A Paper on the Relevance of Vegetation Stratification in Avifauna Enhancement: An Additional Concept in Planting Design for Urban Green Spaces

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Abstract

Avifauna wildlife species have been displaced due to urban expansion. Urban green spaces should be designed in a manner that caters to avifauna habitat needs. This involves the application of botanical species in a stratified or layered structure from the floor layer composed of groundcover and shrubs all the way to tree species up to canopy and emergent layers. Avifauna or bird species have specific requirements that include habitat locations or niches within this layered vegetation structure. The paper explores the vertical component of planting hierarchy. Planting Design, as a component of the practice of Landscape Architecture, is to be reinforced with this concept on vegetation layering to ensure that the planting or softscape component provides a suitable habitat for various avifauna species to thrive in urban green spaces. Planting Design cannot simply be for aesthetic purposes in urban parks and open spaces. As the study is conducted in the Philippines, selected open spaces of the University of the Philippines (U.P.) in Diliman Quezon City and selected parks in Makati City, underwent simple observation techniques to understand local current conditions pertaining to present vegetation layers and the occurrences of avifauna species. Results showed that generally, the observed parks and open spaces exhibited some characteristics ideal for avifauna habitat however only two to three layers of stratification were seen which translated to low numbers of observed avifauna species. The parks in Makati City did show a variety of botanical species but were only limited to the floor or understory layers. The Eurasian tree sparrow (*Passer montanus*) numbers was found to be relatively high but can be explained based on their high adaptability in urban areas. The study underscores the need to introduce more and varied botanical species for floor, understory to lower and upper canopy, and emergent layers. Plants must be chosen carefully vis-à-vis the need to enhance the population of birds within the parks and open spaces of the urban environment.

Keywords: Vegetation stratification, Urban Planting Design, Ecological Niche, Avifauna Species

1. Introduction

Avifauna is important in cities and form part of the so-called nature-in-cities ideal where contact and experience with them provide benefits for people. (Berg, 2021; Daniels et al., 2020). As a study conducted in the Philippines, countless studies and research have shown that the country is endowed with a rich biodiversity of zoological wildlife. The country of course is part of a region that contains a surprisingly large quantity of species both zoological and botanical. “An estimated 1,084 species of terrestrial vertebrates are found in Philippine forests of which 45 percent are endemic.” (Department of Environment and Natural Resources, 1996). It has been estimated that about 60 - 90 percent of life exist within forest trees (Butler, 2010). If this number, there are about 558 species of avifauna with 31 percent endemism (Department of Environment and Natural Resources, 1996). From this number, there are individual species of birds found in the Philippines comprised of 300 - 400 subspecies with 104 passage migrants; there are about 160 estimated endemic species (Gonzales & Rees, 1988). One possible reason for this high number of migratory species is found in the geographic location of the country. The Philippines is part of the East Asia flyway; a migratory route used by avifauna when they travel from Northern Asia down to Australia during the winter months of the Northern Hemisphere (Gonzales & Rees, 1988). Evidence that the country is a stopover for these migratory species can be seen within the grounds of the University of the Philippines in Diliman where within its open grassed spaces and those near the University’s arboretum, several migratory species have been observed.

It has been studied that even at the level of the urban street, trees provide the habitat for avifauna species (Wood & Esaian, 2020). The rising trend of urbanization today has reduced the tree plantings and cover of the once green spaces of Manila’s metropolis. In fact, the Philippines has already lost about 97 percent of its original vegetation and has more critically endangered avian and mammalian species than any other country (Maala, 2001). Metro Manila has about 13 percent green cover left, the majority of which are found only in the Diliman and La Mesa districts of Quezon City (Vallejo, 2009). Quezon City in the Philippines tops the list being the greenest with 25 percent green cover while Manila is the least with 5 percent green cover (Vallejo, 2009). These figures show that avifauna populations are dwindling because of the destruction of habitat. On the other hand, it must not be forgotten that there is also the presence of urban-tolerant species of which high densities have been measured in heavily built-up urban areas.

