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The role of urban green space design to support bird community in the urban ecosystem

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Abstract. *Prihandi DR, Nurvianto S. 2022. The role of urban green space design to support bird community in the urban ecosystem. Biodiversitas 23: 2137-2145.* The increase in human population due to urbanization causes the expansion of urban areas that threatens forest lands to be lost and makes a serious threat to its biodiversity. Along with changes in the landscape due to urbanization, open green space is an alternative solution to maintaining biological diversity in urban areas. However, various types of open green spaces were developed following certain objectives of landscape management that potentially have different effects on biodiversity. This research aimed to identify the role of various open green spaces designs on bird biodiversity. Birds can be a good indicator of environmental quality because birds are a type of animal that can move in different habitat types and habitat areas and are often used as an indicator of habitat quality in urban areas. Bird observation was conducted using the point count method, while the environmental conditions were recorded using the nested and protocol sampling method. Those data were collected in five different open green spaces of Daerah Istimewa Yogyakarta Province. Species diversity shows the diversity of species in a bird community in a certain area using the Shanon-Wiener index. Bird communities were also analyzed using rarefaction analysis. This analysis was used to standardize the species abundance in each type of green open space to estimate the ideal species richness of open green space from the different number of samples. The Kruskal-Wallis test was used to compare the value of diversity, richness, and relative abundance of bird species among five different types of open green space. We used Canonical Correspondence Analysis (CCA) to visualize the bird's response toward environmental gradients. Generalized Linear Model (GLM) was employed to determine the effect of the environmental factors on the diversity of bird species. The result showed that different types of urban green spaces have different richness and relative abundance of bird species. We found 5925 individual birds from 40 species in five different types of open green spaces. The garden was the type of open green space with the highest bird species diversity. Of the many variables taken, the slope and the number of vehicles per minute affected the diversity of species. Those two variables were also negatively correlated with the diversity of bird species in the five types of open green spaces. The number of vehicles causes noise and pollution, which causes a decrease in bird populations. Flat slopes can also help birds get food, such as seeds on a flat surface. Creating more gardens for public and private spaces becomes an alternative solution to enhance bird diversity in the urban area.

Keywords: Bird diversity, garden, GLM, urbanization, urban ecology

INTRODUCTION

Urbanization is caused by the increasing human population inhabiting urban areas. The increase of the human population due to urbanization causes the expansion of urban areas that threatens forest lands to be lost and makes a serious threat to its biodiversity (Filloy et al. 2019). Forest destruction due to urbanization can threaten the existence of wild animals with species that are sensitive to their environment and wildlife habitats (Idilfitri and Mohamad 2012). Along with changes in the landscape due to urbanization, open green space is an alternative solution to maintaining biological diversity in urban areas.

Open green space is a space in urban areas whose cover is dominated by trees, shrubs, or grasses, either naturally or intentionally planted (Rakhshandehroo et al. 2017). The existence of open green space can increase the variety of landscape forms in urban areas with the presence of vegetation between cities. Open green space is an important component for biodiversity conservation in urban areas, as a sanctuary that allows certain species to survive in urban areas (Leveau et al. 2019) and the important element of space for a city to maintain the quality of the city environment by controlling air pollution and water infiltration media (De La Barrera et al. 2016). As a supporter of urban ecosystems, open green space has various forms, such as urban parks, gardens, greenways, cemeteries, and agriculture (Carbó-Ramírez and Zuria 2011; Lestari et al. 2012).

Open green space in urban areas plays an important role in providing corridors to maintain the remaining native biodiversity (Callaghan et al. 2019; Fernández-juricic and Jokimäki 2001; Tryjanowski et al. 2017). However, the magnitude of the effect of open green space on biodiversity depends on the characteristics or design of open green space, such as management, cultivation, extent and form of natural vegetation, or even shrub and tree cover, which add to the complexity of habitats, nesting sites and food sources for birds (Korányi et al. 2020; MacGregor-Fors et al. 2010; Paker et al. 2014). This open green space allows the emergence of species that are less tolerant of disturbances in urban landscapes (Carbó-Ramírez and Zuria 2011; Fernández-juricic and Jokimäki 2001).

There are various types of open green spaces that were developed following certain objectives of landscape management that potentially have different effects on biodiversity. This research aimed to identify the role of various open green spaces designs on bird biodiversity. Birds can be a good indicator of environmental quality because birds are a type of animal that can move in different habitat types and habitat areas and are often used as an indicator of habitat quality in urban areas. It is important to conduct research on bird species diversity in open green space to find out how good open green space is to protect biodiversity in urban areas.

