Spring bird surveys in the Gloucester Tops

Alan Stuart[1] and Mike Newman[2]

[1]81 Queens Road, New Lambton, NSW 2305, Australia almarosa@bigpond.com
[2]72 Axiom Way, Acton Park, Tasmania 7021, Australia omgnewman@bigpond.com

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Spring surveys between 2010 and 2017 in the Gloucester Tops in New South Wales recorded 92 bird species. The bird assemblages in three altitude zones were characterised and the Reporting Rates for individual species were compared. Five species (Rufous Scrub-bird *Atrichornis rufescens*, Red-browed Treecreeper *Climacteris erythrops*, Crescent Honeyeater *Phylidonyris pyrrhopterus*, Olive Whistler *Pachycephala olivacea* and Flame Robin *Petroica phoenicea*) were more likely to be recorded at high altitude. The Sulphur-crested Cockatoo *Cacatua galerita*, Brown Cuckoo-Dove *Macropygia phasianella* and Wonga Pigeon *Leucosarcia melanoleuca* were less likely to be recorded at high altitude. All these differences were statistically significant.

Two species, Paradise Riflebird *Lophorina paradiseus* and Bell Miner *Manorina melanophrys*, were more likely to be recorded at mid-altitude than at high altitude, and had no low-altitude records. The differences were statistically significant. Many of the 78 species found at low altitude were infrequently or never recorded at higher altitudes and for 18 species, the differences warrant further investigation.

There was only one record of the Regent Bowerbird *Sericulus chrysocephalus* and evidence is provided that this species may have become uncommon in the area. The populations of Green Catbird *Ailuroedus crassirostris*, Australian Logrunner *Orthonyx temminckii* and Pale-yellow Robin *Tregellasia capito* may also have declined.

INTRODUCTION

Watson (2010) noted that although the term "island" is generally used to describe landmasses surrounded by water, a range of other geographic features (e.g. caves, mountain tops, lakes, glacial moraines, rocky massifs) share similar ecological properties. Worldwide these landmasses are characterised by unique flora and fauna assemblages with a high level of endemism including specialised bird species (for example see Robin *et al*. 2015; Forero-Medina *et al*. 2011; Lindenmayer *et al*. 2010; Hernandez-Banos *et al*. 1995; Mayr & Diamond 1976). In Australia, two classes of terrestrial island are of particular importance: lakes and mountain tops (Watson 2010).

Montane "islands" supporting distinctive communities of plants and animals are isolated from other patches by inhospitable habitat. In an era of erratic climate changes and a trend to increasing temperature the extent of these montane islands shrinks and they become increasingly isolated. Any flora or fauna that are unique to the montane island and which cannot survive in the surrounding hostile environment are trapped there and potentially are doomed to extinction. The Rufous Scrub-bird *Atrichornis rufescens*, a skulking species with minimal flight capability, is an avian example of a restricted-range montane island species. It is exclusive to five high-altitude areas in New South Wales and southern Queensland. A predicted consequence of climate change is that all five locations will become unsuitable habitat and that Rufous Scrub-birds will need to be translocated to Tasmania if the species is to survive (Garnett & Franklin 2014; Garnett & Zander 2014).

All five of these isolated areas of montane vegetation in New South Wales and southern Queensland are biodiversity hot spots; each has been designated as a Key Biodiversity Area (KBA) based on the occurrence of avian endemic and restricted-range species (Dutson *et al*. 2009; BirdLife Australia 2017). One of them is the Barrington Tops National Park; it was designated as a KBA on the basis of the presence of seven threatened or range-limited species: Rufous Scrub-bird, Green Catbird *Ailuroedus crassirostris*, Regent Bowerbird *Sericulus chrysocephalus*, Australian Logrunner *Orthonyx temminckii*, Paradise Riflebird *Lophorina paradiseus*, Flame

Robin *Petroica phoenicea* and Pale-yellow Robin *Tregellasia capito* (Dutson *et al.* 2009). The Rufous Scrub-bird was the trigger species for the KBA nomination, with the other six species listed to support the nomination.

