habitat of the southern scrub-robin – dense *Acacia*, *Aluta maisonneuvei* and *Eremophila* spp. on sandplain (photograph: J. Turpin).



Fig. 5. Habitat of the southern scrub-robin – dense *Acacia aneura*, *A. ramulosa*, *Aluta maisonneuvei* and *Eremophila forrestii* on a sandy swale between dunes (photograph: J. Turpin).

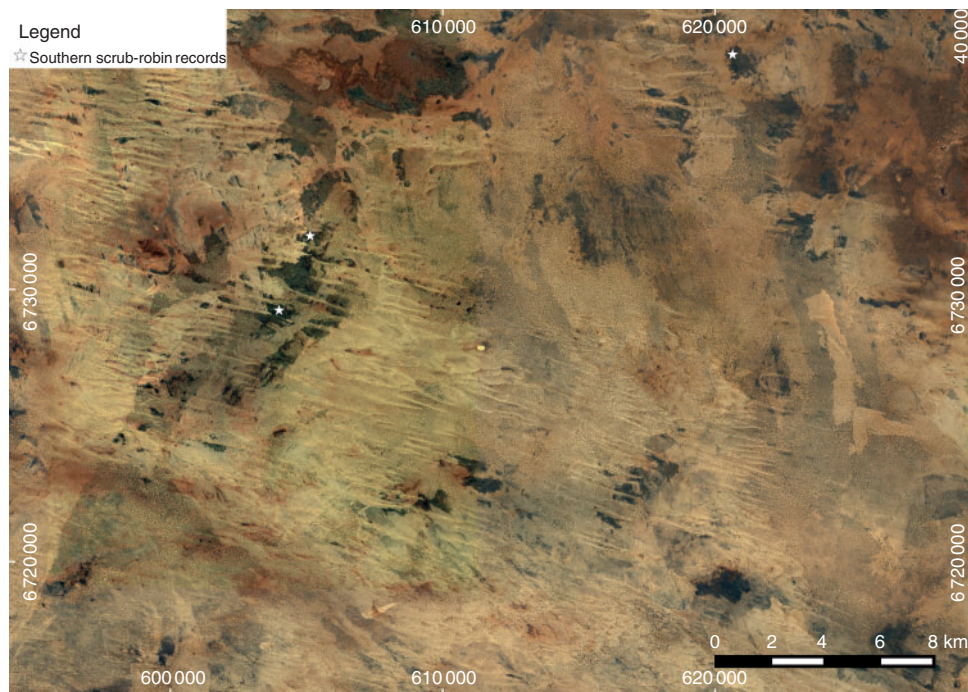


Fig. 6. Habitat fragments of the southern scrub-robin. An example of aerial imagery showing the limited extent of habitat (dark, dense mulga shrublands) surrounding by extensive areas of lighter-coloured spinifex-dominated hummock grasslands.

Table 2. Dominant vegetation recorded at southern scrub-robin sites

Species name	Site															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Dominant overstorey																
<i>Acacia aneura</i> complex ^A	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
<i>Acacia burkittii</i>								×	×	×			×			
<i>Acacia ramulosa</i> var. <i>ramulosa</i>	×		×	×		×	×	×	×	×		×		×		
<i>Acacia sibirica</i>						×		×		×	×					
<i>Acacia tetragonophylla</i>		×						×					×			
<i>Alyxia buxifolia</i>								×		×			×			
<i>Allocasuarina helmsii</i>													×			
<i>Eucalyptus leptopoda</i>	×	×		×	×	×	×			×	×	×			×	×
Dominant understorey																
<i>Aluta maisonneuvei</i> ssp. <i>auriculata</i>	×	×	×	×	×	×	×		×	×	×			×	×	×
<i>Eremophila clarkei</i>						×		×		×				×	×	×
<i>Eremophila decipiens</i>										×						
<i>Eremophila forrestii</i> ssp. <i>forrestii</i>		×	×		×		×			×	×	×				
<i>Eremophila latrobei</i> ssp. <i>latrobei</i>		×		×	×			×		×	×	×	×			
<i>Eremophila latrobei</i> ssp. <i>glabra</i>				×	×	×				×				×	×	×
<i>Eremophila platythamnus</i>							×				×			×		
<i>Scaevola spinescens</i>				×	×			×	×	×		×	×		×	
<i>Dodonaea lobulata</i>				×				×	×	×		×	×			
<i>Psyrax suaveolens</i>		×		×	×			×		×	×	×		×	×	
<i>Senna artemisioides</i>							×	×		×			×			
<i>Prostanthera laricoides</i>									×							
<i>Spartothamnella teucriflora</i>															×	
<i>Grevillea nematophylla</i>											×					
<i>Phebalium canaliculatum</i>																×

