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Floral Distribution and Diversity of Alien and Native Plants in Cebu Memorial Park, Cebu City, Philippines

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Abstract. Metro Cebu, Philippines has a history of over 800 years of urbanization, making it a unique location for urban ecological studies. Urbanization can have a significant impact on floral communities, but the species composition and variety of urban cemeteries in Metro Cebu have not been reported. We calculated floral species richness (N), abundance (n), evenness (PE), and diversity (H' and D) by conducting the first floral survey (local plants and alien plants) in an urban cemetery in Metro Cebu. Subsequently, we evaluated the distribution pattern of floral species and the relationships between the richness of floral species and human activities. A total of 61 floral species (n=1,515) were recorded, with the proportion of APs (n=53; 86.88%) being much larger than the number of NPS (n=8; 13.11%). Shannon-Wiener Diversity index was calculated to be 2.69, Simpson's Diversity index was 0.16, and Pielou's Evenness was 0.65. Our research provides the first information on floral species in Metro Cebu, Philippines, and serves as a baseline for future studies and conservation efforts.

Key words: alien plants, anthropogenic activities, ecosystem services, native plants, urban cemetery

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INTRODUCTION

The Philippines is a megadiverse state, but it has been losing biodiversity fast since the 1990s due to socioeconomic growth and urbanization (Muzafar et al., 2018; Hashim et al., 2018; Hakkila et al., 2020). In recent years, urban land coverage in the Philippines has increased, and this trend is anticipated to continue (Altay et al., 2020). The Philippine government has acknowledged the importance of urban green spaces (UGS**s**), such as urban cemeteries, to the conservation of biodiversity considering the continuous urbanization of the country (Wu, 2014; Zhou et al., 2014; Quinton et al., 2020). Urban cemeteries are regarded as one of the most significant UGSs in urban ecosystems that are negatively affected by anthropogenic disturbances and consequently result in substantial CO_2 accumulation and pollutant production (Bhaskar, 2012). These UGS**s** also provide numerous ecosystem services, or "nature's benefits," such as provisioning, regulating, cultural, and supporting services. To protect and conserve the biodiversity in urban areas, the "required city developers to design biodiversity plans in urban cemeteries; use native plant species in cemeteries; and conserve natural landscapes, vegetation, water systems, and wetlands as part of urban planning" (Whittinghjill & Rowe, 2011; Gomez-Baggethun et al., 2013; Value of Nature, 2017; Millennium Ecosystem Assessment [MEA], 2020).

In addition to enhancing biodiversity in urban cemeteries, NPs and APs also provide a variety of ecosystem benefits to humans (Quinton & Duinker, 2019). Urban cemeteries are excellent instances of UGS**s**, particularly in densely populated cities (Hakkila et al., 2020). It serves as a vast repository of biotic diversity with numerous plant and animal species, as well as a habitat for local, exotic, and a few rare species (Yilmaz et al., 2017; Quinton & Duinker, 2019). In addition, urban cemeteries are regarded as a significant refuge for animals and plants, making them an ideal location for the protection of urban

biodiversity. Numerous urban cemeteries are also referred to as climate management areas and sites that produce chilly air (Allam, 2020). Yilmaz et al. (2017) and Kowarik et al. (2016) undertook floristic inventories in Berlin and Istanbul, identifying numerous plant species, including some of the most severely endangered, threatened, and protected species. During the investigation done in Berlin, two new species were also found. Due to their scale, environmental variability, and habitat continuity, urban cemeteries serve a crucial role in preserving urban biodiversity (Bhaskar, 2012; Altay et al., 2020).

Globally, urban settings are characterized by poor floral richness and diversity (Hahs et al., 2009). The neglect of urban vegetation necessitates a floristic inventory to save and preserve its abundance and diversity (Foster, 1992; Birks et al.,1998). It is used to assess the diversity of taxa and the presence of invasive plant species. Given that cemeteries host foreign, native, and endangered floral species, it is vital to do such research to safeguard and preserve these plants (Hakkila, 2020; Altay et al., 2020). Floral inventories in urban cemeteries are limited, and, as of this writing, no floristic inventory has ever been done in the Philippines. Identification of floral distribution and diversity in the Philippines is a crucial aspect of urban biodiversity and urban people' quality of life. It plays a significant function in urban ecosystems and is a crucial component of nature in urban regions that are expanding. Construction and maintenance of UGs as well as an increase in recreational activities might lead to the destruction of native vegetation. Generally, native vegetation is restricted to highly cultivated areas and is under pressure to be converted for urban and recreational uses. To ensure the preservation of natural vegetation in urban environments, the decision-making and design processes must be enhanced (Muzafar et al., 2018; Nowinska et al., 2020). Specified conservation measures may be required for urban habitats with abundant native vegetation and wildlife.

Metro Cebu is a metropolis with a long and rich history that has been home to several civilizations and cultures from the past to the present. It is one of the few cities in the Philippines where it is possible to witness numerous cultural structures in proximity. In this city, several religious communities maintained their own cultural development. Cemeteries are one of the legacies of these diverse cultures. Species in cemeteries, like diverse religious societies, have preserved their own evolution. In this way, urban cemeteries should serve as a link between the past and the future. From this perspective, studies of biodiversity in urban cemeteries in various cities indicate that human activities play a significant role in determining floral diversity. These obstacles prompted us to conduct a comprehensive assessment of one of Metro Cebu's largest cemeteries. Surprisingly, to the best of our knowledge, there have been no reports of the distribution and influence of urbanization on floral species in urban cemeteries in Metro Cebu. Patterns of floral diversity are frequently reflected in distantly related taxonomic groups, such as birds and insects that serve as "indicator species." According to studies conducted in other Chinese cities, for instance, the species diversity of floral species and human activities are considerably positively associated. The discovery that the highest rates of extinction of floral species in India's lengthy history occurred during a period of heavy urbanization in the 1900s could serve as a cautionary tale from another ancient capital, India.

