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Bird distribution along environmental gradients In North Bandung, West Java

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Abstract

Bird distribution and abundance were studied along environmental gradients from urban areas to forested habitats in North Bandung, West Java. Bird and habitat data were collected from 192 sampling points between May 2006 and April 2007. The relationship of bird assemblage patterns and species distribution with habitat and land cover attributes was explored by canonical correspondence analysis (CCA). We further tested whether particular attributes of bird assemblages such as the relative abundance of ground gleaners, tree foragers, omnivores, insectivores, generalist and endemic species were linked to environmental attributes. The assemblage measures were compared with the environmental gradients and with the environmental variables from which those gradients were derived using bivariate plots, correlations and distance weighted LS regression. Canonical correspondence analyses revealed that forest land use, tree canopy cover and altitude were important factors affecting bird distributions in the study site. Moving south to lower altitude along the gradient to urban areas with more intensive land use, human-tolerant species were encountered more often, and absolute abundance of omnivores and ground gleaners increased. Bird diversity and total bird abundance peaked in forested habitats, as did the absolute abundances of tree foragers, insectivores and endemic species. Thus, habitat, land use and landscape variables acted in concert to shape bird distribution in North Bandung region.

Keywords: bird, distribution, environmental gradient, land use, urbanization, north Bandung.

Introduction

Patterns of bird distribution and abundance within a landscape are influenced by multiple factors that interact in space and time[1]. Habitat structure and floristic composition, such as percent canopy cover, tree species diversity and the distribution of specific plant taxa, are known to have a significant role in defining the occurrence of bird species in space[2,3]. It is now increasingly understood that land use and landscape factors, together with local-scale factors, define the niche space and how individual birds perceive and use habitats along environmental or geographic gradients at a local, regional, and continental scales[1, 4].

Urbanization processes, which transform natural ecosystems and landscapes into new man-made systems, have caused global change on earth[5,6,7]. The replacement of forests by agriculture and various kinds of urban land use changes plant and animal communities. Land use intensification reduces, subdivides and isolates habitat required by forest species. Species requiring contiguous forest areas above some minimum size therefore tend to disappear from highly fragmented landscapes[8]. Expansion of land use also creates habitat for generalist species, omnivores and granivores capable of exploiting resources associated with forest edges and human-built environments[9].

There is widespread concern about the effects of changes in land use due to urbanization on bird populations. Urbanization processes can lead to biodiversity homogenization[9].

Most studies of urban bird communities have reported that species richness generally decreases with urbanization and that total abundance generally increases with urbanization[9, 10, 11, 12].

Urbanization can create a complex environmental gradient, from undisturbed natural areas to highly-modified urban landscapes. However, the study of environmental gradient across urban-rural landscapes in the tropics is relatively new, and little is known about the actual patterns of bird distribution and abundance along such gradients[13].

This study was conducted in North Bandung region, West Java. North Bandung has undergone significant changes in its landscape due to urbanization processes in the last decades. Forest area in North Bandung reduced the most, from 5,470 ha in 1992 to 1,746 ha in 2002, or about 3,732.12 ha (68%) in ten years. In the opposite, agricultural area was increased from 2,491 ha to 4,358 ha (43%), and so was residential area from 359 ha to 1,612 ha (78%) between 1992 and 2002[14]. Landscape changes in North Bandung are predicted to continue in the subsequent years.

Located in Bandung Basin and surrounded by range of hills and volcanoes, the landscapes of the study site are heterogeneous, which are predominately agricultural. In the southern part, an urban matrix exists that has been greatly impacted by both agriculture and urban development.

In the northern part, large protected forest area still exists, which is part of Mt. Tangkuban Perahu Natural Reserve. The large variation in habitat structure due to urban development, the heterogeneity of the landscape terrain, and the diversity land uses impacts within this region provide an opportunity to investigate the influence of habitat, land use and landscape factors on bird diversity and distribution.

The study aims to explore the responses of bird assemblages across these environmental gradients in North Bandung, West Java. The topic is of much interest given intensity of habitat conversion in this area and the lack of knowledge how birds and other species respond to such changes.

Material and Methods

Study Sites: The study was conducted in North Bandung region, West Java, Indonesia. Area of study was limited between geographic coordinates of 107°35’46”-107°39’04” E and 6°46’09”-.6°54’48” S. To represent various land use types within this region, the study site was selected based on a digital land use map of the West Java Province in a vector format at a nominal scale 1:25,000, which showed land use around the year of 2004. Using ArcView GIS 3.3, the study site was systematically divided into observation plots forming grid cells of 1 km × 1 km. Three grids were positioned horizontally from west to east and 16 grids were positioned vertically from south to north. Data collection was conducted in each grid (48 grids in total). Four subplots of observation were systematically selected in each grid. Subplots were regularly arranged so that distance between subplots was 500 m. Each subplot was checked in the field with reference to a handheld Global Positioning System (GPS Garmin 12XL) for correct placement and site accessibility. The list of the study sites are graphically represented in figure-1.

