doi: 10.25750/1995-4301-2022-2-198-208

Tree diversity and carbon stock in North Poblacion and South Poblacion (Dipaculao, Aurora, Philippines)

© 2022. J. M. Bambalan ORCID: 0000-0003-0657-9482, I. K. S. Palapal ORCID: 0000-0001-5315-2137,
R. V. Guleng ORCID: 0000-0002-7359-479X, E. E. Coracero ORCID: 0000-0002-2569-3179,
R. B. J. Gallego ORCID: 0000-0003-0626-1562, M. J. A. Suniega ORCID: 0000-0001-8932-8720,
Aurora State College of Technology,
Barangay Zabali, Baler, Aurora, Philippines, 3200,
e-mail: jaybambalan15@gmail.com

Trees are very important components of an ecosystem which act as key elements of biodiversity which also provides countless benefits and protection from adverse events such as climate change. This study focused on the assessment of diversity and carbon storage potentials of tree species in Barangay North Poblacion and Barangay South Poblacion in Dipaculao, Auorora. The study covered a 100% inventory of the trees with diameter at breast height of at least 5 cm. The area was found to have a high overall diversity (H' = 3.278; 1-D = 0.963) with 68 morpho-species of trees, 1290 individuals and 23 families. The most abundant species were *Swietenia macrophylla* King, *Mangifera indica* L., and *Gmelina arborea* Roxb. Ex Sm. collectively with 465 individuals. Ecological status assessment revealed 32 indigenous, four threatened (IUCN [18]), six threatened (DAO 2017-11 [19]), and three invasive species. Notable among the species were the three Philippine endemics – *Artocarpus blancoi* (Elmer) Merr., *Ficus pseudopalma* Blanco, and *Drypetes falcata* (Merr.) Pax & K. Hoffm. The overall tree biomass estimates were 2367.60 tons using Brown formula while 2328.90 tons using the equation of Chave. For carbon storage potential, the overall estimated values of two barangays were 1183.8 tons (16.28 t/ha) using Brown and 1164.45 tons (16.01 t/ha) using Chave. *Samanea saman* (Jacq.) Merr. had the highest carbon storage potential of 407.4 tons using Brown and 342.2 tons using Chave. The results of the study can serve as a guide to the local government in the planning the conservation and protection measures for the tree species in the area.

Keywords: developed areas, Philippine trees, tree carbon stock, tree diversity, urban trees.

УДК 630+574.36

Разнообразие древесной растительности и запасы углерода в Северном и Южном Побласьоне (Дипакулао, Аврора, Филиппины)

© 2022. Дж. М. Бамбалан, студент,
И. К. С. Палпал, студент,
Р. В. Гуленг, студент,
Э. Э. Корачеро, инструктор,
А. Б. Дж. Гальего, PhD, доцент,
М. Дж. А. Саниего, инструктор,
Государственный технологический колледж Аврора,
3200, Филиппины, Аврора, Балер, Барангай Забали,
e-mail: jaybambalan15@gmail.com

Деревья являются очень важными компонентами экосистемы, выступающими в качестве ключевых элементов биоразнообразия, а также обеспечивающими защиту от неблагоприятных явлений, таких как изменение климата. Цель данного исследования заключалась в оценке разнообразия древесных пород и их способности накапливать углерод в округах Северный и Южный Побласьон в Дипакулао, Аврора (Филиппины). В ходе исследования на территории округов проведена 100% инвентаризация деревьев с диаметром на высоте груди не менее 5 см. Было обнаружено, что территория отличается высоким общим разнообразием (H' = 3,278; 1-D = 0,963), оно представлено 68 морфовидами деревьев, 1290 особями и 23 семействами. Наиболее многочисленными видами были *Swietenia macrophylla* King, *Mangifera indica* L. и *Gmelina arborea* Roxb. Ex Sm., в совокупности они составили 465 особей. Оценка экологического состояния выявила 37 коренных видов, 10 видов, находящихся под угрозой исчезновения (4 вида из списка IUCN [18], 6 видов из DAO 2017-11 [19]), и 3 инвазивных вида. Среди видов деревьев выделялись три филиппинских эндемика – *Artocarpus blancoi* (Elmer) Merr., *Ficus pseudopalma* Blanco и *Drypetes falcata* (Merr.) Pax & K. Hoffm. Общая биомасса деревьев составила 2367,6 т по формуле Брауна и 2328,9 т по формуле Чаве. Что касается потенциала накопления углерода, общие оценочные значения для Северного и Южного Побласьона составили 1183,8 т (16,28 т/га) с использованием формулы Брауна и 1164,45 т (16,01 т/га) с использованием формулы Чаве. Вид *Samanea saman* (Jacq.) Merr. имел самый высокий потенциал накопления углерода: 407,4 т при использовании формулы Брауна и 342,2 т при использовании формулы Чаве. Результаты исследования могут быть использованы органами местного самоуправления при планировании мероприятий по сохранению и защите древесных пород в районе исследования.