This prompted us to begin detailed research of native and exotic flora at Cebu Memorial Park, Metro Cebu, Philippines. We conducted the first floral survey of Cebu Memorial Park, the largest urban cemetery in Metro Cebu, with the following objectives: (a) determine the total number of NPs and APs in the surveyed Metro Cebu urban cemetery; (b) calculate species abundance (n), species richness (N), species evenness (PE), and species diversity (H' and D) of NPs and APs in Metro Cebu urban cemetery; (c) study the distribution pattern of floral species that were mapped within the urban cemetery during 2018-2019.

METHODS

Study site

Cebu Memorial Park is one of the largest urban cemeteries located between Mandaue City and Cebu City on Cebu Island, Philippines (10.3389° N latitudes and 123.9165° E longitudes) (Cebu Daily News, 2014). Its overall land area is 16 hectares. It is located at an altitude of 1000 meters above sea level and has spread throughout the entire cemetery during the previous decade. Cebu Memorial Park was founded on August 26, 1966 **and** is known as "The Pioneer Memorial Park of the South" and

"The Garden of Peace and Remembrance" (Cebu Daily News, 2014). Cebu Memorial Park is the final resting place for several renowned Cebu citizens who have passed away. This includes, to name a few, the former president of the Cebu Doctors' Hospital, Dr. Potenciano Larrazabal Jr., the former senator Ernesto "Boy" Herrera, the former "Champion of the Masses," Cebu Governor Vicente Ramon Jose Maria "Tingting" de la Serna, and "The Father of Cebu City," Don Vicente Rama.

The city has experienced a significant growth in urban sprawl during the past decade. According to recent news articles published by Cebu Daily News (2014), the city's UGSs has increased from 950 km^2 in 2002 to 1062.88 km^2 at present and has a current population of 798,634. The cemetery is visited by the relatives of the deceased, who often bring flowers, candles, and even food influenced by their culture and beliefs (i.e., sweeping the grounds and paths, cutting of grasses, and even burning of the leaf clippings that have been swept). Visitors swarm to the cemetery on All Souls' Day and All Saints' Day. As part of Filipino custom, these are significant dates on which we can visit our deceased loved ones and pray for their souls. As preparation for the annual visit, horticultural techniques such as cleaning and sweeping the grounds and burning the swept leaves and grasses are prevalent before to these dates. Metropolitan Cebu has a mild continental climate (Garces, 2019a; Garces 2019b). From June to August, the climate in the city is warm and dry, while from December to February, it is rainy. The average temperature in July is 25 ˚C (between 15˚C and 29˚C), whereas the average temperature in January is 13˚C (between 8˚C and 19˚C) (Philippine Atmospheric Geophysical Astronomical Services Administration [PAGASA], 2011).

Prior Informed Consent (PIC) and Research Design

As the researchers walked around the cemetery, the total number of NPs and APs was determined and recorded using the Ground Surveying technique (Muzafar et al., 2018). During the 30-day course of the fieldwork, the cemetery was separated into divisions, each of which comprised a distinct region that was surveyed (Kowarik et al., 2016). The researchers walked along the cemetery, including around graves with unrestricted access (e.g., mausoleums or graves without fences or gates that permitted the entry of unrelated individuals to the buried), paths, walls, and remnants with natural vegetation, and recorded every plant they encountered. During the whole course of data collection, anthropogenic activities within the cemetery were monitored and recorded. The Metro Cebu Department of Cemeteries provided an inventory of site-specific data. The necessary permit for the study was received from the authorities in charge of the entire cemetery.

Floristic Survey, Collection Methods and Inventory of Native and Alien Plants

Using reconnaissance floristic surveys, a detailed inventory of NPs and APs was compiled for the cemetery. This was accomplished by traversing the urban cemetery on foot and identifying all plant species along the chosen spots. To record the vegetation turnover and guarantee that no species were improperly documented, dry and wet season field surveys and image collecting were done. All NPs and APs were recognized to the species level using trustworthy sources such as plantlist.org, Philippine Native Plant Group, and Co's Digital Flora of the Philippines. Angiosperm Phylogeny Group was used to assign taxa to their respective families (The Angiosperm Phylogeny Group, 2019; Winston, 1999). Additionally, plants with numerous cultivars were identified; when identification was impossible, cv. was composed after a particular epithet (Winston 1999; The Angiosperm Phylogeny Group IV, 2016). The methodology for photographing the plant followed Matt Walter's "Plant Photographs and Captions for Identification."

Using regional floras, field manuals, monographs, and e-floras, such as e-floras viz., all plant species, both cultivated and wild, were taxonomically defined up to the series level. Co's Digital Flora of the Philippines, eFloras, and professional taxonomic investigation. All of these provided as a detailed reference on how plants should be photographed and contain essential notes on what should be included while shooting the plant. The Angiosperm Phylogeny Group-IV Classification of 2016 was used to assign acceptable names to recognized plants based on the classification of taxonomic families (Winston 1999; The Angiosperm Phylogeny Group IV, 2016). Herbs, shrubs, trees, and climbers, to name a few, were used to further classify the plants. Species that are still cultivated in the cemetery, but also grow in the wild on occasion, were placed in a different category,

namely, cultivated-and-wild species. wild/cultivated. Approximately 7 a.m. to 4 p.m. was the timeframe for the survey and data collecting. In accordance with the cemetery's policies, photographs of the NPs and APs discovered were taken due to a lack of voucher specimen. The researchers utilized a Canon 1300D DSLR camera to photograph the plants encountered, as voucher specimens were unavailable due to cemetery restrictions, and to document the entire fieldwork procedure. During the fieldwork, notebooks and pencils were utilized to take notes and document vital data. Obsmapps was installed on smartphones owned by the researchers, and Google MyMaps was used to input GPS coordinates. The final map was created with the use of the computer program Photoshop CS6 Portable.