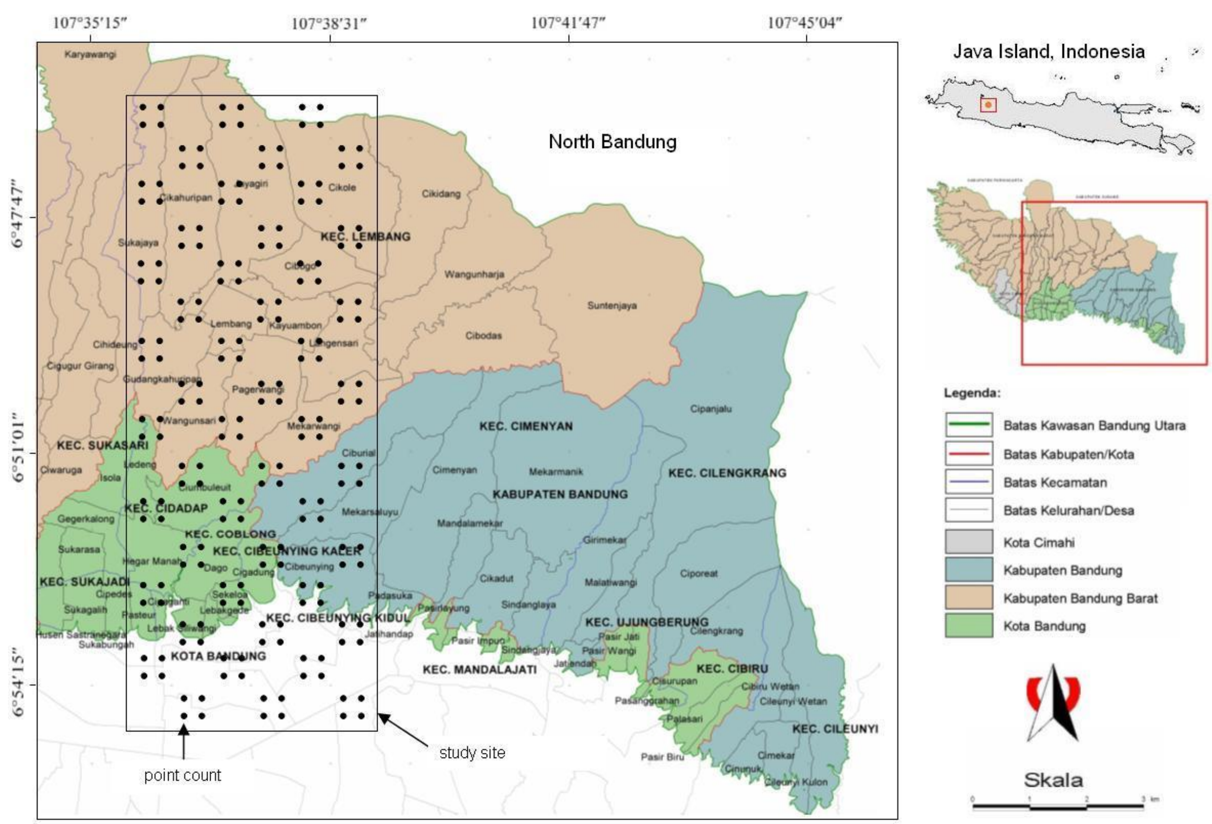


Figure-1
Sampling Location in North Bandung Region, West Java, Indonesia

Table-1
Explanatory Variables Used in Ordination to Explain Bird Distribution in North Bandung

Variable	Description	Min	Mean	Max
Canopy	Percentage of tree canopy cover, untransformed (%)	3	45.5	95
Understory	Percentage of understory cover, untransformed (%)	4	32.8	45
Strata	Number of strata, untransformed	1	3.2	5
Forest	Percentage of forest area, untransformed (%)	0	16.9	84.8
Orchard	Percentage of orchard area, untransformed (%)	0	13.6	49.7
Cropland	Percentage of cropland area, untransformed (%)	8.3	50.0	76.5
Residential	Percentage of residential area, untransformed (%)	0	19.5	90.9
Road	Road density, untransformed (number of road per grid)	1	12.3	22
House	House density, square-root transformed (number of house building per grid)	3	109.6	439
Urban distance	Distance to nearest built-up area, square-root transformed (meters)	55	1384.0	4802
Altitude	In meter above sea level, untransformed (m a.s.l.)	702	1102.2	1704

Field Methods: Bird surveys were conducted using the fixed radius point count method[15] in four subplots of observation. Each subplot was visited once from May 2006 to April 2007. At each visit, all birds seen or heard within a radius of 50 m during a 10-min period were recorded to species. Counts were made by a single observer in the morning between sunrise and 10.00 am local standard time on days with minimal precipitation. For the entire study sites, a total of 2304 point counts were obtained. Bird identification was based on MacKinnon field guide[16].