The Gloucester Tops, which forms the central eastern part of the Barrington Tops National Park, hosts a substantial population of the southern sub-species of the Rufous Scrub-bird (Stuart & Newman 2018a). The Action Plan for Australian Birds 2010 (Garnett *et al*. 2010) called for ongoing monitoring of the Rufous Scrub-bird; we responded to the challenge by conducting surveys for bird species over the period 2010-2017 in a 5,000 ha area of the Gloucester Tops. Those surveys provided insights into the bird communities present at high altitude (at 1,100−1,300 metres above sea level (masl)) in spring, and suggested that several species may be montane specialists locally (Stuart & Newman 2018b). In contrast, a comparison of montane forest and cool temperate rainforest habitats in Victoria found no significant differences in bird species richness or in the composition of the bird assemblages (Lindenmayer *et al*. 2010).

This paper examines the altitudinal stratification of avian species in the Gloucester Tops based on surveys conducted at three altitude ranges in 2010-2017. There is a dearth of such information in Australia and no previous comparable study for the Barrington Tops National Park.

METHODS

The study area

The boundaries and general location of the Barrington Tops National Park are presented in **Figure 1**, which also shows two zones of the study area, at 1,100−1,300 masl and 350−450 masl respectively. The high-altitude zone was centred at 32°05'S, 151°36'E and the low-altitude zone at 32°04'S, 151°41'E. The third part of the study area was centred on the winding road that connects the high- and low-altitude zones. The Gloucester Tops rise rapidly from ~350 masl to >1,100 masl. **Figure 2** shows altitudes at 1 km intervals by road. The zones indicated in **Figure 2** represent the three altitude zones reported in this study (Zone 1 = 350−450 masl, etc).

A detailed summary of the botanical characteristics of the Gloucester Tops is available elsewhere (Binns 1995). For the purposes of this paper, the habitats in each of the three zones that were studied may be summarised as follows:

Zone 1. 350−450 masl: Principally comprising temperate rainforest, which includes areas of regrowth post-logging. Also within the study area there is a well-grassed picnic area and camping ground. The study area includes the junction of Sharpes Creek and the Gloucester River and it is often referred to colloquially as “the Sharpes Creek site”.

Zone 2. 450−1,100 masl: Principally comprising open eucalypt woodland interspersed with patches of temperate rainforest. In several cases, the woodland areas adjoin open valleys.

Zone 3. 1,100−1,300 masl: Principally a mosaic of open eucalypt woodland and Antarctic Beech *Lophozonia moorei* rainforest.

Bird surveys

Surveys were carried out by volunteers between September and November annually over 2010-2017. The primary aim for the overall study was to monitor Rufous Scrub-birds and the timing coincided with their breeding season, when calling males are most reliably detectable (Ferrier 1984). All surveys were done only when conditions were favourable (low–medium wind, zero–low rainfall).

Transect-based surveys involving 1-3 people (typically 2 people) were conducted in the mid- and high-altitude zones. In both zones, a series of 1-km transects were established along existing roads and tracks. The surveys commenced *c*. 0800 h with surveyors taking several hours to complete all the surveys for a set of 3-5 transects. Typically, *c.* 1 h was spent in each 1-km transect. Surveyors recorded the presence of all bird species seen or heard along each transect, including any birds flying over (although extensive canopy cover in most transects limited the opportunities for the latter). No limit was set for the maximum distance from the track for records; under favourable conditions, a calling Rufous Scrub-bird can be heard 150 m away (Ferrier 1984), but for many other species the sampling width would have been less than that.

Every surveyed transect at high altitude (1,100−1,300 masl, Zone 3 in **Figure 2**) was visited several times each spring, although in some years some of the less-accessible transects were not surveyed (because of logistical constraints).

The mid-altitude zone (450−1,100 masl, Zone 2 in **Figure 2**) was surveyed systematically in 2013 and 2016. In both years, every 1-km mid-altitude transect (nine transects in total) was surveyed on a single morning, all of them being performed as single-pass downhill surveys. Some of the higher-altitude transects within this altitude zone were also surveyed in other years. All surveys took approximately one hour per 1-km transect and the general protocol was the same as for the high-altitude surveys.