^ANote: *Acacia aneura* complex groups *A. caesaneura*, *A. incurvaneura* and *A. aneura* var. *intermedia* as the dominant overstorey.

Table 3. Measurements of the southern scrub-robin

Bird	Weight (g)	Wing (mm)	Bill exposed (mm)	Bill entire (mm)	Bill depth (mm)	Bill width (mm)	Tail (mm)	Tarsus (mm)	Toe, claw (mm)
1	33	95	13.25	17	4.7		115	33.7	17.7
2	28	96	13	18	4.7	4.9	103	37.5	19
3	34	94					97		
4	35	96	14.7	18.1	4.6	6.4	98	36	14
5	—	95	14	18			115	37	14
Mean	32.5	95.2	13.7	17.8	4.7	5.6	105.6	36.1	16.2

Eremophila species. Twenty-five dominant taxa were recorded across sites where the southern scrub-robin was present (Table 2). Three *Acacia* species (*A. caesaneura*, *A. incurva-neura* and *A. aneura* var. *intermedia*) dominated the shrubland canopy (overstorey above 2 m), which also included scattered *Acacia burkittii*, *Acacia ramulosa* var. *ramulosa* and *Eucalyptus leptopoda*. The understorey shrub layer was dominated by *A. maisonneuvei*, *E. forrestii*, *E. latrobei* (subspecies *latrobei* or *glabra*), *E. clarkei*, *Acacia ramulosa*, *Dodonaea lobulata*, *Scaevola spinescens* and *Psydrax suaveolens*. Such taxa (particularly *A. maisonneuvei*) form dense understorey shrub layers within mature mulga shrublands. The southern scrub-robin was not recorded within recently burnt (within 10 years), immature or developing shrublands (shrublands yet to reach their maximum height) or shrublands with a spinifex-dominated or sparsely vegetated understorey, seemingly because they fail to provide sufficient understorey habitat (as birds rely on dense understorey shrubs and litter layers for feeding and nesting: Brooker 2001).

The distinctive shrublands supporting the southern scrub-robin occurred in small, discrete areas ('patches') within a landscape dominated by spinifex sandplain (a characteristic of mulga observed throughout the region and elsewhere in dune-dominated deserts: Tischler *et al.* 2013) (see Figs 6, 7). Patch boundaries were readily visible on both satellite imagery and in the field as they corresponded to the often parapatric edge of mulga- and spinifex-dominated communities (a feature often observed across the arid zone: Bradstock *et al.* 2012). Occupied patches ranged in size from 46 ha to 813 ha (Fig. 7, Table 1). Most (11 of 16) were 120 ha or smaller (12 less than 1 km wide), with the seven smallest less than 60 ha (Table 1). While there appeared to be no relationship between patch size and sightings (correlation coefficient: 0.02, $n = 55$), the species was not recorded from habitat patches smaller than 46 ha ($n = 7$). The southern scrub-robin was not recorded from adjacent habitats despite extensive sampling across all major vegetation types (by us and others: Storr 1986; ecologia Environment 2009a, 2009b, 2009c, 2009d; Turpin 2014a, 2014b, 2015).