MATERIALS AND METHODS

Study area

This research was conducted in open green spaces of the Yogyakarta Province, Indonesia. The research was conducted on various types of open green spaces located in urban and suburban areas (7° 47' 49.4448" S, 110° 22' 13.9044" E). The level of urbanization was determined by the percentage of a built-up area using the classification of Marzluff et al. (2001) with the output in the form of grids. The spatial data used for the delineation process in this study were Landsat 8 OLI/TIRS images with the help of QGIS Desktop 3.18 mapping software. This process began with processed Landsat 8 OLI/TIRS images, namely the atmospheric correction process or, in other words changing the reflectance at the satellite to surface reflectance. The next process was to quantify the percentage of the built-up area using the tools in the QGIS Desktop 3.18 software, namely the Semi-automatic Classification Plugin (SCP) and raster layer unique values report. After carrying out the process of quantifying the built-up area, the next process will determine the point on each open green space in the grid by looking at the land classification through images. We found 178 open green spaces that we used for observation points.

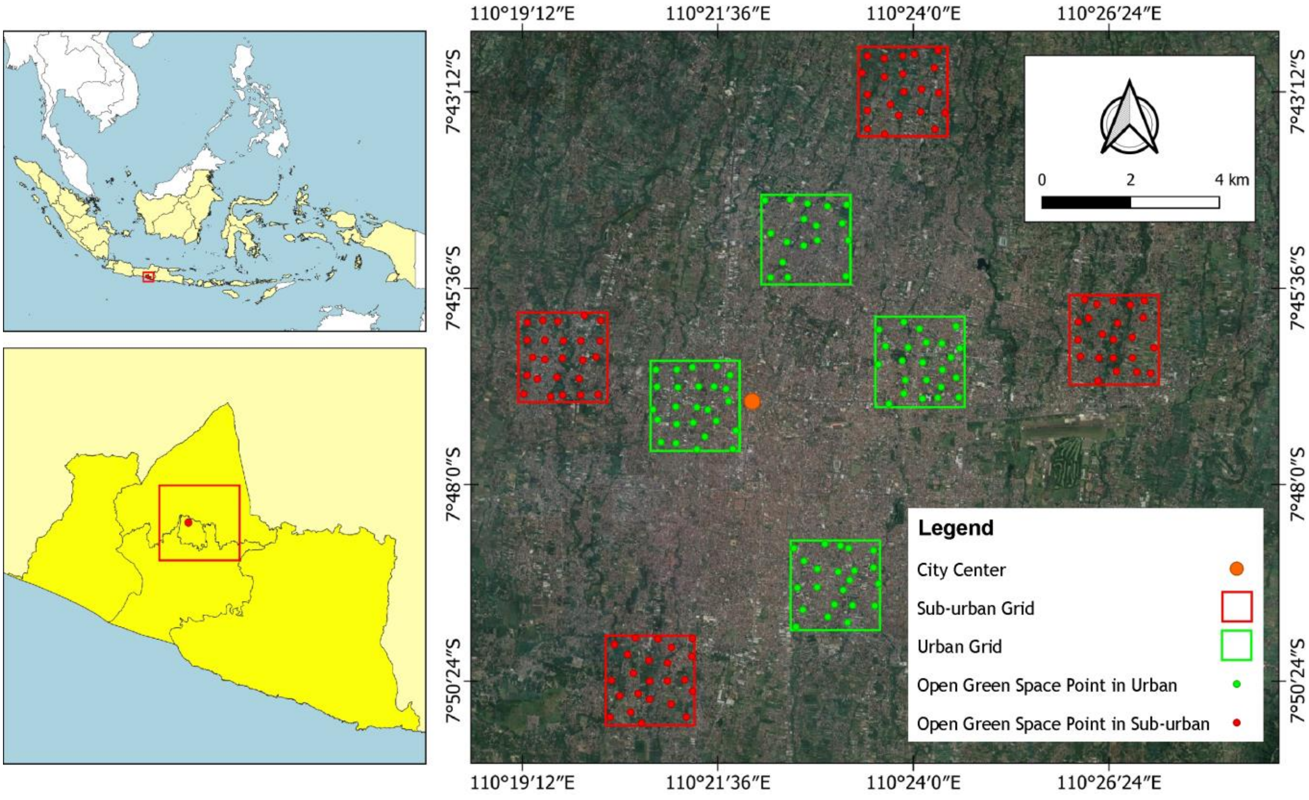

Figure 1. Location of Yogyakarta Province, Indonesia (*left*) and the sampling sites of this research that located in urban and sub-urban areas of Yogyakarta Province (*right*)