Ключевые слова: развитые районы, деревья Филиппин, запас углерода в деревьях, разнообразие деревьев, городские деревья.

Trees are one of the most important components of the ecosystem. They provide several benefits to the environment, animals, and even to humans. Trees sustain a livable environment by producing oxygen through photosynthesis and releasing it for consumption of animals and humans [1]. Trees also serve as key elements of biodiversity as it provides habitat and food for wildlife species [2]. Humans also obtain countless benefits from trees. Trees provide and maintain a safe environment by giving protection from natural calamities such as typhoons, landslides, floods, and even from the impact of climate change by storing carbon in its biomass [3]. A life sustaining environment is made possible by trees through enhancing the food production livelihood of the people [4].

Unfortunately, trees and forest cover are generally decreasing in the global scale. Since 1990, an estimated amount of 420 million hectares of forest have been lost due to agricultural expansion, forest degradation, and land conversion [5]. Also, development of areas which eventually leads to its rapid urbanization greatly contributes to the loss of remaining trees [6]. Forested areas across the world are continuously converted into commercial areas being driven by urbanization [7]. Due to these scenarios, the supposedly numerous benefits that trees can provide also decrease with its number. Inclusion of trees in urbanized and developed areas are being done, however, inappropriate locations, choice of species, lack of sufficient monitoring and maintenance can be observed [8]. Thus, it is important to regularly assess and monitor the trees present in an area with respect to its diversity and ecosystem services (i.e., carbon storage potential) they provide.

Tree diversity and carbon stock assessments are effective tools in uncovering useful information concerning the underlying problems relating to their overall diversity, ecological status, and carbon storage potentials [9, 10]. Product of these assessments can also be used in development of strategies and plans to combat loss of trees especially in developed areas where land use planning is vital [11].

The two barangays, namely North Poblacion and South Poblacion are the central and most developed part of Dipaculao, Aurora. It is where the public markets, municipal halls, convenience stores, schools, residence and other infrastructures are located making it the densest portion of the municipality. The establishment of these commercial and residential spaces affected the forest in the area leaving only the trees in the street sides, house yards, and compounds of schools and municipal hall. To prevent trees of being completely lost in the barangays, their diversity and carbon storage potentials shall be assessed. The product of this study will greatly help development of plans and ordinances that can protect the trees in the area.

The issues concerning loss of biodiversity especially the trees and the intensifying impact of climate change had driven the researchers to pursue the description and quantification of tree diversity and carbon stock. This study was conducted to assess the tree diversity and carbon storage potentials in North and South Poblacion, Dipaculao, Aurora with reference to the developed areas within the study area. The research was also directed to explore the species composition and diversity, ecological status of tree species, as well as the biomass and carbon storage potentials of the trees in the area.

Methodology

Study Site. The study was conducted in two barangays, North Poblacion and South Poblacion in Dipaculao, Aurora. Dipaculao is a municipality with a total land area of 361.64 square kilometers equivalent to about 11.54% of Aurora's total area. North Poblacion and South Poblacion have a land area of 72.72 hectares (Fig. 1, see color insert V).