The occurrence of the southern scrub-robin within a mulga patch was restricted to areas of dense understorey development. As most surveyed mulga patches occurred as a heterogeneous mix of vegetation, and understorey varied (from sparse to densely vegetated or spinifex dominated, reflecting variations in fire history and substrate) the southern scrub-robin was not observed to be continuously distributed throughout. The species was recorded away from patch edges where vegetation was

sparse or where spinifex encroached the understorey. On most occasions the species was recorded more than 100 m from the patch boundary (16 of 18 records, mean 177 m, range 42–279 m).

While the southern scrub-robin was recorded at Tropicana over a total area of ~1200 km² (60 km × 20 km at range extremes), it occupies only a fraction of the landscape within this range (Fig. 7). Regional habitat mapping identified a total of 682 patches corresponding to 40 284 ha of potential habitat within ~60 km of Tropicana and an average patch size of 59 ha (Fig. 7). Across the known range of the southern scrub-robin at Tropicana, 467 habitat patches were recognised (totalling ~30 276 ha, mean of 65 ha) (Fig. 7). This corresponds to only 5.24% of the landscape. Potential habitat diminishes even further to the north of Tropicana, with 215 patches (totalling ~10 008 ha) or 1.61% of the landscape recognised within 60 km. As only a subset of the potential habitat patches will be suitable for the southern scrub-robin (suitable age, size, fire history and understorey shrub development; reflected in the species being detected at only 29% of sites; and many contain extensive open areas or a spinifex understorey), habitat suitable for the southern scrub-robin is likely to comprise an even lower percentage of the landscape.

Discussion

The southern scrub-robin records from Tropicana extend the species' range further into the arid zone, a region where the species is poorly documented (Johnstone and Storr 2004; BirdLife Australia 2015b). The records represent the first in the region despite over a decade of sampling (attributable to the birds' scarcity and cryptic nature). Few arid-zone populations are known (outlying Western Australian populations fringe the arid zone at Peron Peninsula, Menzies and Eyre) and the Great Victoria Desert supports the only known desert population (Johnstone and Storr 2004; BirdLife Australia 2015b). In a recent wide-scale survey and review of birds in the adjacent Great Western Woodlands the southern scrub-robin was shown to occur in the south-west (away from desert regions) and neither the species nor suitable habitat was detected in north-eastern areas fringing the Great Victoria Desert (absent east of Coolgardie and north and east of Norseman: Fox *et al.* 2016). Due to the discontinuity of habitat, the desert population appears isolated from the species' main range to the south and west (BirdLife Australia 2015b; Department of Parks and Wildlife 2015; Fox *et al.* 2016; J. Turpin, pers. obs.) and Tropicana lies near the species' northern, arid extreme.