Table 1. Open green space area

Type of open green space	Number of points	Range area (ha)	Mean area (ha)
Garden	46	0.06-6.38	0.64
Agriculture	36	0.27-7.39	2.01
Greenway	32	0.06-1.05	0.47
Park	32	0.03-2.34	0.58
Cemetery	32	0.04-2.22	0.24

From 178 observation points observed, five different types of open green space were obtained, including gardens, agricultural land, parks, cemeteries, and greenways (Table 1). The type of open green space was identified by direct survey and observation on location. Garden was the most common open green space typically found in the study area with 46 points, followed by agriculture with 36 points and the parks, cemeteries, and greenways with 32 points. The area size of the five types of open green space was also different. The widest type of open green space is agriculture, with an average of 2.10 ha, while the open green space which has the smallest average area is the cemetery, which is 0.24 ha. Table 1 shows the range of each open green space area.

Procedures

Environmental data collection

We measured environmental data in each observation point. The variables that are collected are presented in Table 2, including biotic and abiotic variables. Vegetation data were collected using the nested sampling method. The nested sampling plot size used was 1 x 1 m for shrubs, 2 x 2 m for seedlings and undergrowth (height below 1.5 m), 5 x 5 m for saplings (diameter below 10 cm and height above 1.5 m), 10 x 10 m for poles (10-20 cm in diameter) and 20 x 20 m for trees (over 20 cm in diameter) (Oosting 1948). This method was developed to quantify and describe vegetation conditions. Variables that were collected are shown in Table 2. Protocol sampling was used to collect data on tree and shrub cover (Noon 1981). Slope, foliage density, distance from water, road, and city center were collected from the same points as the protocol sample. Human, vehicle, and predator presence was recorded by the used same protocol as bird observation method (Paker et al. 2014). Some research used these variables to identify environmental conditions in open green spaces (Lancaster and Rees 1979; MacGregor-Fors et al. 2010; Mörtberg and Wallentinus 2000; Mirski 2020; Paker et al. 2014; Shih 2018; Shwartz et al. 2008).

Bird data collection

Bird observations were carried out using the point count method. The points were determined by locating the observation points in each open green space's type with the distance between points being 400 m (Knutson et al. 2016). The grid design in this study is presented in Figure 1. Data collection was carried out in the morning at 06.00-10.00 WIB (GMT+7) and in the afternoon at 15.00-18.00 WIB (GMT+7) with the consideration that the peak of bird activity occurred at that time. The recording method was direct, and the observer used binoculars or a camera.

Table 2. List of environmental variables

Variable
• Number of tree species
• Number of shrub species
• Tree cover (%)
• Shrub cover (%)
• Foliage density (%)
• Height
▪ 0-30 cm
▪ 30-100 cm
▪ 100-200 cm
• Open Green Space's type
• Distance from water (m)
• Distance from road (m)
• Distance from city center (m)
• Human presence
• Vehicle presence
• Predator presence
• Slope (%)

Data analysis

The vegetation data that has been taken in each open green space is then processed to get the Important Value Index (IVI). IVI is a quantitative parameter used to determine the dominance of species in a plant community (Martono 2012). Bird species diversity was analyzed using the diversity index of Shannon-Wiener (Tramer 1969). Species diversity shows species diversity in a bird community in a certain area. The Kruskal-Wallis test was used to compare the value of bird diversity among different types of open green space (Mansor and Sah 2012). After knowing the results the significantly different from the Kruskall-Wallis test, Pairwise Wilcoxon-tests were used to find out which sites were different (Paker et al. 2014). The Canonical Correspondence Analysis (CCA) method was used to visualize bird responses to environmental factors (McGarigal et al. 2000; Morrison et al. 2001; Dray et al. 2003). The CCA method is very suitable for using data generated from complex data collection designs (McGarigal et al. 2000). Generalized Linear Model (GLM) analysis was employed to identify environmental factors affecting bird diversity in the open green spaces (Caprio et al. 2009). All statistical analyses were performed by R software version 4.1.1with the Stats package.

RESULTS AND DISCUSSION

Vegetation structure and composition

In the five open green spaces, a total of 187 shrub species and 64 tree species were identified. The total of shrubs and trees species is shown in Figure 2. The shrubs that were commonly found in every open green space included *Acalypha indica*, *Ageratum conyzoides*, *Asystasia gangetica*, *Digitaria sanguinalis*, *Rivina humilis*, *Sphagneticola trilobata*, *Synedrella nodiflora*, and *Tridax procumbens*, while for tree species were *Artocarpus heterophyllus*, *Mangifera indica*, and *Muntingia calabura*.

