Floristic Inventory and Distribution of Trees Along Urban National Streets and Roads in Cebu City, Philippines

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In urban landscapes, understanding the diversity of roadside vegetation is essential for better planning and designing of sustainable cities. The city of Cebu, located in central Visayas Philippines, is considered an urban tree biodiversity hotspot due to threats from continuous infrastructure development, road widening, and anthropogenic activities. To provide an update on tree diversity, as well as to determine the ecological status of the remaining trees thriving in Cebu City's urban corridors, a floristic inventory and tree distribution survey (i.e. five national streets /roads) were conducted. Following a standard protocol for urban tree inventory, a tree distribution map was created using GIS, and information on urban corridors' name, BDH of each tree, wire conflict, and tree condition were provided. Data showed 2,203 trees (45 genera and 27 families) were listed from these roadsides, with the proportion of alien trees higher (84.75%) than native trees (15.25%). Among these trees, 12.94% were in excellent tree condition, with narra (*Pterocarpus indicus*) and Manila palm (*Adonidia merrillii*) as the most abundant native tree, and mahogany (*S. macrophylla*) as the most exotic species. The distribution of trees by DBH classes along the five national roads showed that most trees belonged to the range of ≥ 70 cm, suggesting that mature trees dominated five urban corridors. In terms of tree protection and management, most trees in Cebu City were recommended for silvicultural treatment to salvage mother trees from further damage. Baseline data gathered in this study may serve as guide for urban planners for a responsible and sustainable urban tree conservation and management.

Keywords: floristic inventory; urban trees; alien trees; native trees; Cebu City

INTRODUCTION

Cultivation and conservation of urban trees is a global initiative (Pearlmutter et al., 2017). All over the world, major cities acknowledge that they are at the forefront of battle against climate change – as the most vulnerable area to feel its impact, but with the highest potential to mitigate its effect. Recent call from the United Nations' Sustainable Development Goals [UN-SDG] Partnership Platform invites all mayors of major urban metropolis to undertake a "Trees in Cities Challenge," whereby pledges on planting specific number of trees are recorded under a defined monitoring scheme (UN-SDG, 2019). This program has been instrumental in helping cities to attain most of the sustainable development goals established by the United Nations (Turner-Skoff & Cavender, 2019), particularly SDG 11 focusing on sustainable cities and communities (UN, 2015). In the Philippines, similar initiatives have already been implemented across regional scales since the start of the National Greening Program in 2011. These initiatives encouraged communities to establish and manage arboretum of trees, including those in highly-urbanized areas (DENR-FMB, 2015).

Urban trees comprise the most essential component of urban greenspaces (Wolf et al., 2020) where they are commonly distributed across public domains (e.g. national highways, parks, recreation areas and riverbanks) (Konijnendijk et al., 2006) and private properties (e.g., schools, residential areas, gardens and industrial zones) (Tyrväinen et al., 2005). Aside from shrubs and underground vegetation, trees in cities provide an array of benefits and various forms of ecosystem services to make cities livable to humans and other life forms. While various species of trees ensure that watersheds can provide a steady supply of fresh water for domestic and industrial use, prevent flooding, and cool the air, they also provide socio-economic, psychological, visual, and sensory benefits as well as symbolic functions valued by humans (Dwyer et al.,1992; Good, 2010). Most importantly, they provide habitat for urban wildlife, thus ensuring a relatively diverse ecosystem (Roy et al., 2012). However, various anthropogenic activities in major cities have been noted to cause decrease of tree covers (Ejares et al., 2016), and as tree cover deteriorates in cities, so will the availability and access to associated ecosystem services, thereby affecting environmental quality and human health. Thus, it is imperative that current tree diversity status in major Philippine cities be assessed to address this urgent concern.

Cebu City is one of the six congested and polluted cities in the Philippines. In 2010, 93.5% of Cebu City's total population lived in urban barangays, and these were localities where infrastructure development have increased rapidly in the last few years. Despite massive industrial developments, patches of tree vegetation still thrive in Cebu City where they are scattered among parks and recreation areas, building structures, street lanes and residential spaces (Flores et al., 2020). Cebu City is also home to an immense number of endemic trees that are considered indispensable for maintaining urban biodiversity (Cebu Biodiversity Conservation Programme [CBCP], 2017). As of 2014, trees in Cebu City were reported to cover an area of 15,674,341.8 m2, or 25.11% of the city's urban barangays, citing Brgy. Talamban (37.95%), Lahug (31.29%) and Guadalupe (25.70%) to have the three highest percentage of tree cover among the lowland barangays (Ejares et al., 2016). However, current knowledge on the diversity of trees in the city is scant, and previous studies on Cebu city trees focused only on carbon sequestration (Pansit, 2019; Parilla et al., 2018) and tree canopy mapping using LiDAR (Ejares et al., 2016).

There is a need to assess whatever remaining old-age trees flourishing in Cebu City because the greatest challenge now is to focus on managing urban ecosystems, which may include direct and indirect ecosystem services that urban dwellers can avail freely. Trees located along the urban corridors such as street roads and highways are an important component of urban greening because the combined area is much larger than the green spaces and formal parks alone (Shackleton, 2016). It has also been noted that trees in urban areas are rarely monitored, are disappearing at alarming rates, and are not documented sufficiently (Babalola et al., 2013). Except for the inventory of trees to be cut down for Bus Rapid Transit (BRT) and other road widening projects, few tree inventories have been undertaken in Cebu City to date. This study reports the current list of remaining trees on the selected urban corridors (national streets/roads) in Cebu City. A distribution map of each tree located along the selected urban corridors was also produced to show how each tree in the selected urban corridors of Cebu City is distributed, highlighting its abundance, conservation status, and tree condition. Wire conflict, tree protection initiatives, and tree management were also discussed.

MATERIALS AND METHODS

Site Identification

The study was conducted in five selected urban corridors (national streets/roads) that were densely populated by trees based on the researchers' ranking of national streets/roads in Cebu City with their respective existing length: (1) N. Bacalso Avenue: 2.472 km - (10.288838 and 123.866707 E), (2) Cebu South Road (C. Padilla-Bulacao) : 2.550 km - (10.279706 N and 123.855548 E), (3) Osmeña Boulevard: 2.035 km - (10.304312 N and 123.895168 E), (4) Rama V. Street: 3.050 km - (10.312346 N and 123.886167 E), and (5) Salinas Drive: 0.896 km - (10.312346 N and 123.886167 E).