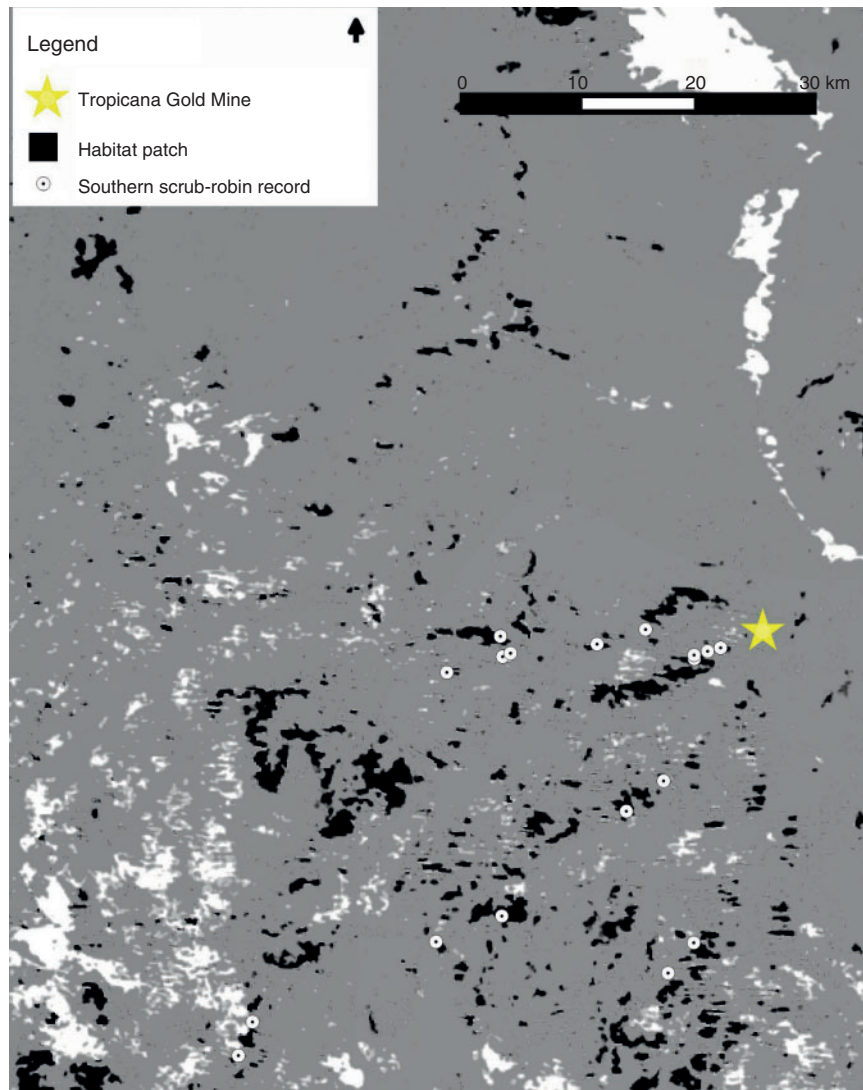


Fig. 7. Habitat patches of the southern scrub-robin (black) in the Tropicana area.

Across its range, Ford (1971) noted that southern scrub-robins did not differ significantly in size and colouration. The Tropicana birds fall within published size ranges; however, they show some variation in colour (Table 3, Johnstone and Storr 2004). In Western Australia, specimens from Peron Peninsula (the far north of the species' range) are distinctly paler when compared with birds from the south-east of the state (i.e. Israelite Bay and Nuytsland Nature Reserve). The single male specimen from the Great Victoria Desert, Tropicana area (WAM A38986) was noted to be considerably darker than specimens from Peron Peninsula and its physical appearance was most similar to that of specimens from the far south-east (Israelite Bay and Fraser Range), but was overall slightly paler. Judging from specimens in the Western Australian Museum, the trend from dark to paler birds is clinal from south to north (see plate 17 in Johnstone and Storr 2004) (Fig. 8).

In the Great Victoria Desert, the southern scrub-robin has a highly scattered distribution due to the fragmented nature of its habitat (Fig. 7). It is known only from a handful of locations,

restricted to long-unburnt *Acacia* (mulga) shrublands with a dense shrubby understorey dominated by fire-sensitive *Eremophila* and *Aluta* species (Walker and Hopkins 1998; Nano and Clarke 2008). While floristically different, such habitat shares structural similarities to that supporting the southern scrub-robin in its stronghold of the Great Western Woodlands, where mallee (e.g. *E. calycogona*, *E. livida* and *E. urna*) overlies a dense understorey dominated by *Melaleuca* shrubs (*M. uncinata*, *M. pauperiflora*, *M. adnata*, *M. lateriflora*, *M. eleuterostachya*, J. Turpin, pers. obs.).