Such a species is the *Passer montanus* or Eurasian tree sparrow. The presence and population of these birds however should not be an indicator of a thriving mixture of birds in that they are just representative of one species. The general objective is to bring back a rich avifauna diversity that once populated the land area of the current metropolis. Only 4 urban tolerant species are found in Metro Manila, this represents 48 percent of the total estimated. The other 52 percent are uncommon to rare (Vallejo, 2009). In the University of the Philippines, Diliman alone 6 species of birds that used to be found are now no longer present (Ong et al., 1999). Species like the Eurasian tree sparrow (*Passer montanus*) are found in high numbers probably because they can tolerate the urban conditions. They have probably adapted through time to survive on minimal tree cover. Bottom-line is, the existing urban conditions only give survivability to a very select and few species thus resulting in a very low biodiversity (Vallejo, 2009).

Planting Design is part of Landscape Architecture and is a process of site analysis, research, selecting and locating plants artistically in the landscape for desired effects (Austin, 2002, p.23). Planting Design serves to make coherent landscapes within the urban environment and bridge spaces to create habitat (Müller et al., 2013). The current practice of Planting Design primarily considers two aspects: aesthetics and function. Aesthetics in this sense, caters to the need for a landscape space to be visually pleasing, while function can pertain to plants used as a control for environmental problems such as erosion, air and water pollution, control of excessive sunlight, heat protection and the like. Integrating the idea of wildlife enhancement via vegetation stratification as an additional element in the process of planting design would be a move that parallels several thrusts of Landscape Architecture which include conservation, preservation, suitable human use, and enhancement of the natural environment.

According to the Green City Index (GCI) study commissioned by Siemens, Manila performs below average as compared to cities from neighboring Asian countries in terms of its land use, with only 5 square meters of green space per person as opposed to the Green City Index (GCI) standard of 39 (Siemens, 2010). Most of these green areas are concentrated in low density residential areas (Moriwake et al., 2000). The same study by Moriwake described the tree heights in different areas. Parks generally had higher trees, residential areas had about average height trees, and central business districts had generally low trees.

A study by Dunlavy (1935), shows that some bird species may occupy a different nesting niche from its feeding niche. Different levels of vegetation may therefore serve different functions for a single species. In Singapore, the succession of planting from grassland to understory to inland forest helped to facilitate the inhabitation of bird species in reclaimed areas. (Ward, 1968).

2. Vegetation Stratification

Layering in vegetation is a naturally occurring phenomenon. Through successive stages, a stand of plants will eventually allow the growth of other species consequently resulting in a layered structure. The process continues until a climax community is achieved. Avifauna live and thrive within specific locations in this structure (Walther, 2002). The distribution of avian species within this structure can be seen in two ways: vertical distribution and horizontal distribution. This vertical distribution pertains to vertical stratification where the ecosystem is subdivided by the layers of its vegetation and determined by the sizes and kinds of plants that are found of which are home to various species of birds inhabiting specific niches within (Carter, 2005).

A specific niche does not necessarily create a pleasing environment for a group of species but can be home to one (1) avifauna species. Each "strata within a vegetated stand corresponds to its own environmental factors, habitat and meso-climate" (Radboud University Nijmegen, 2011). This fact severely impacts the survivability of a particular species when that specific niche is compromised or destroyed. Specific niche destruction is possibly a result of urban intensification.

Forested areas can be analyzed as a system of different layers at varying heights. Research has shown that avifauna species inhabit specific layers within this system (Butler, 2020; Dunlavy, 1935) (Figure 1). Each layer in turn provides for some if not all the requirements needed for the survival of those species. The continued removal of that specific layer can eventually result in the endangerment of that species in question.