In the agricultural type, we found 70 shrubs and 25 species of trees, with *D. sanguinalis* being dominated for shrub species and *Swietenia macrophylla* being dominated for trees species. In the garden type, there were 84 shrubs and 30 species of trees, with *A. gangetica* being the most common shrub species and *Falcataria moluccana* being the most common tree species. The greenways type found 47 species of shrubs and 30 species of trees. *Digitaria sanguinalis* was the most common shrub species, and *Pterocarpus indicus* was the most common tree species. We found 54 shrubs and 40 species in park type, with *Sida acuta* being the most common shrub species and *S. macrophylla* being the most common tree species. The last type of open green space, the cemetery type, contains 43 types of shrub species and 14 types of trees species. *Ageratum conyzoides* was the common shrub species, and *M. indica* was the most common tree species.

Besides the important value index, tree cover and shrub cover could also show the structure and composition of vegetation in open green spaces. Of the five types of open green space, tree cover and shrub cover have similar values. In Figure 2, which shows the value of cover in the five open green spaces, the garden type has relatively higher shrub and tree cover than the other types. Almost all types of open green space have a higher tree cover value than shrub cover, except for the agricultural type (Figure 3). This fact is because agricultural open green spaces were used for agricultural functions for people and dominated by plants such as *Oryza sativa*.

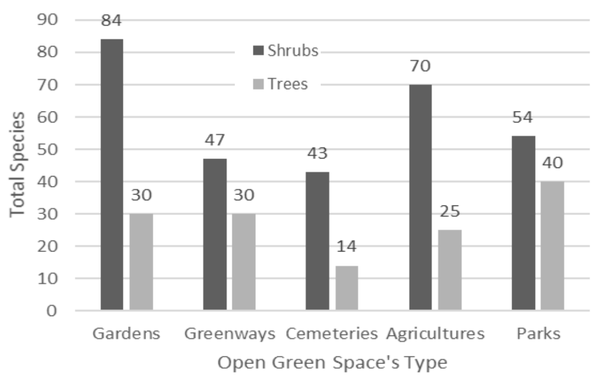

Figure 2. Total species of shrubs and trees in open green space

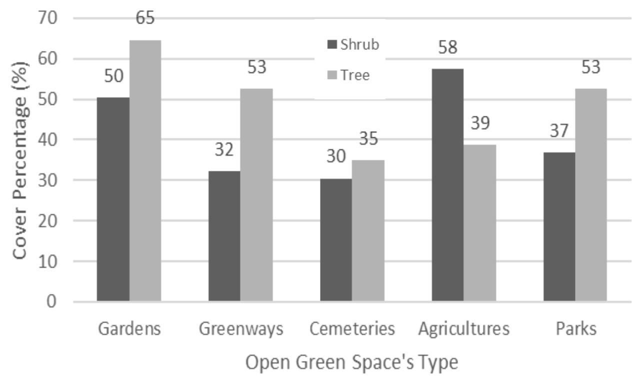

Figure 3. Shrub and tree cover in open green spaces (%)

Table 3. Shrub and tree species with Important Value Index (IVI)

Species name	Important Value Index (IVI)				
	Agricultural	Cemetery	Garden	Park	Greenway
Shrub species					
Acalypha indica	1.69	18.49	0.76	8.62	1.81
Ageratum conyzoides	6.08	20.98	7.43	10.08	8.52
Asystasia gangetica	11.82	13.43	21.64	1.54	4.90
Chromoalena odorata	12.86	4.17	9.65	-	7.44
Desmodium triflorum	3.37	-	3.15	9.15	6.71
Digitaria sanguinalis	23.72	12.86	4.08	11.01	27.07
Rivina humilis	3.16	2.73	3.54	6.32	11.43
Sphagneticola trilobata	9.73	9.29	5.77	7.98	12.53
Synedrela nodiflora	5.22	5.58	7.26	3.93	17.26
Tridax procumbens	3.55	7.97	2.31	1.17	11.26
Tree species					
Artocarpus altilis	32.32	21.67	23.99	-	2.90
Artocarpus heterophyllus	32.30	5.49	32.16	5.35	3.14
Falcataria moluccana	11.90	-	42.29	20.57	4.50
Ficus benjamina	-	5.47	-	27.04	40.04
Mangifera indica	23.50	63.63	23.18	15.60	5.05
Plumeria sp.	-	54.89	-	2.03	7.98
Polyalthia longifolia	19.70	-	1.74	6.85	30.00
Pterocarpus indicus	-	-	2.08	9.95	53.23
Pterospermum javanicum	13.39	8.28	26.54	-	17.41
Samanea saman	3.44	-	4.55	11.03	20.84
Swietenia macrophylla	44.19	-	35.88	31.62	28.23