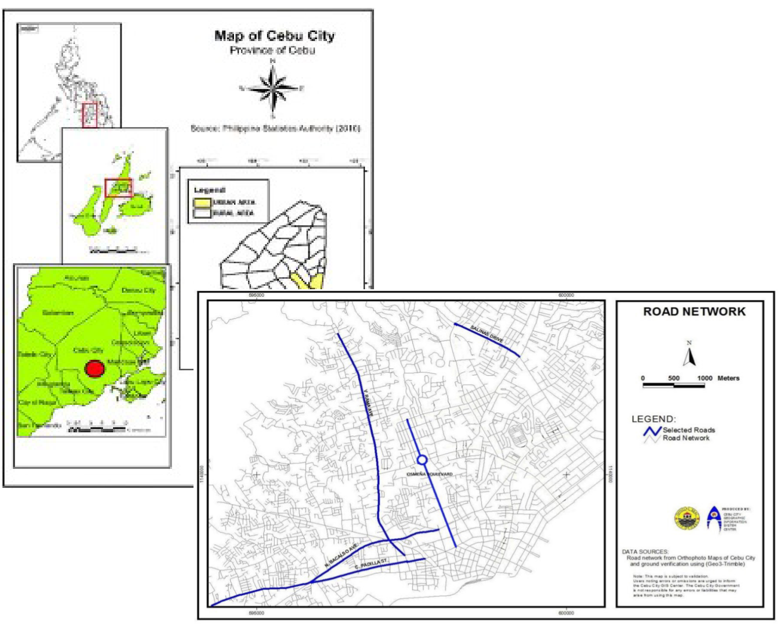

Figure 1. Map of Cebu City (first box figure) and map of the selected national streets/roads, namely: (1) N. Bacalso Avenue, (2) Cebu South Road (C. Padilla-Bulacao), (3) Osmeña Boulevard, (4) Rama V. Street and (5) Salinas Drive

Data Collection and Analysis

The method for roadside tree inventory and tree risk assessment was based on the study of Sreetheran et al. (2011). The inventory was conducted from October 2018 to April 2019, following a descriptive survey design. Roadside trees were selected through purposive sampling, making sure that both sapling and mature trees were included in the inventory. Mapping of tree distribution was produced by using the handheld GPS, where the coordinates were inputted to a GIS-based software (Manifold System).

Data were collected as follows. Once a tree is encountered along the selected urban corridor, the following information were noted: GPS coordinates, local name/common name, diameter at breast height, wire conflict (e.g., presence and absence of overhead utility wires), characteristic vegetation and tree condition. Characteristic vegetation may either belong to (a) residential gardens, (b) grassland, (c) scrubland, (d) plaza/park area, or (e) near buildings such as schools, business edifices, residential houses, and churches. Meanwhile, tree condition was derived from a general observation from ground level up, and was rated either as excellent, good, fair, poor or very poor, following the criteria of Sreetheran et al. (2011). 'Excellent' trees are characterized by sound and solid tree structure and composition, absence of pests, and full and balanced crown development. 'Good' and 'Fair' trees, however, can be distinguished, by their missing bark sections one major/several dead, broken, or missing minor limbs, in terms of tree structure; presence of one or more pests, in terms of tree condition; and full but unbalanced crown development. 'Poor' and 'Very Poor' trees can be recognized by either an extensive decay or hollowness in terms of tree condition; two or more dead, broken, or missing major limbs, in terms of tree structure; presence of two or more pests; and full but unbalanced crown development. The conservation status of each tree species was determined based on International Union for the Conservation of Nature (IUCN) guidelines ("The IUCN Red," 2021) .

Taxonomic identification of trees was done by utilizing primary reference materials for native trees, namely, Philippine Native Trees: Up Close and Personal Series 101, 202 and 303 published by Green Convergence for Safe Food Healthy Environment and Sustainable and Hortica Filipina Foundation, Inc. Philippines. Verification of exotic trees' ID was done using

Plants of the World Online (POWO), an online database maintained by the Royal Botanic Gardens, Kew, Richmond, UK as well as Co's Digital Flora of the Philippines. Photos of each tree encountered were also taken, including the most essential parts such as leaves, trunk, whole stature of trees, flowers and fruits, if present. Initial identification suggested by parataxonomists and gardeners were also noted, especially for those trees that were not recognize on the spot. Data were collated, cleaned, and analyzed using descriptive statistics, such as means and frequency function of MS Excel.

RESULTS AND DISCUSSION

Tree Composition

A total of 2,203 trees with 50 species under 45 genera from 27 families were encountered in the five selected national roads in Cebu City (see Table 1). Natalio Bacalso National Road had the highest number of trees (654 trees) followed by Cebu South Road (591 trees), Osmeña Boulevard (583 trees), Vicente Rama national road (315 trees) and Salinas Drive (131 trees) (see Figure 2). N. Bacalso had the most diverse tree composition with 35 genera (Fig.3), and this is reflected in the distribution pattern observed in the data of N. Bacalso Road (see Figure.4). Considering that Vicente Rama national road was the longest site in the study, the data may suggest that the length of a national road/street is not directly proportional to the diversity and number of trees planted.

Table 1
List of Urban Trees (Family, Species and Local Name), Abundance, Conservation Status and Origin in Five Selected National Roadside/s or Road/s in Cebu City, Philippines

Family	Species	Local Name	Abundance	IUCN Status*	Origin	Location/s
Anacardiaceae	*Mangifera indica* L.	Manga	5	DD	Native	Cebu South Road, N. Bacalso, Osmeña Blvd, and V. Rama
Annonaceae	*Annona squamosa* L.	Atis	11	LC	Alien	Cebu South Road, N. Bacalso, Osmeña Blvd, and V. Rama

