Varied Sittellas in the Hunter: distribution, habitat and threats

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The Varied Sittella *Daphoenositta chrysoptera* is a widely distributed but relatively uncommon species in the Hunter Region, consistent with its occurrence elsewhere. Long-term monitoring in the Paterson area of the Hunter Region has demonstrated that remnant woodland on farms and protected public lands provides important habitat for this species.

In the Paterson area studies there was evidence of a long-term decline in the status of the Varied Sittella with the frequency of occurrence decreasing by more than 50% in the last decade. A similar magnitude of decline during this period was apparent in the results of BirdLife Australia Birdata area surveys for the whole of the Hunter Region. However, this decline, which was statistically significant, was not apparent throughout the broader bio-region of the east coast of Australia.

Clearing of remnant vegetation, particularly the selective removal of the rough-barked tree species which provide food for sittellas was suspected to have contributed to the decline in the Paterson area studies. As observers primarily encounter sittellas in modified habitat, particularly near roads, habitat loss and gradual degradation provide a plausible cause of the observed decline throughout the Hunter Region.

The status of the Varied Sittella, which exclusively forages on the trunks and branches of trees, is considered to be limited by food availability. As an adaptation to these circumstances sittellas form collaborative groups and clans which occupy large territories. Any factor which decreases food availability, such as the removal of the preferred rough-barked trees, would be expected to decrease sittella numbers and increase their vulnerability to factors such as drought, which may cause short-term fluctuations in food availability.

It would be courageous for land managers to assume that the widespread distribution of the Varied Sittella provides a buffer against processes threatening the status of the species. Evidence presented in this paper suggests that the species may favour modified and even fragmented habitats when they occur adjacent to larger patches of remnant vegetation. However, if such habitat is progressively degraded across the landscape, as appears to be occurring in the Hunter Region, the level of threat to the species' viability will inevitably increase.

INTRODUCTION

The Varied Sittella *Daphoenositta chrysoptera*, which is listed as Vulnerable under the NSW *Threatened Species Conservation Act 1995* is not a common species in the Hunter Region. In north-eastern NSW Varied Sittellas occurred in sedentary groups or clans holding weakly-defended territories of 13-20ha (Noske 1998). Observations in the Hunter Region, where this species is intermittently encountered in woodland areas, are consistent with this lifestyle.

The BirdLife Australia (BLA) Atlas archive Birdata provides information on the distribution of the Varied Sittella in the Hunter Region. However, for relatively uncommon species like the sittella interpretation of temporal trends in occurrence is difficult because of a combination of inadequate survey sample sizes and variation in survey effort. Fortunately, within large data sets like BLA Birdata there are subsets of information which have been generated with rigid control of survey method and effort in areas of defined habitat. A number of such studies were conducted by the author in the Paterson area of NSW between 1996 and 2013 and these provide insights into the status and conservation requirements of the Varied Sittella.

Varied Sittellas are mostly found in eucalypt woodlands and forests where rough-barked trees and mature eucalypts with hollows and dead branches are present (Higgins & Peter 2002). Noske (1985 & 1998) suggests that group-living and philopatry in the Varied Sittella probably developed to increase foraging efficiency. Noske further suggests that large territories, feeding of the

incubating female, as well as a specialised foraging niche and cryptic prey, all suggest that food may be limiting for this species.

This paper examines the Varied Sittella's status and habitat preferences in the Hunter Region, with emphasis on studies in the Paterson area.

METHODS

The analysis presented herein is based on observations undertaken across the entire Hunter Region and includes more comprehensive long-term datasets in several locations (e.g. Green Wattle Creek, Butterwick and *Warakeila* and other sites; see **Table 5** below). Most of the survey data was submitted to the BLA Atlas and is available in their Birdata archive. All the Birdata records for the period 1998 to 2014 for the Hunter Region were obtained in 2015. Survey data was separated into two categories for analysis:

- 2ha surveys - which involved listing all bird species present in a 2ha area during a 20-minute survey.

- Area surveys - which involved listing all species present in areas bounded by a radius of either less than 500m or less than 5km. While there is no constraint on survey time in this data set, most surveys were conducted within a 24-hour period.

Other data sources containing sittella records such as the Atlas of NSW Wildlife were not considered.

Distribution

Results from both survey types were combined to determine the distribution of Varied Sittellas in the Hunter Region.

Reporting Rates

Annual reporting rates (RRs) indicating the frequency of occurrence of Varied Sittellas in the Hunter Region, were calculated as a percentage of the number of surveys conducted in 10-minute grid blocks where Varied Sittellas have been recorded at least once between 1998 and 2013 (i.e. surveys in grids where the Varied Sittella had not been recorded were ignored). RRs calculated in this manner avoid dilution from surveys conducted in unsuitable habitat. RRs were also calculated for individual survey sites.

2ha surveys generate the most consistent data because the area and duration (20 minutes) of the survey are constant. However, RRs are low for scarce species like the Varied Sittella making it difficult to draw statistically significant conclusions concerning differences between temporal changes in the frequency of occurrence and the relative importance of different survey sites without very large numbers of this type of survey.

Area surveys usually involve more effort in terms of both the area covered and the time spent searching for species. While this results in higher RRs for sparse species the survey effort is often variable, confounding comparisons between sites and temporal analysis using this source of data. However, there are some long-term data sets involving area surveys where the survey effort was constant as discussed in the next section.

During the subsequent presentation and discussion of results any percent values reflecting the frequency of occurrence of sittellas have been calculated as reporting rates.