Data Collection. The researchers conducted a 100% inventory of trees with diameter at breast height (DBH) of at least 5 cm. Numerous publications in the tropical countries in Asia and the Philippines also followed the 5-cm cut-off for their surveys [12–14], thus, the researcher

**J. M. Bambalan, I. K. S. Palapal, R. V. Guleng,
E. E. Coracero, R. B. J. Gallego, M. J. A. Suniega
"Tree diversity and carbon stock in North Poblacion
and South Poblacion (Dipaculao, Aurora, Philippines)". P. 198**

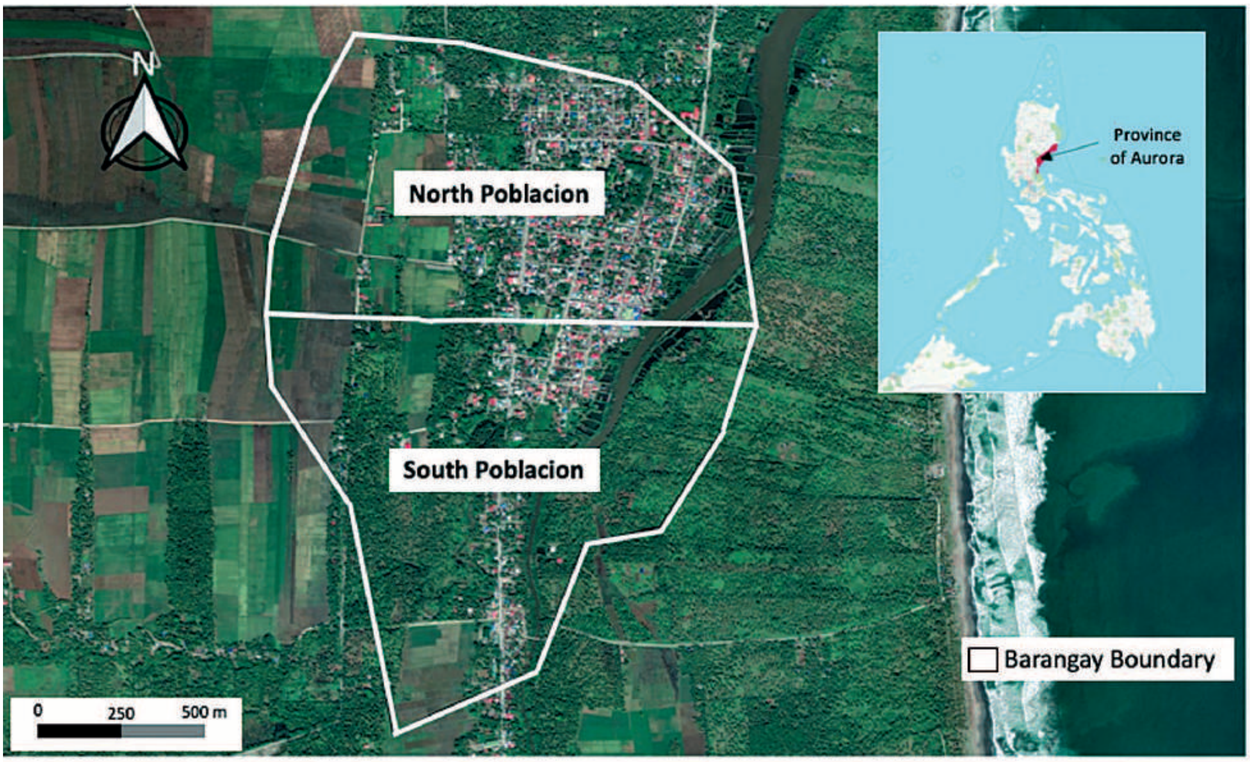

Fig. 1. Location map of the study site

Table 1

Fernando biodiversity scale [15]

Relative Values	Shannon Index	Evenness Index
Very high	3.5 and above	0.75–1.00
High	3.0–3.49	0.5–0.74
Moderate	2.5–2.99	0.25–0.49
Low	2.0–2.49	0.15–24
Very low	1.9 and below	0.05–0.14

followed the same. The parameters measured during the data gathering were DBH (obtained at 1.3 m from the ground), merchantable height, total height and remarks on its location. Species identification was done in the field based on morphological characteristics of the trees.