	Annona muricata L.	Guyabano	11	LC	Alien	Cebu South Road, N. Bacalso, Osmeña Blvd, and V. Rama
	Polyalthia longifolia Benth. & Hook.	Indian mast pine tree	34	NE	Alien	All selected national roads
Apocynaceae	*Alstonia scholaris* L.	Dita	1	LC	Native	Osmeña Blvd.
	Cascabela thevetia L.	Yellow oleander	4	LC	Alien	Cebu South Road and N. Bacalso
	Plumeria rubra L.	Kalachuchi	7	NE	Alien	Cebu South Road, N. Bacalso, Osmeña Blvd. and V. Rama
Arecaceae	*Adonidia merrillii* Becc.	Manila plam	117	NT	Native	All selected national roads
	Wodyetia bifurcata A.K. Irvine	Foxtail palm	11	LC	Alien	Cebu South Road and N. Bacalso
	Arenga pinnata (Wurmb.) Merr.	Kaong	1	LC	Native	V. Rama
	Cocos nucifera L.	Coconut tree	2	NE	Alien	Osmeña Blvd.
	Corypha utan Lam.	Buri	1	LC	Native	N. Bacalso
	Roystonea regia (Kunth) O.F. Cook	Royal plam	13	NE	Alien	Salinas Drive
Asparagaceae	*Cordyline australis* (G. Forst.) Endl.	New zealand cabbage tree	2	NE	Alien	N. Bacalso
Bixaceae	*Bixa orellana* L.	Achuete	2	LC	Alien	V. Rama
Caricaceae	*Carica papaya* L.	Papaya	6	DD	Alien	Cebu South Road, N. Bacalso and Osmeña Blvd
Casuarinaceae	*Casuarina equisetifolia* L.	Agoho	3	LC	Native	Cebu South Road, N.Bacalso and Osmeña Blvd.
Combretaceae	*Terminalia catappa* L.	Talisay	7	LC	Native	N. Bacalso and Osmeña Blvd.
Cycadaceae	*Cycas rumphii* Miq.	Pitogo	1	NE	Native	N. Bacalso
Dipterocarpaceae	*Hopea plagata* (Blanco) S.Vidal	Yakal	1	CR	Native	N. Bacalso
Euphorbiaceae	*Macaranga grandifolia* (Blanco) Merr.	Binuñgang malapad	1	VU	Alien	Cebu South Road
	Melanolepis multiglandulosa (Reinw. Ex Blume) Rchb. & Zoll.	Alim	5	LC	Native	N. Bacalso, Salinas Drive and V. Rama

Fabaceae	*Acacia propinqua* A. Rich	Acacia	2	NE	Alien	Osmeña Blvd and Salinas Drive
	Caesalpinia decapetala (Roth) Alston	Mysore thorn	4	LC	Alien	Cebu South Road and N. Bacalso
	Leucaena leucocephala (Lam.) de Wit	Ipil-ipil	7	CD	Native	N. Bacalso, Cebu South Road, Salinas Drive and V. Rama
	Tamarindus indica L.	Sambag	7	LC	Alien	Cebu South Road, N. Bacalso, and Osmeña Blvd.
Lamiaceae	*Gmelina arborea Roxb. ex Sm.*	Gmelina	31	LC	Alien	All selected national roads
	Premna odorata Blanco	Abgaw	1	LC	Native	N. Bacalso
	Vitex parviflora A. Juss.	Tugas	5	LC	Native	N. Bacalso
Lauraceae	*Persea americana* Mill.	Avocado	1	LC	Alien	V. Rama
Leguminosae	*Pterocarpus indicus* Willd.	Narra	1704	EN	Native	All selected national roads
Malvaceae	*Ceiba pentandra* (L.) Gaertn.	Duldul	4	LC	Alien	Cebu South Road and N. Bacalso
Meliaceae	*Azadirachta indica* A. Juss.	Neem tree	5	LC	Alien	Cebu South Road and V. Rama
	Swietenia macrophylla King	Mahogany	90	VU	Alien	Cebu South Road, Osmeña Blvd, N. Bacalso and Salinas Drive
Moraceae	*Artocarpus heterophyllus* Lam.	Nangka	10	NE	Alien	Cebu South Road, Osmeña Blvd and N. Bacalso
	Ficus septica Burm.f.	Lagnob	45	LC	Native	V. Rama, Cebu South Road and Osmeña Blvd
	Ficus benjamina L.	Dakit	45	LC	Alien	V. Rama, Cebu South Road, N. Bacalso and Osmeña Blvd
	Ficus religiosa L.	Sacred fig tree	45	NE	Alien	V. Rama, Cebu South Road, N. Bacalso and Osmeña Blvd
	Morus rubra L.	Wild berry/ red berry	1	LC	Alien	N. Bacalso
Moringaceae	*Moringa oleifera* Lam.	Malunggay	4	NE	Alien	Cebu south Road and N. Bacalso

Muntingiaceae	*Muntingia calabura* L.	Mansanitas	4	NE	Alien	N. Bacalso, Cebu South Road and Osmeña Blvd.
Myrtaceae	*Psidium guajava* L.	Bayabas	4	LC	Alien	N. Bacalso and Cebu South Road
	Syzygium cumini (L.) Skeels	Lomboy	16	LC	Alien	Cebu South Road, N. Bacalso, Osmeña Blvd and V. Rama
	Syzygium aqueum (Burm.f.) Alston	Tambis	16	NE	Alien	Cebu South Road, N. Bacalso and V. Rama
Oxalidaceae	*Averrhoa bilimbi* L.	Iba	5	NE	Alien	Cebu South Road, N. Bacalso and V. Rama
Rhizophoraceae	*Carallia brachiata* (Lour.) Merr.	False kelat	2	NE	Alien	Cebu south Road and N. Bacalso
Rubiaceae	*Morinda citrifolia* L.	Noni tree	1	NE	Native	V. Rama
Sapotaceae	*Chrysophyllum cainito* L.	Kaimito	5	NE	Alien	Osmeña Blvd.
	Manilkara zapota (L.) P. Royen	Chicos	5	NE	Alien	V. Rama, Cebu South Road and N. Bacalso
Strelitziaceae	*Ravenala madagascariensis* Sonn.	Traveler's palm	1	NE	Alien	Osmeña Blvd

Legend: *NE- Not evaluated, DD-Data deficient, LC-Least concerned, NT- Near threatened, VU-Vulnerable, EN-Endangered, CR-Critically endangered, EW- Extinct in the wild, CD-conservation dependent ("The IUCN Red List," 2021). The conservation dependent category is part of the IUCN 1994 Categories & Criteria (version 2.3), which is no longer used in evaluation of taxa, but persists in the IUCN Red List for taxa evaluated prior to 2001, when version 3.1 was first used. Using the 2001 (v3.1) system these taxa are classified as near threatened, but those that have not been re-evaluated remain with the "conservation dependent" category (IUCN, 2016).

The current study also found that about 77.3% of the street trees belonged to the Leguminosae family (see Table 2). It is also evident in the distribution map that trees belonging to this family were widely distributed among the five selected national roads (see Figure 6). Trees from this family are hardier and more resilient to harsh roadside environment and possess the ability to fix nitrogen (N2) into usable forms (nitrate) (Tyrväinen, 2001; Sreetheran et al., 2011). This species is followed by family *Arecaceae*, which had been planted widely in the city because of its exotic appearance and fast development, with a spectacular display of flowers after a dry spell. These trees are well known for their great heights, exclusive foliage, conspicuous inflorescences, and big seeds (Nowak et. al., 2015).

