Small Things Matter: The Value of Rapid Biodiversity Surveys to Understanding Local Bird Diversity Patterns in Southcentral Mindanao, Philippines

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Small Things Matter: The Value of Rapid Biodiversity Surveys to Understanding Local Bird Diversity Patterns in Southcentral Mindanao, Philippines

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Abstract

Rapid assessment biodiversity surveys are usually employed when resources or time is limited. In terrestrial ecosystems, birds are important ecological indicators of ecosystem health. Our study used rapid inventories to show that species differ across habitat types; species richness and rarity were higher in pristine habitats (native and restored areas) while non-protected habitats (e.g., plantations and orchards) mainly had common and nonendemic species. Our findings demonstrate the importance of collective local biodiversity studies in elucidating species diversity patterns, though is equally important to bolster regional conservation prioritization. We hope that our findings will benefit future decision-making for sustainable development and conservation planning.

Keywords

anthropocene, deforestation, local biodiversity, oil-palm, Philippines

Introduction

Increasing land degradation and changing climate threatens biodiversity and associated ecosystem services (Ceballos et al., 2015; Foley et al., 2005; Metzger, Rounsevell, Acosta-Michlik, Leemans, & Schröter, 2006). Wide-scale destruction and fragmentation of native vegetation are primarily due to an unprecedented rate of human pressure across the globe (Jones et al., 2018; Newbold et al., 2015; Wilson et al., 2016). In tropical Southeast Asia, deforestation for agricultural expansion (e.g., oil-palm plantations) and urbanization are among the greatest threats to biodiversity in many countries (Hughes, 2017a, b; Hughes, 2018; Sodhi et al., 2010).

High endemism coupled with extensive and rapid habitat loss makes the Philippines a priority for conservation (Myers, Mittermeier, Mittermeier, Da Fonseca, & Kent, 2000; Posa, Diesmos, Sodhi, & Brooks, 2008) and this is particularly demonstrated on birds (Lohman et al., 2010). The Philippines has over 600 bird species with 200± country endemics (Kennedy, Gonzales, Dickinson, Miranda, & Fisher, 2000) and will increase when molecular approaches are applied

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(Lohman et al., 2010). High bird biodiversity provides key ecosystem services, for example, seed dispersal in forested and successional areas aiding the restored in many degraded habitats (Gonzales, Ingle, Lagunzad, & Nakashizuka, 2009; Ingle, 2003; Maas et al., 2016). Yet, despite the high species diversity of birds and designated biodiversity areas ($n = 117$ spp.; 3,230,177 ha of Important Bird and Biodiversity Areas), many important habitats are threatened by anthropogenic activities (Brooks, Pimm, Kapos, & Ravilious, 1999; Haribon Foundation, 2014). In the Philippines, nearly 60% of birds spend their all or part of their life in the forest (Haribon Foundation, 2014). The majority of endemic species are forest dwellers (e.g., Ates & Delima, 2008; Paz, Ngoprasert, Nuneza, Mallari, & Gale, 2013; Relox, Leano, & Camino, 2011), but rapid deforestation represents a major threat (Birdlife International, 2018; Brooks et al., 1999). An estimated of 56.48 kha of tree cover loss per annum has been recorded in the Philippines with 39% associated with deforestation and 41% with shifting agriculture (Global Forest Watch, 2018; Tanalgo & Hughes, 2019). Conservation of primary forests is essential (Mittermeier, Turner, Larsen, Brooks, & Gascon, 2011; Pimm et al., 2001) but can only protect a small area and thus nonprimary forests (e.g., plantations and agroforest systems) are also essential for the survival of many species (Achondo et al., 2011; Gordon, Manson, Sundberg, & Cruz-Angón, 2007; Jose, 2009; Moguel & Toledo, 1999; Smith et al., 2015). However, few comparative studies on bird diversity across habitats have been conducted in the Philippines, with most focusing on natural ecosystems, for example, primary forests (e.g., Ambal et al., 2012; Balete, Tabaranza, & Heaney, 2006; Española, Collar, & Marsden, 2013). Yet sustainable evidence-based management of these ecosystems is essential for effective species and habitat protection (Brito & Oprea, 2009).