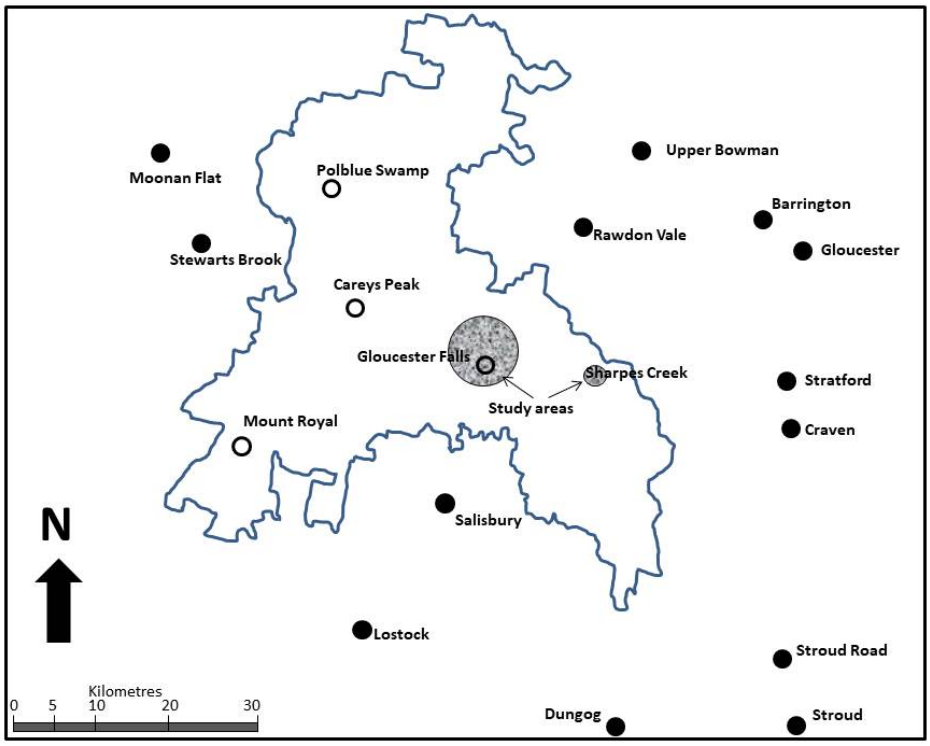

Figure 1. Barrington Tops National Park showing the 350−450 masl (low-altitude Zone 1, centred at Sharpes Creek) and 1,100−1,300 masl (high-altitude Zone 3, centred in the Gloucester Falls area) study areas. Zone 2 was centred on the road which connects Zones 1 and 3.

Figure 2. Altitude profile in the Gloucester Tops study area, commencing from the Sharpes Creek site (the location of the low-altitude study area).

Surveys in the 350−450 masl study area (Zone 1 in **Figure 2**) involved multiple observers (up to 8 observers, more typically 4-6 people) and spanned several hours of elapsed time. The surveys were unstructured and the intensity of effort varied. Surveying in the early morning included birds heard in the dawn chorus or observed in approximately the first hour after dawn (before surveyors relocated to higher altitudes). Additional records were obtained in the final hours of the day (after surveyors had returned to camp). A daily list of all species seen or heard in the low-altitude zone was compiled each evening. Nocturnal birds were included in the daily list for this altitude zone if any were detected, whereas the surveys at higher altitudes were made diurnally and hence unlikely to detect such species.

The BirdLife Australia Atlas (Birdata) was used for storing the records from the surveys and retrieving them later for analysis. All surveys were entered as 500 m-radius area surveys, which are one of Birdata's two main survey options. For each 1-km transect, the mid-

point (i.e. 500 m from each end of the transect) was used as the survey location. This approach is considered valid because a 1-km transect through a 500 m radius area is a fixed route means of surveying that area.

Reporting Rates (RRs) for each species in each altitude zone were calculated. The RR is the number of times the species was recorded divided by the number of surveys conducted (expressed as a percentage). The RR is based on presence/absence; records of multiple birds within the same survey do not affect the RR.

Statistical analysis

The methods used in the high- and mid-altitude zones were identical, involving ~1 h of survey effort within each 1-km transect. Therefore, direct comparison of the results for those two altitude zones is valid. Pearson's Chi-Square (Goodness-of-Fit) test (Fowler & Cohen 1994) was used to assess differences between the observed and expected number of records for a species across the various altitude zones. It is important to note that the Chi-Square test requires the use of raw data (number of surveys, number of records) and not RRs, which are a ratio. Probability p values were calculated using the Chi Square test procedure and species with p <0.05 or p <0.01 were identified. Standard statistical nomenclature refers to observed differences as significant (when p <0.05) or highly significant (when p <0.01). Although there were fewer surveys in Zone 2 than in Zone 3 (27 surveys; 306 surveys) the Chi Square test is robust to differences in sample size (i.e., survey effort) between treatments (i.e. altitudinal zones) except when the expected frequencies are less than 5 (Fowler & Cohen 1994).