The frequencies of individual tree genus (see Table 3) showed an overwhelming dominance of four main genus *Pterocarpus* (77.35%), *Adonidia* (5.39%), *Swietenia* (4.09%), and *Ficus* (2.04%), which constituted about 88.87% of the total tree population. *Pterocarpus*, a deciduous native tree in the Philippines, is the most abundant and is known for its hardiness, rapid growth, and pest resistance. This tree is commonly found all over the Philippines and is known to provide good quality of wood and shade. Its roots are fibrous that help keep the soil intact and prevent landslides caused by flood or even earthquakes (Sanders, 1981). Aside from its inherent abilities, *Pterocarpus* species such as *P. indicus* (narra), as it is locally known, are recognized for its aesthetic values as it blooms with yellow flowers that cover the tree's entire crown foliage and produce a good smelling fragrance. For quite a long time, this tree has been a preferred choice as urban tree among foresters for its array of benefits. The Head of the Parks and Playground Commission in Cebu City noted that "narra has been mostly planted here in Cebu as early as Spanish colonization, and these trees were used as the main material for constructing boats during the time" (L. Macaraya, personal communication, April 12, 2019). The dominance of narra as a heritage street tree was observed in Thailand, sharing 42% of the total street tree population in Bangkok (Thaiutsa et al., 2008) as well as in Yogyakarta, Indonesia, where it is commonly used as a shading tree in most main roads of the city (Syahbudin et al., 2018).

Meanwhile, Adonidia species like *Adonidia merrillii*, locally known as Manila palm, are commonly planted along the streets for its aesthetic value due to its splendid structure and colorful fruits that are edible to some birds. Since these trees are native to the Philippines, they enrich local biodiversity, thus benefitting other organisms in terms of food and habitat. Recent publications have claimed that Manila palm is native to Palawan (i.e., grows on karst limestone cliff) and neighboring islands in the Philippines, as well as to the coast of Sabah, Malaysia (Dransfield et al., 2008). The use of Manila palm as a popular ornamental plant along roadside, parks and gardens in the Philippines is due to its adaptability to tropical climate, favoring sunny areas under a well-drained, fertile soil. Recently, it has been used extensively for landscaping and interior design in shopping malls and atria (Lim, 2012).

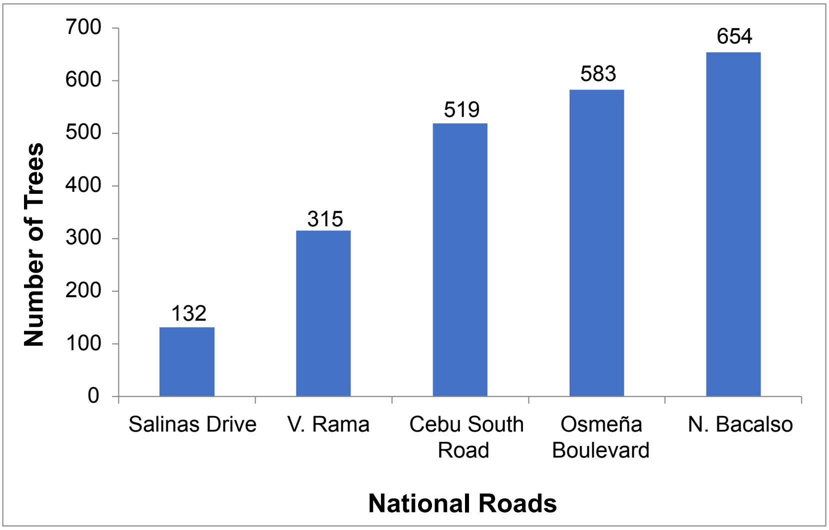

Figure 2. Number of trees encountered in each selected national road

Genus *Swietenia* coexisted with the native trees along the national roads due to its unintentional introduction to our indigenous flora (see Table 1 and Table 3). The species that belongs to this genus include *Swietenia macrophylla*, locally known as mahogany which is easily distinguishable due to its wide range of seed dispersal. Wind easily spreads the seeds of these trees because the seeds of *S. macrophylla* is samara (has a wing like structure). Previous studies on Cebu's urban trees reported that mahogany, being dominant in the city (Flores et al., 2020), had a potential use for carbon sequestration (Parilla et al., 2018; Pansit, 2019). Similar findings were reported by Nagendra and Gopal (2010) where mahogany was also one of the ten most commonly planted street trees in Bangalore, India. The same paper also highlighted that since mahogany was considered medium-sized tree with large canopies, it was more suitable to be planted among narrow roads with minimal sidewalk space. In Indonesia, mahogany trees were also favored in huge urban centers, considering that its cooling effect could effectively mitigate urban heat island (i.e. an urban area that is significantly warmer than its surroundings due to anthropogenic activities) (Ihsan & Rosleine, 2020).

The fourth dominant genus among the selected national roads was Ficus. It is composed of relatively common species namely, *F. septica* (local name: lagnob, a native tree), *F. benjamina* (local name: dakit/balete, an alien tree), and *F. reliogiosa* (local name/ common English name: sacred fig tree, an alien tree) which were easily determined by the researchers based on the morphology of their leaves, trunks, flowers, fruits, and bark texture (see Table 1). Sacred fig trees were observed in four national roads due to their versatile plant habit. When young, the fig tree is an epiphytic, climbing plant that attacks tree species, walls, and sidewalk strips. When it reaches maturity, it develops into a huge tree. Despite the detrimental effect of *Ficus* spp. As an invasive plant in urban landscapes (Corlett, 2006), its leaves can capture heavy metal particles from atmospheric dusts in urban areas (F. benjamina, Reyes et al., 2012). Most importantly, a majority of its species are essential tropical frugivores (Shanahan et al., 2001) and are hence labeled as "keystone resource" in tropical forests and urban landscapes (Corlett, 2006).

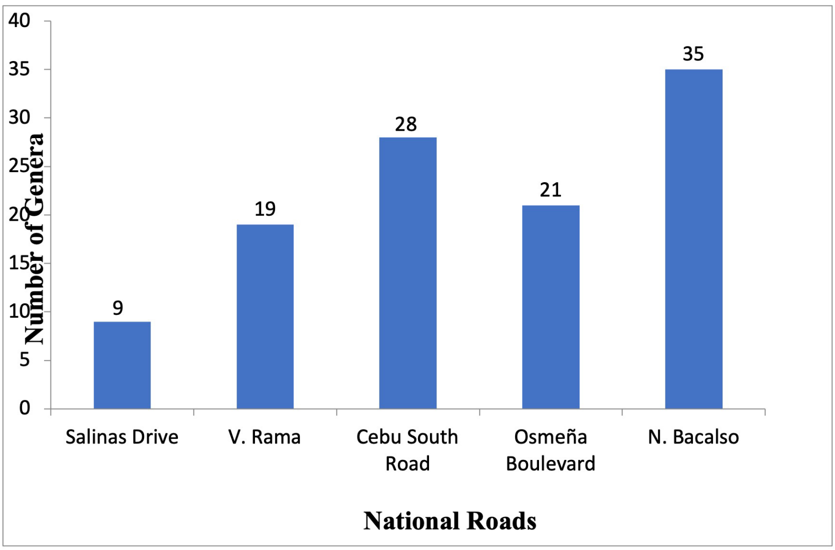

Figure 3. Number of tree genera identified in each selected national road

Table 2
Frequency of Individual Tree Family Found in Selected Urban Roadsides/ Roads in Cebu City, Philippines

