Targeted surveys for Rufous Scrub-birds in the Hunter Region in 2020

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The threatened Rufous Scrub-bird *Atrichornis rufescens* occurs in some isolated high-altitude locations in parts of north-eastern New South Wales and south-eastern Queensland, including within the Hunter Region where there is a known population of the southern subspecies *ferrieri* in the Gloucester Tops. The distribution of Rufous Scrub-bird elsewhere within the Hunter Region has been uncertain. Although there exist some reports from other locations, none of those reports appear to have been followed up for confirmation, and nor has there ever been any systematic assessment of other parts in the region. Bushfires in the summer of 2019-20 destroyed large amounts of habitat in New South Wales including in montane areas where the Rufous Scrub-bird potentially could occur.

The surveys conducted in this report covered areas that were burnt in the 2019-20 bushfires, seldom-visited sites where there was believed to be suitable habitat, and locations where there were historical reports for the species. A combination of transect-surveys and site-specific surveys was used. At each site surveyed, a description and current status of the habitat was recorded along with an assessment of suitability for the Rufous Scrub-bird.

The present study is the first systematic assessment of Rufous Scrub-bird distribution within the overall Hunter Region. Areas where scrub-birds might be present were identified by studying aerial photographs, topographical maps and vegetation maps and from a review of all the previous records. Three sub-sections of the Hunter Region were selected as priority areas for field assessment, and from within those areas 71 sites or transects were surveyed in 2020. All 71 sites/transects were visited during October/November when scrub-birds are most vocal. Many of the sites had been burnt in the 2019-20 bushfires.

Only six of the 71 surveys recorded a singing Rufous Scrub-bird. These sites were all near the periphery of the known population in the Gloucester Tops. Ten sites had previous reports of Rufous Scrub-birds calling but we did not hear birds calling at any of these sites. The majority of these ten sites did not appear to have the generally accepted habitat requirements for Rufous Scrub-bird. However, the habitat at 21 other sites was deemed to be suitable for scrub-birds and potentially suitable habitat was identified at 13 additional sites. At the six sites where scrub-birds were found in the surveys, the habitat was deemed to be typical of that used by scrub-birds elsewhere in the Gloucester Tops.

An important outcome of these surveys was that scrub-birds were only confirmed to be present in a small area of the Gloucester Tops, near to where there were previously-known territories. No scrub-birds were detected in any other part of the Hunter Region. This suggests that the local Rufous Scrub-bird population is much smaller than previously thought to be the case. That finding has important implications for the Rufous Scrub-bird's conservation status.

INTRODUCTION

The Rufous Scrub-bird *Atrichornis rufescens* is a cryptic species that lives in parts of north-eastern New South Wales and south-eastern Queensland. Its range is limited to a few isolated high-altitude locations, such as Barrington Tops National Park, the Hastings Range, and the New England National Park, where there is dense ground cover and deep leaf-litter in rainforest and wet eucalypt forest (Ferrier 1984). There are two subspecies, *rufescens* in the north of the range and *ferrieri* in the south (Garnett *et al*. 2011).

The Rufous Scrub-bird is classified as endangered under the Commonwealth *Environment Protection and Biodiversity Act 1999* and in the IUCN Red List of threatened species, and as vulnerable in NSW under the New South Wales *Biodiversity Conservation Act 2016*. Threats to the species include destruction of habitat through fire, predation by feral animals, increased frequency of drought, and extreme weather. For these reasons the

population of this cryptic species was thought to have contracted between 1984 and 2005 (Ekert 2005).

Within the Hunter Region, an area of core Rufous Scrub-bird habitat in the Gloucester Tops has been surveyed annually since 2010 and the status of that population is well understood (Stuart 2020). However, little is known about the distribution of scrub-birds elsewhere in the region. Although there were past reports from some other locations, very few of those reports were supported by a follow-up visit to the site to confirm the presence of a scrub-bird. The validity of those records was uncertain, and, in some instances, there even was uncertainty as to whether the habitat at that location would be capable of hosting a scrub-bird, which has specific habitat requirements particularly related to the structure of the habitat (Ferrier 1984). **Figure 1** shows an example of the habitat at a known Rufous Scrub-bird site in the Gloucester Tops.

Figure 1. Known Rufous-Scrub-bird habitat in the Gloucester Tops (photo: Rob Kyte)

Severe and widespread bushfires in 2019-20 adversely affected a considerable amount of the known and potential habitat for the *ferrieri* subspecies including sites from where there were past reports of Rufous Scrub-birds (Stuart *et al.* 2021). Because of the fires, funding became available for a study of the Rufous Scrub-bird's distribution status in the Hunter Region. We were commissioned by Hunter Local Land Services (HLLS) to carry out the study. The objectives were to identify the Rufous Scrub-bird's current distribution status in the region plus any areas where it may have been present prior to the recent bushfires and establish a baseline for future scrub-bird monitoring programs across the entire region.

We also used indicator avian species as an additional means of identifying suitable Rufous Scrub-bird habitat (as outlined in Barton *et al.* 2014).

Our intentions were:

- To identify all the sites in the Hunter Region from which there had been prior reports of the Rufous Scrub-bird;
- To identify potential additional scrub-bird sites through analysis of vegetation and topographic maps to find locations at which the habitat might be suitable;
- To prioritise the two sets of sites for in-field assessment;
- To visit the prioritised sites and determine if any scrub-birds were present;
- To assess each site's potential for hosting scrub-birds, by assessing its vegetation community and also noting the presence or absence of indicator bird species;
- To assess each site's burn status, as a baseline for future surveys.