Constant survey effort data sets

Most of the work described below involved studies in which surveys, both 2ha and area, were conducted in an identical manner. In the case of area surveys a constant route through the survey site was used, with approximately the same survey duration on every occasion. Consequently, temporal variations in the RRs at these sites were not affected by variations in survey effort. However, there were differences in the size of the area searched and survey duration between studies at different locations which compromised inter-site comparisons. Because all 2ha surveys were conducted with the same survey effort (i.e. 2ha searched for 20 minutes), between-sites comparisons were possible. For instance, a statistically significant difference in occurrence of Varied Sittellas between two 2ha survey sites may indicate a difference in the suitability of the habitat at and surrounding the sites (i.e. the survey site is a sample of the habitat at that location).

Four data sets involved a hybrid survey technique in which a number, usually four, of 2ha sites were embedded in an area survey conducted along a fixed route between the 2ha sites. These studies (Newman 2006 & 2009; Newman & Lindsey 2008) were part of the Royal Australasian Ornithologists Union (now BLA) Birds on Farms project and a fourth unpublished shorter term study used a similar design. For the hybrid survey studies the total survey data was a combination of all the species recorded at the 2ha sites and during the fixed route walk between the sites. Hence the 2ha and total survey results in the hybrid studies are not independent. In analysing the results of hybrid surveys the entire survey is treated as an area search (i.e. the combined records at 2ha sites and those made while walking between the sites) and is reported as the "hybrid" value in **Tables 2**, **3** and **4**.

Response to weed removal and fire

A sub-project was conducted at Green Wattle Creek (Newman 2014b) to determine the response of woodland birds, including the Varied Sittella, to habitat management using a combination of controlled burns and manual removal of invasive weeds (e.g. lantana). Three 2ha sites, Post-burn 1, Post-burn 2 and Post-burn 3, were subjected to both weed removal and controlled burns conducted in spring 2010 (Post-burn 3) and autumn 2011 at the other two sites. Weeds were removed at a fourth 2ha site (Rehab), but it was not burnt. The 2ha surveys were conducted in three campaigns, two in spring and one in autumn, over an 18-month period in 2012 and 2013.

RESULTS

Hunter Region

The Varied Sittella is widely distributed in the Hunter Region (**Figure 1**) with records from just over half the 151 ten-minute grids which comprise the region. However, within that range it is relatively infrequently recorded with a RR of 6.9% in area surveys (**Table 1**). Records of the Varied Sittella in the Hunter Region submitted to the BLA Birdata archive between 1998 and 2014 are summarised in **Table 1**.

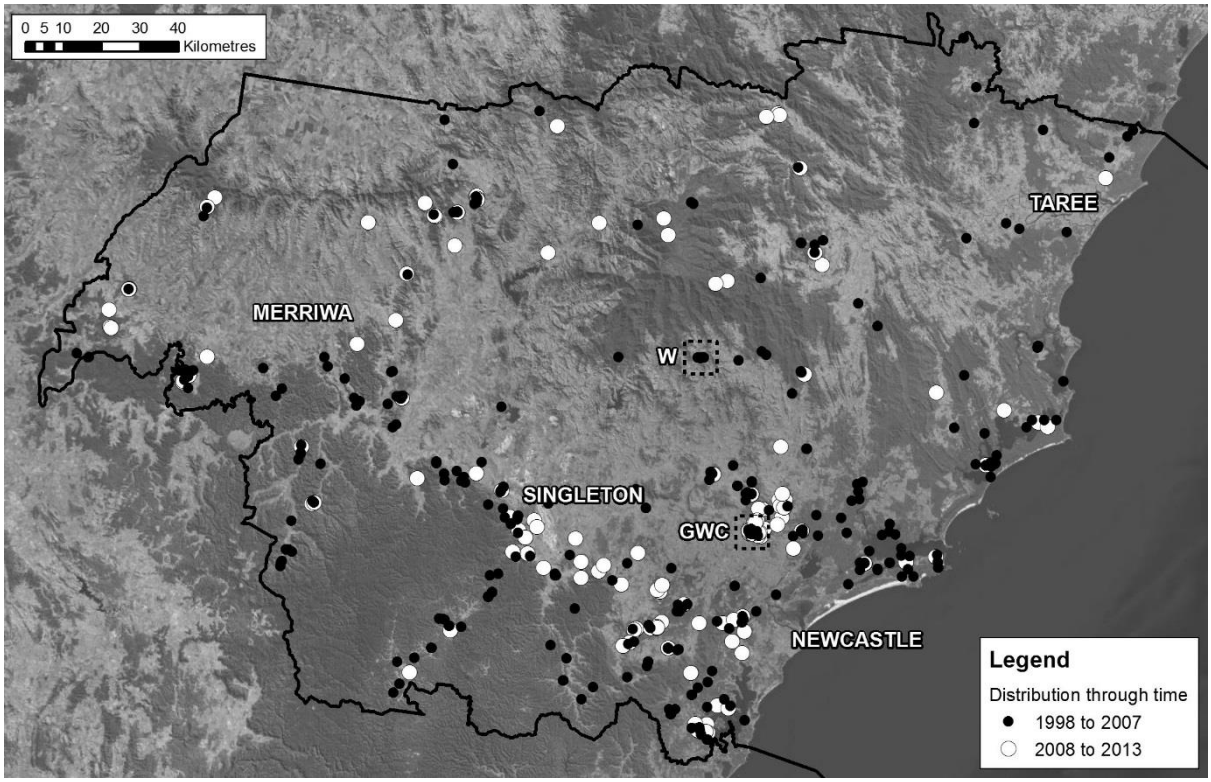

Figure 1. The distribution of Varied Sittellas in the Hunter Region of NSW. The two boxed areas indicate locations where long-term studies were conducted at Green Wattle Creek and the adjacent Butterwick cattle property (GWC) near Paterson and at *Warakeila* (W) in the Allyn River valley.

Table 1. Summary statistics of Varied Sittella records submitted to the BLA Birdata archive for the period 1998-2014.