The Philippines is home to an abundant number of avifauna with each inhabiting a specific layer within this vertical stratification. For example, the Kulasisi or Philippine hanging parrot (*Loriculus philippensis*) forages in the canopy and middle forest layer while the Pied fantail (*Rhipidura javanica*) prefers the dark understory (Tan, 2001). Analysis of an avifauna species' requirements can yield information on its habitat type, more so its ecological niche within the layers. By making sure that the planting design caters to the needs and requirements of as many species as possible, the enhancement of avifauna populations existing in a city is feasible. It is also possible to bring back species that have been driven out by urbanization and possibly to bring in new species that is ideal and/or that can adapt to an urban setting. Doing so adds to the experience of users as they use these urban green spaces and parks.

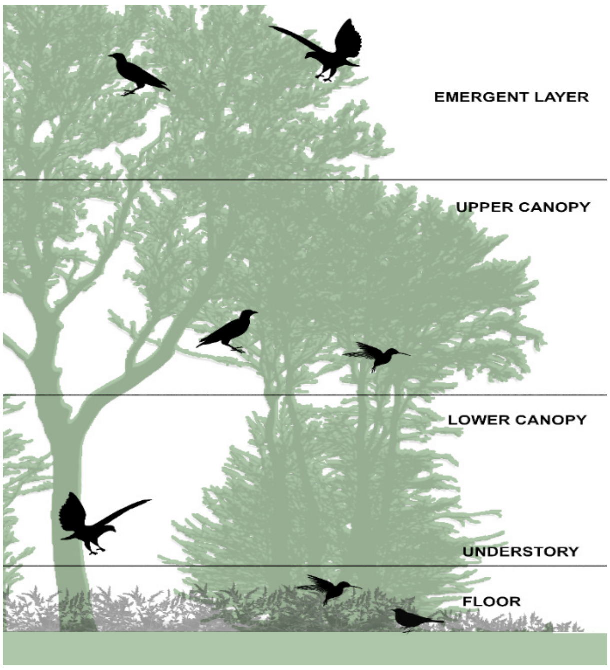

Figure 1 Each vegetation layer or strata provides the living conditions that avifauna species need to thrive.
Note: Adapted from "Vegetation Layers" by Texas Parks and Wildlife Department (1999).

Horizontal distribution on the other hand pertains to distribution of species on the edges of habitats or ecotone areas. Ecotone areas as a community generally have a greater variety and density of life because they contain species from adjoining habitats. The abundance of wildlife in these areas is known as the "edge effect" (Carter, 2005). Where fields and forests meet; where there is great contrast in planting material there is a large variety of wildlife (Texas Parks and Wildlife Department, 1999).

An avifauna species typically found in such forest and grassland edge areas is the Spotted dove (*Stretopelia chinenis*) (Tan, 2001). Avian communities in these definable areas (both vertical and horizontal) exist because the vegetation structure allows them to thrive and be diverse (Campos-Silva & Piratelli, 2021). These requirements range from plant species existing on site, and degree of succession to layer structure of the vegetation. Bringing back native avifauna species is possible where the usage of native vegetation as a requirement is met (Chace & Walsh, 2004). Alterations to these requirements affect the numbers of birds in each area.

Vegetation hierarchy as a terminology and as part of planting design should not just pertain to creating a background, middle ground, and foreground in the planting composition. The intended outcome of planting design structure as geared towards the enhancement of avifauna in urban spaces should mimic that of a lowland forest pattern where the floor or understory, lower canopy, upper canopy, and emergent layers are present. Proper selection of botanical species will consider the mature heights of plants in the composition eventually establishing a layered structure (Figure 2).