METHODS

Identifying sites to survey

We identified sites with previous reports of Rufous Scrub-bird by reviewing the records in Birdata (www.birdata.com), the Atlas of Living Australia (ALA) and Bionet, the NSW threatened species database (http://www.bionet.nsw.gov.au/). The ALA records were provided to us by HLLS. To identify areas with potential scrub-bird habitat we analysed aerial photographs (sourced from Google Earth and the NSW Spatial Information Exchange https://six.nsw.gov.au/), digital topographic maps (sourced from NSW Government Spatial Services www.spatial.nsw.gov.au/products_and_services/topographic_maps) and Upper Hunter vegetation maps (sourced from Day & Roff 2018).

From the foregoing, we identified three Priority Areas for assessment – shown in **Figure 2** along with the locations of all previous reports of Rufous Scrub-bird in the region and from just outside the boundaries.

A few of the prior reports were not from higher altitude sites and did not lie within any of the Priority Areas (i.e., we did not consider them to have any of the required Rufous Scrub-bird habitat). These reports were considered unlikely, and it seemed that they probably were associated with incorrect data input (for example a report from Myall Lakes National Park, almost at sea level). We ignored those reports in planning our surveys.

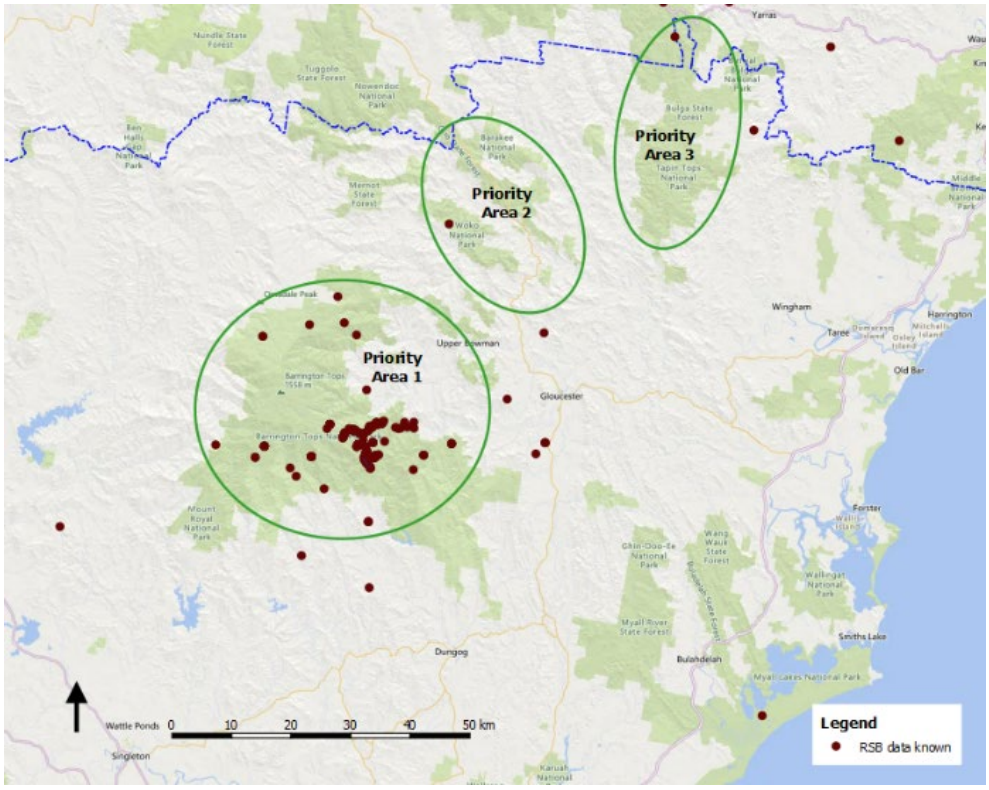


Figure 2. Rufous Scrub-bird data points in the Hunter Region (south of the blue dash-dot line). The red dots show all previously reported locations of a Rufous Scrub-bird. The three Priority Areas for field visits are also indicated.

Details of the three Priority Areas are as follows:

- Priority Area 1: this comprised a large section of the Barrington Tops National Park (including the Gloucester Tops section).
- Priority Area 2: this comprised Giro Nature Reserve, Bretti Nature Reserve and Woko National Park. Khatambuhl Nature Reserve was discounted from this survey as there were no previous records from this area and the highest point is only 661m.
- Priority Area 3: this comprised The Cells State Conservation Area, Cottan-Bimbang National Park, Bulga State Forest and Tapin Tops National Park.

We excluded from our planning, the area in the Gloucester Tops which is surveyed annually (Stuart 2020) although we walked through that area during parts of our study.

From within the three Priority Areas, we selected sites to survey as we travelled through them. The reason for this was because our task was to cover areas thought to have suitable habitat for Rufous Scrub-birds as well as covering sites where there were previous records. Each site was of an area of between two and five ha and seemed to be representative of the general habitat locally.

Our selection criteria for the survey sites were:

- Existence of prior Rufous Scrub-bird reports;
- The site's elevation and vegetation appeared to be suitable for scrub-birds to be present; and
- The general accessibility of the site (for example, the status of the road or track to the site, and if there were any access restrictions because of logging activities).