Assemblage Measures: We analysed four aspects of assemblage structure: bird diversity, total bird abundance, relative abundance and bird functional group composition. Bird diversity is measured as species richness or number of bird species at each grid. To measure total bird abundance, individual totals at each grid were summed accross the whole species found and then divided by the number of point counts conducted at the grid (individuals per count). Relative abundance were estimated to analyse the predominant species in each land-use type.

To estimate the relative abundance, individual totals of each species were summed and then divided by individual totals of all species found in each land-use type. Predominant species were species that has relative abundance value above 10 percent[17]. To measure bird functional group composition, each of the species recorded was classified to functional group according to four criteria: foraging technique, dietary preference, habitat and distribution[16], as shown in Appendix. The absolute abundance (individuals per count) of ground gleaner, tree forager, omnivore, insectivore, generalist and endemic species were examined for each grid's assemblage.

Environmental Measures. Percent cover of tree canopy, number of strata within forests and percent cover of understory layer were visually estimated for each plot. To reduce bias in estimates of percentages, data were categorized based on Braun-Blanquet method[18] into the following classes: 0-5%, 5-25%, 25-50%, 50-75% and 75-100%. In addition, for each bird sampling point, altitude was also measured by standard surveying techniques using a GPS.

Land use-land cover (LULC) of each grid was classified into forest, orchard, cropland and residential by extracting Landsat TM satellite imagery based on data from 2004. The LULC classification was used to determine the proportions of each land use in a grid. Road density, building density and distance to nearest built-up area were also determined for each grid from satellite imagery data. table-1 gives an overview of environmental variables used, as well as their range.

Data Analysis: Eleven environmental variables were selected for analysis. These variables characterized the habitat (canopy coverage, understory volume, strata complexity) and the surrounding landscape (forest, orchard, cropland, residential, road density, house density, nearest distance to built-up land and altitude). Environmental variables were transformed as necessary to standardize their distributions prior to analysis. Canonical Correspondence Analysis (CCA) was performed on the bird and environmental data using CANOCO for Windows ver. 4.5[19, 20] to examine relationships between bird community and environmental gradients in the study sites.

CCA is a form of direct gradient analysis that calculates a set of ordination axes based on a primary matrix of bird abundances at each sampling point. Scores plotted in CCA diagrams are linear combinations of environmental variables[20]. Biplot arrows shown in figures represent the direction of the increasing environmental gradient[20, 21]. The value of a variable increases in the direction of the arrow's head and decreases in the direction of its tail. The length of the arrow is proportional to the correlation between the variable and the ordination, which indicates the relative importance of that variable. The angle between arrows indicates the strength of correlations between variables.

Table-2
Correlation (*r*) of Site Score on the First Two Environmental CCA Axes (ENV1, ENV2) and Bird CCA Axes (SPEC1, SPEC2) with the 11 Variables from which It was Derived

Variable		Environmental gradients		Bird gradients	
Feature	**Attribute**	**ENV1**	**ENV2**	**SPEC1**	**SPEC2**
Habitat	Canopy	0.75	–0.56	0.73	–0.51
	Understory	0.03	–0.88	0.02	–0.80
	Strata	0.54	–0.09	0.53	–0.08
Land use	Forest	0.92	–0.02	0.89	–0.02
	Orchard	0.03	–0.66	0.03	–0.60
	Cropland	–0.49	–0.66	–0.48	–0.60
	Residential	–0.41	0.85	–0.39	0.77
	Road	–0.76	0.56	–0.74	0.51
	House	–0.44	0.84	–0.43	0.76
	Urban distance	–0.34	0.15	–0.33	0.14
Landscape	Altitude	0.85	–0.38	0.83	–0.34
% Variance in data accounted for by axis		50	21	26	11

The arrows thus can be interpreted as secondary axes and help to explain the distribution of bird species in relation to environmental gradients[21].

CCA site scores on the first two environmental and bird axes were correlated with the environmental variables from which the gradients were derived, as shown in Table-2. These correlations cannot be assigned statistical significance, but are useful for interpretation because the square of the correlation coefficient is equal to the proportion of each variable's variance shared with the CCA axis[22]. The abundance of each bird functional group was compared with the CCA environmental gradients and with the environmental variables from which the gradients were derived using bivariate plots, Spearman rank correlations and distance weighted least square (LS) regression.