Diversity Indices Computation. This study computed the diversity of trees (Shannon and Simpson) using Paleontological Statistical Software Package for Education and Data Analysis (PAST 4.18). Shannon Index measures diversity using species richness and distribution. Simpson Evenness measures diversity in terms of evenness in the distribution of individuals species. Diversity values were interpreted using the scheme of Fernando Biodiversity Scale [15] (Table 1).

Ecological Status Assessment. Endemism, indigeneity, invasiveness, and conservation status of each species were assessed and verified through different sources and databases. Data on endemism and indigeneity were obtained on the comprehensive database of plants in the Philippines, the Co's Digital Flora of the Philippines [16]. Species invasiveness was assessed using the paper on Invasive alien species (IAS): concerns and status in the Philippines [17]. For the conservation status, worldwide category was based on the International Union for Conservation of Nature Red list [18]. For the Philippine scheme, the local list of threatened species under DAO 2017-11 was used [19].

Carbon Stock Computation. Two allometric equations were used in estimating the aboveground biomass of trees, the Brown [20] and Chave et al. [21] which were found suitable due to the climatic zone of the area being tropical moist. The formula of Brown used diameter in cm as input.

$$Y = \exp(-2.134 + 2.530 \cdot \ln(D)) \quad (1),$$

where Y – Tree aboveground biomass (in kilograms), D – Diameter at breast height (in centimeters).

The formula of [21] incorporated the specific wood density. The specific wood density values for this study was obtained from the World Agroforestry wood database.

$$Y = p \cdot \exp(-1.499 + 2.148 \cdot \ln(D) + 0.0207 \cdot (\ln(D))^2 - 0.0281 \cdot (\ln(D))^3 \quad (2),$$

where p – Specific wood density.

The belowground biomass (BGB) was also estimated as 15% of the aboveground biomass (AGB or Y) expressed as BGB = AGB · 15%. Lastly, the carbon storage (CS) was estimated as the 50% of the total tree biomass expressed as CS = (AGB + BGB) · 50%.

Results and Discussion

Tree Composition and Diversity

There were 68 morpho-species of trees and 1290 individuals belonging to 23 families recorded in North Poblacion and South Poblacion. Among these families, Fabaceae, Moraceae, and Annonaceae were the most specious with 12, 9, and 5 species, respectively. In terms of number of individuals, Meliaceae, Fabaceae, and Anacardiaceae were the most abundant with 258, 205, and 180 individuals, respectively. Species-wise, *Swietenia macrophylla* King or Big Leaf Mahogany was the most dominant with 191 individuals (14.8% of the total number of individuals), followed by *Mangifera indica* L. with 172 (13.33%) and *Gmelina arborea* Roxb. ex Sm. with 102 (7.91%). These three most abundant species alone had a total of 465 individuals which is equivalent to 36.05% of the total individual trees recorded. The overwhelming individual counts of these species are somehow anticipated. Two of these species, *S. macrophylla* and *G. arborea* were recorded as invasive alien species to the Philippines with aggressive capacity to adversely affect the native species existing in the area [17]. A number of diversity studies in public green spaces and human settlements also found *S. macrophylla* and/or *G. arborea* either as most abundant species or dominant species [22, 23].

In terms of diversity, the two barangays collectively were highly diverse in Shannon Index (H') value of 3.278 and very highly diverse for Simpson Evenness (1-D) with 0.963 (Fig. 2). Individually, South Poblacion had a higher tree diversity than North Poblacion. There were 48 tree species and 390 individuals in South Poblacion with H' of 3.224 and 1-D of 0.935. On the other hand, North Poblacion had 60 species and 900 individuals with H' of 3.181 and 1-D of 0.933. However, both areas fell under the category of high tree diversity.