Site assessments

We received a pro forma Rufous Scrub-bird site assessment sheet from HLLS, which we modified to suit the purposes of the current study. A copy of the modified pro forma is provided in the **Appendix**. At each site we recorded: a general site description; the GPS coordinates and altitude; the presence or absence of any Rufous Scrub-bird; the presence or absence of any other bird species that may be indicative of Rufous Scrub-bird habitat; the burn status of the site; a general assessment of the vegetation community; and various weather-related conditions.

To determine whether the habitat at a site was potentially suitable for the Rufous Scrub-bird we drew upon our previous experiences with scrub-birds in the Gloucester Tops. The assessment criteria we used included altitude above 1,000m, presence of open woodland forest (of Messmate *Eucalyptus obliqua* and Brown Barrel *Eucalyptus fastigata*) with adjacent Antarctic Beech forest (*Nothofagus moorei*), relatively open under/middle storey, relatively dense groundcover comprised of grasses, Blechnum fern *Blechnaceae*, Lomandra *Lomandraceae* and Gahnia *Cyperaceae* patches, larger fallen logs, and some shrubs plus the presence of indicator bird species. In the Gloucester Tops, the Rufous Scrub-bird has been recorded at altitudes below 1,000m

but not for the past 20 or so years (Stuart & Newman 2018a).

We used the presence of indicator species as an additional pointer to potential habitat for the Rufous Scrub-bird. The indicator species were Red-browed Treecreeper *Climacteris erythrops,* Crescent Honeyeater *Phylidonyris pyrrhopterus*, Olive Whistler *Pachycephala olivacea*, Satin Flycatcher *Myiagra cyanoleuca*, Paradise Riflebird *Lophorina paradisaea*, Rose Robin *Petroica rosea* and Flame Robin *Petroica phoenicea.* Although some of these are altitudinal migrants, all six species are regularly recorded in and around Rufous Scrub-bird habitat in the Gloucester Tops in springtime (Stuart & Newman 2018b). However, Paradise Riflebird and Rose Robin are less useful indicator species because they also occur at lower altitude rainforest habitats in springtime (Stuart & Newman 2019).

Conducting the surveys

We chose the late spring period for the surveys, because male Rufous Scrub-birds sing actively and have high levels of detectability in that period (Stuart & O'Leary 2019; O'Leary & Stuart 2021; Ferrier 1984). The surveys spanned 19 October 2020 to 19 November 2020. For logistical purposes we surveyed each Priority Area in turn, visiting all the sites in that area in campaigns spanning several days. Because male scrub-birds are liable to sing at any time of day in spring (O'Leary & Stuart 2021) we were able to survey throughout the day. The surveys started in Priority Area 3 and concluded in Priority Area 1.

We walked or drove to each survey location, depending on the site's accessibility. Where required, we obtained access permission from the relevant authority, which usually was granted after a general discussion and after resolving any identified health and safety issues. For example, where a forestry road was blocked, we contacted the relevant Forestry Corporation office and received permission to carefully traverse that section.

Whilst walking or driving to each site we also conducted transect surveys en-route, during which we listened for singing scrub-birds. The transect surveys varied in their duration depending on the distance covered. If the transect survey was done whilst driving, we limited our speed to walking pace.

We spent 20 minutes at each survey location, listening for singing Rufous Scrub-birds and noting the presence of indicator bird species. We did not make records of any other species present. We were separated by up to 100 m while conducting each survey, in order to cover a larger area. We then re-convened and filled out the survey pro forma.

RESULTS

We visited 71 survey sites/transects in three campaigns spanning 2-3 days each (Priority Areas 2 and 3) and 17 days (Priority Area 1). We found six scrub-birds and identified 34 sites that potentially could host a scrub-bird. We did not find any scrub-birds during the transect surveys. A detailed report of the study was submitted to HLLS (Kyte & Little 2020).

Priority Area 3

This area had 15 sites or transects, which we surveyed during 19-21 October 2020. **Figure 3** shows the locations of the sites and transects. In the three-day period we experienced various issues such as forest closures for logging, trails being graded and fallen trees. Weather conditions also limited our ability to access certain areas by car, but these were accessed on foot instead.

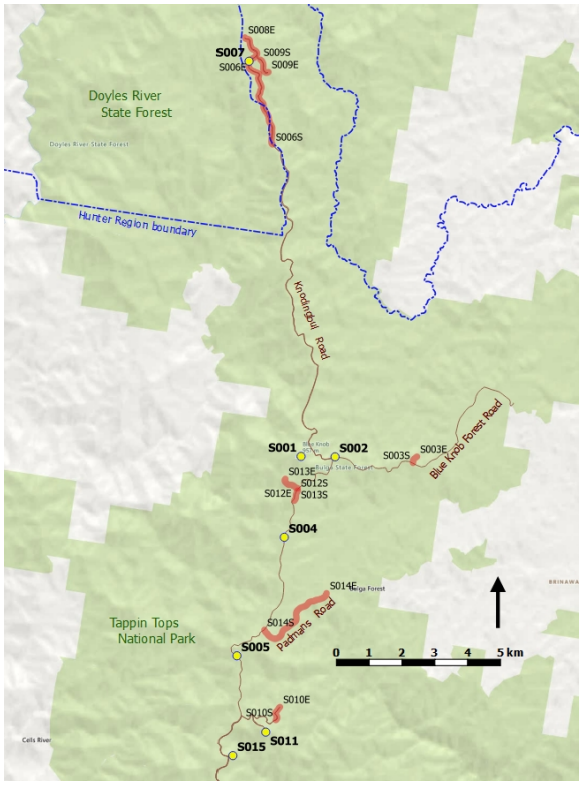


Figure 3. Map showing the survey points and transects for Priority Area 3

Table 1 summarises the site/transect assessment results for Priority Area 3. We did not find a Rufous Scrub-bird anywhere in the area and our assessment was that there was no suitable habitat for scrub-birds at any of the sites we visited. However, seven of the sites had been burnt to some extent with burning at four of those sites being moderate to extreme in severity. The only two indicator bird species we encountered were Paradise Rifle-bird and Rose

Robin, neither of which are strong indicators for the presence of Rufous Scrub-bird.