Comparison of the results from the 350−450 masl zone with those from higher altitudes was thus more problematic and Chi Square tests were used for only some species where expected frequencies were greater than 5. The low-altitude surveys usually involved a less-intensive rate of effort than the surveys done at the higher altitudes but they had longer elapsed times and, in general, more observers participated. Therefore, the probability of detecting any given species was increased. In particular, the low-altitude surveys included birds detected in the dawn chorus, whereas the surveys at higher altitudes took place well after dawn.

Some general conclusions about bird populations in the low-altitude zone were inferred by assuming that those species with many records at low altitude and none or very few records at higher altitudes were candidates for classification as low-altitude specialists.

The possibility of using a list length analysis technique (Szabo *et al*. 2012) to compare the low altitude and higher altitude results was considered and rejected. List length analysis generally is applied to situations where the quantum of survey effort is highly variable and unknown.

RESULTS

Table 1 shows the number of 1-km transect surveys conducted within each altitude zone between 2010 and 2017 and the total number of species recorded for each zone. An additional three nocturnal species were recorded in unstructured surveys of the low- and mid-altitude zones at night; the Greater Sooty Owl *Tyto tenebricosa*, Masked Owl *T. novaehollandiae* and Powerful Owl *Ninox strenua*. Thus, 95 species were confirmed to be present in spring in the Gloucester Tops study area over 2010−2017.

In the **Appendix** (which is available at www.hboc.org.au/the-whistler-volume-13/) we present the number of records and the RR for each of the 92 species in each of the three altitude zones. The more noteworthy examples of apparent or confirmed altitudinal stratification are reported below.

High-altitude (Zone 3)

Five species (Rufous Scrub-bird, Red-browed Treecreeper *Climacteris erythrops*, Crescent Honeyeater *Phylidonyris pyrrhopterus*, Olive Whistler *Pachycephala olivacea* and Flame Robin) were only recorded at >1,100 masl. These differences were highly significant (p <0.01) when compared to the mid-altitude zone and assessed using the Chi Square test. Nine other species were exclusively recorded at high altitude, but there were insufficient records (1-5 for each) for statistically valid conclusions to be drawn. Those species were the Lewin's Rail *Lewinia pectoralis*, Grey Goshawk *Accipiter novaehollandiae*, Collared Sparrowhawk *A. cirrocephalus*, Australian Hobby *Falco longipennis*, Fuscous Honeyeater *Ptilotula fusca*, Varied Sittella *Daphoenositta chrysoptera*, Satin Flycatcher *Myiagra cyanoleuca*, Australian Magpie *Gymnorhina tibicen* and Scarlet Robin *Petroica multicolor*.

Sulphur-crested Cockatoo *Cacatua galerita* and two pigeon species, the Brown Cuckoo-Dove *Macropygia phasianella* and Wonga Pigeon *Leucosarcia melanoleuca*, were recorded infrequently in the 1,100−1,300 masl altitude zone (RRs below 2%) and much more frequently in both lower altitude zones (with RRs ranging from 26.3% to 53.5%). Compared to the high-altitude zone, the differences were highly significant (p <0.01) when assessed using the Chi Square test.

Table 1. Summary of results for the three Gloucester Tops altitude zones, for surveys in 2010-2017

	Zone 1 350-450 masl	**Zone 2 450-1100 masl**	**Zone 3 1100-1300 masl**	**Overall**
No. of surveys	43	27	306	376
No. of species	78	51	71	92

Table 2. Species which are candidates for classification as low-altitude specialists (recorded more frequently in the 350−450 masl zone than in the higher altitude zones) and their Recording Rates in each altitude zone.