Notes: The colored columns were the most common species in every Open Green Space's type. They were the five highest IVI in every Open Green Space's type

Bird species richness and diversity

The data collection results in five types of open green space found as many as 40 bird species with a total abundance of 5925 individual birds. Some species that are often found include Javan Munia (*Lonchura leucogastroides*), Eurasian Tree Sparrow (*Passer montanus*), and Yellow-vented Bulbul (*Pycnonotus goiavier*). Of the 40 species encountered, almost all species have a low conservation status (least concern/LC) according to the IUCN (BirdLife International 2016; BirdLife International 2016; BirdLife International 2017). The species that have a high conservation status according to the IUCN were the Bar-winged Prinia (*Prinia familiaris*) which was categorized as Near Threatened/NT (BirdLife International 2018), Javan Flameback (*Chrysocolaptes strictus*), which was categorized as Vulnerable/VU (BirdLife International 2016), and Javan myna (*Acridotheres javanicus*) which considered as Vulnerable/VU (BirdLife International 2020). These three types are only found in one type of open green space with a few amounts. Of the five types of open green space, gardens had the highest species richness with 35 bird species, followed by agriculture (27), greenways (19), parks (18), and cemeteries (16). The agricultural type had the highest total abundance, namely 2169 individual birds, followed by the garden (1221), cemetery (982), park (788), and greenways (761) types, as can be seen in Table 4.

Species diversity showed the diversity or differences of species in a bird community in a certain area. The Shannon-Wiener diversity index (H') described bird diversity in each open green space. From the results obtained, the diversity of bird species in the five types of open green space was not significantly different. Garden was a type of open green space with the highest H' value of the other four types, as shown in Table 5.

Table 4. Bird species listed in Open Green Space's type

Species name	Conservation status	Open green spaces type				
		Agricultural	Garden	Park	Cemetery	Greenway
Lonchura leucogastroides	Least Concern/LC	+	+	+	+	+
Lonchura punctulata	Least Concern/LC	+	+	+	+	+
Lonchura maja	Least Concern/LC	+	+	+	+	+
Passer montanus	Least Concern/LC	+	+	+	+	+
Orthotomus sepium	Least Concern/LC	+	+	-	-	+
Cisticola juncidis	Least Concern/LC	+	+	-	+	+
Todirhamphus chloris	Least Concern/LC	+	+	+	+	+
Halcyon cyanoventris	Least Concern/LC	+	+	+	+	+
Dicaeum trochileum	Least Concern/LC	+	+	+	+	+
Geopelia striata	Least Concern/LC	+	+	+	+	+
Hirundo rustica	Least Concern/LC	+	-	-	-	+
Ardeola speciosa	Least Concern/LC	+	+	+	+	+
Artamus leucorynchus	Least Concern/LC	+	+	-	-	+
Pycnonotus aurigaster	Least Concern/LC	+	+	+	+	+
Prinia familiaris	Near Threatened/NT	-	+	-	-	-
Orthotomus sutorius	Least Concern/LC	+	+	+	+	+
Spilopelia chinensis	Least Concern/LC	+	+	+	+	+
Cacomantis merulinus	Least Concern/LC	+	+	+	-	-
Cacomantis sepulcralis	Least Concern/LC	-	+	-	+	-
Dendrocopos macei	Least Concern/LC	-	+	-	-	-
Aegithina tiphia	Least Concern/LC	+	+	+	+	+
Cinnyris jugularis	Least Concern/LC	+	+	+	+	+
Hirundo tahitica	Least Concern/LC	+	-	+	+	-
Prinia inornata	Least Concern/LC	+	+	-	-	-
Pycnonotus goiavier	Least Concern/LC	+	+	+	+	+
Zosterops palpebrosus	Least Concern/LC	-	+	-	-	-
Megalaima haemacephala	Least Concern/LC	-	+	+	+	-
Alcedo meninting	Least Concern/LC	-	+	-	-	+
Amaurornis phoenicurus	Least Concern/LC	+	+	-	-	+
Dendrocopos moluccensis	Least Concern/LC	+	-	-	-	-
Bubulcus ibis	Least Concern/LC	+	+	-	-	-
Treron vernans	Least Concern/LC	-	+	+	-	-
Chalcophaps indica	Least Concern/LC	-	+	-	-	-
Phaenicophaeus curvirostris	Least Concern/LC	-	+	-	-	-
Anthreptes malacensis	Least Concern/LC	+	-	-	-	-
Egretta garzetta	Least Concern/LC	-	+	-	-	-
Chrysocolaptes strictus	Vulnerable/VU	-	+	-	-	-
Aplonis minor	Least Concern/LC	-	+	-	-	-
Zapornia fusca	Least Concern/LC	+	-	-	-	-
Acridotheres javanicus	Vulnerable/VU	-	-	+	-	-