Results and Discussion

CCA of environmental variables highlighted the differences between the southern and the northern parts of the study site. The first two environmental CCA axes captured 71.4% of the variance in set of environmental variables (table-2). The first CCA axis of the environmental data (ENV1) distinguished between relatively undisturbed natural areas at high elevations, with lower road densities, larger forests cover and high percentage of canopy cover and number of strata to the north, and more disturbed modified areas at lower elevations, with greater road densities, residential areas and open spaces to the south. Forest area in the landscape and altitude showed the strongest correlations (r = 0.92 and 0.85, respectively), as shown in Table-2. Habitat variables (canopy, strata) were also positively correlated with ENV1 (r=0.75 and 0.54, respectively). This contrasted with negative correlations for anthropogenic measures in the landscape (road density, house density, residential, cropland, urban distance; $r \leq -0.3372$). The second CCA axis of the environmental data (ENV2) reflected the similarity of bird communities at the cropland and orchard, and accentuated the differences with the residential area, judging from its positive correlations with residential (r = 0.85), house density (r=0.84) and road density (r=0.56), and its negative correlation with other land-uses (orchard, cropland; r = –0.66). The second CCA axis thus reflected characteristics of urban ecosystem. Correlations of ENV2 with vegetation structures (understory, canopy; r=–0.88 and –0.56, respectively) were also consistent with the characteristics of urbanized area.

During the study 59 bird species from 28 families and 5261 individuals were recorded. A total of 51 species were recorded in the forest, 45 species in the orchard, 33 species in the residential area and 31 species in the cropland. In each land use type, predominant species (relative abundance ≥10%) were glossy swiflet (Collocalia esculenta), Eurasian tree-sparrow (Passer montanus) and oriental white-eye (Zosterops palpebrosus). Dominance of a certain species was not the same for each land use type. Based on our observation, there were some bird species with large number of individuals, such as Sunda minivet (Pericrocotus miniatus), orange-spotted bulbul (Pycnonotus bimaculatus), bar-winged prinia (Prinia familiaris) and Javan munia (Lonchura leucogastroides), but had limited distribution to certain type of land use.

Figure-2 shows the ordination of bird species at the study area. CCA biplot of sites and bird species with environmental variables produced two significant axes (p = 0.001 for each axis) that explained 58.7% (CCA axis 1) and 24.9% (CCA axis 2) of the total variance in the data set. CCA axis 1 tended to reflect the urbanization gradient, which separate counts made in forests from those made in urban-rural area. Altitude was an important variable, as were strata and canopy cover, all of which attained higher values in the forest land use at higher altitudes in the northern part of the study site ($r \geq 0.54$). It is also shown from the increasing value of site and species scores on bird CCA1 moving north along the dominant environmental gradient (ENV1) to more developed areas situated in lower elevation landscapes with less natural vegetation and more anthropogenic disturbance.

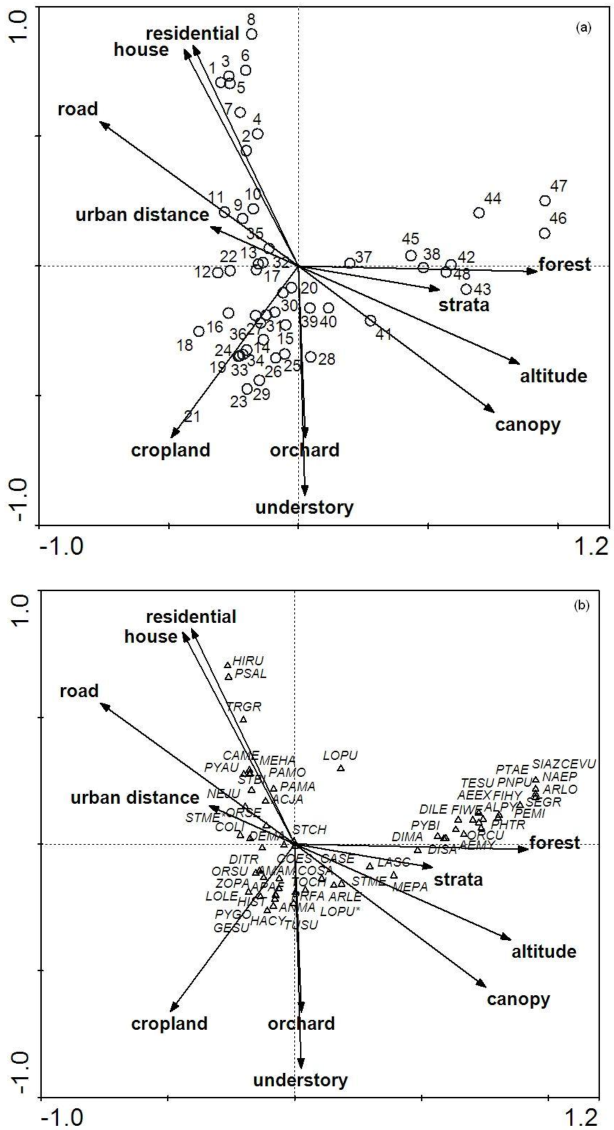


Figure-2
CCA of Bird Counts Made at the Study Area in North Bandung: (a) Biplot of Grids (N = 48) and Environmental Variables (Given as Vectors), and (b) Biplot of Bird Species (N = 59) and Environmental Variables, in Relation to the First Two CCA Axes (See Appendix for Abbreviation of Bird Species Names and table-1 for Description of environmental Variables)

On the other hand, road density was strongly negatively correlated with CCA axis 1, reflecting the greater anthropogenic disturbance at lower altitudes in the southern part of the study site, as shown in figure-2. Other environmental variables were correlated with both CCA axis 1 and the non significant CCA axis 2.