Rapid biodiversity surveys address the lack of baseline biodiversity information as a basis for conservation and management (Patrick et al., 2014). Due to resource scarcity (e.g., funding, time, workforce, and equipment), many researchers rely on rapid biodiversity studies (i.e., species richness and occurrence) as a basis to develop conservation recommendations. The relevance of rapid assessment and local-scale studies should not be overlooked (Cardinale, Gonzalez, Allington, & Loreau, 2018; Fuentes, 2018; Jongman, 2013; Kosanic, Anderson, Frère, & Harrison, 2015). Yet this technique has limitations in the breadth and depth of information generated (Conservation International, 2019). Outcomes from these local regional assessments change at different scales (Fuentes, 2018; Kosanic et al., 2015). In addition, local studies should complement wider scale conservation efforts (Fuentes, 2018; Jongman, 2013; Kosanic et al., 2015; Tantipisanuh & Gale, 2018), for example, Tanalgo and Hughes (2018, 2019) demonstrated that if local information is carefully integrated and synthesized it helps assessment of national-level priorities which also reflect regional or global perspectives (see also Tantipisanuh & Gale, 2018). Here, we aim to determine the differences in the distribution patterns and rarity of bird species and feeding guilds across habitat types in Southcentral Mindanao based on records from local rapid biodiversity assessment studies, with the hope to bolster future conservation strategies and policy-making initiatives in the region.

Methods

Southcentral Mindanao includes the municipalities in the province of North Cotabato. The province is characterized by a tropical climate with consistent rainfall throughout the year and temperatures varying from 23.7°C to 32.7°C annually (Philippine Atmospheric, Geophysical and Astronomical Services Administration, 2019). Southcentral Mindanao (North Cotabato) ranks 12th in the Philippines for deforestation losing 8.8 kha of *forest* (6.7%) 2000 to 2017 (Global Forest Watch, 2018).

We collated regional bird records from rapid assessments, including species locality, habitat types, and feeding guild (see Supplementary Material). Sampling efforts were standardized to include at least 100-mist net days in closed systems, and whereas open areas (i.e., agricultural) used point count methods (at least 15 points with 200 m linear distance), for example, Verner & Ritter, 1985). Due to the bias in methods, we disregard bird abundance in the analysis. We then categorized each bird record to major habitat types, namely: (a) native forest, (b) restored site, (c) rubber plantation, (d) oil-palm plantation, (e) mixed-orchard, (f) ricefields, and (g) roads. Bird species were grouped based on five main bird-feeding guilds, namely, frugivorous, insectivorous, carnivorous, granivorous, and omnivorous.

Rarity was assessed based on species occurrence across habitat types; we measured species-site rarity using the site-rarity index ($site = Nsite/f$, $Nsite$ is the number of sites assessed and f is the frequency the species occurred) based on presence–absence data (Tanalgo, Tabora, & Hughes, 2018). Values near to 1.00 indicate species which are common to all habitat types or sites. We used the nonparametric Kruskal–Wallis test and Mann–Whitney U test to assess the significant difference in species/family and feeding group distribution within (a) habitat types, (b) endemism, and (c) rarity. We used a χ^2 test of independence to determine the difference in population status within habitat types. To assess the relationship between site rarity and body size, we applied Spearman correlation test. Bray-Curtis single-link was used to measure at the family and feeding group level using species frequency of occurrence to assess similarity across different habitat types (e.g., Tanalgo, Pineda, Agravante, & Amerol, 2015). Statistical tests and diversity analysis were done using STATISTICA v10 (StatSoft Inc., 2011) and PAST v 3.18 (updated version 2018; Hammer, Harper, & Ryan, 2001) respectively. We set all significance at $p = .05$.