Notes: +: Exist; -: Not exist

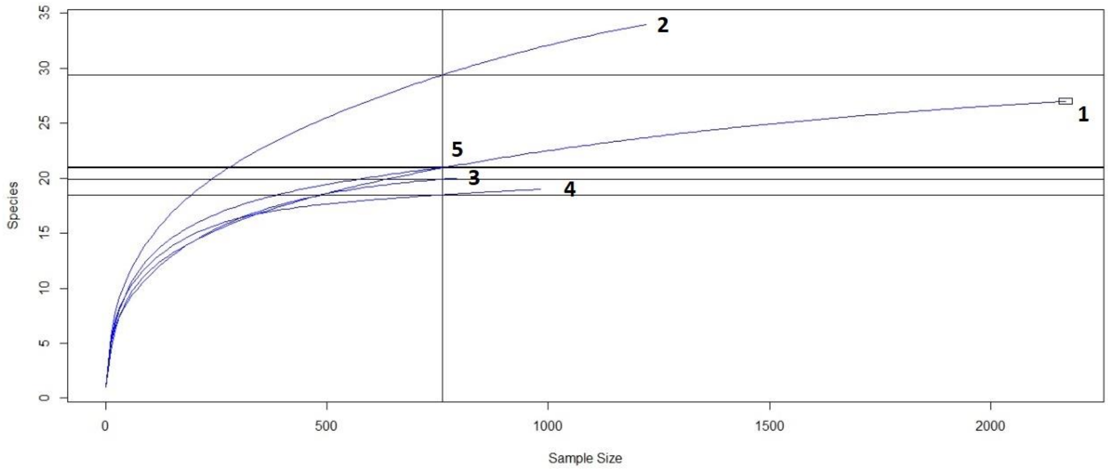

Figure 4. Rarefaction curve result. The curve showed the ideal species richness in every type of open green space. (Number 1: Agriculture land; Number 2: Garden, Number 3: Park, Number 4: Cemetery, Number 5: Greenway)

Table 5. Result of General Linear Model (GLM) Analysis

	Estimate	Std. Error	T value	Pr(>|t|)	
(Intercept)	1.3971767	0.0439090	31.820	<2e-16	***
Slope	-0.0099541	0.0045870	-2.170	0.0314	*
Vehicle/minute	-0.0019312	0.0009053	-2.133	0.0343	*
Null deviance		33.875			
Residual deviance		32.274			
AIC		209.2			

Note: P<0.05 symbolized by *, P<0.01 by **, P<0.001 by ***

Table 6. The value of species abundance, richness, and diversity in five types of Open Green Spaces

Open Green Space's type	Species abundance	Species richness	Species diversity (H')
Gardens	1221	34	2.1
Agricultures	2169	27	1.58
Parks	788	20	1.84
Cemeteries	982	19	1.91
Greenways	761	21	1.88

In theory, the difference in the number of plots could affect the species richness and abundance already counted. Therefore, bird communities were also analyzed using rarefaction analysis. In this analysis, standardization was used to standardize the species abundance in each type of green open space to estimate the ideal species richness of open green space (Irham 2015; James and Rathbun 1981; Kale 2014; Walker et al. 2008) so that the results were objective. The analysis was carried out by taking the type of green open space with the least number of plots as the standard, in this case, the greenway type. From the rarefaction curve results obtained, the highest bird species richness remained in the garden type with 29 species, followed by greenways (21), agriculture (20), gardens (19), and cemeteries (18). Gardens have a higher species richness than other types. This result follows the research conducted by Paker et al. (2014), which states that gardens can provide suitable habitats for many bird species. In addition, species richness in a habitat provides food availability for bird communities (Tu et al. 2020).

Effect of environmental factors on bird community

The result of the Kruskall-Wallis analysis showed that the bird diversity among the types of open green spaces statistically was not significantly different (K=12,351, df=4, p-value=0.6778), while the bird species richness and abundance among the types of open green space were significantly different to species richness (K=12.351, df=4, p-value=0.01492) and bird species abundance (K=43.304, df=4, p-value<0.001). From the Pairwise Wilcoxon test, it was known that species richness in the types of agricultural open green spaces and greenways was significantly different, while the abundance of agricultural types with other open green spaces has a very significant difference.