Survey Method	Varied Sittella records	Number of surveys	Reporting Rate (%)	10-minute grids[1]	Hunter coverage (%)
Area	656	9471	6.9	79	52
2ha	108	3767	2.9	33	22
Combined	764	13238	5.8	84	56

[1] The Hunter Region comprises 151 grids of 10-minute latitude/longitude size.

There was a statistically significant decline in the occurrence of Varied Sittellas in area surveys conducted in the Hunter Region during the period 1998-2014 as shown in **Figure 2**.

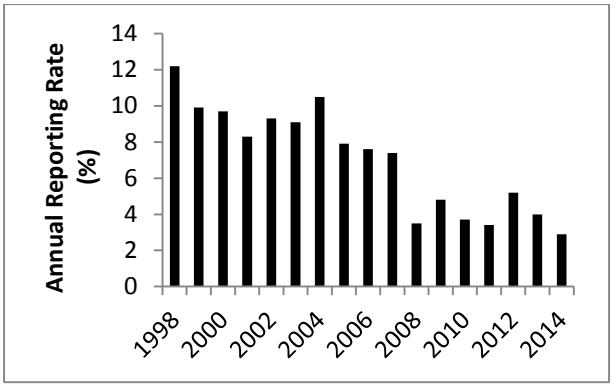

Figure 2. The variation of the annual reporting rate of Varied Sittellas in area surveys for the Hunter Region for the period 1998-2014. The mean number of surveys/annum was 525. The linear correlation factor *r* of -0.92 (n=17) was statistically highly significant ($p<0.01$).

Green Wattle Creek
(32.661°S 151.649°E)

Surveys were conducted monthly between 1996 and 2013 in remnant forest at the end of Green Wattle Creek Road, Butterwick. This land is an 81-hectare Crown Conservation Reserve (Reserve No. 1014828), which is currently reserved for the public purpose of Environmental Protection. It is currently subject to a 15-year incentive Property Vegetation Plan through the Hunter Local Land Services. The hybrid survey technique, survey sites and habitat are described in Newman (2009). The area was historically grazed and logged and there were no wildfires since at least 1992. Observations of Varied Sittellas are summarised in **Table 2**. Varied Sittellas were recorded at all four 2ha sites with an average frequency of 2.3%. They occurred most frequently at site 2 where the habitat initially involved open woodland. However, trees were progressively removed from this site up to the edge of the bordering wetter creek-zone vegetation. Five of the seven records occurred during the period 1996 – 2001 and other than two records in 2005 there were no subsequent records, suggesting that habitat modification had rendered the site unsuitable for sittellas. The majority of the records involved sittellas encountered while walking between the 2ha survey sites. Sittellas were recorded during 31.7% of the hybrid surveys, which took approximately four hours, with evidence of decline during the second half of the study (**Figure 3)**.

Table 2. Records of the Varied Sittella during 186 monthly surveys in woodland at Green Wattle Creek near Paterson, NSW between 1996 and 2011.

Site	Reports	RR (%)	Surveys
1 (2ha)	4	2.2	186
2 (2ha)	7	3.8	186
3 (2ha)	3	1.6	185
4 (2ha)	3	1.6	184
All 2ha	17	2.3	741
Hybrid	59	31.7	186

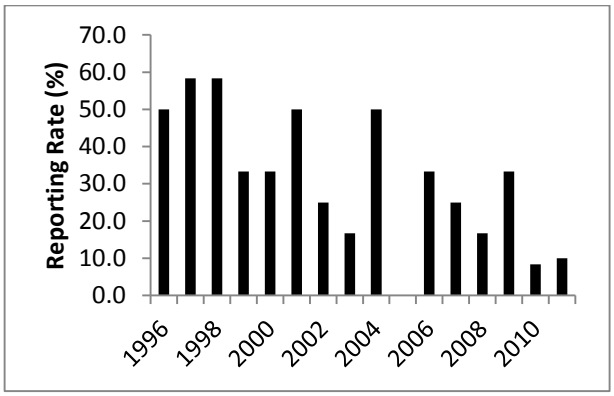

Figure 3. Variation in annual RR of Varied Sittellas during monthly fixed-route surveys of four hours' duration in woodland at Green Wattle Creek between 1996 and 2011.

Farm Studies

The three farm studies involved the hybrid survey approach using a combination of area and 2ha surveys. At *Yaraandoo* surveys were also monthly, but over a more limited period from 2010 to 2013. The Butterwick (1996 to 2013) and *Warakeila* (1996 to 2010) studies involved surveys at three-monthly intervals. Results for the Butterwick and *Warakeila* properties are discussed in the following sections. The *Yaraandoo* results are contained in the subsequent section on other large data sets.

Cattle property at Butterwick
(32.655°S 151.640°E)

Surveys were conducted quarterly between 1996 and 2011 on a property at Butterwick adjacent to Green Wattle Creek Road and the Green Wattle Creek Crown Reserve. The hybrid survey technique, survey sites and habitat are described in Newman (2006). The Varied Sittella records are summarised in **Table 3**.

Table 3. Records of the Varied Sittella during 64 quarterly surveys on a cattle property at Butterwick near Paterson, NSW between 1996 and 2011.

Site	Records	RR (%)	Surveys
1 (2ha)	5	7.9	63
2 (2ha)	1	1.6	64
3 (2ha)	4	6.3	64
4 (2ha)	6	9.4	64
Combined 2ha	16	6.3	255
Hybrid	18	28.1	64

The property has about 15% remnant vegetation in which the four 2ha sites were located. Sittellas were recorded at all four 2ha sites at an average RR of 6.3%. Occurrence at site 2, which predominantly involved creek-side vegetation, was lower (1.6%) than at the other three sites (6.3% to 9.4%), which involved copses of trees. Sittellas were seen at the 2ha sites and walking between the sites, during 28.1% of the 64 surveys.