Nativity

The plant species recorded at the sampling sites were classified as either native or exotic. The natural range of the species was determined by sifting through all conceivable and accessible sources, such as floras, manuals, and specialist internet webpages (GRIN: Germplasm Resource Information Network) and related research publications (Hobbs & Huenneke, 1992). Based on standardized language, foreign species were classed as cultivated, casual, naturalized, and invasive (Hobbs & Huenneke, 1992). The species' geographic ranges were determined using a distribution method created by (Barrett & Barrett, 2001). Lastly, an inventory database of plant species, including their life forms, wild/cultivated, native/exotic, and invasion status, was created.

Plant Mapping

Obsmapps, a smartphone application, was used to map the plants. Using a handheld GPS, the geo-coordinates of all sampled regions in the urban cemetery were recorded. The GPS coordinates of all indigenous and invasive plant species discovered were gathered and recorded. These locations were entered manually into Google MyMaps. This Google Inc. program allows users to customize their own maps. After manually entering GPS coordinates into Google MyMaps, a computer program was used to build a map. Adobe Photoshop CS6 Portable was utilized to produce the final map result. The information entered Google MyMaps serves as the foundation for the software. A GIS expert was consulted to confirm the accuracy of the created map. Small herbaceous plants were gathered in their whole, while flowering branches and twigs were gathered from shrubs, climbers, and trees.

Plant's Ecosystem Services

To discover the PES offered by plants, a comprehensive examination of literatures describing the ES provided by a particular plant species was read, analyzed, and synthesized. This allowed the researchers to determine the ES of a cemetery-identified plant species. Only pertinent and necessary information was utilized in the identification of plant ES.

Diversity indices and statistical analysis

Using Microsoft Excel 2016, statistical analyses of species abundance, species richness, species evenness, and species diversity were calculated. The following formulas were used to calculate the species abundance, richness, evenness, and diversity of the NPs and APs discovered:

For Species Abundance, it is shown in Eq. 1 and 2.

$$\bar{x} = \frac{\text{total no.of alien plant species (APs) found}}{\text{sum of total species found}} \text{ X } 100 \quad (1)$$

$$\bar{x} = \frac{\text{total no.of native plant species (NPs) found}}{\text{sum of total species found}} \text{ X } 100 \quad (2)$$

For Species Richness, it is shown in Eq. 3 and 4.

Species richness $_{NP}$= number of NP found in the cemetery (3)

Species richness $_{AP}$= number of AP found in the cemetery (4)

For Species Evenness, it is shown in Eq. 5.

Pielou's Evenness Index:

$$PE' = \frac{H}{\ln (S)}$$

where H is the Shannon-Wiener Index.
ln= natural
logarithm and S= total number of species (5)

The Shannon-Wiener index is a measure of diversity that takes the species richness and the proportion of species in an area. This index considers the proportional share among the species as much as their numbers. The index will be high when there is a richness of species and an equal share of the number of species. In this study, Shannon Wiener index was calculated, which is shown in Eq 6:

$$H' = -\sum_{i=1}^{S} \frac{ni}{N} \ln \frac{ni}{N}$$

Where ni= number of individuals,
N=total number of species

(6)

Lastly, Simpson's Diversity index (D) was calculated and is shown in Eq. 7.

$$D = \sum_{i=1}^{S} \frac{ni(ni-1)}{N\,(N-1)}$$

where ni= number of individuals,
N=total number of species

(7)

RESULTS AND DISCUSSION

Native and alien plant diversity in Cebu Memorial Park, Metro Cebu, Philippines

A total of 1,515 NPs and APs from 30 households were documented in Cebu Memorial Park, Metro Cebu, Philippines. Intriguingly, 30 of the 30 wild-growing species were APs; of the 31 cultivated species, 8 were NPs and 23 were APs; and all 53 wild/cultivated species were APs. *Heliconia psittacorum* x *spathocircinata*, which belongs to the family Heliconiaceae, was the most abundant species in this record (n = 567). This was followed by *Lantana camara* (n=78) and *Ixora coccinea* (n=157). Asparagaceae and Malvaceae, each with seven species, were the dominating families. The Apocynaceae and Myrtaceae families each had four species. *Heliconia psittacorum* x *spathocircinata* (n=567; 37.43%) is the species with the greatest number of occurrences. Likewise, Muzafar et al. (2018) and Quinton & Duinker identified this species as belonging to the most prevalent family (2019). *Ixora coccinea* (10.36%), *Lantana camara* (5.15%), and *Callisia fragrans* (3.7%) follow this species in abundance. These are pantropical rainforest-dwelling species (Garces & Genterolizo 2018; Garces, 2019a; Garces, 2019b). Meliaceae, represented by *Adonidia merillii* (3.50%), is the sole native species with the highest abundance among all plant species at the site. In addition, it is noteworthy to note that several species belong to plant families that are predominantly found in temperate climates, such as Meliaceae, Acanthaceae, and Annonaceae. In addition, the species least represented are *Dracaena reflexa* (2.77%) and *Moringa oleifera* (2.64%).