There had been a previous report of a Rufous Scrub-bird at site 007, which lies off Knodingbul Road in the Cottan-Bimbang National Park. The eBird data records three individuals at that site on 10 November 2014. This site, at 930m altitude, was not burnt in the 2019-20 bushfires. It did not appear to have suitable habitat for the Rufous Scrub-bird.

Table 1. Site assessment results for Priority Area 3

Site ID	GPS coordinates		Prior scrub-bird record	Habitat assessment			Scrub-bird this study
	Lat. (deg S)	Long. (deg E)		Suitable	Possible	Unsuitable	
001	31.5774	152.1700				●	No
002	31.5776	152.1809				●	No
003*	31.5792	152.2060				●	No
004	31.5996	152.1646				●	No
005	31.6321	152.1494				●	No
006*	31.4922	152.1608				●	No
007	31.4691	152.1533	●			●	No
008*	31.4686	152.1543				●	No
009*	31.4689	152.1569				●	No
010*	31.6497	152.1619				●	No
011	31.6530	152.1587				●	No
012*	31.5868	152.1690				●	No
013*	31.5861	152.1689				●	No
014*	31.6250	152.1581				●	No
015	31.6594	152.1481				●	No

* Indicates a transect survey. The GPS coordinates are the starting point for the survey. The finishing point for the survey was at the next site or transect.

Priority Area 2

We surveyed 14 sites or transects in this area between 22 and 23 October 2020. **Figure 4** shows the locations of the sites and transects. In this period we experienced occasional wet weather which affected the condition of some trails but did not disrupt the surveys as we were able to alter our schedule to suit the conditions. It was our intention to survey along the Pigna Barney Trail but this was impossible due to overgrown and impenetrable tracks. Logging activity at the edge of Bretti Nature Reserve also prevented us from surveying further down Baxters Ridge Road/Khatambuhl Creek Road.

Figure 4. Map showing the survey points and transects for Priority Area 2

Table 2 summarises the site/transect assessment results for Priority Area 2. Although we did not find any scrub-birds during the site visits, we recorded four indicator bird species (Paradise Riflebird, Rose Robin, Flame Robin and Red-browed Treecreeper) and we concluded that five sites had potential. Twelve sites had been burnt to some extent in the 2019-20 bushfires with ten of the sites estimated to suffer moderate to extreme burns. However, site 024, although burnt appeared to have potential habitat for scrub-birds, with Blechnum Fern, Gahnia and tree ferns present. Sites 016, 023, 025 and 026 were regarded as being possible scrub-bird habitat as the elevations of each were around the 1000m range but the ground cover and canopy had not recovered sufficiently from the fire.

Table 2. Site assessment results for Priority Area 2.

Site ID	GPS coordinates		Prior scrub-bird record	Habitat assessment			Scrub-bird this study
	Lat. (deg S)	Long. (deg E)		Suitable	Possible	Unsuitable	
016*	31.6021	151.7583			●		No
017*	31.6149	151.7643				●	No
018	31.6769	151.8501				●	No
019	31.6811	151.8684				●	No
020	31.7024	151.9002				●	No
021*	31.7114	151.9052				●	No
022	31.7082	151.9226				●	No
023	31.5648	151.7928			●		No
024*	31.5752	151.8057		●			No
025	31.5964	151.8257			●		No
026	31.6009	151.8397			●		No
027	31.7497	151.7504	●			●	No
028*	31.7561	151.7525				●	No
029	31.7273	151.7163				●	No

* Indicates a transect survey. The GPS coordinates are the starting point for the survey. The finishing point for the survey was at the next site or transect.

There had been a previous report of a Rufous Scrub-bird at site 027, which lies off the Mount Myra Trail in the western portion of Woko National Park. This record from the NSW Bird Atlassers was made on 17 November 1992 with no other information recorded. This site, which had not been affected by the 2019-20 bushfires, did not appear to have suitable habitat for Rufous Scrub-bird as the elevation was under 700m and there was very little ground cover or fallen timber.

Priority Area 1

We surveyed 42 sites or transects in this area over eight days during 3-19 November 2020. **Figure 5** shows the locations of the sites and transects. The surveys involved hiking and camping along The Mountaineer Trail and at the Polblue Swamp Campsite and the Wombat Creek Campsite near Careys Peak. **Table 3** summarises the results. None of the sites/transects had been burnt in the 2019-20 bushfires. Eight sites had prior reports of Rufous Scrub-bird being present but we did not find scrub-birds at any of those sites. However, several of them, and many other sites in this Priority Area, had suitable or potential habitat, as discussed below. We recorded five indicator bird species during the surveys (Olive Whistler, Rose Robin, Satin Flycatcher, Red-browed Treecreeper and Crescent Honeyeater) and we found a Rufous Scrub-bird at each of six sites.

Five of the sites where we found a Rufous Scrub-bird were towards the eastern end of the Careys Peak Link Trail (sites 065-067 and 069-070) and the other (site 053) was about half-way along the Glowang Trail. All these sites were in the Gloucester Tops and were in the general vicinity of known territories (Stuart 2020; www.birdata.com). The Rufous Scrub-bird locations found in this study are plotted in **Figure 6**, and the locations of nearby known scrub-bird territories are also indicated.