Warakeila
(32.247°S 151.513°E)

Surveys were conducted quarterly between 1996 and 2010 on *Warakeila*, a cattle property in the Allyn River valley, NSW. The survey technique, survey sites and habitat are described in Newman & Lindsey (2008). Observations of Varied Sittellas are summarised in **Table 4**.

Table 4. Records of Varied Sittellas during 59 quarterly surveys between 1996 and 2010 at *Warakeila*, a cattle property in the Allyn River valley, NSW.

Site	Reports	RR (%)	Surveys
1 (2ha)	0	0.0	59
2 (2ha)	3	5.1	59
3 (2ha)	0	0.0	58
4 (2ha)	3	5.1	59
Combined 2ha	6	2.6	235
Hybrid	11	18.6	59

The property had about 15% remnant vegetation. The four 2ha sites were located in this vegetation. Sittellas were recorded at sites 2 and 4 with a frequency of 5.1% in both instances. Both these sites featured numerous trees and had good connectivity to other woodland. There were no sittella records at site 1, which involved creek-side vegetation, or at site 3 which was an isolated copse. Sittellas were recorded, either at the 2ha sites or walking between them, during 11 of the 59 surveys (18.6%), which typically took at least four hours. Approximately half the sittella observations were made while moving between the 2ha sites.

Other studies with large survey sets

The results in **Table 5** were drawn from the literature and the author's unpublished records. In each case the data was collected in a standard manner at individual sites. However, there were differences in survey effort between studies as indicated in **Table 5**.

Table 5. Summary of results of other studies with large data sets involving constant survey effort.

Location	Surveys	Area	Duration	Records	RR (%)	Period
Forest Road, Duns Creek[7]	74	500m	90min	0	0	2005-2014
Black Rock, Martins Creek[1]	104	5km	135min	22	21.2	1999-2013
Columbey South Trail[8]	6	500m	40min	2	33.3	2013
Blue Gum Hills Regional Park[5]	44	500m	200 min	2	4.5	2012-2015
Wirrumbirra, Laguna[2]	296	5km	Monthly	23	7.8	1979-2012
Yaraandoo[6]	45	5km	180 min	10	22.2	2010-2013
Yaraandoo[6]	140	2ha	20 min	1	0.7	2010-2013
GWC Rehab[3]	49	2ha	20min	4	8.2	2011-13
GWC Post-burn 1	47	2ha	20min	2	4.1	2011-13
GWC Post-burn 2	44	2ha	20min	1	2.0	2011-13
GWC Post-burn 3	42	2ha	20min	1	2.0	2011-13
Curracabundi National Park[4]	190	2ha	20min	3	1.6	2010-13

[1] Newman (2014a); [2] Raine (2014), (32.984°S 151.102°E); [3]Newman (2014b); [4]Drake-Brockman (2015), (31.667°S 151.750°E); [5]Greg Little unpublished results (32.891°S 151.622°E); [6,7,8]Newman unpublished results [6](32.635°S 151.659°E), [7](32.631°S 151.513°E), [8](32.600°S 151.739°E).

Comparison of Hunter studies

Results for the Hunter studies were compared with values for the entire Hunter Region over the period 1998 to 2014 (**Figure 4**).

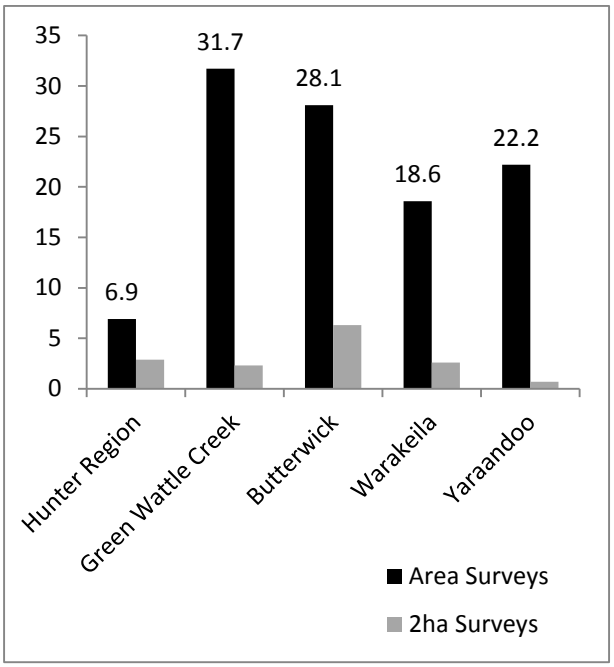

Figure 4. Comparison of reporting rates for Varied Sittellas during the farm and Green Wattle Creek studies with the rates for the entire Hunter Region for the period 1998 - 2014. Durations of individual area (hybrid) surveys were 3 hours at Butterwick and *Yaraandoo*; 4 hours at Green Wattle Creek and *Warakeila*. The mean duration of area surveys for the entire Hunter Region is unknown, but expected to be considerably less than 3 hours.

East Coast Bioregion trend

The State of Australia's Birds Project has established dynamic trends for the occurrence of a number of bird species using Birdata based on methodology described in the recent report of headline trends for terrestrial birds (Ehmke *et al.* 2015). The trend for the Varied Sittella in the East Coast Bioregion, which includes the Hunter Region, is shown in **Figure 5**.