Species	**RR (%): Zone 1 350−450 masl**	**RR (%): Zone 2 450−1100 masl**	**RR (%): Zone 3 1100−1300 masl**
Australian Brush-turkey *Alectura lathami*	62.8	0	1.3
Fan-tailed Cuckoo *Cacomantis flabelliformis*	65.1	26.3	24.5
Laughing Kookaburra *Dacelo novaeguineae*	81.4	21.0	11.4
Yellow-tailed Black-Cockatoo *Zanda funereus*	25.6	0	10.1
Australian King-Parrot *Alisterus scapularis*	51.2	0	10.8
Superb Lyrebird *Menura novaehollandiae*	88.4	42.1	28.8
Satin Bowerbird *Ptilonorhynchus violaceus*	69.8	21.0	15.7
Superb Fairy-wren *Malurus cyaneus*	88.4	0	1.3
Eastern Spinebill *Acanthorhynchus tenuirostris*	60.5	31.6	29.4
Yellow-faced Honeyeater *Caligavis chrysops*	53.5	15.8	19.9
Australian Raven *Corvus coronoides*	41.9	0	0.3
Spectacled Monarch *Symposiarchus trivirgatus*	20.9	0	0
Rose Robin *Petroica rosea*	74.4	42.1	40.2
Eastern Yellow Robin *Eopsaltria australis*	88.4	36.8	48.0
Red-browed Finch *Neochmia temporalis*	76.7	5.3	1.3
Welcome Swallow *Hirundo neoxena*	76.7	0	0
Russet-tailed Thrush *Zoothera heinei*	72.1	5.3	0.3

Mid-altitude (Zone 2)

Two species, Bell Miner *Manorina melanophrys* and Paradise Riflebird, were recorded in all three altitude zones, but more frequently at mid-altitude. The RRs for both species at 450−1,100 masl were >40% compared with RRs below or considerably below 10% in both the other altitude zones. Using the Chi Square test, these differences between the mid and high-altitude cases were significant (p <0.05).

Low-altitude (Zone 1)

Fifteen species were only recorded within the 350−450 masl altitude zone (see **Appendix** for details: www.hboc.org.au/the-whistler-volume-13/). However, with the exception of the Spectacled Monarch *Symposiarchus trivirgatus*, discussed later, and three nocturnal species, all had very few records. There were insufficient data to draw any conclusions about altitudinal preference for those 15 species. Also, three of them, Tawny Frogmouth *Podargus strigoides*, Australian Owlet-nightjar *Aegotheles cristatus* and Southern Boobook *Ninox boobook*, were nocturnal birds, which therefore were unlikely to have been detected in the diurnal surveys done at higher altitudes.

A further 17 species were recorded in more than one altitude zone and had RRs which were higher in the 350−450 masl zone than at higher altitudes. These are listed in **Table 2**, with their RRs in each of the three altitude zones.

Key Biodiversity Area nomination species

The overall study was conducted within the Barrington Tops and Gloucester Tops KBA. The trigger species for the KBA listing was the Rufous Scrub-bird, which was recorded frequently, but only at high altitude. Of the other species listed to support the KBA nomination, the Flame Robin and Paradise Riflebird were recorded frequently and the Green Catbird, Australian Logrunner and Pale-yellow Robin less frequently. There was only one record of the Regent Bowerbird from any of the surveys (a male in the 350−450 masl zone in October 2011). The Flame Robin was found to prefer the high-altitude zone (1,100−1,300 masl)

and the Paradise Riflebird to prefer the mid-altitude zone (450−1,100 masl). There were insufficient records for the other three species to draw any conclusions concerning differences in their altitudinal distribution.

Observations in other seasons

All the structured survey effort took place in spring when Rufous Scrub-birds breed (Ferrier 1984). A few insights were developed from unstructured non-spring visits to the study area, especially over 2014-2017. An influx of honeyeaters was noted to occur each autumn in the high-altitude zone; the main species involved being Eastern Spinebill *Acanthorhynchus tenuirostris* and Yellow-faced Honeyeater *Caligavis chrysops*, with lesser numbers of various other honeyeater species. This seemed to be associated with flowering of *Banksia* species. Although the Yellow-faced Honeyeater is a passage migrant through the Hunter Region in autumn (Stuart 2017), high numbers of them persisted in the Gloucester Tops for about two months (April-May) in at least some years and perhaps originated from a nomadic local population rather than migrating birds.

The Bassian Thrush *Zoothera lunulata* became more common in the low-altitude zone in winter, with several birds often observed foraging in the open grassy areas around the campsite. Although birds continued to be recorded at low altitude at all other times of the year, a spring-summer movement to higher altitudes was noted.