Similar to many arid-zone birds, the distribution of the southern scrub-robin in the Great Victoria Desert appears highly influenced by the distribution, composition and extent of mulga shrublands. Mature shrublands (with a tall canopy, dense foliage, extensive leaf litter and a distinctive cohort of understorey shrubs) support distinctive bird assemblages (Reid *et al.* 1991; Cody 1994; Leavesley 2008; Pavey and Nano 2009; Burbidge *et al.* 2010; Leavesley *et al.* 2010), which in the Great



Fig. 8. Specimens of the southern scrub-robin from northern (A17701; Peron Peninsula, upper), central (A38986; Tropicana area, middle) and southern (A19948; Israelite Bay, lower) parts of its range showing the apparent cline in colour. Ventral (left), and dorsal (right) views show that specimens from the far north of the species' range are distinctly paler than birds from the south-east of the State (photograph: R. Johnstone).

Victoria Desert includes the southern scrub-robin. Where mulga occurs as small, discrete and isolated groves (e.g. in eastern areas of the Simpson Desert: Tischler *et al.* 2013) bird assemblages become less predictable, as many mulga birds are sedentary and rely on large areas of intact habitat to survive (Reid *et al.* 1991; Cody 1994; Schodde 1994; Huggett *et al.* 2004; Leavesley 2008). Our observations suggest that the southern scrub-robin requires large areas of intact and proximal habitat to survive in the Great Victoria Desert, a pattern also observed elsewhere (Huggett *et al.* 2004).

Many arid-zone birds are widespread, mobile or nomadic (Johnstone *et al.* 2000; Dean 2004; Burbidge *et al.* 2010; Tischler *et al.* 2013; Woinarski *et al.* 2014; BirdLife Australia 2015a). While some specialist, sedentary species persist, including in mulga (Cody 1994), very few have restricted distributions (e.g. *Amytornis*: Christidis *et al.* 2013). Most birds occurring in the Great Victoria Desert are widespread and occur across much of the arid zone. A small number of Bassian (southern) associated species have ranges that extend along the region's temperate-influenced southern margins, including a few wide-ranging, mobile species that visit during favourable conditions: regent parrot (*Polytelis anthopeplus*), purple-crowned lorikeet (*Glossopsitta porphyrocephala*), red wattlebird (*Anthochaera carunculata*) (J. Turpin, pers. obs.). Very few Bassian-associated species are resident; however, small, restricted populations of the Gilbert's whistler (*Pachycephala inornata*) and rufous treecreeper (*Climacteris rufus*) occur in mature woodland, and the southern scrub-robin is an unusual Bassian-associated mulga species. Unlike many mulga birds, which are widespread, arid-zone specialists (Cody 1994; BirdLife Australia 2015a, 2015b), the southern scrub-robin favours the temperate-influenced zones of southern Australia (Fox *et al.* 2016) and appears to lack many characteristics suitable to life in the arid zone (the species is sedentary, ground-dwelling, has a low reproductive rate, reduced dispersal capabilities, narrow habitat requirements favouring long-unburnt habitats, and is sensitive to isolation and habitat fragmentation: Johnstone and Storr 2004; Huggett *et al.* 2004). The species therefore appears highly susceptible to environmental stresses such as predation and fire, particularly

at the arid periphery of its range (such as at Tropicana), where environmental conditions are stressful and populations are comparatively small and fragmented (Woinarski and Recher 1997; Huggett *et al.* 2004; Scoble 2012).