Majority of Cebu Memorial Park's plant species were herbs (24 spp.), followed by shrubs (30 spp.), herbs (3 spp.), grasses (2 spp.), and vines and bulbs (1 sp., respectively) (Figure 1). Most herbs (n=30) were wild-growing APs, whereas most of the trees and shrubs were farmed APs. It is also reported that this cemetery was dominated by APs (53 species; 86.89%), while only 8 species (13.11%) were native. Intriguingly, the proportion of APs differed significantly between families (Figure 1). There are more than six cities and towns in Cebu that are considered megacities since their populations exceed 922,611. These estimates are inflated for APs and NPs inhabiting Metro Cebu, a city with a human population of over 500,000. Such information regarding NPs and APs is beneficial for urban management.

The predominant forms of life within the cemetery are trees and bushes. The biggest number of individuals belong to the tree species *Polyalthia longifolia*, *Adonidia merrillii*, *Moringa oleifera*, and *Artocarpus heterophylla*. In terms of plant life types, *Lantana camara* has the greatest number of individuals (Figure 2). These plant species are significant alien species due to their extreme abundance and dominance over native species. These AP species are thought to thrive best in tropical regions, particularly *H. psittacorum* x *spathocircinata* (Figure 2). In addition, these plants' style of reproduction enables them to proliferate at a faster rate. Their status as APs may also contribute to their abundance. Even in the most unexpected environments, including as urban settings with impervious surfaces, APs are known to thrive. In addition, human activities such as horticulture and landscaping practices play a role in determining their abundance.

The Shannon-Wiener Index (H') is a commonly used diversity index that measures the degree of uncertainty in a sample. If the uncertainty is **high**, then the diversity is also high (Garces 2019); H' includes both species richness and species evenness (Seto et al., 2012). Simpson's Index (D), on the other hand, measures dominance; it estimates species diversity and offers the likelihood that any two randomly selected members of a community belong to distinct species. The values closest to 0 are infinitely diverse, but the values closest to 1 are less diverse. The numbers between 0 and 1 in Pielou's Evenness (PE) indicate how evenly and evenly dispersed a given environment's species are (Studeny 2010). **This demonstrates** that