Results

We recorded 63 bird species belonging to 32 families from seven major habitats from Southcentral Mindanao (Figure 1; Table S1). The distribution of bird species by families (Kruskal–Wallis test, $H = 76.550$, $df = 6$, $p < .0001$) and feeding guild (Kruskal–Wallis test, $H = 27.121$, $df = 6$, $p < .0001$) differed significantly across habitat types. The native forest and restored forest have the greatest number of species ($n = 33$ spp., 52%) followed by mixed-orchard plantations ($n = 28$ spp., 44%). Roads ($n = 24$ spp., 38%) and ricefields ($n = 25$, 40%) sites are almost equal in terms of a number of species. The two plantation types of rubber ($n = 23$ spp., 37%) and oil-palm ($n = 18$ spp., 29%) had the lowest richness (Figure 1). Insectivorous birds

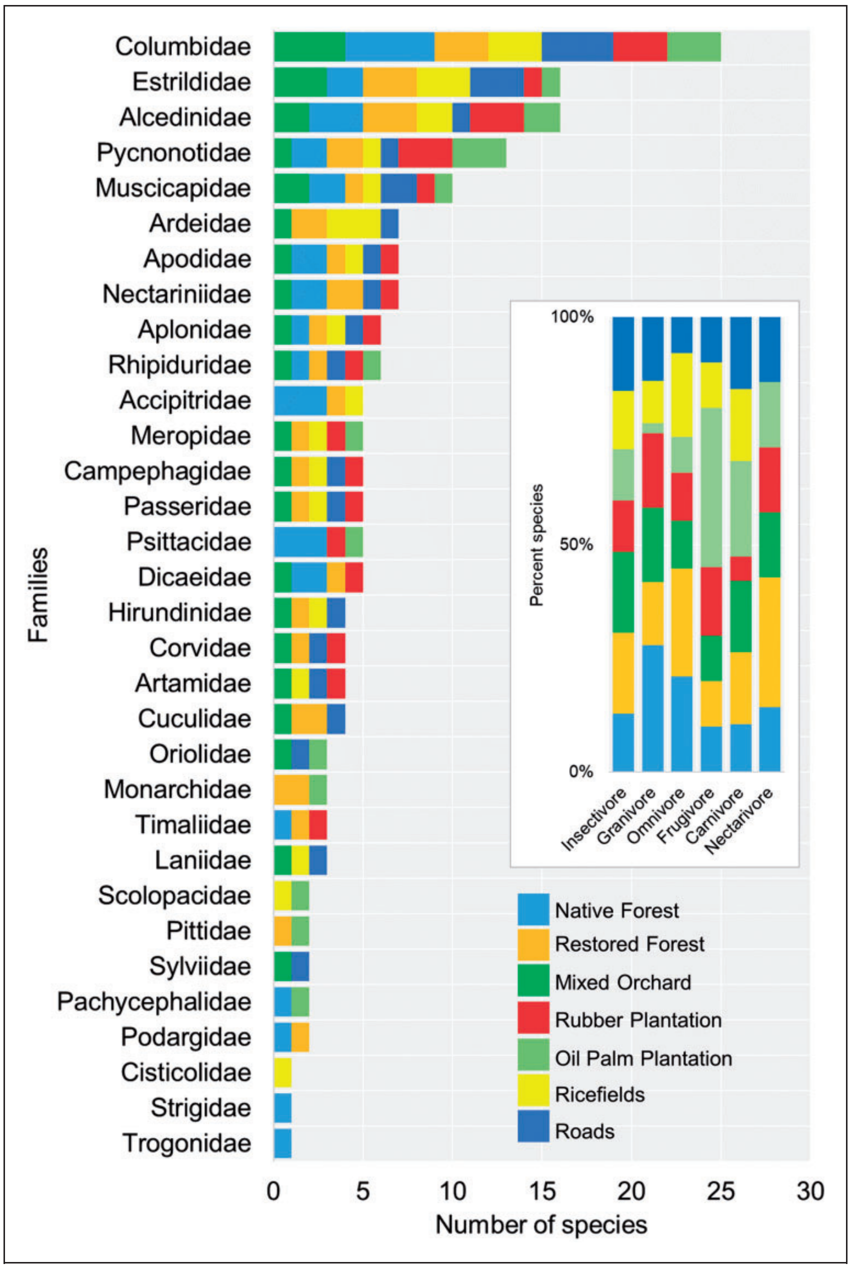

Figure 1. Bird species richness according to families and percentage distribution of feeding guilds (inset) across different habitat types.