CCA biplot also showed that species with lower scores on bird CCA1 tended to be more tolerant of humans and to have more southern ranges with lower altitude. These birds were plotted mainly at the left end of CCA axis 1, which prefer more open habitats. Species that was more common at the right end of CCA axis 1 had higher scores on bird CCA1 and tended to prefer forest conditions with denser canopy cover.

Among the species with the lowest scores was a migrant species, the barn swallow (Hirundo rustica). This species is considered as a very urbanophilic species[23], and have a greater density in urban environments[24]. Other species with low scores on this axis, such as red-breasted parakeet (Psittacula alexandri), black-winged starling (Sturnus melanopterus) and grey-cheeked green-pigeon (Treron griseicauda) occupy urban parks. There were also species that often visit residential areas and backyard, such as sooty-headed bulbul (Pycnonotus aurigaster) and olive-backed sunbird (Nectarinia jugularis). Ubiquitous species that can be found everywhere in the study site, such as Eurasian tree sparrow (Paser montanus), also had low score on this axis.

Species with intermediate scores were more varied in their habitat requirements. Among those species were species that use forests and forested residential areas such as fulvous-breasted woodpecker (Dendrocopos macei), spotted-dove (Streptopelia chinensis) and great tit (Parus major), farmland birds such as scaly-breasted munia (Lonchura punctulata), barred buttonquail (Turnix susciator) and long-tailed shrike (Lanius schach), and forest edge specialist such as orange-spotted bulbul (Pycnonotus bimaculatus), crescent-chested babbler (Stachyris melanothorax) and rusty-breasted cuckoo (Cacomantis sepulcralis). The highest scoring species were predominantly forest interior specialists, mostly from timaliids such as chestnut-fronted shrike-babbler (Pteruthius aenobarbus), pigmy wren-babbler (Pnoepyga pusilla) and eye-browed wren-babbler (Napothera epilepidota).

Bird CCA2 scores were correlated most strongly with understory ($r = -0.80$, $p<0.0001$; table 1) and ENV2 ($r = 1.00$, $p = 0.0000$). However, their association with ENV1 was not significant ($r = -0.41$, $p = 0.21$). Bird CCA2 thus reflected response of bird assemblages to the presence of understory, which was a function of habitat structure (ENV2). Understory was dominant in agricultural land uses, and thus bird species with the highest scores on this axis were commonly a rural-farmland species which have a strong association with understory vegetation[16]. Among the species with the highest scores was barred buttonquail (Turnix suscitator), which feed and forage on the ground in the agricultural land use.

In Figure-3, we can see that all assemblage measures were significantly correlated with ENV1 ($p< 0.0001$), except bird diversity, bird total abundance and tree forager abundance. Bird diversity tended to increase moving north along the dominant environmental gradient (ENV1), but the correlation was not significant ($p = 0.0039$). At an intermediate position along the environmental gradient (ENV1), there was a slight decrease in numbers.

Total bird abundance also showed similar pattern with diversity. Decrease in bird diversity and total abundance in the intermediate values of site scores on the CCA axis of environmental data indicated that suburban areas in the study site, which matrix were dominantly consisted of agricultural area, had a low bird richness and abundance, due to relatively low number of trees.

Ground gleaner abundance declined moving north along the entire environmental gradient, as did omnivore abundance. Tree forager abundance showed no linear response, but their numbers increased in a more forested areas. Insectivore abundance generally increased moving north, but was also constrained on sites with moderate level of human settlement and agriculture dominated areas.

Endemic species abundance was increased proportionally moving north, where as habitat generalist abundance proportionally decreased. The number of generalist species appeared constrained at extreme south of the gradient, judging from the triangular pattern for the points.

The total bird abundance for northern forest areas was therefore attributable to insectivore species, which diets were correlated positively with vegetation attributes[25].In the southern urbanized areas, bird community was composed mainly of omnivorous resident species that did not use trees as foraging substrates.

Those species with the lowest scores on bird CCA1, which mainly human-tolerant species, meet these criteria.

Bird richness measured was relatively higher for forest areas than for other land use types. This pattern was attributed to the greater numbers of niches provided by forests owing to their higher canopy cover and complexity of the strata[22]. Complex vegetation structure and floristic composition heterogeneity increase niche diversity, which is thought to also increase avian diversity[26]. Furthermore, bird species richness was significantly higher in natural than urban habitats[24].