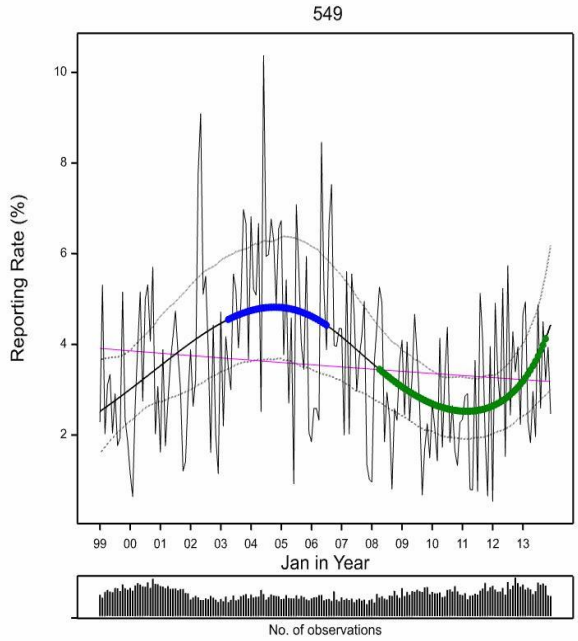

Figure 5. Dynamic variation in the occurrence of the Varied Sittella in the East Coast Bioregion of Australia, indicating a peak RR(%) about 2005 followed by a decline and the start of a recovery in 2011. Ehmke *et al.* (2015) provides a detailed explanation of the observed trend. Area surveys were used for this analysis.

DISCUSSION

In the Hunter Region Varied Sittellas are recorded in only 1 in 14 area surveys compared with a ratio of 1 in 2 for common species like the Superb Fairy-wren *Malurus cyaneus*. As Varied Sittellas are encountered as active, noisy family groups in open woodland they are easily detected and their infrequent recording is a genuine indication of scarcity rather than difficulties in detection. It has been suggested that sittellas, which are obligate trunk and branch feeders, have larger territories than foliage-feeding species like thornbills (*Acanthiza* species*)* because their food availability is limited (Noske 1985 & 1998); hence their relatively sparse occurrence.

Varied Sittellas were more frequently recorded in the south and west of the Hunter Region (**Figure 1**). However, this conclusion should be treated with caution because the unstructured nature of the surveys (i.e. variable survey areas and time spent surveying), together with low survey sample sizes in the remoter western and northern areas, compromise comparisons between sub-regions.

Fortunately the long-term studies (e.g. on farms and at Green Wattle Creek) described above generated quantitative information on the occurrence of Varied Sittellas at RRs above the mean level for the Hunter Region (**Figure 4**) and for the East Coast Bioregion of Australia (**Figure 5**). As will be discussed in the following section, these studies set bench-mark RR levels for areas which support Varied Sittellas and provide some insights into the habitat requirements of the species.

In each of the studies involving farms with remnant vegetation and the remnant woodland at Green Wattle Creek the Varied Sittella area survey RR was more than twice the mean level for the Hunter Region (**Figure 3**). This provided compelling evidence that the Paterson and Allyn River areas provided important habitat for Varied Sittellas. The extent to which these locations provided superior sittella habitat was uncertain because these studies involved more comprehensive survey effort than was the norm for the Birdata citizen science data set for the Hunter Region. However, the difference in the frequency of occurrence is sufficiently large (e.g. 1:3 surveys at Green Wattle Creek compared with 1:20 surveys for the entire Hunter Region or 1:14 for grids where the Varied Sittella has been recorded) to suggest the inference that these locations provide important habitat is justified.

Green Wattle Creek

At Green Wattle Creek where surveys were conducted at monthly intervals, Varied Sittellas were usually encountered as a single flock with continuous presence for a number of months, including breeding, interspersed by prolonged periods of absence. Hence, the impression was gained of a species which is locally nomadic rather than holding fixed territory indefinitely (see Newman 2010b), which is consistent with Noske's finding in north-eastern NSW (Noske 1998).

In the first half of the Green Wattle Creek study, which involved monthly hybrid surveys between 1996 and 2013, the annual RR was 50% or greater in five out of nine years (**Figure 3**). Potential explanations of the cause of the subsequent decline after 2004 (**Figure 3**) include a regional decline in the species and deterioration in the suitability of the woodland at Green Wattle Creek for Varied Sittellas. There is evidence supporting both these possibilities as discussed below.

There was a corresponding decline in the RRs for area surveys throughout the Hunter Region (compare **Figures 2** and **3**), although in **Figure 2** the trend may be influenced by variations in survey effort associated with the unstructured nature of the surveys. Across the broader East Coast Bioregion there was no evidence of a long-term decline over the same period (**Figure 5**). However, fluctuations occurred with a peak in 2005 followed by a prolonged period of decline through to 2011. The post-2011 recovery across the broader East Coast Bioregion (**Figure 5**) is not apparent in the Hunter Region data (**Figure 2**) suggesting any decline involving the Hunter Region is of limited geographic extent. Fluctuations like that shown in **Figure 5** are an expected feature of stable populations, whereas extended declines of the type shown in **Figures 2** and **3** may suggest a species is experiencing a longer-term decline in status. There is limited information on the longevity of Varied Sittellas (Higgins & Peter 2002), but based on the estimate of five years for the generation time (Debus & Soderquist 2008) the long-term decline evident in **Figure 2** would appear to exceed two generation times.

In 1996 when the study commenced Green Wattle Creek was a lightly grazed woodland and, other than near the creek at the northern end, involved open woodland with very little understorey. Cattle grazing ceased soon after the start of the study, and understorey vegetation progressively increased to the detriment of ground-foraging species such as the Speckled Warbler *Chthonicola sagittata* (Newman 2010a). It is not obvious why this vegetation change should have impacted on the Varied Sittella which forages on the trunks and limbs of trees as opposed to the ground (Higgins & Peter 2002). However, during this period a considerable number of trees, particularly mature ironbark species, were illegally removed for firewood and fencing. These mature trees, particularly rough-barked trees, are important features of sittella habitat (Higgins & Peter 2002). Any decrease in rough-barked tree numbers would decrease the availability of food, which is scarce in the specialised niche exploited by sittellas (Noske 1998). Consequently selective removal of rough-barked trees may have contributed to the Varied Sittella's apparent decline at Green Wattle Creek. For instance Noske (1998) suggests that the densities and sizes of territories of sittellas may be determined by the abundance of rough-barked eucalypts at a site. Periods of drought may also have contributed to both local and regional decline

of insectivorous species like sittellas, as has been suggested in relation to fluctuations in the occurrence of Grey Fantails *Rhipidura fuliginosa* at Green Wattle Creek (Newman 2012). A long-term decline in aerial insectivores was described in the recently published State of Australia's Birds 2015 report (Ehmke *et al*. 2015).