At four sites for which there were prior reports of a Rufous Scrub-bird (043, 044, 047 and 057), we did not consider the habitat to be suitable for scrub-birds. These sites were either on steep slopes and/or had very little ground cover. At three other sites (032, 035 and 056) the habitat seemed to be suitable with ground cover of bracken, Gahnia and Lomandra and fallen timber present and at a fourth site (055) it seemed potentially suitable with ground cover of Gahnia and ferns but with also a fairly dense mid-layer.

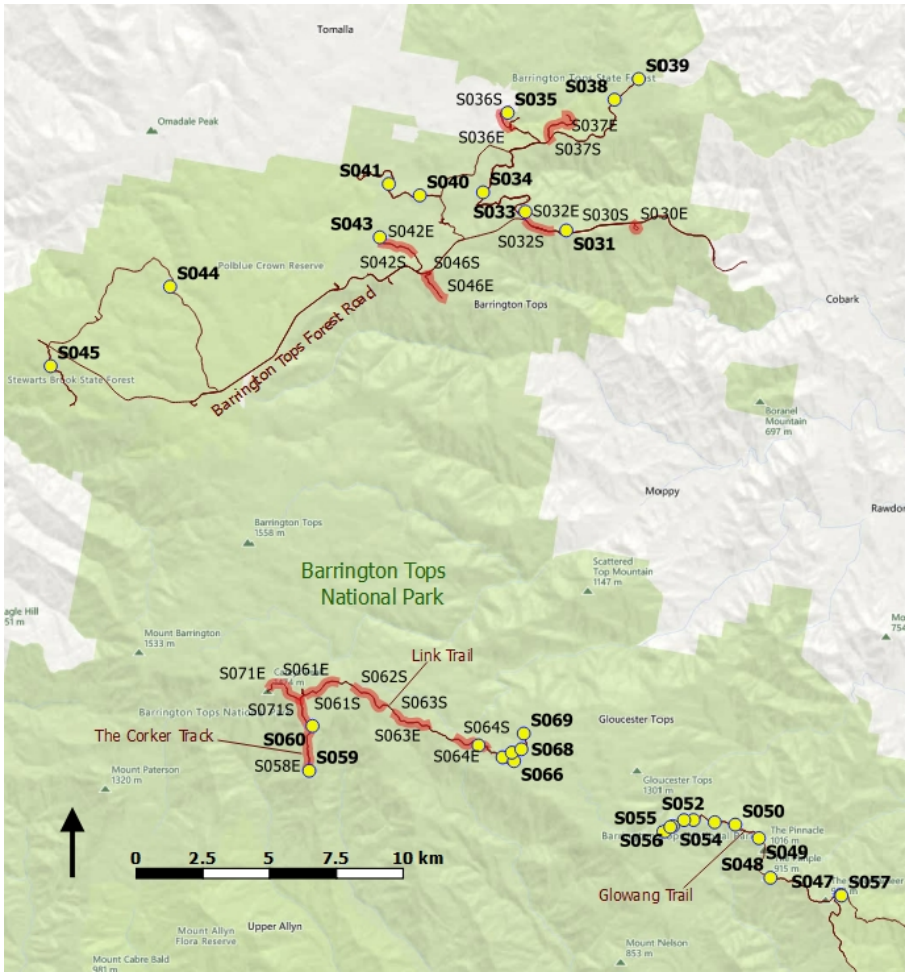
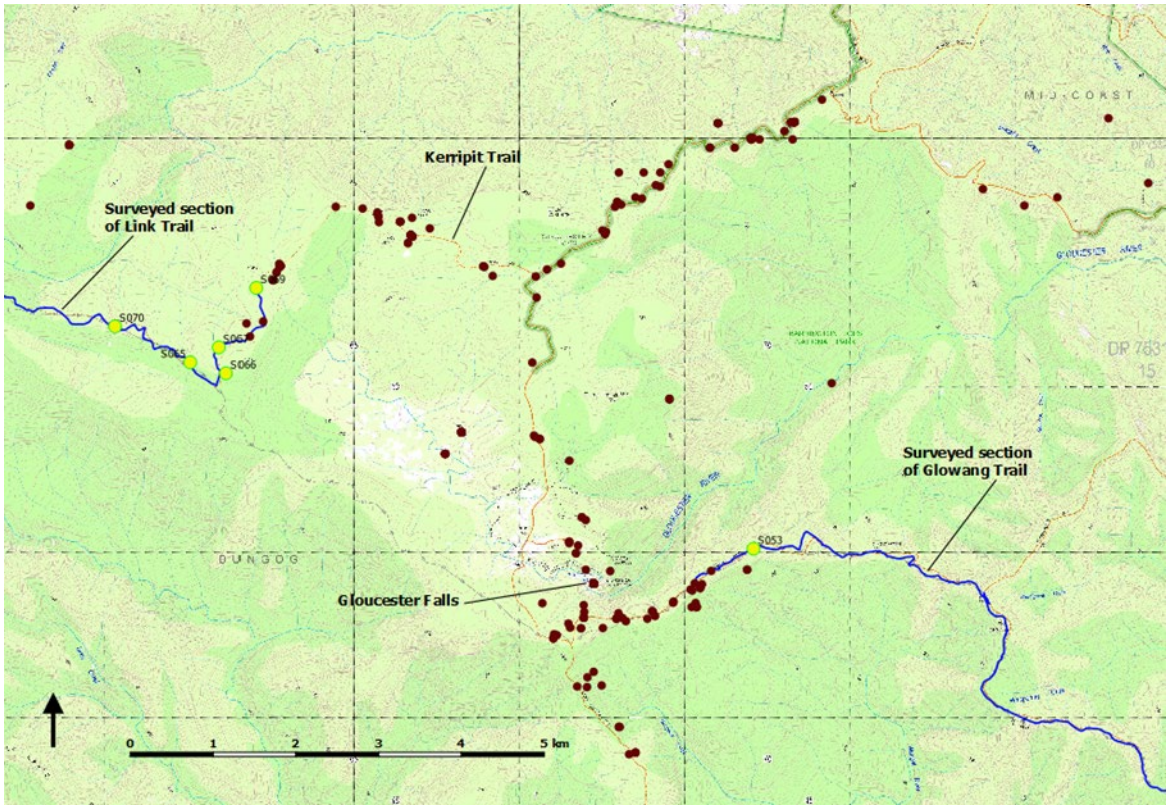