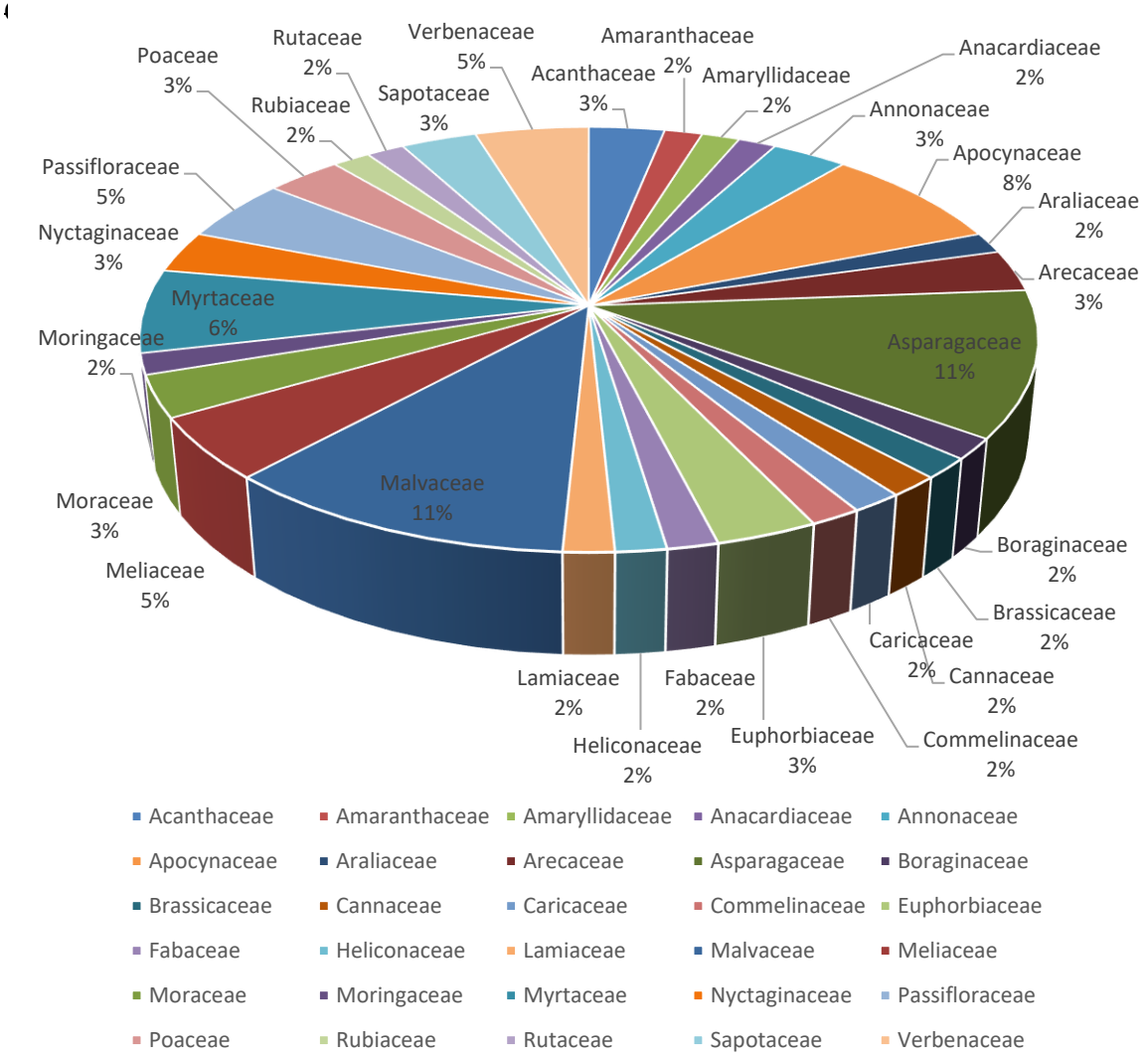

Figure 1. Plant families and their corresponding number of species

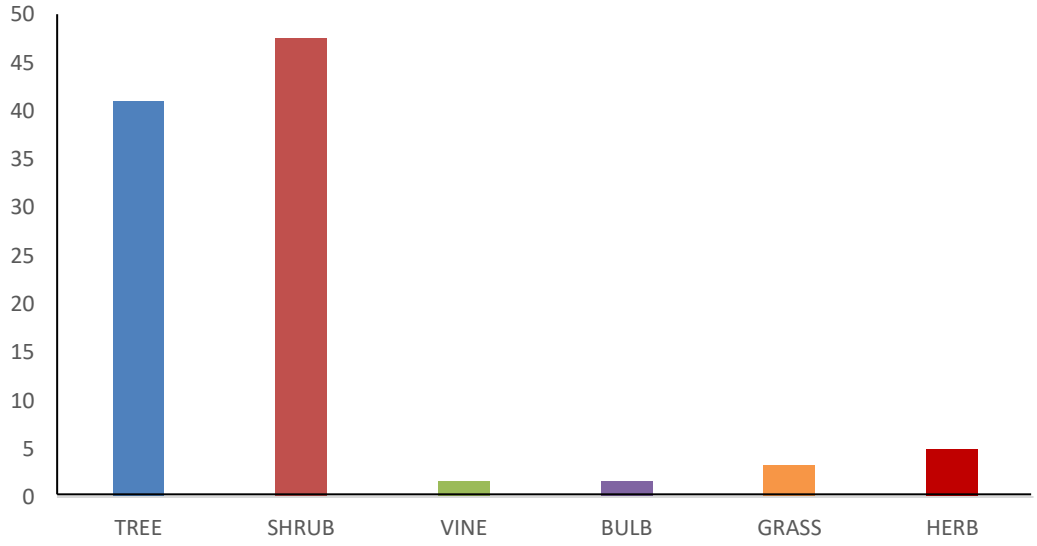

Figure 2. Percentage of Plant Life Type

D=0.16). In Cebu Memorial **Park's plants** are dispersed uniformly, as indicated by the species evenness (PE= 0.65).

Through plant mapping, the locations of the NPs and APs in Cebu Memorial Park were visually displayed. The recorded species diversity of Cebu Memorial Park included 7 NPs and 53 APs (Figure 3). This map is an example of a species richness map that can locate the NP and AP concentrations or areas of high biodiversity within the cemetery (Studeny, 2010). The map created for this study provides as a visual guide to the whereabouts of numerous plant species. This would aid in deciding which portions of a given study site require conservation and preservation, and which areas require improvement to promote the growth and proliferation of additional plants.

Various Growth Forms and Cultivation Categories of APs and NPs

It is evident from the dispersion of flora into distinct phytoclimatic features that all plants are classified under all biological forms. Using Raunkiaer classification, it was determined that Geophytes (23 species, 37.70%) and Phanerophytes (10 species, 16.39%) dominated the flora (Figure 4). This showed that the area under study was subject to intense biotic pressure. Raunkiaer (1934) distinguished three major phytoclimates based on life form on the earth. It consists of phanerophytic climate in the tropics, therophytic climate in deserts, and hemicryptophytic climate in most of the cold temperate zone. However, our study demonstrates that geophytic flora dominates the total spectrum. Comparing geographically and habitually dissimilar plant communities relies heavily on biological spectra, which are also regarded as an indicator of the prevailing environmental situation. Biological spectra change because of biotic impacts such as agricultural activities, grazing, deforestation, trampling, climate change, and extensive urbanization.

The present study further revealed that many of these plants are under tremendous pressure from various anthropogenic activities and lack of sustainable urban planning. Therefore, proper**,** and organized documentation of plants present in urban cemetery, identification of potential species for prioritization of conservation through