CCA analysis was also carried out to visualize the response of the bird community to environmental factors related to the environmental aspect. It can be seen that along with the 1st (horizontal) axis, most bird species are located at the left-hand part of the axis (squares 1 and 4), where tree species, distance from water sources, and shrub cover indicate that these variables have a positive effect on bird community structure. Fewer bird species are located on the right-hand part of this axis (squares 2 and 3), where slope, presence of people, and predators are high, indicating that these variables have a negative effect on bird community structure.

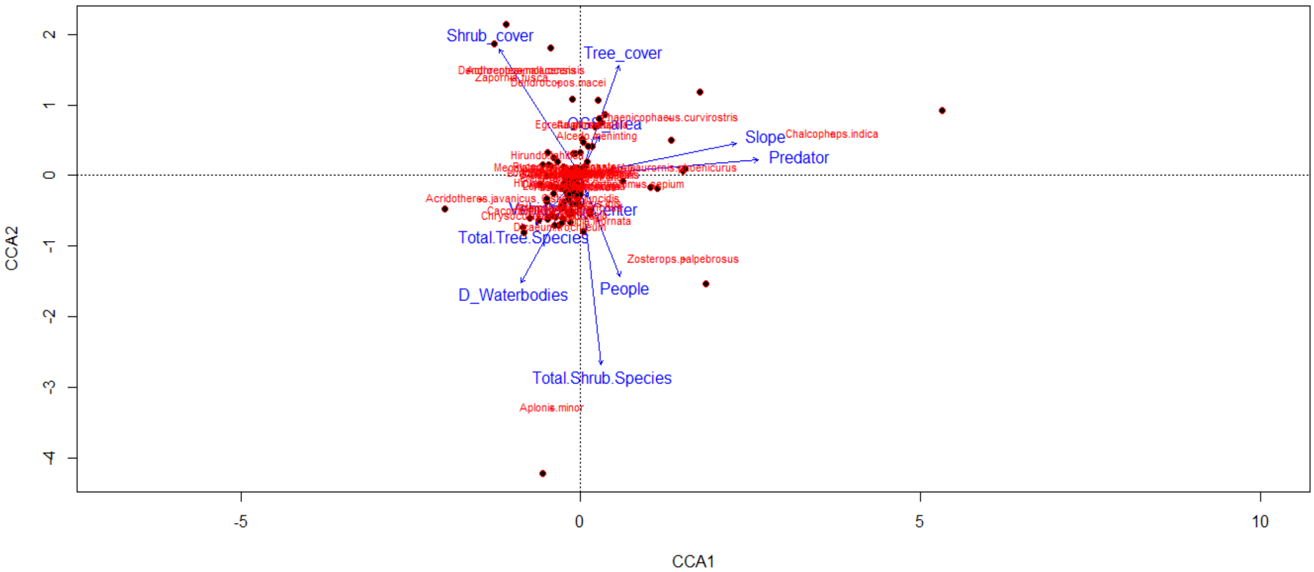

Figure 5. The graphic of Canonical Correspondence Analysis (CCA) result; the blue colored text presented the environmental factors, while the red colored text presented the bird species

Based on the result of the General Linear Model (GLM) analysis, from the 16 environmental variables that have been taken, only the slope (-0.0099541±0.0045870, P=0.0314) and the number of vehicles per minute (-0.0019312±0.0009053, P=0.0343) affect the diversity of bird species. Based on the regression analysis results, both are negatively correlated with bird species diversity. This result indicates that the higher the slope and the number of vehicles passing in the Open green space, the lower the diversity of bird species. A flat surface will help birds get to food such as fruit or seeds that fall to the ground. In addition, the high number of vehicles will cause increased pollution and noise, which can reduce bird populations in the area (Kociolek et al. 2011).

Discussion

From the data, it was known that the richness of bird species in open green spaces was significantly different between locations. Gardens had higher species richness than other types, following the research conducted by Paker et al. (2014), which stated that gardens could provide suitable habitat for many bird species. The diversity of bird species was not significantly different between open green spaces, but compared to other open green spaces, gardens had a higher bird diversity index than other open green spaces. This fact could be due to the complex characteristics of the vegetation in the garden. Compared to other open green spaces, the garden had a relatively high number of tree species and the number of shrubs species and tree cover and shrub cover. In the research of Mörtberg and Wallentinus (2000) and Mason et al. (2007), the number of tree species positively correlated with the high diversity of birds in open green spaces. Canopy cover also has a significant impact on the bird's presence (Shah and Sharma 2022). Landscape elements such as these could prevent homogenization within avian communities by offering a wider spectrum of food sources for granivores and insectivores and providing shelter where the human disturbance was lower than in other urban areas (Ortega-Álvarez and MacGregor-Fors 2009). Another study in Australia also indicated that high shrub and tree cover had an important influence on bird diversity (Daniels and Kirkpatrick 2006). Efforts to improve ecological conditions due to urbanization could be carried out by building open green spaces by creating gardens for both public and private spaces, which will become an alternative solution to enhance bird diversity in urban areas. In order to improve the quality of habitat for bird communities, the development of open green spaces needs to pay attention to the number of species and cover of shrubs and trees.