The four 2ha survey sites were selected to sample different vegetation sites representative of the total study area. Varied Sittellas were recorded at all four sites with a mean RR of 2.3% (**Table 2**). Assuming that the frequency sittellas were encountered was proportional to the survey time the mean RR for a four-hour total survey time would be 27.6%, which is in reasonable agreement with the observed value of 31.7% in the hybrid survey (**Table 2**). The total area surveyed during the four hours was estimated to be approximately 15ha of suitable continuous woodland, which is of the magnitude required to support a sittella clan (Noske 1998), consistent with the high RRs in the initial years of the study (**Figure 2**). Decreased occurrence since 2005 suggests that the survey area no longer permanently supports a sittella clan and is now visited intermittently as part of an extended sittella territory.

The 3.8% RR for 2ha site 2 was more than double the mean rate for the other three sites. This site was initially selected because it involved an area of open woodland with scattered mature trees and grassy understorey. This area was subsequently cleared to establish an equestrian centre requiring the survey site to be shifted closer to the less open habitat adjacent to the creek. The possibility that the open nature of this site when initially established might provide optimum sittella habitat is supported by the high 2ha RR of 11.8% during the first six years of the study. Occurrence was also at a similar level (8.2%) during a short-term project at the GWC 2ha Rehab site (**Table 5**), where the habitat was superficially similar to site 2 at the start of the study in 1996. In a contemporaneous set of surveys at Post-burn sites 1-3 (**Figure 6**) adjacent to the unburnt Rehab site the mean RR was 2.7% (**Table 5**). At all four of these sites the shrub layer had been largely removed by a combination of manual removal of lantana and burning at the post-burn sites. The burn was carefully controlled in order to leave the canopy intact, but may have affected the viability of the tree trunks as a food resource for sittellas. This would explain the higher RRs at the unburnt rehab site. The net impact of the rehabilitation effort at the rehab and post-burn sites was to restore the habitat to a structure which was similar to that at the start of the long-term study when the shrub layer was controlled by grazing. However, as indicated by **Figure 6,** there was more groundcover in the absence of grazing. The rehabilitation temporarily benefitted the Speckled Warbler and the Eastern Yellow Robin *Eopsaltria australis* (Newman 2014b). It is possible that the Varied Sittella was similarly advantaged as the mean RR for these post-burn sites of 2.7% was greater than the long-term mean of 2.3% for the four 2ha sites (**Table 2**) during a period in which the Varied Sittella was declining. It must be stressed that the post-burn and rehab sites are different survey sites to those in the long-term Green Wattle Creek study.

While the above results demonstrate that carefully controlled cool burns have limited adverse impact, an extensive hot wildfire impacting on trunks, branches and the canopy would be expected to render an area unsuitable for sittellas, at least in the short term.

Figure 6. Habitat at the GWC Post-burn survey site 1, which had been restored to a condition structurally similar to that which existed throughout much of the Green Wattle Creek study area when the project commenced in 1996. However, following the burn in autumn 2011 and in the absence of cattle there was extensive grass groundcover.

Farm studies

The range of 2ha RRs for Varied Sittellas in the farm studies varied from 0.7% at *Yaraandoo* to 6.3% at Butterwick, straddling the mean value of 2.9% for all 2ha sites in the Hunter Region between 1998 and 2014. A key reason for this general correspondence of the farm study RR

magnitudes with other data is that the farm study data sets form a large proportion of the 2ha data set for the Hunter Region. This bias is much less pronounced for the area search data where the ratio of farms to other surveys is more than five times lower.

The farm studies (Butterwick, *Warakeila* and *Yaraandoo*) all involved properties which were grazed by cattle throughout the survey period. In each case extensive clearing had occurred with only about 15% vegetation retained. The 2ha sites were located in these fragmented woodland remnants which, even collectively, were of insufficient size to support a sittella clan. The magnitudes of the long-term hybrid survey RRs were in the range 18 to 28% (**Figure 4**) suggesting these areas are regularly visited by sittellas, even if they do not support a resident clan. However, at each study location there were extensive areas of bush in close proximity to the farms capable of providing extended territories.

At Butterwick and the adjacent woodland at Green Wattle Creek, the long-term hybrid survey RRs were similar at 28.1% and 31.2% respectively (**Figure 4**). The mean RR (7.9%) for the three 2ha sites at Butterwick (**Table 3**), which involved copses of trees with limited shrub layer, was higher than the 2.6% found at the nearby Green Wattle Creek 2ha sites over the period 1996-2011. However, the RR is very similar to the 8.2% found at the Green Wattle Creek rehabilitation site (**Table 5**). The highest Butterwick 2ha RR was 9.4% at site 4, where the species has bred. Structurally the vegetation at Butterwick site 4 (**Figure 7**) was similar to nearby Green Wattle Creek site 2 before cattle grazing ceased and trees were removed when the equestrian centre was established (Newman 2006 & 2009) and to the GWC Rehab site (Newman 2012). Collectively these observations suggest that open woodland with limited shrub layer suits Varied Sittellas and that light grazing may help maintain these conditions. In contrast, in dense creek-side vegetation at Butterwick site 2, sittellas were only present occasionally (1.6%), primarily in a small copse of trees near the creek.

Figure 7. Habitat at Site 4 on the Butterwick property, where Varied Sittellas have bred, showing the presence of rough-barked trees and the open structure of the woodland. Cattle grazing has removed the understorey and groundcover vegetation.