accounted for 37% of all species and had the highest richness in mixed-orchards ($n = 11$ spp.). This was followed by frugivorous species particularly in native forests ($n = 12$ spp., 25%). Carnivorous birds are richest in restored forests ($n = 9$ spp., 23%) and native forest ($n = 8$ spp., 21%). While nectarivores were the least represented guild with only two species (3.17%) and were absent in ricefields and oil-palm (Figure 1 (inset), Table S2).

Fifty percent of all species recorded in Southcentral Mindanao were Philippine endemics. The highest endemism was noted in the native forest with 45% of species, while ricefields (4.5%) and oil-palm (11% proportion) has the least endemic species (Figure 2; Table S2). Among feeding guilds, most endemics were frugivores (56% proportions) and insectivores (35% proportions); no endemic species recorded for granivores and nectarivores (Figure 2; Table S2). Across habitats, endemism differed significantly (Mann–Whitney U test, $p < .002$) while marginally significant across feeding guilds (Mann–Whitney U test, $p < .07$). Although the number of species based on population status does not differ significantly across habitats (χ^2 test of independence, $p > .05$), the majority of the species with decreasing status are found in the native forest ($n = 14$ spp., 33% proportion) and restored forests ($n = 9$ spp., 21% proportion).

Among families, Columbidae ($n = 5$ spp.) was recorded in all habitat types, followed by Accipitridae, Alcedinidae, and Psittacidae ($n = 3$ spp.). We found that 16% ($n = 5$) of the families, namely, Columbidae, Estrildidae, Alcedinidae, Pycnonotidae, and Muscicapidae, are all common in all habitat types, whereas 41% are occurring rarely (≤ 3 sites) across habitats. The species-level analysis showed that 23 species (37%) are rare and occur in single habitat types (see Table S1). The highest number of rare species or species that appears exclusively in a single habitat was recorded in the native forest ($n = 11$ spp., $site = 0.481$ (standard deviation $\pm$ 0.329)) and restored forest ($n = 7$ spp., $site = .567$ (standard deviation $\pm$ 0.320; Figure 3). There are five ubiquitous species, namely, *Aplonis panayensis*, *Chalcophaps indica, Geopelia striata*, *Pycnonotus goiavier*, and *Todirhamphus chloris* occurred in all habitat types ($site = 1.00$). Site rarity significantly differs across habitat types (Kruskal–Wallis test, $H = 13.483$, $df = 6$, $p = .03$), family (Kruskal–Wallis test, $H = 88.076$, $df = 31$, $p < .0001$), and feeding guilds (Kruskal–Wallis test, $H = 13.364$, $df = 5$, $p < .05$), but does not significantly correlate with body–mass (Spearman's test, $\rho = .185$, $p > .05$).

The similarity index showed that there is a disproportionate similarity in the representation of species between families and feeding groups. Based on family-level similarities, the native forest has the highest dissimilarity across all habitat types (50%). While, rubber plantation (60%) has the highest similarity to pristine