No.	PLANT FAMILY	FREQUENCY	%
1	Strelitziaceae	1	0.05
2	Lauraceae	1	0.05
3	Rubiaceae	1	0.05
4	Cycadaceae	1	0.05

5	Dipterocarpaceae	1	0.05
6	Bixaceae	2	0.09
7	Asparagaceae	2	0.09
8	Rhizophoraceae	2	0.09
9	Casuarinaceae	3	0.14
10	Muntingiaceae	4	0.18
11	Malvaceae	4	0.18
12	Moringaceae	4	0.18
13	Anacardiaceae	5	0.23
14	Oxalidaceae	5	0.23
15	Caricaceae	6	0.27
16	Euphorbiaceae	6	0.27
17	Combretaceae	8	0.36
18	Sapotaceae	10	0.45
19	Apocynaceae	12	0.54
20	Fabaceae	20	0.91
21	Myrtaceae	20	0.91
22	Lamiaceae	37	1.68
23	Annonaceae	45	2.04
24	Moraceae	56	2.54
25	Meliaceae	95	4.31
26	Arecaceae	149	6.76
27	Leguminosae	1,703	77.3

Table 3

Frequency of individual tree genus found in selected urban roadsides/ roads in Cebu City, Philippines

No.	PLANT GENUS	FREQUENCY	%	ORIGIN
1	Alstonia	1	0.05	Native
2	Ravenala	1	0.05	Native
3	Arenga	1	0.05	Alien
4	Morinda	1	0.05	Native
5	Persea	1	0.05	Alien
6	Corypha	1	0.05	Native
7	Cycas	1	0.05	Native
8	Hopea	1	0.05	Native
9	Morus	1	0.05	Alien

10	Premna	1	0.05	Native
11	Macaranga	1	0.05	Alien
12	Acacia	2	0.09	Alien
13	Cocos	2	0.09	Alien
14	Bixa	2	0.09	Alien
15	Carallia	2	0.09	Alien
16	Cordyline	2	0.09	Alien
17	Casuarina	3	0.14	Native
18	Caesalpinia	4	0.18	Alien
19	Cascabela	4	0.18	Alien
20	Ceiba	4	0.18	Alien
21	Moringa	4	0.18	Native
22	Muntingia	4	0.18	Alien
23	Psidium	4	0.18	Alien
24	Areca	4	0.18	Native
25	Chrysophyllum	5	0.23	Alien
26	Mangifera	5	0.23	Native
27	Averrhoa	5	0.23	Alien
28	Azadirachta	5	0.23	Alien
29	Manilkara	5	0.23	Alien
30	Melanolepis	5	0.23	Native
31	Vitex	5	0.23	Native
32	Carica	6	0.27	Alien
33	Plumeria	7	0.32	Alien
34	Tamarindus	7	0.32	Alien
35	Terminalia	7	0.32	Native
36	Leucaena	7	0.32	Alien
37	Artocarpus	10	0.45	Alien
38	Annona	11	0.5	Alien
39	Wodyetia	11	0.5	Alien
40	Roystonea	13	0.59	Alien
41	Syzygium	16	0.73	Alien
42	Gmelina	31	1.41	Alien
43	Polyalthia	34	1.54	Alien
44	Ficus	45	2.04	Alien
45	Swietenia	90	4.09	Alien
46	Adonidia	117	5.39	Native

47	Pterocarpus	1,704	77.35	Native
TOTAL		2,203	100	

Tree Condition

During the inventory, the researchers observed the urban trees' trunk condition, structure, presence and absence of insects and disease, and crown development. All of these characteristics served as bases for categorizing them according to a specific tree condition (i.e., excellent, good, fair, poor and very poor). These arboricultural tree condition ratings are commonly used to determine the overall health status of planted trees in urban landscapes (Roman et al., 2013). Overall, 12.94%, 34.18%, 52.38%, 0.41% and 0.09% of trees were in excellent, good, fair, poor, and very poor conditions, respectively (see Table 4). Data also show that the five selected urban corridors contained trees that were mostly in excellent, good, and fair conditions. However, N. Bacalso had a number of trees in poor condition (i.e., 52 trees), and this may imply that these trees were given less attention by the city management due to its distant location from the city.

Table 4
Number of Trees under Each Condition Class Surveyed in Selected Urban Roadsides of Cebu City, Philippines

Condition Class	Osmeña Boulevard	V. Rama Street	Cebu South Road	N. Bacalso Street	Salinas Drive	Total
Excellent	111	26	57	78	13	285
Good	217	55	175	238	68	753
Fair	255	229	284	335	51	1 154
Poor	0	5	2	52	0	9
Very Poor	0	0	1	1	0	2
Total	583	315	519	654	132	2 203

In this study, it was found that trees under excellent condition were vigorous and completely clear (i.e., free of any signs of pest or insect infestations and symptoms of disease, defects or cavities). Crown development was full and balanced. Trees that were in good condition had minor structural defects especially on trunks and branches in which peripheral parts were damaged by parasites or from the previous pruning. Some defective parts of the tree had a 10% lack in natural symmetry. Leaf development became deficient and other observable pest issues and damage on other parts could be observed. Trees under fair condition revealed a moderate branch dieback. Shoot elongation showed stressed growing conditions, and obvious pest problems could be observed, and these contributed to the trees' 30% crown decline and low life expectancy. Evidence of surface root and trunk damage with decay was present, and lack of full crown development contributed to the scoring system.

Trees under poor condition indicated major damage in all parts of the tree. Trunk structure had a major defect, and 50% of the trunk had been missing. The formation of branches that were structurally important were broken and dead, and had poor attachments. Overall, the apparent stress of the tree could be observed in its stature. There were severe infestations by insects, and disease and human intervention caused the major decay and hollow sections of the tree. This condition suggests that the life expectancy of the tree was low. Trees under very poor condition were found to have an extensive damage in the whole tree structure, indicated by 75% structural defects that can make a trees' health become weaker and put an end to its existence.