Figure 5 (left).
Map showing the survey points and transects for Priority Area 1

Figure 6 (below).
The six new Rufous Scrub-bird locations found in the current study (yellow dots) and the known Rufous Scrub-bird locations from the same general area (red dots).



Summary of overall results

In **Table 4** we have summarised the results from the overall study. Priority Area 1 had 29 sites which potentially could support a Rufous Scrub-bird, including 20 sites where the habitat seemed highly suited for scrub-birds. Priority Area 2 had five potential sites but only one of those seemed highly suited. We did not find any likely sites in Priority Area 3.

Table 3. Site assessment results for Priority Area 1.

Site ID	GPS coordinates		Prior scrub-bird record	Habitat assessment			Scrub-bird this study
	Lat. (deg S)	Long. (deg E)		Suitable	Possible	Unsuitable	
030*	31.8965	151.6011		●			No
031	31.8976	151.5742		●			No
032*	31.8979	151.5674	●	●			No
033	31.8913	151.5579		●			No
034	31.8848	151.5410		●			No
035	31.8579	151.5508	●	●			No
036*	31.8579	151.5508		●			No
037*	31.8668	151.5676		●			No
038	31.8535	151.5933		●			No
039	31.8465	151.6030			●		No
040	31.8859	151.5159			●		No
041	31.8820	151.5035			●		No
042*	31.9049	151.5125			●		No
043	31.9000	151.4999	●			●	No
044	31.9166	151.4165	●			●	No
045	31.9434	151.3690				●	No
046*	31.9126	151.5194		●			No
047	31.1212	151.6828	●			●	No
048	32.1154	151.6549				●	No
049	32.1025	151.6503				●	No
050	32.0979	151.6409				●	No
051	32.0971	151.6327				●	No
052	32.0964	151.6242			●		No
053	32.0964	151.6205		●			Yes
054	32.0984	151.6160		●			No
055	32.1002	151.6128	●		●		No
056	32.0987	151.6150	●	●			No
057	32.1212	151.6828	●			●	No
058*	32.0567	151.4684		●			No
059	32.0798	151.4719				●	No
060	32.0647	151.4732			●		No
061*	32.0537	151.4718				●	No
062*	32.0522	151.4905				●	No
063*	32.0609	151.5065			●		No
064*	32.0692	151.5313			●		No
065	32.0753	151.5488		●			Yes
066	32.0765	151.5534		●			Yes
067	32.0737	151.5525		●			Yes
068	32.0725	151.5563		●			No
069	32.0672	151.5572		●			Yes
070	32.0712	151.5392		●			Yes
071*	32.0558	151.4680				●	No

* Indicates a transect survey. The GPS coordinates are the starting point for the survey. The finishing point for the survey was at the next site or transect.

Table 4. Summary of survey effort and results.

Priority Area	No. of sites visited	Sites with suitable habitat	Sites with potential habitat	No. of scrub-birds found
1	42	20	9	6
2	14	1	4	0
3	15	0	0	0

DISCUSSION

Detection probabilities

Out of the 71 sites/transects visited in the surveys, only six scrub-birds were detected. Of the other 65 sites/transects, 37 were not considered to have suitable or potential habitat for a Rufous Scrub-bird. However, there were 28 sites/transects which potentially might have had a scrub-bird present but no bird was detected. This raises for consideration the possibility that a scrub-bird may have been present at some of those locations but that it was not detected.

In the Gloucester Tops between mid-September and December on fine days, male scrub-birds were found on average to produce more than 1,200 songs per day and to sing for 79% of the 20-minute daylight periods, with an average of 36 singing events in each 20-minute period (O'Leary & Stuart 2021). However, for any individual bird the singing behaviour was less predictable and at any time of the day there could be intervals with no singing.

We listened for 20 minutes at each site, generally in fine conditions although sometimes with light rain falling. In spring the Rufous Scrub-bird singing behaviour was found to be unaffected by light rainfall (Stuart & O'Leary 2019). At any single site, for the 20-minute time frame, there was a 21% probability (on average) that a Rufous Scrub-bird was present but not singing. Thus our surveys might have overlooked birds at some sites. However, the general behaviour of the bulk population of male scrub-birds is to sing often in spring. In Priority Area 2, for example, we identified five sites with apparently suitable habitat but found no scrub-birds. The probability of not detecting *any* of those birds, if present, after listening for 20 minutes at each site is *c* 0.04%. For Priority Area 1, with 14 such sites, the probability of not detecting a bird at *any* of the 14 apparently suitable sites is considerably lower still.