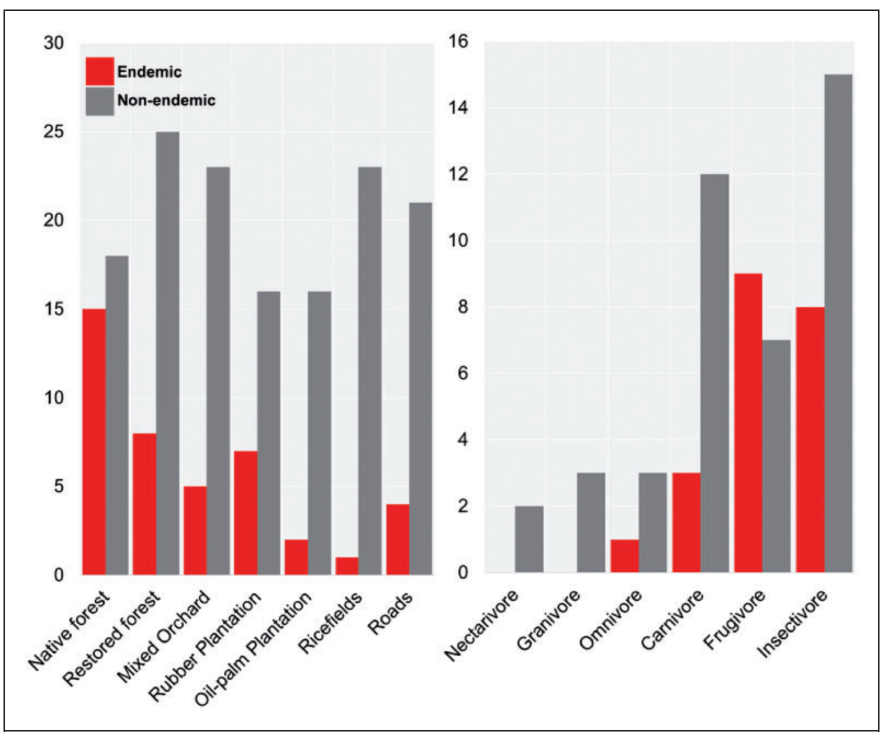

Figure 2. Proportion of endemic species across habitat type (left) and feeding guilds (right).