The diversity of trees in specific areas at each barangay was also assessed. Diversity values ranged from 1.714 (very low) to 3.349 (high) for Shannon while 0.475 to 0.903 for Simpson Evenness (Fig. 3). Trees in the roadside and residential area had the highest diversity in terms of Shannon index (H' = 3.349) mainly contributed by its high number of species (60) and individuals (578) but was lowest in terms of Simpson Evenness (0.0475) due to the uneven distribution where Mahogany and Mango dominated the area with 134 and 123 individuals, respectively. It was equivalent to 44.46% of all trees in the road/residential. Moreover, the number of individuals per species in the road/residential ranged from 1 to 90. On the other hand, the church area had the highest Simpson Evenness diversity of 0.903. It was brought by the even distribution of 56 tree individuals among 17 species in the area where no one or two species dominated the area. The number of individuals per species in the church area only ranged from 1 to 9.

In South Poblacion, there were only two main areas namely, roadside/residential and the Dipaculao Central Elementary School (DCES). The diversity was higher at the roadside/residential area (H' = 3.184; 1-D = 0.933) which fell in highly diverse category than in DCES (H' = 2.499; 1-D = 0.863) that fell under the moderately diverse category for Shannon while very highly diverse for Simpson Evenness (Fig. 4). An overwhelming dominance of one or two species was not observed in these two areas of South Dipaculao which possibly prevented the diversity to fall under the low to very low category of diversity. The 390 individuals of trees in the barangay were distributed in a relatively even manner among 48 species. Individuals per species only ranged from 1 to 57.

The areas are considered as the premiere portions of Dipaculao in terms of infrastructure and development. Thus, results of this study must be compared in researches conducted in the same settings, developed or urban areas. As of today, there were very limited studies in the Philippines on tree diversity in developed areas with human settlements and presence of commercial spaces. Some of these are the studies of Coracero et al. in Laguna State Polytechnic University (LSPU) at San Pablo City, Laguna with H' of 1.705 and 1-D of 0.367 which fell to the very low diversity category [24]. Another study was conducted in Bicol Kalikasan Park at Legazpi City, Albay where H' was 2.84 and 1-D was 0.92 [22]. A tree study in six public green spaces in Bacolod and Iloilo revealed Shannon index values ranging from 0.43 to 0.91 which were considered to be of very low diversity. Generally, the overall diversity in North Dipaculao and South Dipaculao as well as the diversity across specific areas within the barangays were relatively higher than the studies mentioned. One reason is that, Dipaculao has not reached the level of urbanization and development in the compared areas. However, the same fate with these urbanized areas may also happen to Dipaculao if the trees will not be part of the planning and priority of the government.

Ecological Status of Trees in North Poblacion and South Poblacion

Philippine Native and Endemic Tree Species. Thirty-two out of 68 tree species (47.1%) were found to be native to the country (Table 2). Among these, four were endemic or restricted only to the Philippines. These endemic species were *Artocarpus blancoi* (Elmer) Merr., *Ficus pseudopalma* Blanco, and *Drypetes falcata* (Merr.) Pax & K. Hoffm.

Threatened Species. Forty-four (44) species were listed in either the IUCN Redlist and/or DAO 2017-11 (Table 3). Among these, 42 species were found in the IUCN Redlist of which four has threatened status (two Vulnerable, two Endangered) while the remaining 38 has records of assessment (1 Data deficient, 36 Least concern, and a Near threatened). On the other hand, six species were threatened as per the list of DAO 2017-11 (two Other Threatened Species, and four Vulnerable). Notable among these species were the two forms of Narra, namely *Pterocarpus indicus* Willd. forma *echinatus* (Pers.) Rojo (Prickly Narra) and *Pterocarpus indicus* Willd. forma *indicus* (Smooth Narra).

Invasive Species. There were three invasive species found in the area (Table 4). These species had a total of 302 individuals equivalent to 23.41% of all individuals of trees in the two barangays.