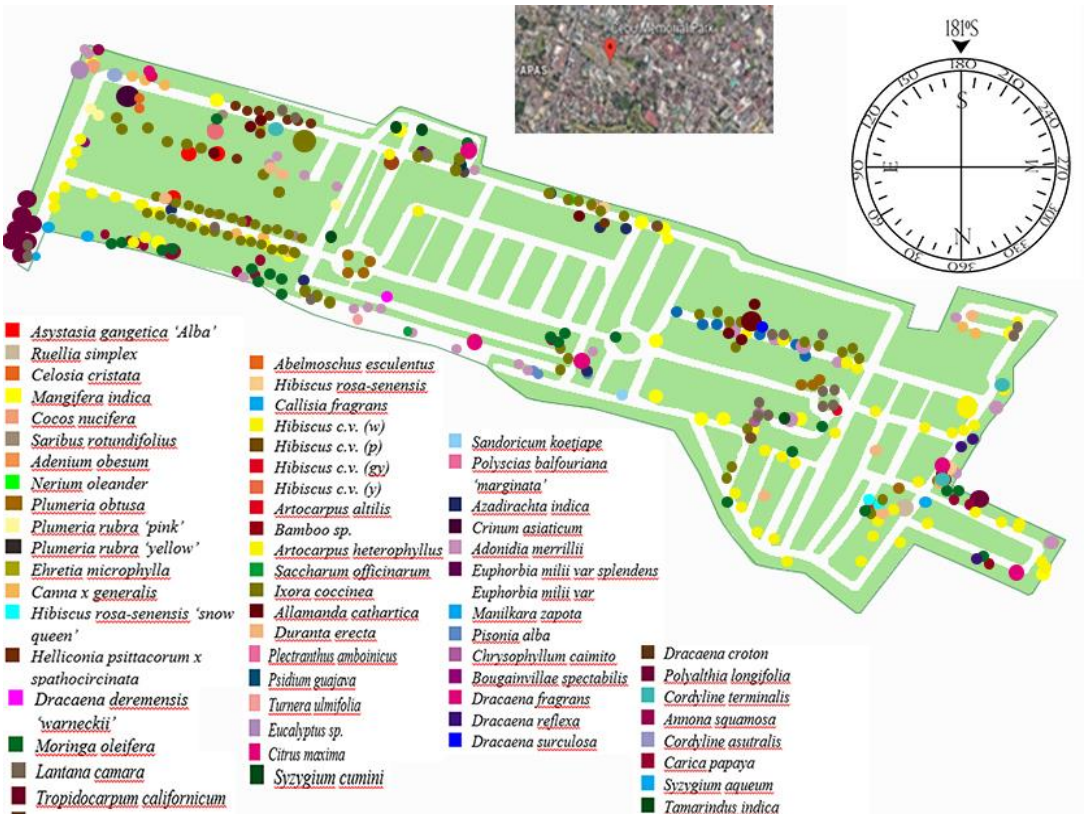

Figure 3. Distribution of APs and NPs in Cebu Memorial Park, Cebu Island, Philippines

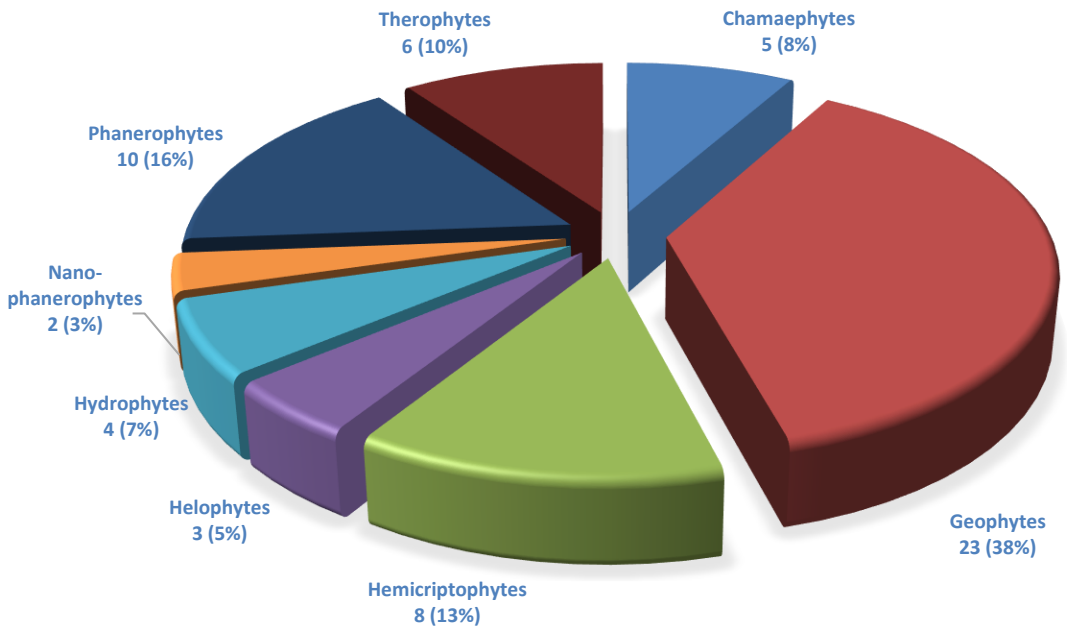

Figure 4. Phytoclimatic characteristics based on the biological forms of APs and NPs in Cebu Memorial Park, Metro Cebu, Philippines

sustainable management so that the resources and knowledge can be preserved, managed and utilized. In other words, conservation and management of APs and NPs in urban cemetery will help enhance and maintain regional biodiversity with minimal adverse impact on the biodiversity of urban communities. The biological form reflects physiognomy of flora and vegetation, which is the result of all life processes in combination with environment. It helps in the recognition of ecological elucidation of vegetation. Life form of Raunkiaer (1934) classification is more reliable, which is based upon the principal of position and degree of protection to perennating bud during the unfavorable or adverse condition.

Numerous plant species were declining in the study site. Most APs and NPs were uprooted for aesthetic and decorative grounds. Due to the area's significant urbanization, most plant species have been eradicated. Even fruiting orchards and trees were removed from the surrounding environment and used for private building developments and in other cases as decorations. Understanding the causes, methods, and effects of flora changes in urban cemeteries has numerous ecological and economic ramifications. This type of study was also conducted by (Zhou et al., 2014; Quinton and Duinker, 2019). While the potential for studying biological characteristics of APs and NPs remains to be determined, this landscape ecological approach has been quite successful in several biological studies, including several urban ecological examples (Grime 2006; Seto et al., 2012). The urban cover has produced lasting alterations to the site's biodiversity. This study was simply a preliminary effort to comprehend the flora, structure, and function of the local landscape. Understanding the mechanisms involved in the evolution of urban landscape patterns requires a more complete framework that explicitly combines topographical, ecological, socioeconomic, and political factors. Protecting plant resources would be the moral and ethical obligation of the local population and government organization.