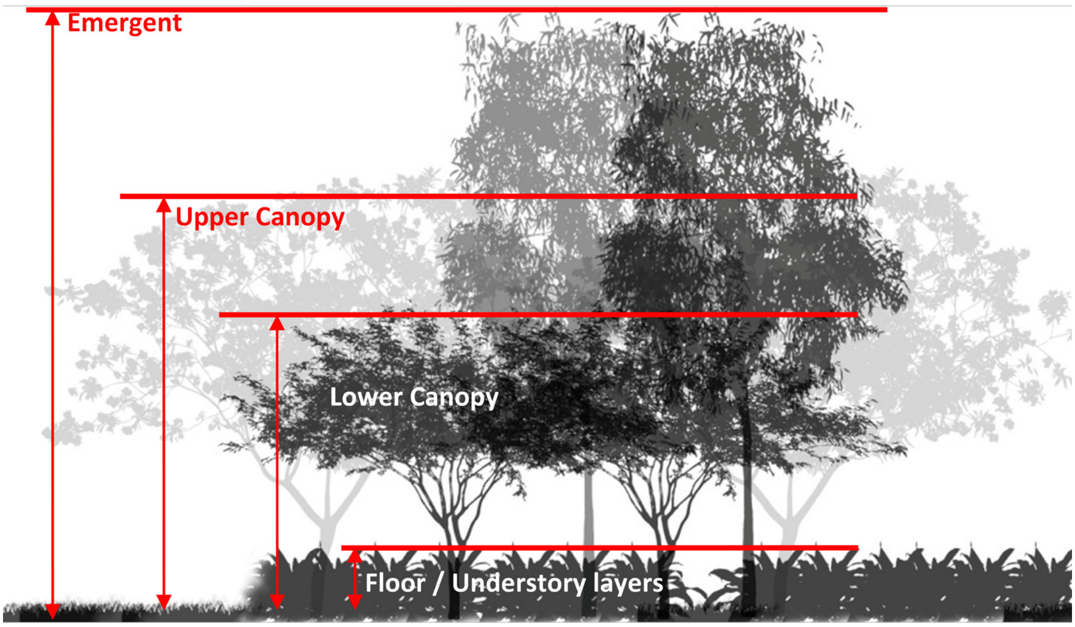

Figure 2 Ideal layering structure for Planting Design. Shrubs and groundcovers for the floor or understory, small tree species for the lower canopy and large tree species for the upper canopy and emergent layers. (Villa Juan, 2013).

This concept of creating well defined layers with plants can be integrated easily into current planting design process, techniques and practices adding not just to aesthetics but more importantly adding more on avifauna wildlife habitat function for designed urban open spaces consequently providing more experience for people using these spaces. (Figure 3).

Figure 3 Sample application of vegetation layering on a hypothetical park in an urban setting. The process of Planting Design will specify and allocate within the planting area different botanical species to become habitat for avifauna species from floor/understory all the way up to the emergent layer. (Villa Juan, 2013).

3. Objective

A simple direct observation of two urban spaces (Figure 4), the open space and residential area of the University of the Philippines, Diliman particularly the open spaces of Osmena and Roxas Avenues, the residential area, and the University of the Philippines (U.P.) Sunken Garden (Table 1); and Makati City's parks particularly Ayala Triangle Gardens, Salcedo Park, and Washington SyCip Park (Table 2) was conducted to ascertain local avifauna wildlife vis-à-vis the vegetation layers they are found in. These observation areas were chosen based primarily on their fit as to the definition of the Philippine urban open space (Housing and Land Use Regulatory Board, 2017) especially for the parks in Makati City, and secondarily on accessibility, clear and evident presence of vegetation layers, and evident mix of vegetation species especially for the open spaces in the University of the Philippines (U.P.), in Diliman, Quezon City. The paper aims to explore vegetation stratification for use in the Planting Design of the urban landscape / green open spaces and serves to forward it beyond performing standard basic functions as barrier, as shade elements, as elements for environmental cooling among others, and beyond being simply a cosmetic element of urban space per the preconceived ideas of many.

The paper explores how a layered or a stratified system in urban planting design can allow avifauna species to thrive in the urban landscape.