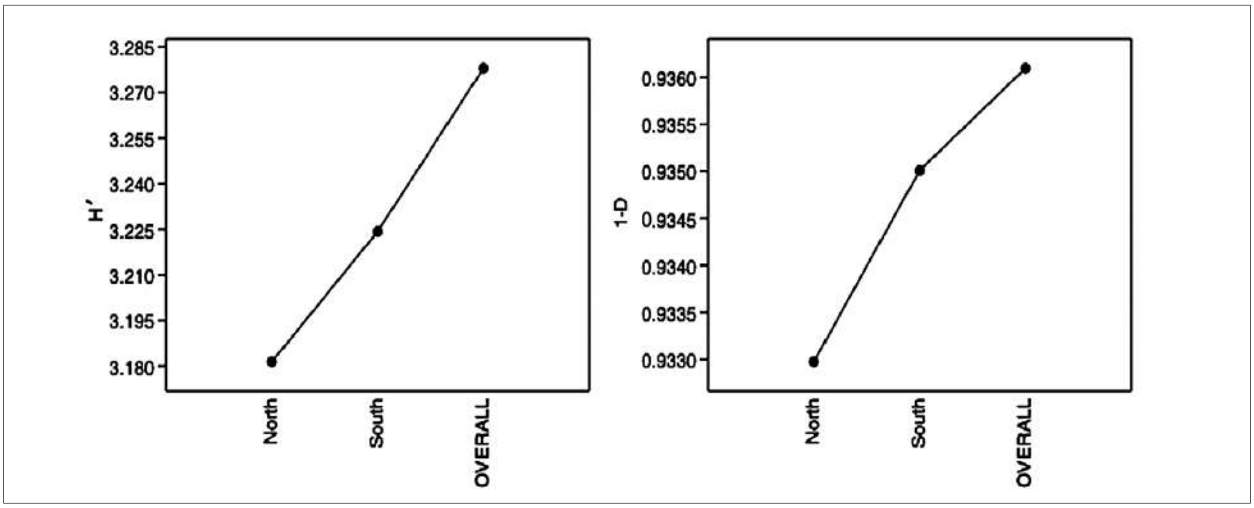

Fig. 2. Computed Shannon diversity (left) and Simpson Evenness (right) of trees in North Poblacion and South Poblacion

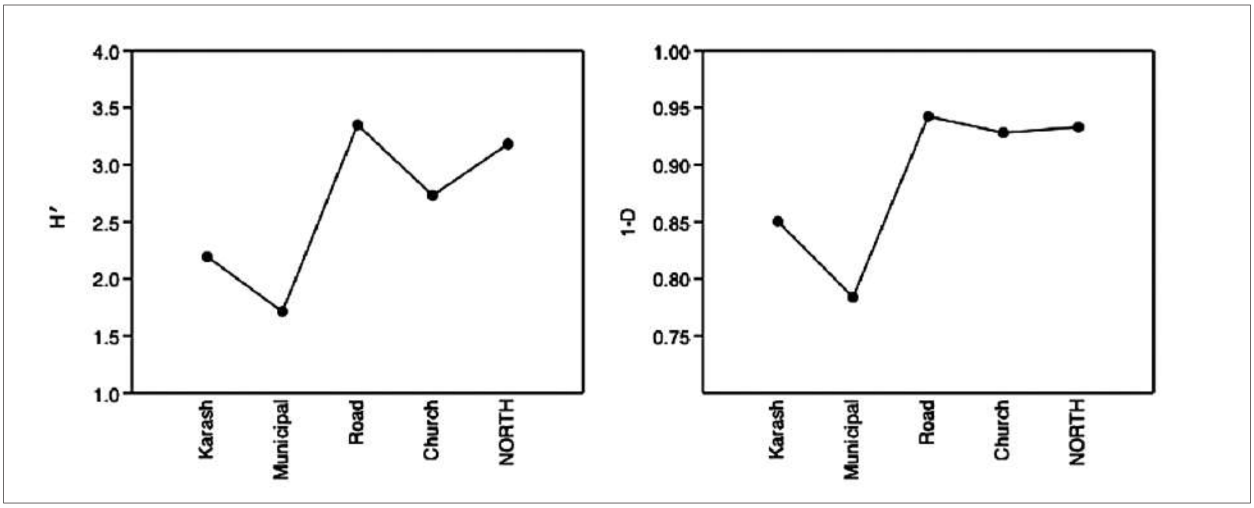

Fig. 3. Computed Shannon diversity (left) and Simpson Evenness (right) of trees in North Poblacion: Karash, Road/Residential, Municipal Hall, Church