In other countries, researchers found that more urban trees were rated as having poor conditions when cultivated in the warmest areas of the city (i.e., with more impervious cover) (Dale & Frank, 2014). Impervious pavements and compacted soil surfaces reduces the access of trees to fertile soil, thus increasing their level of stress due to drought, temperature changes, and herbivory (Meineke et al., 2016; Just et al., 2019). Related studies have also suggested that regardless of latitude where the city was located, herbivore abundance increased as urbanization also increased (Koslov et al., 2017). Moreover, one of the best approaches to keep urban trees in good condition is to reduce these impervious surfaces and provide more access to fertile soil (Just et al., 2019).

Tree Structure

The distribution of trees according to diameter at breast height (DBH) classes in the five national roads shows that most trees belonged to a range of 90 to 110 cm DBH, suggesting that the five urban corridors were dominated by mature trees (see Figure 4). Mature trees' diameter ranged from 70 cm and above (Sreetheran et al., 2011). In Figure 5, the highest mean tree diameter belonged to the genus Acacia followed by genus Gmelina, Cordyline, Hopea, and Mangifera. These trees' diameter measured >70 cm, and in the inventory, the population of these trees did not exceed 5% (see Figure 4 and Figure 5). Although there were only two large Acacia trees found in all the five sampling sites, the canopy size of these trees were remarkable and dominant.

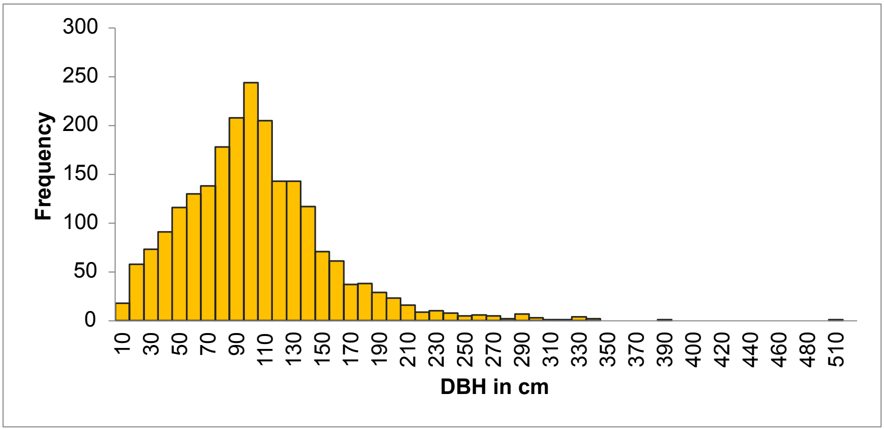

Figure 4. Distribution of DBH Classes of Trees Being Surveyed in the Five Urban Street Corridors

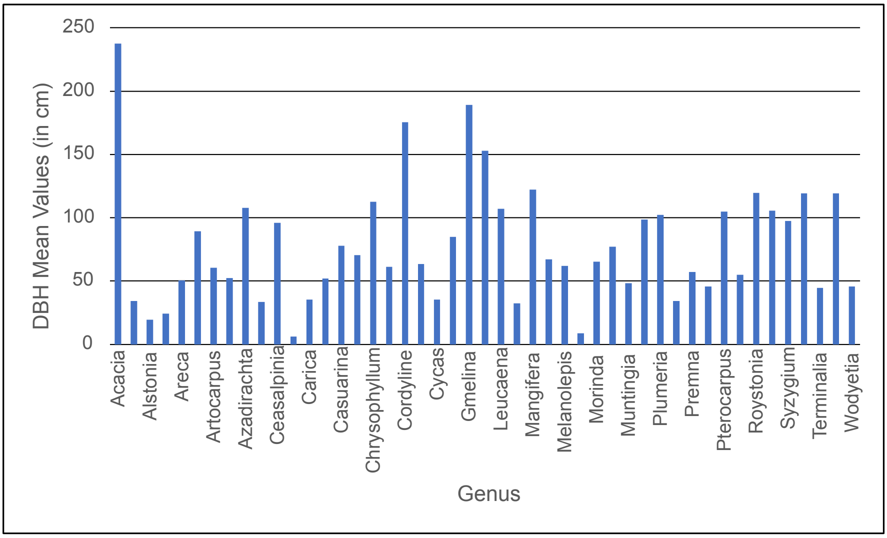

Figure 5. Distribution of DBH Mean Values by Genus of the Street Trees Distributed in Five Urban Street Corridors

Table 5 shows the tabulated mean diameter and relative standard deviation of the trees grouped according to the national roads where they were located. The results show that among the five selected national roads, trees on Salinas National Road had the highest mean tree diameter. Salinas National Road was dominated by genus Swietenia that comprised 44% of the total tree population in the area. This was followed by Osmeña Boulevard which was dominated by genus Pterocarpus, constituting 85% of the total tree population in the area. Natalio Bacalso national road ranked third as most of the trees encountered during the inventory had <70 cm diameter. Moreover, this road had the highest tree population. It can also be observed in the data that most trees on the urban corridors with high mean tree diameter were old or fully mature, while most trees on N. Bacalso street and Cebu South Road were replacements of the old ones, and thus registered lower tree diameters. Compared to Osmeña Boulevard which was developed during the American period, N. Bacalso and Cebu South Road were developed more recently (early 1980s). Moreover, aside from being selected as a tree of choice for urban sidewalk tree planting, *P. indicus* (narra) had actually been recorded even during the pre-American occupation (1886) as existing in the central part of Cebu Island, together with molave which was the most dominant tree species at the time (Abella, 1886, as cited by Seidenschwarz, 1988).

Table 5

Mean Tree Diameter Tabulated by Road

National Road/Street	Mean tree diameter (in cm) ± RSD
Osmeña Boulevard	101.57 ± 66.4
Salinas	114.06 ± 41.1
V. Rama	94.59 ± 43.6
N. Bacalso	96.18 ± 46.7
Cebu South Road	95.92 ± 44.3

The importance of measuring tree diameter using standardized biometrics cannot be overemphasized because the social, economic, and ecological valuation of trees depends on this measurement. Diameter at breast height (DBH) is a core element of forest trees surveys because of its convenience and simplicity of use (Maragik et al., 2020). Previous studies utilized DBH for a variety of purposes, such as defining trees (Beech et al., 2017), quantifying ecosystem services (McHale et al., 2009), measuring radial stem growth (Evans et al., 2015), estimating biomass and carbon (Chave et al., 2005), and estimating standing volumes of timber (Oderwald & Johnson, 2009).