DISCUSSION

High-altitude zone specialists

The study identified that five species had a clear preference for the high-altitude parts of the Gloucester Tops. The Rufous Scrub-bird is now only known at high-altitude locations throughout its range in eastern Australia (Higgins *et al*. 2001; Cooper *et al*. 2016). In the past there have been records of it to approximately 1,000 masl in the Gloucester Tops (Ferrier 1984; Ekert 2005). That appears to be no longer the case; the areas where previously they had been recorded below 1,100 masl were badly affected by fires in 2009 and 2016 (Stuart & Newman 2018b).

Across its range, the Crescent Honeyeater is recorded from a wide variety of dense vegetation, from coasts to sub-alpine areas (Higgins *et al.* 2001). Its absence below 1,100 masl in the Gloucester Tops is intriguing, since apparently suitable habitat (e.g. woodland with an under-storey of shrubs) is present particularly in the 450−1,100 masl altitude zone. There are just two records from lower altitude locations anywhere in the Hunter Region of New South Wales. In both cases, the birds were present for only a short time (Raine 2014; Stuart 2015).

The Olive Whistler was recorded in Watagans National Park (near Cooranbong, New South Wales) in 1990 and 2000 (Higgins & Peter 2002), which are the only records in the Hunter Region outside Barrington Tops National Park (Stuart 2017). Northern populations of Olive Whistler mainly occur in cool-temperate rainforest dominated by Antarctic Beech (Higgins & Peter 2002). Although some of the high-altitude Gloucester Tops records were of birds in eucalypt woodlands, Antarctic Beech rainforest was always adjacent. In contrast, the Watagans National Park spans altitudes mainly of 100−500 masl, with highest altitude 621 masl (Wikipedia 2017) and has no Antarctic Beech. The records from Watagans National Park presumably involved vagrant birds.

The Flame Robin is well known to be an altitude migrant, breeding within mountainous areas in south-eastern Australia and Tasmania and spending winters at lower altitudes (Higgins & Peter 2002; NSW Office of Environment and Heritage 2011). That description is applicable for Flame Robins in the high-altitude zone of the Gloucester Tops. Birds were absent in autumn and most of the winter, beginning to return from late August (AS pers. obs.). There were many breeding records for them in the 2010-2017 spring surveys.

Across its range in eastern Australia, the Red-browed Treecreeper occupies a variety of habitats and a range of altitudes, with the highest densities occurring in wet sclerophyll forests in gullies of foothills and dry sclerophyll forests on ridges in hilly and mountainous areas (Higgins *et al.* 2001). The lower-altitude parts of the Gloucester Tops seemingly offer habitat matching the former description. Hence, the reasons for the absence of Red-browed Treecreepers below 1,100 masl in the Gloucester Tops warrants closer investigation.

In a Gloucester Tops context, these five species would seem to be most at risk from the effects of climate change. If the amount of suitable habitat for them above 1,100 masl should decrease, they apparently would not be able to exist as sustained populations at lower altitudes.

Mid-altitude zone specialists

The preference of the Bell Miner for the mid-altitude zone is consistent with its habitat preference for open eucalypt forests and woodlands; it is rarely found in rainforest (Higgins *et al.* 2001). The Paradise Riflebird generally is considered to be a bird of subtropical and temperate rainforests and of sclerophyll forests adjacent to rainforests (Higgins *et al.* 2006). In the present study, it was noted that the Paradise Riflebird was more likely to be recorded in eucalypt woodlands adjoining open valleys and having large dead trees which provided advantageous perching sites. The proximity to rainforest habitat was not noted. In the 2016 surveys of all nine 1-km transects in the 450−1,100 masl zone, Paradise Riflebird was recorded in seven of them and some of those records were of multiple birds.

Low-altitude zone specialists

Seventeen species may be candidates for classification as low-altitude specialists. Three of these 17 species mainly utilised the well-grassed picnic area and camping ground – a habitat that was not available elsewhere in the study area. These species were Superb Fairy-wren *Malurus cyaneus*, Red-browed Finch *Neochmia temporalis* and Welcome Swallow *Hirundo neoxena*. The other 14 species seemed to show a strong preference for the temperate rainforest habitat of the lower altitudes. It is noted that the Spectacled Monarch *Symposiarchus trivirgatus* did not arrive in the Gloucester Tops until mid-October each year (AS pers. obs.) and hence was not recorded in any September surveys. As there were no records of it from higher altitudes in September or October, its preference for the low-altitude rainforest would be more strongly apparent if the September data were excluded from analysis. A similar comment may be made about the Noisy Pitta *Pitta versicolor*, which also arrived in the Gloucester Tops in mid-October each year (AS pers. obs.).