Diversity usually peaks at an intermediate position along a regional urban gradient[22]. It can be attributed to increases in environmental heterogeneity induced by moderate human disturbances[9]. However, we found that sites with moderate level of disturbance, which were dominated by agricultural land uses, had a similar number of birds with that of residential areas. Low bird diversity and abundance in cropland and orchard was due to low number of tree canopy cover and simple vegetation structure. Birds are highly depends on vegetation, especially trees[27]. This result highlighted the importance of trees as habitat for birds in a land use[28]. Expansion of intensive land use homogenizes the environment and thereby facilitates the replacement of a relatively diverse group of human-intolerant species with a smaller number of opportunistic, human-tolerant species[29].

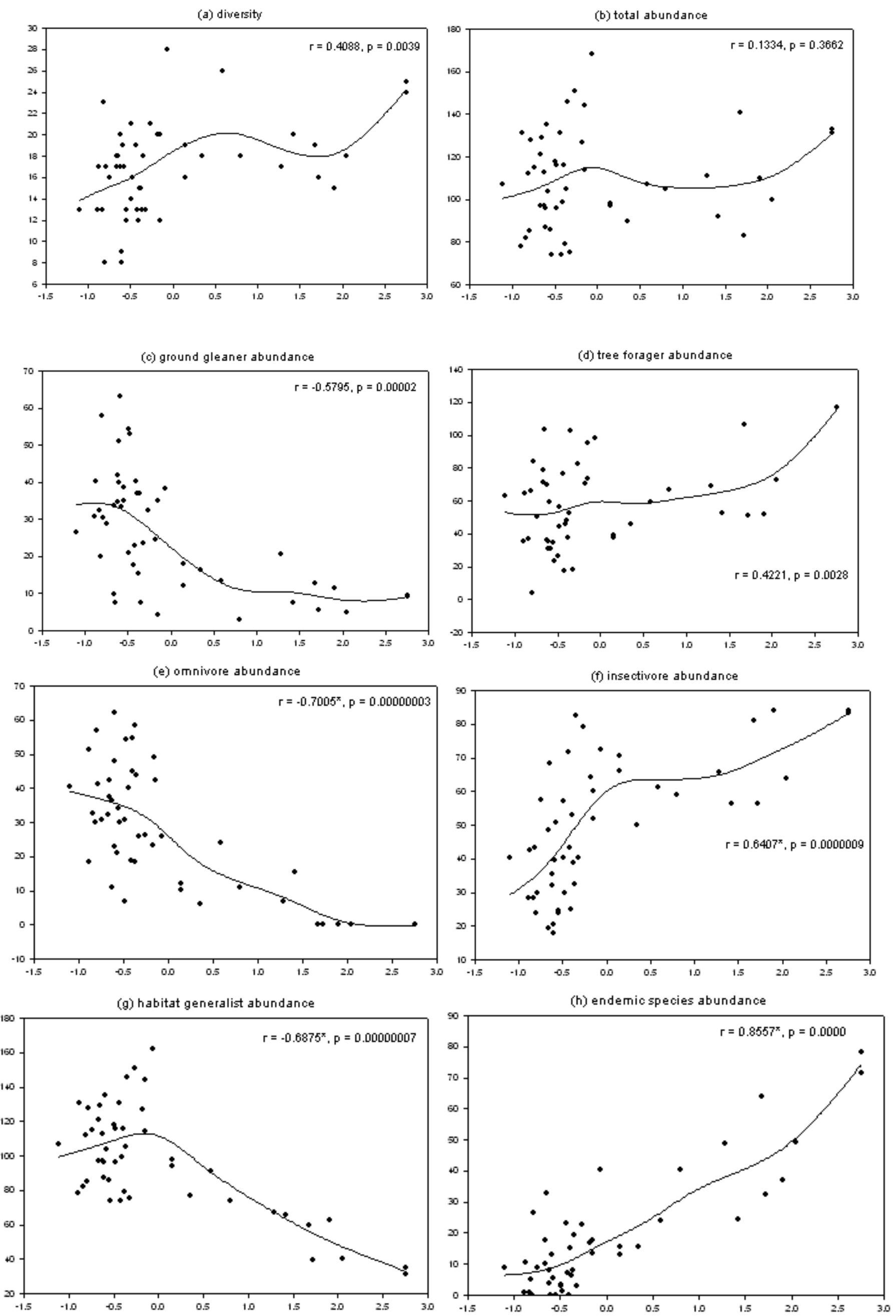
Our findings were consistent with this explanation. Land use was associated with proportional increases in ground gleaners and omnivores (opportunist and generalist) and proportional declines in tree foragers and insectivores along the entire gradient, as shown in figure-3c, e, d, f, respectively.