Ecological Status

There were about 1,867 native trees which were mostly *Pterocarpus* and *Adonidia*. The rest were 336 alien trees which were mostly *Swietenia* and *Ficus*. However, alien trees were represented in more genera (31 genera) compared to native trees (16 genera) (see Table 3). A graphical representation in Figure 6 shows the ecological status composition of each tree along the national roads. It can be observed that except for Salinas Drive, all four other urban roadsides registered a higher number of native species, with N. Bacalso having the highest number of native tree species (549 individuals) planted. Photographs of native and alien trees are shown in Figure 7 and Figure 8, respectively.

Trees surveyed were located 2.62 m to 3 m from the road's white strip indicating pedestrian boundaries from the road. All these trees were located along the national roads with a code E characteristic vegetation (i.e., all trees surveyed were found along the roadsides, near buildings or infrastructures in general). In these five selected urban corridors, trees were either planted on elevated concrete plant boxes/plots or on designated plots surrounded with cement on the roadsides. The area of the tree plots were not collected, but it can be observed that in these areas, weeds which were ephemeral were growing along with the trees. Traces of animal litters and human garbage (single-used plastics) were also evident in trees along the urban corridors.

Presently, there are approximately 3,600 native trees found in the Philippines, 67% of which are country endemic (Green Convergence & Horta Filipina Foundation, Inc., 2012). However, majority of floristics conducted in Cebu were based on forest inventories, typically Key Biodiversity Areas (KBAs). Previous survey shows that *Ficus* spp. was the most abundant in both Cantipla and Tabunan forest (Cadiz & Buot, 2010). While there are records from upland barangays of Cebu City on native tree diversity, there is still a dearth of published information on native trees in the highly urbanized portion of Cebu City.

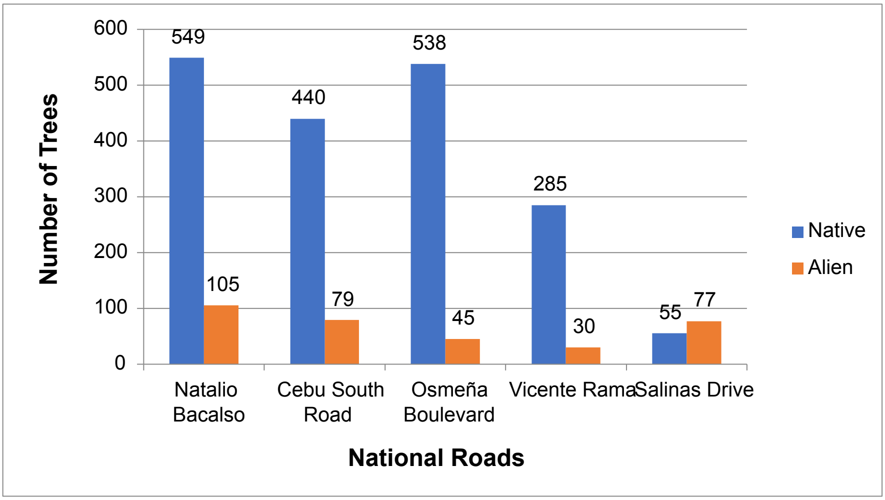

Figure 6. Ecological status of trees in urban roadsides/roads of Cebu City, Philippines

Wire Conflicts, Tree Protection, and Management

Wire conflicts have been frequent concerns of urban communities most especially during calamities (Clatterback & Simpson, 1914). In many areas in Cebu City, electrical wirings are also considered a primary threat to tree growth and development. In this research, Figure 9 shows that national roads, such as N. Bacalso, Cebu South Road, Osmeña Boulevard, and Vicente Rama, had serious wire conflicts, exposing the trees to many anthropogenic activities such as pruning, removing of the tree crown, and getting rid of some parts so that electrical wirings can be installed. During the conduct of the study, the researchers were informed that the city management office conducted scheduled pruning for the trees located along the urban corridors for the safety of the public. Electric companies' perspective concurred with the idea of pruning but in a risky manner because they wanted to cut only those branches that might affect the wirings (i.e., branches that found at the center crown of the tree). In urban areas where trees can cause serious conflicts, many anthropogenic activities are progressing that can compromise urban vegetation. For instance, improper pruning of trees has resulted in serious injuries, and cutting down trees are often disregarded by most households, especially if those trees are outside of their property. However, such practices are deleterious to the trees themselves because removing their crown makes them more susceptible to any diseases and termites which might feed on them (Most & Weissman, 2012).

Figure 7. Photographs of native trees encountered along the five (5) urban roadsides of Cebu City presented in duplicate (close up photo & photo taken from a distance)

1: *Vitex parviflora* A. Juss. (Tugas), 2: *Terminalia catappa* L. (Talisay), 3: *Pterocarpus indicus* Willd. (Narra), 4: *Melanolepis multiglandulosa* (Reinw. ex Blume) Rchb. & Zoll. (Alim), 5: *Mangifera indica* L. (Manga), 6: *Leucaena leucocephala* (Lam.) de Wit. (Ipil-ipil), 7: *Hopea plagata* (Blanco) S. Vidal (Yakal), 8: *Corypha utan* Lam. (Buri), 9: *Casuarina equisetifolia* L. (Agoho), 10: *Arenga pinnata* (Wurmb) Merr. (Kaong), 11: *Alstonia scholaris* L. (Dita), and 12: *Adonidia merrillii* Becc. (Manila Palm).

Figure 8. Photographs of alien trees encountered along the five (5) urban roadsides of Cebu City presented in duplicate (close up photo & photo taken from a distance)

1: *Annona squamosa* L. (Atis), 2: *Annona muricata* L. (Guyabano), 3: *Artocarpus heterophyllus* Lam. (Nangka), 4: *Averrhoa bilimbi* L. (Iba), 5: *Azadirachta indica* A. Juss. (Neem tree), 6: *Carallia brachiata* (Lour.) Merr. (False Kelat), 7: *Carica papaya* L. (Papaya), 8: *Cascabela thevetia* L. (Yellow Oleander), 9: *Caesalpinia decapetala* (Roth) Alston (Mysore Thorn), 10: *Chrysophyllum cainito* L. (Caimito), and 11: *Cocos nucifera* L. (Coconut Tree).