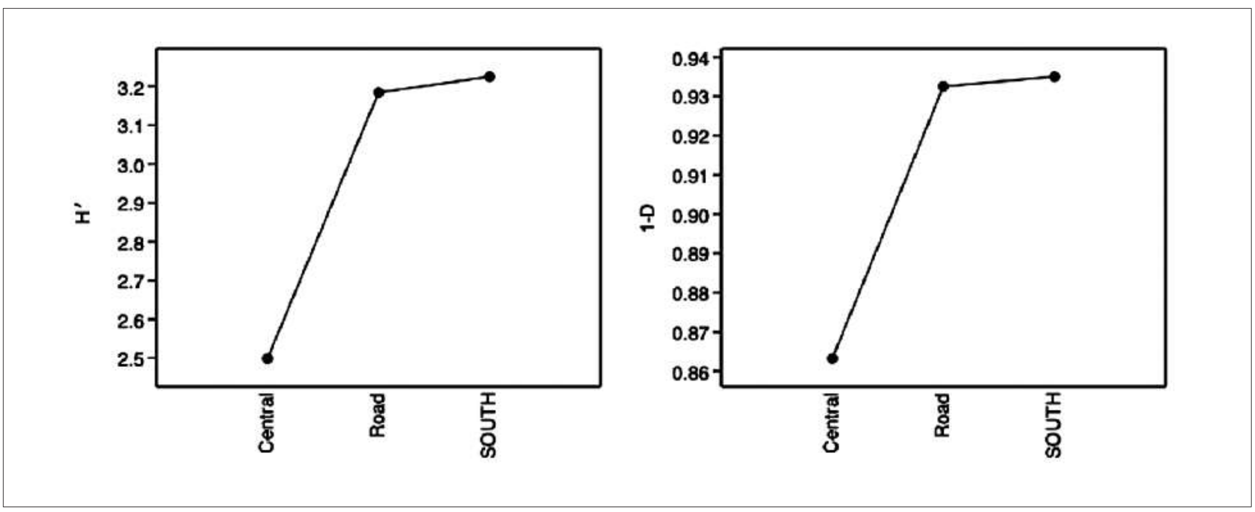

Fig. 4. Computed Shannon diversity (left) and Simpson Evenness (right) of trees in South Poblacion: Central School and Road/Residential

Table 2

Taxonomic list of Philippine native species in the area with notes on their endemism