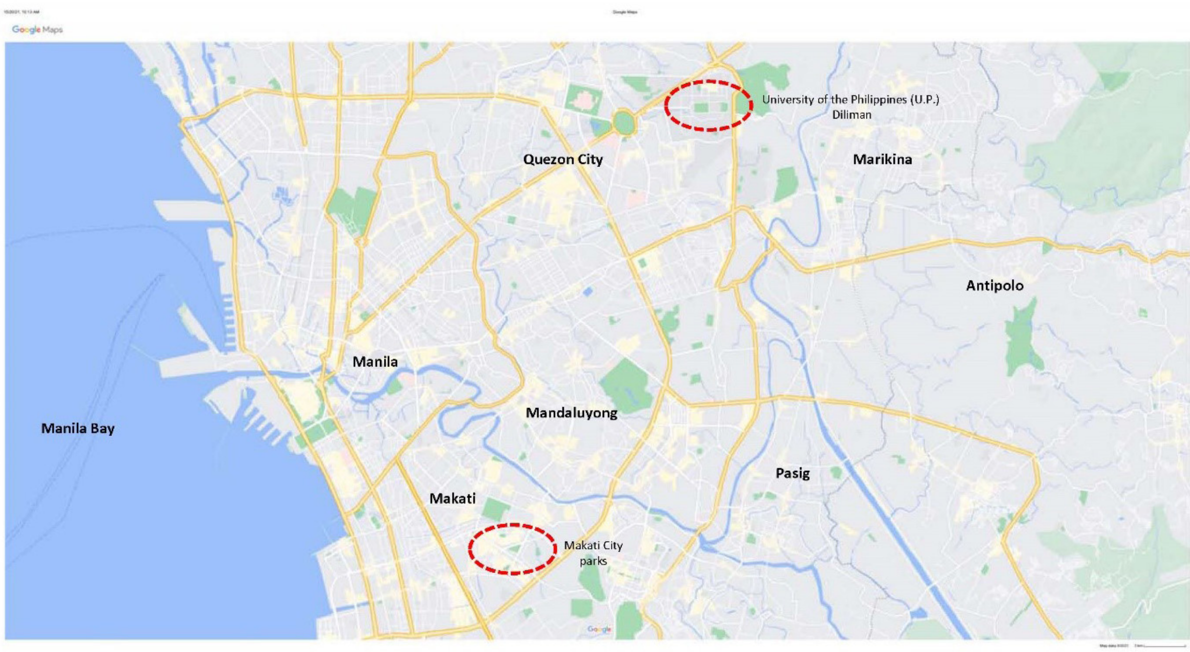

Figure 4 Map showing the locations of the 2 observation areas (Google Maps, 2021); open spaces of the University of the Philippines (U.P.), Diliman in Quezon City and selected parks in Makati City.

4. Methodology

A simple methodology of direct observations of avifauna species were done during the early mornings, usually from 6:30 to 9 am at two (2) selected areas namely a university and a city's open spaces. According to bird watching practices, mornings were suitable for bird watching because of the increased activity due to feeding. Bird sightings were listed down according to species. The number of occurrences was also listed down. They were identified through visual and auditory confirmation. The different strata were recorded for each site and images of the open spaces were taken. Figures 3, 4, 5 and 6 show images of the observation areas. Birds were categorized according to which stratum they were seen in regardless of whether it is a feeding or resting niche. The levels were classified as follows. Following levels adapted from (Raghunath, 2013). **Emergent layer** – more than 40 meters, **Upper canopy** – 20-30 meters, **Lower canopy** – 10-20 meters, **Understory** – 5-10 meters, and **Floor** – 0-5 meters.

These levels or strata were chosen because they represent the general layers found in a typical forest system. Forests are known to harbor and provide for a diverse number of wildlife species (Brockerhoff et al., 2017). Gradual succession eventually allows for a multilayered system and would be indicative of a stable community and ecosystem that in turn would be able to support numerous wildlife species (Farabee, 2007). Similar studies by Thiel et al. (2021) showed that forests are composed of 6 levels namely soil, forest floor, herbaceous, shrub, tree, and emergent layers.

5. Results of observation

5.1 University of the Philippines

Table 1 Showing strata and number of occurrences of avifauna species observed within each strata.