Fire, and particularly fire frequency, has been highlighted as a significant threatening process to avian communities across arid Australia (Woinarski and Recher 1997; Bradstock *et al.* 2012). While fire is a key contributor to a mosaic of habitats and successional stages of vegetation that can enhance biodiversity, it can also threaten many species (e.g. specialist fauna with narrow habitat requirements such as hollow-nesters or leaf litter feeders, Woinarski and Recher 1997) and causes an almost complete turnover of species inhabiting mulga (Leavesley 2008). In the Great Victoria Desert fire poses a significant threat to the persistence of the southern scrub-robin as populations are small and fire impacts the composition, structure and extent of habitat (fire-sensitive mulga shrublands) on which the species relies (Reid *et al.* 1991; Latz 1995; Woinarski and Recher 1997; Nano 2005; Nicholas 2007; Nano and Clarke 2008; Leavesley 2008; Leavesley *et al.* 2010; Bradstock *et al.* 2012). Due to the birds' use of leaf litter layers for feeding and nesting, Brooker (2001) suggested that the southern scrub-robin was vulnerable to changes in quality and quantity of leaf litter, and such changes are likely to arise from fire. The species' limited range and restrictive biology (sedentary, limited reproductive potential, poor dispersal ability and narrow habitat requirements) are identified risk factors to single fire events (Woinarski and Recher 1997; Huggett *et al.* 2004). Regular, repeated fire events arising from changes to the region's fire regime (cessation of traditional burning practices) (Latz 1995; Nicholas 2007; Bradstock *et al.* 2012) cause changes to habitat composition and the contraction or elimination of habitat (mulga shrublands) (Williams 2002; Leavesley 2008; Bradstock *et al.* 2012). In the Tropicana area, extensive fires within the last decade have burnt large areas of mulga and many patches supporting the southern scrub-robin have had their margins reduced, replicating the pattern of contraction seen elsewhere in arid Australia (see Figs 9, 10) (Bradstock *et al.* 2012; J. Turpin, pers. obs.).



Fig. 9. Recently burnt mulga shrubland, showing the complete modification to the southern scrub-robin habitat (photograph: J. Turpin).



Fig. 10. Previously burnt mulga shrubland showing the extensive regeneration of spinifex grassland. Note the intact mature and dense mulga in the background (photograph: J. Turpin).

Avian decline has been documented for parts of Australia's arid zone although few studies have been conducted in the Western Australian portion of the Great Victoria Desert. While most mulga-dwelling birds have shown little decline (Reid and Fleming 1992; Leavesley 2008), the southern scrub-robin in the Great Victoria Desert is an unusual Bassian outlier and mulga-associated species at risk (Reid and Fleming 1992; Woinarski and Recher 1997) with evidence of decline across its range (Saunders and Ingram 1995; Johnstone and Storr 2004; Huggett *et al.* 2004; Garnett *et al.* 2011; BirdLife International 2015). The regional population meets several criteria listed under the IUCN Red List for threatened species (extent of occurrence, area of occupancy, highly fragmented habitat, apparent decline: IUCN 2015) and appears particularly vulnerable to disturbances and stochastic events such as drought.

The southern scrub-robin population at Tropicana is an arid-zone outlier and likely to be at a trailing edge of a range shift for

the species (predicted distribution changes associated with climate change) (Byrne *et al.* 2011; Scoble 2012; CSIRO and Bureau of Meteorology 2015). As the arid extremes of the southern scrub-robin's range may become unsuitable over the coming centuries and the species is sedentary and maintains year-round defended territories it is a prime candidate for ecological monitoring (Reid and Fleming 1992). We suggest that longevity may be an important factor in the species' survival in a resource-variable landscape as the longevity of some ground-dwelling, sedentary passerines has allowed for the persistence of populations in post-fire environments (Woinarski and Recher 1997). However, fragmented populations on the arid fringe (such as Tropicana) are vulnerable and have the potential for localised extinction as populations may be too small to be viable (Saunders and Ingram 1995; Johnstone and Storr 2004). While some of the mulga patches in the greater area are likely to support additional populations, many are likely to be too small, have been too recently burnt and/or support shrublands structurally too sparse to support the species. We recommend the monitoring of the Tropicana population to provide an indication of the species' stability, longevity and resilience in the region. We propose further studies to locate additional desert populations and to increase current understanding of the species' dispersal capability and habitat requirements, which will assist land managers in the conservation of this iconic and vulnerable species.

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