Ecosystem Services of APs and NPs in Cebu Memorial Park, Metro Cebu, Philippines

Our study area is highly significant as one of the largest cemeteries in Cebu, but it also stands, more generally, for old (100 years) urban cemeteries that were established on cleared land and that represent a particular type of secondary

site, shaped by the interaction of cultural and natural processes. Cultural contributions comprise initial plantings and varying intensities of management throughout time and space; natural contributions reflect the evolution of an ecosystem in its natural state. This type of environment occurs in numerous geographical and religious contexts and is, thus, widely useful for urban conservation strategies. In this study, most of the ES provided by cemetery plants fell within the provisioning category. These plants are either edible or medicinal. On the contrary, most ornamental plants provide regulating services, whereas trees and shrubs provide supporting services. In contrast, plants with distinctive blossoms frequently provide cultural functions. Within cities, the habitat functions of plant-dominated green spaces have been demonstrated mostly for forest remnants or big urban parks, although woody urban cemeteries are significantly understudied (Seto et al., 2012; Muzafar, 2018). Rarely do research examine the flora of urban green zones (Wu, 2014; Henri et al., 2017). Our methodology is likely the first to demonstrate (1) an overall positive habitat function of large urban cemeteries for different plant taxa, its life group, and ecosystem services, including some rare and threatened species, and (2) ecosystem services as a significant factor in AP and NP dominance in urban cemeteries. Ecosystem services (ES) serve as the link between ecosystems - their biodiversity and functionality - and human society (Kowarik et al., 2016). Most ecosystems offer a variety of services, including providing, regulating, sustaining, and cultural functions. Global, continental, and regional spatial studies of numerous ES are essential for policy, management, and land planning. New studies assessing the simultaneous identification and provision of various ecosystem services at landscape size should contribute to the comprehension of multiple ecosystem services delivery and trade-offs in support of policy, management, and land planning.

Our work demonstrates the significance of historic urban cemeteries as habitats for NPs and APs, including endangered species. Because many historical cemeteries are also significant heritage sites, there are frequently tensions between biodiversity conservation stakeholders and monument preservation stakeholders. In old graves, cultural and biological values can coexist, as revealed by our research. This demonstrated prospects for coordinating conservation efforts in cemeteries across disciplines (Grime, 2006). From a conservation standpoint, the optimal strategy is to enhance or conserve habitat heterogeneity and a focus on ecosystem services provided by APs and NPs by allowing natural development in some sections of the cemetery while keeping other sections more open with varying degrees of canopy closure. Yet, the growth of natural ecosystems in urban environments is sometimes at odds with tidiness ideals when coupled with notions of neglect (Hidayat et a., 2017). Recent studies indicate, however, that the acceptance of wild elements in UGS by residents is frequently greater than anticipated (Altay et al., 2020), especially when minimal cultural inputs signal natural succession as a desired process (Trombulak & Frissell, 2000). It is anticipated that maintaining route edges in the cemetery's more forested areas will increase visitors' acceptance of associated natural processes.

In scaling up to urban green infrastructure, cemeteries distinguish themselves from other UGS in terms of social and structural characteristics as well as elevated environmental services. Typical urban parks and cemeteries share major structures, but cemeteries are subject to significantly less pressure from visitors and, occasionally, management (Allam, 2020). These factors have been shown to favorably affect species diversity (Hahs et al., 2009). In addition, the extremely diversified sepulchral design contributes to habitat heterogeneity, which is a crucial aspect in elucidating diversification patterns in urban green spaces (Gomez-Baggethun et al., 2013). While many urban parks are increasingly subject to recreational pressure and commercialization (MEA, 2005), abandonment of cemeteries or portions of them permits the emergence of novel urban wilderness near urban population centers – as demonstrated by our case study and some Victorian cemeteries in London (Trombulak & Frissell, 2000). Among these is Abney Park, which has been described as a "gothic wilderness" and a "tranquil and enigmatic oasis" and is the first Local Nature Reserve in the London Borough of Hackney (Whittinghill & Rowe, 2011). In contrast, wild forest remnants are typically found near the urban perimeter. Like other urban green spaces, cemeteries support managing ecological services (such as cooling impacts) based on their size, tree and grassland cover (Bhaskar, 2012; Altay, 2020). However, graves also benefit individuals by providing cultural ecosystem services as

spiritual sites. Particularly abandoned cemeteries offer a combination of wildness and cultural heritage relics. There are also potential connections between biodiversity conservation and cultural ecosystem services. Recent research indicates that species diversity is frequently, though not always, associated with a favorable evaluation of metropolitan surroundings (Hashim et al., 2018).