In addition to the 20-minute site surveys we also conducted transect surveys which allowed us to cover a greater area. We did not hear any Rufous Scrub-bird singing during our transect surveys.

These low probabilities of not detecting any scrub-birds at all, in an area where they occur, strongly suggests that there was not any Rufous Scrub-bird present in the bulk of the areas which we surveyed. At the time of our surveys in October-November 2020, the Gloucester Tops male Rufous Scrub-bird population was singing often (A. Stuart pers. comm.).

The 2019-20 bushfires

Of the 71 sites/transects which we surveyed, twenty of them had been burnt in the recent bushfires, at estimated fire extents ranging from 10% burn to 100% burn. At five of those burnt locations, all in Priority Area 2, we considered the habitat had been suitable (one site) or possibly suitable (four sites) for a Rufous Scrub-bird. Although we did not detect scrub-birds at any of the latter sites, birds might have been present prior to the fires. We suggest three scenarios are possible: the scrub-birds were unable to escape the fire and had perished; they had escaped the fires but had not returned to the site, because of the damage to the habitat; they were at the site but were not singing, perhaps because the habitat damage deterred them from attempting to breed.

Prior Rufous Scrub-bird records

Six of the sites we visited had prior reports of a Rufous Scrub-bird being present but, in our assessment, did not have habitat which was suitable for them. Thus they may be erroneous reports, arising from mis-identification or because incorrect coordinates were entered into a database. However, it is also possible that the habitat had changed from the time of the original report and/or that the reports involved birds dispersing outside of preferred core areas in search of mates and territories. Thus, they may be true historical records. However, the present study has shown that those six reports are not indicators of the current range for the Rufous Scrub-bird in the Hunter Region. For most purposes associated with studying the Rufous Scrub-bird, these six reports should be regarded as unconfirmed records.

Population estimates

Range maps often indicate that the Rufous Scrub-bird is distributed across much of the Barrington Tops National Park (Stuart *et al*. 2021). That presumably has been based upon an assumption that there are many areas with suitable habitat within the park and that scrub-birds would occur there. The present study suggests that understandings about the habitat requirements may have been over-simplified and that it is a small area within the Gloucester Tops section of the park which provides suitable habitat for scrub-birds. The absence of records away from the known Gloucester Tops population has been commented about previously (Newman *et al*. 2014, Stuart & Newman 2018a). The new locations from the present study are all within *c* 1 km of the previously known records.

Thus, all of the confirmed scrub-bird records lie within an area of about 5 km radius (*c* 8,000 ha or 80 km^2) within the Gloucester Tops. Stuart (2020) reported territory densities of 3.8 ± 1.5 territories km^{-2} from surveys in the Gloucester Tops carried out during 2010-2020 in an area of *c* 4 km radius. Extrapolating from that finding, we estimate that there are 190 ± 75 singing male scrub-birds in the Gloucester Tops. That is not a large population. The ratio of singing males to females and immature birds is unknown.

Management strategies

Clusters of Rufous Scrub-bird records found between the Barrington Tops and the Border Ranges National Park are "a series of high-altitude relictual populations that may be impacted by rising temperatures and/or other effects of climate change such as periodic drought" (Office of Environment and Heritage 2017). The Rufous Scrub-bird is classified as Endangered on the IUCN Red List (BirdLife International 2021b). According to BirdLife International (2021a) the scrub-bird has a very small, severely fragmented area of occupancy, and is experiencing habitat destruction and a continuing population decline. Inappropriate management such as logging and fire management in areas close to known scrub-bird habitat as well as the destruction of movement corridors linking suitable sites and known scrub-bird clusters could contribute to the shrinking of numbers from much of its current range. There is a risk that the Rufous Scrub-bird could become victim to the 'Twinkling Light' phenomenon (Ford 2011) that applies to species with poor dispersal abilities in isolated populations.

Dispersing scrub-birds should be able to reach other population clusters thereby helping genetic diversity of the clusters. However, land clearing and predators are making dispersal movements increasing difficult for the Rufous Scrub-bird especially considering this species is not a strongly-flying bird.

The forests of the Barrington Tops and Gloucester Tops area did not suffer from fires during the 2019-20 bushfire season. However, the Rufous Scrub-bird population in the Gloucester Tops appears to be highly vulnerable to bushfire. A fire within the *c* 8,000 ha area of confirmed Rufous Scrub-bird habitat potentially could wipe out much of the population. The fire risk is expected to increase in the future due to warming climatic conditions and the attendant droughts. It seems essential to develop management strategies that will minimise the potential for harm to the Rufous Scrub-bird population from bushfires.

Future Studies

Habitat recovery at the burnt sites which had suitable or possibly suitable Rufous Scrub-bird habitat should be monitored regularly, and the sites surveyed for the presence of any scrub-birds.

The 2020 surveys should be considered as merely a snapshot of the Rufous Scrub-bird's distribution in the Hunter Region. The surveys need to be repeated, focussed onto the areas where suitable scrub-bird habitat was considered to be present, and spending longer time in such areas including visits to additional sites within those areas. It is essential that the interim conclusion from the present study be tested; i.e. that the Rufous Scrub-bird distribution is limited to an 8,000-ha area within the Gloucester Tops.