An alternative explanation for the higher RR of these 17 species may be that they are more common in temperate rainforests, making their distribution independent of altitude. A potential direction for future studies would be to examine more closely the altitudinal and habitat distribution of these 17 species using directly comparable survey methods.

Key Biodiversity Area nomination species

There was only one record of the Regent Bowerbird from any of the surveys (a male in the 350−450 masl zone in October 2011). This result initially seemed surprising; however, it is consistent with the information available from the national bird atlas, Birdata (Birdata 2017). In Birdata since 2010, considering all months and all types of survey, including records of incidental sightings, there have only been two records of the Regent Bowerbird in the entire KBA, from a total of 760 surveys (RR 0.3%; see **Table 3**). The other record was from an area of temperate rainforest north-west from Salisbury (see **Figure 1**). In contrast, between 1998 and 2010 there were 15 records of the Regent Bowerbird in the KBA from 333 surveys over all months (RR 4.5%). Eighty percent of those were from the area north-west of Salisbury, with the other three records being from the Gloucester Tops low-altitude zone of the present study. The Regent Bowerbird seems to have become uncommon in the KBA in recent years.

Table 3. Reporting Rates in Birdata for the Key Biodiversity Area nomination species for the periods 1998-2009 and 2010-2017, using data for all survey types.

	1998-2009 (333 surveys)		2010-2017 (760 surveys)	
Species	**No. of records**	**RR (%)**	**No. of records**	**RR (%)**
Rufous Scrub-bird	20	6.0	282	37.1
Green Catbird	39	11.7	39	5.1
Regent Bowerbird	15	4.5	2	0.26
Australian Logrunner	19	5.7	18	2.4
Paradise Riflebird	19	5.7	31	4.0
Flame Robin	40	12.0	94	12.4
Pale-yellow Robin	11	3.3	6	0.79

Comparison of Birdata records for all seven KBA nomination species for the pre- and post-2010 periods indicates other changes may have occurred (**Table 3**). The two review periods were chosen to coincide with commencement of the annual spring survey program. The results from all survey types including reports of incidental sightings are presented in **Table 3**. Similar patterns were obtained when a single survey type (either 2 ha / 20-minute survey or 500 m-area survey) was compared across the two review periods.

The RR for the Rufous Scrub-bird increased substantially (**Table 3**), reflecting targeted surveys in its core habitat by experienced observers. RRs for Paradise Riflebird and Flame Robin were similar for both periods. However, the RRs for Regent Bowerbird, Green Catbird, Australian Logrunner and Pale-yellow Robin decreased (**Table 3**). A factor in the observed decline may be that a greater proportion of surveys in the KBA have been in areas of unsuitable habitat for these species (*viz* in the core habitat of the Rufous Scrub-bird). However, when the area of the Scrub-bird study was excluded from the Birdata analysis (removing 306 of 760 surveys), the RRs for all four species remained much lower for the 2010-2017 period. A matter for future investigation will be to confirm the apparent decline and seek reasons for it, including assessing either if there are specific areas within the KBA where species have declined or if the changes are more widespread across the KBA.

CONCLUSIONS

Spring surveys between 2010 and 2017 in the Gloucester Tops in New South Wales recorded 92 bird species, with an additional three species recorded in unstructured night surveys. Five species (Rufous Scrub-bird, Red-browed Treecreeper, Crescent Honeyeater, Olive Whistler and Flame Robin) were found to be highly significantly more likely to be recorded at altitudes above 1,100 masl. In a Gloucester Tops context, these five species would seem to be most at risk from the effects of climate change based on the concept of shrinking islands of montane vegetation (Watson 2010).

The Sulphur-crested Cockatoo, Brown Cuckoo-Dove and Wonga Pigeon were found to be highly significantly more likely to be recorded below 1,100 masl. Paradise Riflebird and Bell Miner were significantly more likely to be recorded in the 450−1,100 masl zone. In the lowest altitude zone, 78 species were recorded, including 17 species which are candidates for classification as low-altitude specialists.

There was only one record of the Regent Bowerbird from the surveys and this species appears to have become uncommon in the KBA. The populations of Green Catbird, Australian Logrunner and Pale-yellow Robin may also have declined.

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