At *Yaraandoo*, a lightly grazed property about 5km from Green Wattle Creek, the RR for Varied Sittellas during monthly hybrid surveys was 22.2% between 2010 and 2013 (**Table 5**). Most of the records were in lightly grazed open woodland with grassy understorey, with only one record at the 2ha survey sites which sampled dense creek-side vegetation, a rainforest gully and an olive grove, all of limited suitability to Varied Sittellas. The hybrid survey reporting rate of 18.6% (**Table 4**, **Figure 4**) at *Warakeila*, a property in the Allyn River valley surveyed between 1996 and 2010, was slightly lower than at the other farms. No sittellas were recorded at *Warakeila* 2ha site 1 which involved creek-side vegetation, a finding which was consistent with the result at Butterwick. Perhaps more surprisingly was the absence of sittellas at *Warakeila* site 3, an isolated copse of trees, although progressive ringbarking of trees severely degraded it over the period of the study. Sittellas were recorded at 2ha sites 2 and 4 with RRs of 5.1% in both instances. These sites involved very different types of woodland habitat. *Warakeila* site 2 was on a track perpendicular to a gully supporting rainforest vegetation, whereas site 4 was on flats adjacent to the Allyn River where mature casuarinas were the dominant trees used by the sittellas. At both these sites extensive vegetation clearing occurred during the study, apparently rendering them less suitable for sittellas.

Other studies

Varied Sittellas were frequently recorded (21.2%) at Black Rock, Martins Creek during fixed-route area surveys between 1999 and 2013 (**Table 5**) with evidence of a progressive decline from the 31% recorded during the first three years of the study. They were absent during a period of drought (Newman 2014a). The Black Rock study was mainly conducted along roads in a rural landscape involving patches of remnant woodland. A feature of this study was the occurrence of sittellas in roadside vegetation along fence lines through cleared land. Ongoing clearing, including along fence lines, may have contributed to the apparent decline of sittellas in the study area.

At Forest Road, Duns Creek the Varied Sittella was not recorded during 74 surveys sampling roadside vegetation through an area containing a combination of acreage properties and grazed paddocks. The absence of Varied Sittellas was surprising as superficially the habitat and survey effort was similar to that at Black Rock, Martins Creek.

Sittellas were frequently recorded (33.3%) along the South Trail at Columbey National Park in 2013 (**Table 5**). Unfortunately the sample size was small and the results are merely indicative that this small area of open woodland with shrubby understorey could be important habitat.

The other studies summarised in **Table 5** were included to provide benchmark data for occurrence of sittellas in different areas and habitats of the Hunter Region. Varied Sittellas were located at only three of 21 2ha survey sites (1.6%) during a three-year study at Curracabundi National Park in the north of the Hunter Region (Drake-Brockman 2015). They occurred less frequently during 2ha surveys than for the farms in the Paterson area. At Blue Gum Hills Regional Park in the greater Newcastle area the RR for Varied Sittellas was 4.5% in area surveys involving similar observer effort to those at Green Wattle Creek and the other farm studies where the range was 19 to 32% (**Figure 4**). The results of both these studies highlight the extent to which remnant vegetation studied in the Paterson area appears to provide superior habitat for Varied Sittellas. At Curracabundi many of the survey sites were in wetter heavily wooded mountainous habitat with steep gullies, which seemed to be less suitable. In contrast the Ironbark-Spotted Gum woodland at Blue Gum Hills Regional Park would seem suitable habitat and it is perhaps surprising that Varied Sittellas were seldom recorded. However, at Blue Gum Hills Regional Park, which is located midway between Green Wattle Creek and the coast, the vegetation tends to be denser and wetter, probably because of its proximity (15km) to the coast.

Habitat requirements

Area surveys do not precisely define where surveys were conducted making it difficult to identify the habitat types favoured by sittellas. This issue was overcome when 2ha surveys with precisely defined locations were used, but the sparse occurrence of Varied Sittellas (2.9%, **Table 1**) in this type of survey necessitates large data sets to identify preferred 2ha survey sites and hence habitat. This is not surprising because sittella territories are typically 13 to 20ha (Noske 1998) which is much larger than 2ha survey sites. Within the Hunter Region the intensive studies at Green Wattle Creek and farms in the Paterson region address these requirements, but involved habitat which was highly modified and, except for Green Wattle Creek, is fragmented into small remnants. Even the continuous woodland at Green Wattle Creek involved regrowth with limited numbers of mature trees. However, the high frequency of occurrence of Varied Sittellas in the area survey data demonstrates that all these locations regularly support Varied Sittellas. None of the farms studied appeared to have sufficient habitat to support a sittella clan permanently. At Green Wattle Creek, habitat and related ecological changes occurred during the study resulting in a decline in the sittella's occurrence to magnitudes similar to those on the farms, suggesting that the area of woodland surveyed was no longer capable of permanently supporting a resident sittella clan. A number of potential causes of decline have been identified, including changes in vegetation structure following cessation of grazing. However, degradation by selective removal of mature rough-barked trees is considered to have been a key factor in rendering the Green Wattle Creek woodland less suitable for sittellas.