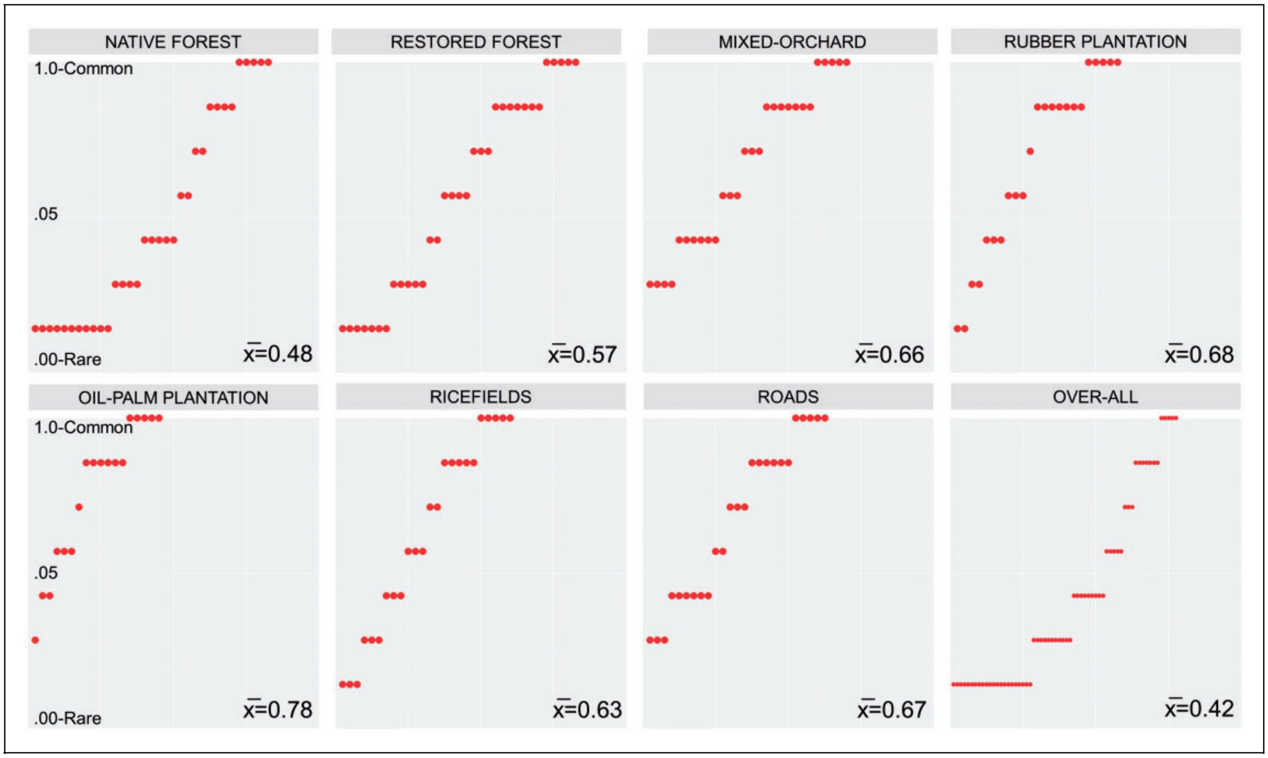

Figure 3. Species rarity (commonness) across different habitat types. Species (red dots) near 1 indicates the species was recorded in all habitat types (common). The mean species rarity (commonness) index (site) is shown.

ecosystems, for example, native forest and restored. Finally, in terms of similarity in feeding groups composition, native forests and restored has the highest similarity at 80%.

Discussion

Birds are good ecological indicators because they occur in almost all habitat types and rely on a wide range of resources (Sekercioglu, 2006). Our present work showed highest bird diversity pattern, that is, species richness, endemism patterns, and rarity patterns in pristine ecosystems such as native forests and restored areas, while lowest diversity was recorded in monocultural habitats, for example, oil-palm plantations. The high species richness of birds in pristine ecosystems are often associated with floral diversity, which is important for foraging and shelter; hence, intact native forest are essential habitat for many species particularly those with narrow range distributions such as endemics and threatened (Azman et al., 2011; Raman, 2006; Rodrigues et al., 2004). The higher tree cover and volume of native and woody plants strongly influence species richness of native birds compared with degraded habitats (Mills, Dunning, & Bates, 1989; Rayner, Lindenmayer, Wood, Gibbons, & Manning, 2014; Thiollay, 1995). In addition to species richness, native and primary forests hold more endemic species are endemic in primary habitats than converted habitats especially monocultures (Davies et al., 2015; Mallari et al., 2011; Mallari, Collar, McGowan, & Marsden, 2016). Agroforestry systems can support some species but have lower diversity and endemism than true forest (Harvey & Villalobos, 2007; Li, Zou, Zhang, & Sheldon, 2013; Prabowo et al., 2016). In tropical Southeast Asia, studies showed bird species richness declined up to 60% following conversion of lowland forests to oil-palm plantations (e.g., Aratrakorn, Thunhikorn, & Donald, 2006; Li et al., 2013) and species similarity between forest and plantation could be as low as 5% (e.g., Srinivas & Koh, 2016).

There are four major plantations in the Southcentral Mindanao region, which are expanding at an unprecedented rate. Rubber and oil-palm are among the most important industries in the region covering around 32,066.79 ha and 1, 150.62 ha, respectively, but it is projected to increase in the coming years as demands and investors are eyeing the region for expansion projects (Philippine Statistics Authority, 2018, Yap, 2016). Aside from these plantations, Banana plantations have been expanding in many areas in the region with 14,787.7 ha at present (Province of North Cotabato, 2019) particularly large ricefield areas are also converted (pers. observation). Forests and agroforests replaced with simplified agricultural systems drive shifts toward less specialized bird communities and altered proportions of functional diversity (Edwards, Massam, Haugaasen, & Gilroy, 2017; Schulze et al., 2004; Sekercioglu, 2012). Species survival in monocultures is also influenced by access to intact native vegetation in surrounding areas (Raman, 2006). Our study shows that between two plantations, rubber plantations support higher diversity and rarer species than oil-palm plantations possibly due to higher complexity and plant diversity (Agduma et al., 2011). Mixed-crop plantations also support higher bird species than monoculture plantations such as oil-palm plantations (Harvey & Villalobos, 2007; Fitzherbert et al., 2008; McNeely, 1995; McNeely & Schroth, 2006). However, oil-palm plantations support common species and may have higher species richness if understorey vegetation is allowed to grow (Nájera & Simonetti, 2010a,b).