UNIVERSITY OF THE PHILIPPINES (UP) DILIMAN								
Osmena and Roxas Ave.			Residential Area			Open Space (UP Sunken Garden)		
Species	Stratum Observed	Number of Occurences	Species	Stratum Observed	Number of Occurences	Species	Stratum Observed	Number of Occurences
Coppersmith Barbet *Psilopogon haemacephalus*	Upper canopy	1	Yellow Vented Bulbul *Pycnonotus goiavier*	Lower canopy	2	White-collared Kingfisher *Todiramphus chloris*	Understory	1
Olive-Backed Sunbird *Cinnyris jugularis*	Upper canopy	1	Eurasian Tree Sparrow *Passer montanus*	Understory	8	Zebra Dove *Geopelia striata*	Floor	1
Black Naped Oriole *Oriolus chinensis*	Upper canopy	2	Zebra Dove *Geopelia striata*	Floor	1	Striated Grassbird *Megalurus palustris*	Floor	1
Pied Fantail *Rhipidura nigritorquis*	Lower canopy	2	Island Swiftlet *Aerodramus inquietus*	None (in flight)	1	Island Swiftlet *Aerodramus inquietus*	None (in flight)	1
Golden Bellied Flyeater *Gerygone sulphurea*	Lower canopy	2	White-Collared Kingfisher *Todiramphus chloris*	None (in flight)	1			
Yellow Vented Bulbul *Pycnonotus goiavier*	Lower canopy	5						
Eurasian Tree Sparrow *Passer montanus*	Understory	More than 10						
White-Collared Kingfisher *Todiramphus chloris*	(not confirmed on site – heard only)	Not confirmed						
Colasisi *Loriculus philippensis*	(not confirmed on site – heard only)	Not confirmed						

Figure 5 View of Osmena Ave, University of the Philippines (UP), Diliman. (Paningbatan, 2013).

Figure 6 View of Roxas Ave., University of the Philippines (UP), Diliman. (Paningbatan, 2013).

Figure 7 View of a residence in Area 1, University of the Philippines (UP), Diliman. (Paningbatan, 2013).

Figure 8 View of Sunken Garden, University of the Philippines (UP), Diliman. (Paningbatan, 2013).

5.2 Makati City, National Capital Region, Philippines

Table 2 Showing strata and number of occurrences of avifauna species observed within each strata.

MAKATI CITY PARKS								
Ayala Triangle Gardens			Salcedo Park			Washington SyCip Park		
Species	Stratum Observed	Number of Occurences	Species	Stratum Observed	Number of Occurences	Species	Stratum Observed	Number of Occurences
Pied Fantail *Rhipidura nigritorquis*	Lower canopy	1	Eurasian Tree Sparrow *Passer montanus*	Understory, floor	More than 10	Eurasian Tree Sparrow *Passer montanus*	Understory, floor	More than 10
Golden Bellied Flyeater *Gerygone sulphurea*	(not confirmed on site – heard only)	Not confirmed						
Yellow Vented Bulbul *Pycnonotus goiavier*	Lower canopy	3						
Eurasian Tree Sparrow *Passer montanus*	Understory, floor	More than 10						

Figure 9 View of Ayala Triangle Gardens / Park. (Paningbatan, 2013).

Figure 10 View of Salcedo Park. (Paningbatan, 2013).

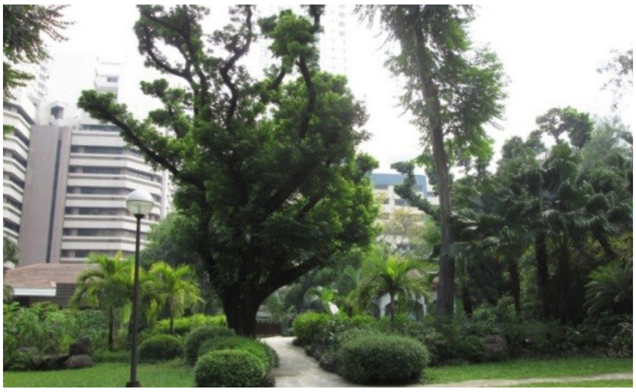

Figure 11 View of Washington SyCip Park. (Paningbatan, 2013).