It may be courageous to conclude that the habitat in these studies, which primarily involved remnant and highly modified vegetation, is optimal for the Varied Sittella, even though the species is recorded more frequently than in other areas of the Hunter Region. The inference is based on the results of survey data sets which on average involved more survey effort than in other areas. In addition, they sampled a limited set of habitat types. In other sub-regions of the Hunter the sittella occurrence rates

will have been diluted by surveys in unsuitable habitat (e.g. heathland and rainforest). Consequently, it is recommended that research is conducted into the habitat requirements of the Varied Sittella across other sub-regions and habitat types using standard approaches with constant survey effort. A focus of the proposed study should be to determine whether sittellas favour more open woodland at forest edges with limited understorey as was found at Green Wattle Creek. It is possible that high survival rates are important for sparse species like the Varied Sittella. For instance their breeding productivity may be lower than for other passerine species because of their specialised foraging requirements. Noske (1998) suggests that the sittella's cooperative lifestyle not only ensures food supply to nestlings is sufficiently high, but also reduces vulnerability to predators. When a member of a sittella clan identifies a threat they become highly vocal and have developed spectacular agonistic group displays (Newman 2007). Survival rates may be higher in more open habitat and in the absence of understorey. During the 1990s Varied Sittellas were observed in mixed foraging flocks, which formed in open areas at Green Wattle Creek outside the spring breeding season (Newman 2015). Buff-rumped Thornbills *Acanthiza reguloides* are nuclear species attracting other species including the Varied Sittella (Bell 1985). The progressive development of understorey at Green Wattle Creek removed the ground-foraging niche essential to the Buff-rumped Thornbills and they declined, as did the occurrence of mixed foraging flocks. This is another example of the potential advantage to sittellas of living in open habitat in terms of strategies which decrease predation and increase survival.

Threats

The final determination by the NSW Scientific Committee (2010) with respect to listing the Varied Sittella as a Threatened Species highlighted decreased habitat quality as being a key factor driving long-term decline. It suggested that because sittellas are sedentary their populations are sensitive to habitat isolation. Although aggression by Noisy Miners *Manorina melanocephala* (Olsen *et al.* 2005) was cited as a threatening process impacting on Varied Sittellas, this was not noted during these studies. The final determination lists the following factors: small-scale clearing for fence lines and road verges, rural tree decline, loss of paddock trees and connectivity, 'tidying up' on farms and firewood collection as current threats to the viability of sittella populations. Relevant Key Threatening Processes listed in NSW under the *Threatened Species Conservation Act 1995* include: 'Clearing of native vegetation', 'Loss of hollow-bearing trees' and 'Removal of dead wood and trees'.

Status Overview

Varied Sittellas are considered to be a species whose population is limited by food availability; hence any action or event which decreases food availability decreases their population viability and makes them more susceptible to the short-term impacts of factors like drought and fire. Recently Green Wattle Creek has been managed by Crown Lands, a division of the NSW Department of Trade and Investment and the area is now known as the Butterwick Crown Lands Reserve. Management protocols have been introduced which should prevent further degradation of the area and should sustain the sittella population at current levels by preventing continuing removal of trees, removing weed growth and managing fire by a series of cool burns conducted infrequently across a mosaic of habitat patches. Of course it is not possible to rectify the losses of mature trees, which are irreversible in the short to medium term.

Community education is required to highlight the factors which cause insidious degradation of habitat. This includes increasing the awareness of local government administrators and front-line staff, who are responsible for the management of the rural landscape. In addition to the aforementioned factors the importance of dead branches and trees to sittellas is an example of a counter-intuitive habitat requirement, which would not usually be appreciated as important. For example, historically, dead timber was allowed to be harvested for fire wood on Crown Land. It is essential for breeding as well as a prime foraging niche. This is classic example of an uninformed decision.

It is of obvious concern that the area survey results (**Figure 2**) suggest a widespread decline of the Varied Sittella across the Hunter Region. It is tentatively suggested that observers primarily survey areas which are easily accessed near roads and vehicular tracks and that these areas tend be modified, at the edges of continuous woodland and often involve fragmented vegetation. In this case the observed decline may be associated with the progressive fragmentation and clearing of this habitat. If the degradation continues a point may be reached at which food availability falls below the critical limit necessary to sustain sittellas. As

pointed out by Noske (1998) the relationship between food availability and sittella territory size is unknown. There may be limits to territory size and the distance breeding sittellas can range to successfully feed their nestlings.

CONCLUSIONS

Long-term studies in the Paterson area of the Hunter Region provide benchmark RRs for the occurrence of Varied Sittellas in standardised surveys. Comparison with other survey data in the Hunter Region suggests that the Paterson area supports important populations of this scarce species which is widespread in the area, although only intermittently present at any specific location. Varied Sittellas appear to favour drier open woodland where they forage on the trunks and branches of trees. Remnant vegetation on farms and road sides provides important habitat. Rough-barked trees are especially favoured. There is evidence of sustained local decline in the Paterson area and throughout the Hunter Region. However, sustained decline is not apparent across the broader scale of the east coast of Australia during the same period. Possible causes of decline include habitat loss by clearing and degradation by the removal of mature trees, with rough-barked species selectively removed, often illegally. Where trees have been excessively thinned, especially at roadsides, there are continual losses when trees are up-rooted during storms. These ongoing habitat losses are permanent as there is no replacement, unless appropriate conservation management actions are undertaken. There is also data to suggest that drought and burning may also have an adverse impact on populations within the region in the short to medium term.

There is an urgent need to halt the decline of Varied Sittellas in the Paterson district and other areas known to be important to the species. Community education is urgently required to ensure that the ecological requirements of the Varied Sittella are widely appreciated. Engagement with land owners, land managers and local government regulators to ensure their awareness of the management actions necessary to protect the Varied Sittella and halt the ongoing degradation of their habitat is a priority.

As discussed previously although the highest known rates of occurrence of the Varied Sittella are in the Paterson area, the highly modified landscape in which these studies were conducted may not be optimal habitat for the species. It is recommended that a research program is initiated to compare sittella occurrence in other regions of the Hunter and in other habitats. Standardised survey approaches should be used which allow comparison with the baseline levels established in this paper.

It would be courageous for land managers to assume that the widespread distribution of the Varied Sittella provides a buffer against processes threatening the status of the species. Evidence presented in this paper suggests that the species may favour modified and even fragmented habitat, but if such habitat is progressively degraded across the landscape, as appears to be occurring in the Hunter Region, the level of threat to the species' viability will inevitably increase.

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