The diversity waterbirds, particularly from families Ardeidae and Scolopacidae, were higher in ricefields. Agricultural wetlands such as ricefields are essential for waterbirds, and other guilds for foraging, especially where native wetlands are absent (Horgan et al., 2017; Smedley, 2017; Stafford, Kaminski, & Reinecke, 2010; Tanalgo et al., 2015). Ricefields serves as feeding areas and stopover sites for migratory species (Acosta et al., 2010; Czech & Parsons, 2002). During rice-growing cycles, carnivorous birds are abundant during the sowing stage, and granivorous during the postharvest flooded fields (Acosta et al., 2010), and insectivores during the flooding stage (Elphick, 2000, 2004). Moreover, the condition of the ricefields is not the sole factor that influences bird species richness, but also the improved surrounding vegetation quality enhances species diversity and composition (Horgan et al., 2017; Lee & Goodale, 2018; Smedley, 2017).

Among all habitat types, roads and urban areas showed the lowest species diversity and endemism in Southcentral Mindanao. Several studies have shown a similar pattern from ours where heavily urbanized areas show these patterns (Blair, 1996; Gamalo & Baril, 2018; Gatesire, Nsabimana, Nyiramana, Seburanga, & Mirville, 2014; Wolff, DeGregorio, Rodriguez-Cruz, Mulero-Oliveras, & Sperry, 2018). The presence of *green spaces*, that is, trees and available foraging sites has higher species richness (Suarez-Rubio et al., 2016). Roads reduce the diversity of birds especially understory species because it inhibits movements as they avoid edge-affected habitats and clearings (Laurance, Stouffer, & Laurance, 2004). At a functional level, urbanization and road channels reduce the diversity of nectarivores in urban areas (Pauw & Louw, 2012).

Among feeding groups in Southcentral Mindanao, insectivorous and frugivorous groups were present in all habitat types, but their distribution differs favoring pristine ecosystems. In the tropics, understory insectivorous birds are higher in diversity in forest ecosystems and are highly sensitive to disturbance (Arriaga-Weiss, Calmé, & Kampichler, 2008), for example, logging and deforestation, hence an effective proxy for assessing forest disturbance or change (Iongh & van Weerd, 2006; Stratford & Stouffer, 1999). Agroforestry could support species richness relative to monocultures, but in a functional level, frugivorous and insectivorous birds often decrease in this systems (Sekercioglu, 2012) and often associated with the availability of fruiting trees and forest cover (Española, Collar, Mallari, & Marsden, 2016). In rubber plantations where vegetation is less dense or diverse than natural forest, no strict frugivores occurred (Li et al., 2013) but more flexible frugivores species may be present, for example, *Chalcophaps indica* (Mitra & Sheldon, 1993; Sheldon, Styring, & Hosner, 2010) and *Pycnonotus goiavier* (Li et al., 2013), these species were common in all sites in Southcentral Mindanao.

Implications for Conservation

Our synthesis showed that the majority of birds in Southcentral Mindanao were the least concern and non-endemic; however, many threatened and endemic species (i.e., narrow distribution or rare) were recorded in a single habitat. Native forests and restored sites support endemic and rare species, and this has important implications on effective conservation measures. Our findings will draw attention to these habitats and promote habitat heterogeneity by allowing native vegetation to persist even in modified agroecosystems. We recognize that there are caveats to our findings, for example, although minimal, the sampling designs of each study we synthesized differ and confounding factors may affect the patterns. The patterns in our study confirm the findings from past large-scale and intensive studies (e.g., seasonal monitoring, large-spatial scales). We demonstrated that assessments based on rapid biodiversity surveys support those of more intensive studies and thus provide a useful tool for conservation prioritization when interpreted with care, though more data from various approaches are needed to garner a more comprehensive understanding of species distributions and habitat preferences across the region.

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