Based on the findings of the present study, it is evident that species belonging to a small number of families predominate in Cebu Memorial Park, as opposed to a proportional representation by numerous families. According to this study, Heliconaceae and Rubiaceae were the two most prevalent families in the cemetery, which is consistent with the findings of previous studies conducted in other parts of the world. In addition, approximately 87.5% of all species observed growing in the cemetery were APs. Both families within the Heliconiaceae, Rubiaceae and Verbanaceae, were not only dominant in terms of overall number of species, but also in terms of APs. A greater number of APs were naturalized. Similar studies in cemeteries around the world indicate that cemeteries are breeding grounds for invasive species and promote their spread to other regions (Trombulak & Frissell, 2000; McDougall et al., 2011). Since cemeteries are characterized by frequent anthropogenic disturbance regimes such as fragmentation (Zhou et al., 2014), run-off water, high temperature due to the heat island effect, and pollution due to vehicular traffic, they not only serve as corridors for the dispersal of APs, but also as favorable niches for their establishment and naturalization (Trombulak & Frissell, 2000). It has been discovered that species tolerant of anthropogenic disturbance regimes, including visits, especially those belonging to the Heliconiaceae or Verbanaceae, are often potential and actual dominant invaders of highly disturbed sites such as cemeteries; consequently, highly urbanized, and disturbed areas such as cemeteries tend to have a very high proportion of APs belonging to these families. Consequently, the taxonomic clustering of invaders of specific families, as observed in the present study, since they tend to share characteristics that facilitate their successful movement and establishment in new settings (Hobbs & Huenneke, 1992). The naturalization of APs is regarded a severe problem in the majority of the world's regions, but its ecological and economic effects are even more devastating in the environmentally sensitive alpine regions (Grime, 2006; McgDougall et al., 2011). Metro Cebu has experienced a plethora of economic activity in recent decades, which has expedited the urbanization process in this urban biodiversity hotspot. The introduction, spread, and establishment of alien species in Metro Cebu have been facilitated by the unprecedented and unplanned infrastructural development and changes in land use pattern, particularly those linked with the construction of roads. Since a greater proportion of plant species flourishing in urban cemeteries during the present study were APs, there is a strong likelihood that they may become invasive in the future, leapfrog into adjacent natural landscapes, and cause problems in this eco-fragile cemetery in Metro Cebu. Therefore, it is urgent that appropriate scientific procedures be implemented to monitor the introduction and spread of these species in this urban cemetery.

In the present study, most species growing within the cemetery were shrubs, whereas **most of these** trees consisted primarily of naturally occurring species. Significant numbers of these trees were not native to North America. The dominance of tree growth pattern in disturbed ecosystems such as urban cemeteries has also been found by other researchers (Wu, 2014). A probable explanation is that the region's continental tropical environment encourages the dominance of tree species over other types of plant life. Since urban areas, particularly cemeteries, are subjected to a high level of disturbance, only rapidly colonizing alien tree species with the potential to exploit resources quickly and easily get successfully established, either intentionally or unintentionally, on these sites (Seto et al., 2012).

Most of the wild species (30 spp. out of 61 spp.), i.e., those planted by urban designers of the city for beautification purposes, were foreign, according to this study. Thus, it is evident that city planners favor the growing of exotic species beside roadways, whereas native species are underrepresented. Moreover, most cemeteries feature roadside corridors, which are the most pervasive of all urban areas, and the vegetation along highways has a significant impact on the public's sense of biodiversity and knowledge of ecosystem goods and services given by green spaces (Bhaskar, 2012). As a result, living in an urban environment where foreign species dominate the flora would make people more familiar with alien floral than with native floral,

which causes obstacles for growing public awareness about the conservation of unique and native flora (Altay et al., 2020). And as Metro Cebu is part of the Philippine biodiversity hotspot, city planners should make greater efforts to integrate more native species for landscaping in urban areas, particularly urban cemeteries, to preserve and protect the rich repository of its natural biodiversity (Troumbak & Frissell, 2000; McDougall et al., 2011; Quinton & Duinker, 2019).

In the lack of historical records of plant diversity in Cebu Memorial Park, our results provide excellent baseline information for future surveys in the other urban cemeteries in Metro Cebu. Data on the distribution and species richness of plants in urban landscapes are very helpful for the creation of plant conservation plans, particularly in National Parks, but are currently unavailable for Cebu. Management strategies and procedures for preserving NPs in urban cemeteries in megacities such as Cebu Island, Philippines, that get a significant number of visitors on a regular basis and are dominated by structures with historical significance are particularly valuable. The ability of urban cemeteries to support plant populations in Asia's expanding megacities could be enhanced by using habitat-specific management measures, such as establishing unmanaged areas in urban cemeteries and connecting disconnected urban cemeteries through greenways.

CONCLUSION

This study provided the first comprehensive inventory of NPs and APs at Cebu Memorial Park, Metro Cebu, Philippines, including an analysis of their ecosystem services and anthropogenic activities that affect the existence and abundance of NPs and APs. Among all NPs and APs at the site, *Adonidia merrillii* was the dominating native plant with the most significant threatened status. This study **illustrates** on the feasibility of plant growth in **UGSs** dominated by impermeable surfaces. It also supports the notion that APs thrive more than NPs in urban environments. In addition, the public must be aware of the ecosystem services given by plants that flourish not only throughout urban cemeteries, but in the broader **UGSs**. The maintenance of vegetation in this cemetery can contribute to the conservation of the natural and cultural heritage of Metro Cebu. To preserve the health and diversity of NPs and APs for future generations, policies for the management and preservation of Cebu Memorial Park should be devised based on the results of this inventory. A unified system of **management** that recognizes and respects variances in religious beliefs, cultures, and site characteristics would assist the maintenance of cemeteries. Although this study tackles the composition and diversity of NPs and APs, it has certain limitations. Additional research and studies on plant metrics and health conditions may lead to a better understanding of landscape composition, the health of woody plants, and the management of APs and NPs. Further research must be conducted to discover acceptable arboricultural treatments and build sustainable management programs for Cebu Memorial Park to preserve its identity and heritage.

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