Fragmentation of forests and human encroachment of forest habitats decreased the number of forest specialists and area-sensitive species[8], which were low in the southern part of this region. Intensive land use also entails removal of the forest canopy, thus abundance of tree foragers which strongly correlated with vegetation were relatively low to the south. Total bird abundance tended to increase with natural areas, as would be expected if areas of higher productivity supported greater numbers of birds. However, total bird abundance was not correlated significantly with the gradient, as shown in Figure-3b, indicating that other factors constrained the abundance of birds in the study site.

One factor was the high quality of habitat in the residential area. Several counts were made in urban parks with high number of tree canopy, and thus contributed to the relatively similar number of birds found in residential areas and other agricultural land uses.

The observed changes in species composition on bird CCA1 were also consistent with broad-scale anthropogenic effects attributable to land use changes. As observed in our study, generalist species increased in number with human encroachment of forest habitats, presumably because they utilize resources the forest specialist has not yet evolved to exploit[22].

Forest specialists are species closely associated with mature forests, whereas generalists, even though preferring mature forests, can make use of a wide variety of successional stages of forests and even non-forested habitats[30]. This suggested the vulnerability of forest specialists to changes in its habitat. Thus changes in forest land use can alter forest bird community composition to more human-tolerant, generalist species.



south
high road and house density
urban area
low altitude

north
low road and house density
forest area
high altitude

Figure-3

Plots Comparing Site Scores on the First CCA Axis of the Environmental Data (ENV1) with: (a) Bird Diversity, (b) Total Bird Abundance, (c) Ground Gleaner Abundance, (d) Tree Forager Abundance, (e) Omnivore Abundance, (f) Insectivore Abundance, (g) Habitat Generalist Abundance and (h) Endemic Species Abundance

We found that the broad-scale bird-environment patterns had associations attributable to habitat structures of each land-use type. Habitat factors induced local-scale differences between land uses with respect to vegetation structures. Habitat structures also induced changes in the species composition of bird assemblages (CCA axis 2 in figure-2) through its influence on the presence of understory vegetation in agricultural land uses. Increased area of cropland and orchard was associated with reduced bird diversity, presumably because these land uses offer fewer trees and so support less diverse bird than forested area with greater vegetation structure.

Conclusion

Land use and other aspects of the environment were interrelated to such an extent with bird distribution in North Bandung, West Java. A common theme we found in our study site was the importance tree canopy cover to the organization of bird communities in the northern forested areas of North Bandung. Bird distribution was correlated with road density and other structures associated with urban development. Land use changes caused by anthropogenic activities in North Bandung will alter bird communities across the landscape. Species restricted to the interiors of Mt. Tangkuban Perahu forest in the north were expected to reduce in number by agriculture and urbanization, while the opportunist and generalist species that have been favorably affected by forest fragmentation at the expense of other species will increase in number.

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Appendix (A)
List of 59 Bird Species Detected in the Study Site, Their Species Codes Used in CCA Ordination, and Their Functional Group Designations as to Foraging Technique (For), Dietary Preference (Diet), Habitat and Distribution (Dist)

Code	Scientific name	Common name	For	Diet	Habitat	Dist
ACJA	*Acridotheres javanicus*	Javan myna	GG	OM	GE	RE
AEEX	*Aethopyga eximia*	White-flanked sunbird	FG	NE	FO	EN
AEMY	*Aetophyga mysticalis*	Scarlet sunbird	FG	NE	FO	EN
ALPY	*Alcippe pyrrhoptera*	Javan fulvetta	FG	IN	FO	EN
AMAM	*Amandava amandava*	Red avadavat	GG	GR	FO	RE
ANMA	*Anthreptes malacensis*	Plain-throated sunbird	FG	NE	FO	RE
APAF	*Apus affinis*	Little swift	AF	IN	GE	RE
ARLE	*Artamus leucorhynchus*	White-breasted wood-swallow	AF	IN	GE	RE
ARLO	*Arachnothera longirostra*	Little spiderhunter	FG	NE	FO	RE
CAME	*Cacomantis merulinus*	Plaintive cuckoo	FG	IN	GE	RE
CASE	*Cacomantis sepulcralis*	Rusty-breasted cuckoo	FG	IN	GE	RE
CEVU	*Cettia vulcania*	Sunda bush-warbler	FG	IN	FO	RE
COES	*Collocalia esculenta*	Glossy swiftlet	AF	IN	GE	RE
COLI	*Columba livia*	Rock pigeon	GG	OM	GE	RE
COSA	*Copsychus saularis*	Magpie robin	GG	IN	GE	RE
DEMA	*Dendrocopos macei*	Fulvous-breasted woodpecker	BP	IN	FO	RE
DILE	*Dicrurus leucophaeus*	Ashy drongo	HA	IN	FO	RE
DIMA	*Dicrurus macrocercus*	Black drongo	HA	IN	FO	RE