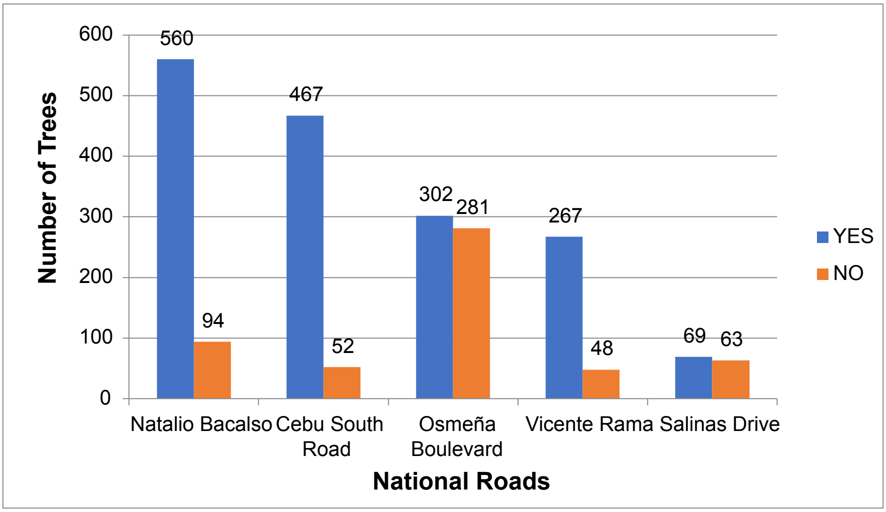

Figure 9. Number of trees that needs recommended pruning or reorganization of electrical wirings

Urban street trees are also susceptible to road widening that is very evident in developing countries, to decongest streets during busy days. The concept of road-widening has been employed since the Japanese occupation. During those times, they used braces or brackets to support trees that were being moved. These braces or brackets are still present along the national roads of N. Bacalso, Cebu South Road and V. Rama. In accordance to Executive Order No. 23, series of 2011, the DENR permits the DPWH to cut trees that might be affected by road widening. Earth balling is also practiced by the DENR to preserve trees that are affected by road widening, but the chances of those trees to survive is slim. These anthropogenic activities determine the chance of survival of urban trees (Konijnendijk, 1997). In Cebu City, trees growing along the urban corridors are also regarded for their aesthetic value during seasonal events like Christmas, election of public officials, and the annual Sinulog festival. Oftentimes, many trees incur severe injuries and scars because they are used as posting areas, where printed materials containing information and announcements are posted using sharp nails and push pins. The researchers were informed by residents that in some occasions, buntings were tied to street trees during various festivities.

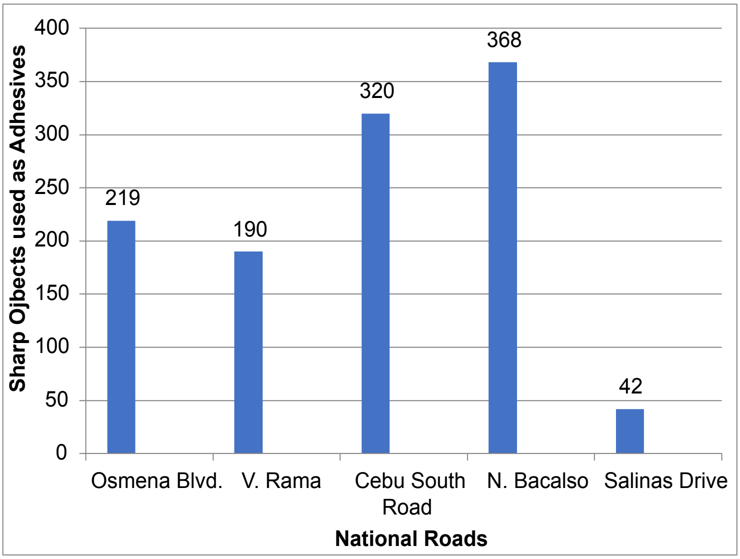

Figure 10. Number of trees that need silvicultural treatment

Trees in cebu city generally require silvicultural treatment, albeit at varying scale. These treatments are usually given to trees to change or maintain their overall condition. Shown in Figure 10 are the data indicating the number of trees that need urgent care and attention in the five study areas. Here, trees growing at N. Bacalso St. needed the most attention, while those from Salinas Drive were likely taken care of by residents and local government officers. These two highways are not comparable in terms of the number of users (e.g., passageway for vehicles) and residential houses nearby. N. Bacalso is a busy street and is more strategic, for people use roadside trees for a variety of purposes. However, all of the five roadside streets recorded a significant number of trees that must be given attention. In this study, narra trees along Osmeña Boulevard were treated for tree cavities, had their damaged stems removed, and were regularly maintained by streetsweepers. Canopy trimming was also noted along V. Rama Avenue, particularly those trees whose branch put heavy weight on roofs of residential houses or were at risk of hurting daily commuters. As of today, domestication of urban trees in the Philippines has not been reported in scientific literature, except the paper of Aguilos et al., (2020) which observed an early growth performance of commercially-important native tree species under domestication. Silvicultural treatment of urban trees, however, had been observed in Yogyakarta, Indonesia where damage to root areas and tree pots were addressed and tree canopy was maintained (Syahbudin et al., 2018).

CONCLUSION

The researchers had successfully achieved the objectives of the study, generated the list and distribution map, and identified the ecological status of each tree encountered in the study. Based on the findings, it can be concluded that Cebu City's urban corridors, specifically the national streets/roads included in this study, were rich in terms of the number of tree genera and families. There were more than two thousand trees encountered during the field survey, and this signifies that Cebu City had never neglected the importance of trees as part of the city's green infrastructure program. The study had also evaluated the condition class of each tree; however, the evaluation was only limited to the superficial structure of the tree and was solely based on the researchers' observations. Moreover, although the study had gathered the DBH to estimate the size and age of each tree, the researchers were not able to collect the total height of each tree since doing so could pose a risk to the researchers, considering that the trees were located along the streets, and the researchers did not have any alternative method to gather the height of each tree. Height was an important biological component in the study as it could help determine the urban forest stand. Another limitation acknowledged in this study is that the field survey only included trees that were publicly available and excluded those trees that were along the streets but were fenced. This implies that counting the actual number of trees (i.e. fenced+non-fenced) in Cebu City may generate a higher number of trees compared to the numbers mentioned in this study. Furthermore, while it is known that trees offer direct and indirect ecosystem services to organisms, this study, unfortunately, cannot arrive at a conclusion on the importance of urban trees to organisms, specifically to the people residing in the city, despite the cited evidence of urban people's abusive treatment of the remaining trees along the streets/roads. Tree inventory such as this research is very important in determining and monitoring the city's tree status; however, due to insufficient data available to date, this study cannot conclude whether the status of trees in Cebu City has improved or not.

Nonetheless, this study may still serve as a guide or basis for protocol for future annual urban tree monitoring activities. Significantly, the record that will be produced from this kind of monitoring will help the locals, landscape planners, and experienced arborists to formulate an effective course of action in order to underscore the significance of urban trees in the city's future urban biodiversity investment.

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