Gardens had higher species richness and diversity, but other types of open green space may have different effects on bird communities, such as agricultural land. In terms of abundance, agriculture had a much higher abundance than other open green spaces. Agricultural landscapes are dominated by crops that are a food source for granivorous and insectivorous birds that feed on seeds and insects on agricultural land (Kale 2014). In this study, it was also known that agriculture has the largest average area size compared to other open green spaces. According to several studies that had been conducted, the area of open green space had a positive correlation to the richness and diversity of bird species and was positively related to the size of open green space (Callaghan et al. 2018; Chamberlain et al. 2007; Mayorga et al. 2020; Pirzio Biroli et al. 2020; Zhang and Huang 2020). This result was different from what was found in this study, where the area of open green space had no significant effect on the diversity of bird species. This fact indicates that the habitat quality in the agricultural type was not that good. Even though the area of open green space is small, the diversity of bird species will still be high if the quality of the habitat is good (Callaghan et al. 2018; Carbó-Ramírez and Zuria 2011).

From the results obtained, several compositions of open green spaces were important in forming bird community structures in urban areas. The number of tree species, distance from water sources, and shrub cover were positively correlated with bird communities in open green spaces (Figure 4). This result confirms the above statement about the number of tree species and high shrub cover formed a good bird community structure, while the distance from the water source showed that the farther the distance, the better the bird community in open green spaces. This event can happen because most bird species were found far from water sources or rivers. In addition, there were several variables such as the number of shrub species, presence of people, presence of predators, slopes, and canopy cover, which had a negative correlation in most bird communities but were positively correlated with some bird species. The presence of predators in question were animals that interfered with the presence of birds in the area, for example, cats and dogs, following the research of Boyle and Samson (1985) and Evans et al. (2009), which states that the presence of humans and predators has a negative correlation on the bird community. Humans usually visit public open green spaces such as parks with their pets in the form of cats or dogs (Paker et al. 2014). The study by Loss et al. (2013) even explained that cats in urban areas predate birds. The presence of people at the cemetery for grave pilgrimages can interfere with the presence of birds in the area. It was necessary to create an area in the open green space where humans and their pets did not have access to the place by planning the path in such a way that the relatively large area consists of shrubs that are not accessible to humans and their pets, and also with the rules for tying up pets (Paker et al. 2014).

From the regression analysis carried out, it was also known that the slope variable and the number of vehicles affected the diversity of bird species. Both had a negative correlation to the diversity of bird species. Urban areas traversed by vehicles can disturb bird communities. According to Kociolek et al. (2011), the number of vehicles causes noise and pollution, causing a reduction in bird populations. Kociolek et al. (2011) also said that passing vehicles could also result in bird deaths. Temporal adjustment of traffic flow and outreach to the public on increasing dependence on mass transit can be made to reduce road noise. In addition, the use of noise-absorbing tires can substantially reduce road noise levels. These features also increase people's quality of life and property value (Kociolek et al. 2011). Besides that, the slope also affected the diversity of bird species.

The slope had a negative correlation with the diversity of bird species, where the flatter the slope, the higher the diversity of bird species. This result was indicated because the research is in urban areas with flat slopes. In addition, open green spaces such as agriculture and gardens were mostly located on flat slope land (Sandström et al. 2006) . In addition, flat slopes helped birds get food, such as grains on a flat surface.

Our results showed that open green spaces with high habitat quality, which in this study consisted of many species of shrub and trees, and shrub and tree cover also had an influence on bird communities. Therefore, when planning to build open green spaces, we recommend that designers avoid designs that do not have tree cover and do not create monocultures of open green spaces without shrub cover. Open green space needs to be built with a composition consisting of various types of shrubs and trees, such as the garden in this study. The high number of shrub species and the number of tree species make the landscape structure more complex so that it will provide a wider spectrum of food sources for the bird community. In addition, open green space designers must consider things that can disturb bird communities, such as pollution and noise, by building vegetation walls around open green spaces to reduce pollution and noise. In addition, because of the negative effects of people and predators on bird community structures, we recommend creating shrub areas that will have limited access to people and their pets. Finally, there is a need for further research by combining urban planning experts with zoologists to continue to create new ideas to build cities with open green spaces that have good structure and habitat quality to conserve wildlife in urban areas.

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