Appendix (B)
List of 59 Bird Species Detected in the Study Site, Their Species Codes Used in CCA Ordination, and Their Functional Group Designations as to Foraging Technique (For), Dietary Preference (Diet), Habitat and Distribution (Dist)

DISA	*Dicaeum sanguinolentum*	Blood-breasted flowerpecker	FG	FR	FO	EN
DITR	*Dicaeum trochileum*	Scarlet-headed flowerpecker	FG	FR	GE	RE
FIHY	*Ficedula hyperythra*	Snowy-browed flycatcher	HA	IN	FO	RE
FIWE	*Ficedula westermanii*	Little pied flycatcher	HA	IN	FO	RE
GESU	*Gerygone sulphurea*	Golden-bellied gerygone	FG	IN	FO	RE
HACY	*Halcyon cyanoventris*	Javan kingfisher	HA	IN	GE	EN
HIRU	*Hirundo rustica*	Barn swallow	AF	IN	GE	MI
HIST	*Hirundo striolata*	Striated swallow	AF	IN	GE	RE
LASC	*Lanius schach*	Long-tailed shrike	HA	IN	GE	RE
LOLE	*Lonchura leucogastroides*	Javan munia	GG	GR	GE	RE
LOPU	*Loriculus pusillus*	Yellow-throated hanging-parrot	FG	FR	FO	EN
LOPU*	*Lonchura punctulata*	Scaly-breasted munia	GG	GR	GE	RE
MEHA	*Megalaima haemacephala*	Coppersmith barbet	FG	FR	GE	RE
MEPA	*Megalurus palustris*	Striated grassbird	FG	IN	FO	RE
NAEP	*Napothera epilepidota*	Eye-browed wren-babbler	FG	IN	FO	RE
NEJU	*Nectarinia jugularis*	Olive-backed sunbird	FG	NE	GE	RE
ORCU	*Orthotomus cuculatus*	Mountain tailorbird	FG	IN	FO	RE
ORSE	*Orthotomus sepium*	Olive-backed tailorbird	FG	IN	GE	RE
ORSU	*Orthotomus sutorius*	Common tailorbird	FG	IN	GE	RE
PAMA	*Parus major*	Great tit	FG	IN	GE	RE
PAMO	*Passer montanus*	Eurasian tree sparrow	GG	OM	GE	RE
PEMI	*Pericrocotus miniatus*	Sunda minivet	FG	IN	FO	EN
PHTR	*Phylloscopus trivirgatus*	Mountain leaf-warbler	FG	IN	FO	RE
PNPU	*Pnoepyga pusilla*	Pygmy wren-babbler	GG	IN	FO	RE
PRFA	*Prinia familiaris*	Bar-winged prinia	FG	IN	GE	EN
PSAL	*Psittacula alexandri*	Red-breasted parakeet	FG	FR	GE	RE
PTAE	*Pteruthius aenobarbus*	Chestnut-fronted shrike-babbler	FG	IN	FO	RE
PYAU	*Pycnonotus aurigaster*	Sooty-headed bulbul	FG	FR	GE	RE
PYBI	*Pycnonotus bimaculatus*	Orange-spotted bulbul	FG	FR	FO	EN
PYGO	*Pycnonotus goiavier*	Yellow-vented bulbul	FG	FR	GE	RE
SEGR	*Seicercus grammiceps*	Sunda warbler	FG	IN	FO	EN
SIAZ	*Sitta azurea*	Blue nuthatch	BP	IN	FO	RE
STBI	*Streptopelia bitorquota*	Island collared-dove	GG	GR	GE	RE
STCH	*Streptopelia chinensis*	Spotted-dove	GG	GR	GE	RE
STME	*Stachyris melanothorax*	Crescent-chested babbler	FG	IN	FO	EN
STME*	*Sturnus melanopterus*	Black-winged starling	GG	OM	FO	EN
TESU	*Tesia superciliaris*	Javan tesia	GG	IN	FO	EN
TOCH	*Todirhamphus chloris*	Collared kingfisher	HA	IN	GE	RE
TRGR	*Treron griseicauda*	Grey-cheeked green-pigeon	FG	FR	GE	EN
TUSU	*Turnix suscitator*	Barred buttonquail	GG	OM	FO	RE
ZOPA	*Zosterops palpebrosus*	Oriental white-eye	FG	OM	GE	RE

Note: Foraging Groups: AF = Aerial Forager, BP = Bark Prober, FG = Foliage Gleaner, GG = Ground Gleaner, HA = Hawker; Dietary Groups: FR = Frugivore, GR = Granivore, IN = Insectivore, NE = Nectarivore, OM = Omnivore; Habitat Groups: FO = Forest, GE = Generalist; Distribution Groups: EN = Endemic, MI = Migrant, RE = Resident