The new Rufous Scrub-bird locations, as found in this study, cannot as yet be classified as scrub-bird territories. Such classification requires re-confirmation of the presence of a singing male more than four weeks after the original record, or in successive years (Stuart & Newman 2018a). At the moment, they could simply be records of roaming young males that were seeking to establish a territory and perhaps then moving on if unsuccessful.

There have been suggestions that, in future, some scrub-birds should be relocated to areas such as Tasmania where the climatic conditions are expected to be more favourable in future (Garnett *et al*. 2011). However, currently there is limited

understanding of the specific habitat requirements to support the Rufous Scrub-bird. There seems to be an urgent need to properly categorise the ecosystems at some known Rufous Scrub-bird sites (for example, the plant and insect communities, and the general topography) and understand why those sites are able to support scrub-birds whereas many other sites, apparently similar, do not host them.

A study is required to better understand the biology and movement of this vulnerable species where the genetic diversity of the population and its distinctness from other relict populations of the southern sub-species can be determined. In light of the 20-year decline in numbers of this species and to effectively maximise the long-term survival of *ferrieri* subspecies scrub-birds, it is recommended that further research is conducted, in conjunction with the preparation of a recovery plan.

CONCLUSIONS

The surveys conducted in October-November 2020 found that Rufous Scrub-birds were not present at ten locations where they had previously been recorded nor in locations where there was thought to be suitable habitat. While there were many survey points where the habitat, vegetation type and the altitude seemed to be suitable, only six new territories were located, all found in the Gloucester Tops region close to existing known territories.

The Rufous Scrub-bird in the Hunter Region is known to rely on a specific habitat type and current populations in this region only occur in protected areas in the Gloucester Tops as outlined in this report. As there are known ongoing threats to this isolated population through fire and the presence of pest species such as cats and foxes it is important that further surveys are conducted to identify other populations in the areas where habitat is thought to be suitable. Due to the unique nature of the Rufous Scrub-bird it will be very difficult to know the exact population size. However, based on this survey the population in the areas covered may be lower than previously thought. Further research into the population, movement and biology of this cryptic species is essential to help us understand the requirements for the survival of this endangered bird.

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Appendix
Pro forma used for site assessments

Rufous Scrub-bird Survey 2020 – Site Data

Site No

Date				**Observers**			**Elevation** metres		
Time start				**Finish time**			**Photos taken** Yes ☐ No ☐		
Atlas Record Site Yes ☐ No ☐				**New Opportunistic** Yes ☐ No ☐					
State Forest Name				**National Park Name**					
Road Name				**Side of road**					
Point survey Easting (GDA94)				**Point survey** Northing (GDA94)					
Transect survey Start Easting / Northing (GDA94)				**Transect survey** End Easting / Northing (GDA94)					
Temperature	Cold (≤14°C)	Cool (15 – 19°C)		Moderate (20 – 24°C)	Warm (25 – 29°C)	Hot (≥30°C)			
Wind Strength	Still	Rustle of leaves		Small branch moving	Large branch moving	Strong			
Cloud Cover	0	25%		50%	75%	100%			
Slope	Flat (0°)	Gentle (1 – 4°)		Moderate (5 – 14°)	Undulating *(Highly Variable)*	Steep (≥15°)			
Aspect	Nil	N	NE	E	SE	S	SW	W	NW
Position	Ridge Top	Upper Slope	Mid Slope	Lower slope	Plateau	River or Creek Flat		Drainage line	
Fire extent *(estimate % of habitat burnt)*		0 – 10 %		10 – 50%		50 – 90%		90 – 100%	
Fire severity	Nil	Cool understorey		Moderate partial canopy scorching		High canopy scorching		Extreme canopy burnt	
Forest type	Dry grassy	Dry multilayered		Moist ferny understorey		Wet mesic understorey		Rainforest	
Age Structure	Even aged regrowth <20cm dbh	Even aged immature <50cm dbh		Mixed but dominantly immature		Mixed mature		Old growth	
Canopy height	<20m	20 – 25m		25 – 30m		30 – 35m		35 – 40m	
Mid layer height	<5m	5 – 8m		8 – 11m		11 – 14m		14 – 17m	
Shrub height *(not below)*	<1m	1 – 2m		2 – 4m		4 – 6		6 – 8m	
Ground habitat type	Bracken	Lomandra		Vine thicket		Rainforest ecotone		Heath	
Ground habitat height	<0.5m	0.5 – 1m		1 – 1.5m		1.5 – 2m		2 – 2.5m	
Weeds present	Lantana	Camphor Laurel		Privet		Morning Glory		Other *(list below)*	
Weed coverage	<5%	5–30%		30–50%		50–75%		>75%	

METHOD *Listen for 20 mins with optional playback at end. Repeat if possible, up to 5 times or as long as possible. Stop if it rains.*

Observations	Was RSB heard calling Yes ☐ No ☐			Time on site from start before RSB was heard calling minutes				
Type of call heard	Chips	Seeps	Whistles	Other			Recording made Yes ☐ No ☐	
Call playback used	Yes ☐ No ☐		Did RSB respond to playback Yes ☐ No ☐			Call playback used		
Approximate distance to call from survey point	<50m	50–100m	100–150m	150–200m	200–250m	250–300m	>300m	
Direction to call from survey point	N	NE	E	SE	S	SW	W	NW

NOTES *Survey limitations (eg rain), specific habitat (eg dominant floristics of dense ground cover) and other comment.*

OTHER *Significant birds, plants or weeds (ecosystem transformers) observed:*

Circle the relevant points and tick boxes where applicable v261020 *Layout by Rob Kyte from original artwork by Phil Spark*