6. Analysis of observation results

The observation areas are composed of large open spaces with tree, shrub, and groundcover species at peripheral areas typical of public parks and gardens. These areas exhibit characteristics that would be ideal for avifauna habitat. The open spaces observed within the University of the Philippines (U.P.) Diliman, particularly the Osmena and Roxas Avenue areas exhibit, at the very least, one to two stratified layers of vegetation from small trees at lower canopy level to the larger upper canopy species. The residential area of the university was seen to exhibit three or more layers and the open space of the Sunken Garden exhibited the same one to two layers like those found along Osmena and Roxas Avenues. The observation areas in Makati City; the Ayala Triangle Gardens and Salcedo Park also exhibited predominantly one to two stratified layers with more shrub and groundcover planting making up much of the understory or floor layers. The lack of additional layers is possibly the cause of the low number of observed avifauna species in the observation areas. An exception is the Eurasian tree sparrow (*Passer montanus*) where relatively high numbers of the species have been observed. This is understandable as the species is considered exotic, dominant, and adaptable to urban conditions and can thus thrive quite easily (Nor et al., 2017).

7. Conclusion

Based on the results of the observations, the following conclusions are being made:

1. The low occurrence of observed avifauna species within the observation areas seems to correlate with the lack of additional vegetation layers.
2. For the Makati City Parks observation areas, though there is a mix / variety of plant species seen, much of the variety are found at the floor layers catering only to a select few avifauna species.
3. Though there are avifauna species such as the Eurasian tree sparrow (*Passer montanus*) observed with relatively high number of occurrences, it can be attributed to their high adaptability nature within urban spaces.
4. The results highlight the need to integrate vegetation hierarchy composed of a multi layered system from floor to upper canopy levels in planting design.

Through simple direct observation of urban open spaces, it can be seen that various bird species need these vegetation layers to thrive. Planting design can be developed as a process not only of choosing the right plant for a given environmental condition for aesthetics and basic function, but also as a deliberate mode to bring in more avian species into the urban setting.

8. Discussion & Recommendations

The low occurrence of observed avifauna species in the observation areas can be addressed with the addition of more botanical species to fill the "gaps" of the ideal stratified system. Where there are only lower canopy or upper canopy layers present, floor or understory species should be introduced. Variety in botanical species should be carried throughout the entire range of the vegetation layers (from floor to canopy and even emergent layers) and not just limited to certain layers as observed in Makati City.

Botanical species must also be chosen carefully in relation to wildlife requirements, as certain plants may only cater to a specific group of avifauna species. Knowledge about these bird species will yield data on their habitat requirements and thus the botanical species - shrubs, groundcovers, or trees - required. There are thousands of documented native forest plant species still waiting for application in Philippine Landscape Architecture most of which hold promise as aesthetic elements as well as habitat elements for many wildlife species (Gozon, 2010). The country as part of the Malaysian Floristic Region, is endowed with many botanical species (University of the Philippines, Science Education Center, 1980) and this richness can bring with it a diverse wildlife that can and should be part of the urban landscape. Native botanical species should be the norm for urban landscapes. It is always possible that there are other factors that affect the number and distribution of avifauna in the urban landscape such as the size and design of buildings perhaps that act as barriers (Isaksson, 2018), there are issues with microclimate, noise, air pollution (Nor et al., 2017), fragmentation of available habitat, etc. (Isaksson & Sumasgutner, 2016) and these can be addressed in future studies. The process of Planting Design should integrate as much variation in botanical species as possible. The plant palette of lawn, groundcovers, shrubs, small, and then large trees should have species that will take on the roles of floor, understory, lower canopy, upper canopy, and emergent vegetation layers within the urban landscape spaces of parks and other open spaces.

Lastly, the adaptation and implementation of plant layers in landscape design will have its limitations and hindrances besides the availability of plant species; project cost implication, availability of space, and the client's preconceived notions of park and open space design are also factors that can affect vegetation stratification. One way to address this would be to make it a collective effort for local governments, developers, and designers to advocate avian species conservation and, thus, pave the way for the acceptance of the role of the stratified vegetation system.

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