No.	Family	Scientific Name
1	Anacardiaceae	*Koordersiodendron pinnatum* (Blanco) Merr.
2	Anacardiaceae	*Spondias pinnata* (L.f.) Kurz
3	Apocynaceae	*Alstonia scholaris* (L.) R.Br.
4	Apocynaceae	*Tabernaemontana pandacaqui* Poir.
5	Bignoniaceae	*Radermachera pinnata* Seem.
6	Euphorbiaceae	*Macaranga grandifolia* (Blanco) Merr.
7	Euphorbiaceae	*Macaranga tanarius* (L.) Müll.Arg.
8	Euphorbiaceae	*Melanolepis multiglandulosa* (Reinw. ex Blume) Rchb. & Zoll.
9	Fabaceae	*Bauhinia purpurea* L.
10	Fabaceae	*Erythrina variegata* L.
11	Fabaceae	*Intsia bijuga* (Colebr.) Kuntze
12	Fabaceae	*Pongamia pinnata* (L.) Pierre
13	Fabaceae	*Pterocarpus indicus* Willd. forma *echinatus* (Pers.) Rojo
14	Fabaceae	*Pterocarpus indicus* Willd. forma *indicus*
15	Lamiaceae	*Premna odorata* Blanco
16	Lamiaceae	*Vitex negundo* L.
17	Lauraceae	*Alseodaphne malabonga* (Blanco) Kosterm.
18	Lecythidaceae	*Barringtonia racemosa* (L.) Spreng.
19	Meliaceae	*Lansium domesticum* Corrêa
20	Meliaceae	*Sandoricum koetjape* (Burm. f.) Merr.
21	Moraceae	*Artocarpus blancoi* (Elmer) Merr.*
22	Moraceae	*Broussonetia luzonica* (Blanco) Bureau
23	Moraceae	*Ficus nota* (Blanco) Merr.
24	Moraceae	*Ficus pseudopalma* Blanco*
25	Moraceae	*Ficus septica* Burm.f.
26	Mrytaceae	*Syzygium tripinnatum* (Blanco) Merr.
27	Myrtaceae	*Syzygium polycephaloides* (C.B. Rob.) Merr.
28	Nyctaginaceae	*Pisonia grandis* R. Br.
29	Phyllanthaceae	*Antidesma bunius* (L.) Spreng.
30	Putranjivaceae	*Drypetes falcata* (Merr.) Pax & K. Hoffm.*
31	Rubiaceae	*Morinda citrifolia* L.
32	Sapindaceae	*Nephelium lappaceum* L.

*Note: * indicates Philippine endemic species.*

Carbon Storage Potentials of Trees

Tree Biomass and Carbon Stock per Area. There was a total tree biomass of 2367.60 tons in North Poblacion and South Poblacion using the formula of Brown [20] while 2328.9 tons using the formula of [21] (Fig. 5). North Poblacion contributed a greater amount of tree biomass (Brown = 1540.4 tons; Chave 1497.82 tons) than South Poblacion (Brown 827.19 tons; Chave 831.07 tons). Among the areas surveyed, the municipal hall had the highest tree biomass using both formulas with a mean value of 765.28 tons using [20] and 694.43 tons using [21] (Fig. 6).

The study revealed an estimated tree carbon stock of 1183.8 tons (16.28 t/ha) using [20] and 1164.45 tons (16.01 t/ha) using [21] (Fig. 7). North Poblacion contributed an amount of 770.20 tons (22.02 t/ha) and 748.91 tons (21.41 t/ha) using [20] and [21], respectively. South Poblacion contributed an amount of 413.60 tons (10.96 t/ha) and 415.54 tons (10.94 t/ha) using [20] and [21], respectively (Fig. 8). Among the areas, municipal hall had the highest contribution 382.64 tons for [20] and 347.21 tons for [21]. This was highly anticipated due to its high biomass content which was the used in estimating the carbon stock of trees.

Table 3

Taxonomic list of threatened species in the area

No.	Family	Scientific Name	IUCN Redlist	DAO 2017-11
1	Anacardiaceae	*Koordersiodendron pinnatum* (Blanco) Merr.	–	OTS
2	Anacardiaceae	*Mangifera indica* L.	DD	–
3	Anacardiaceae	*Spondias purpurea* L.	LC	–
4	Annonaceae	*Annona muricata* L.	LC	–
5	Annonaceae	*Annona reticulata* L.	LC	–
6	Annonaceae	*Annona squamosa* L.	LC	–
7	Annonaceae	*Cananga odorata* (Lam.) Hook. f. & Thomson	LC	–
8	Apocynaceae	*Alstonia scholaris* (L.) R. Br.	LC	–
9	Apocynaceae	*Tabernaemontana pandacaqui* Poir.	LC	–
10	Euphorbiaceae	*Macaranga grandifolia* (Blanco) Merr.	VU	–
11	Euphorbiaceae	*Macaranga tanarius* (L.) Müll.Arg.	LC	–
12	Euphorbiaceae	*Melanolepis multiglandulosa* (Reinw. ex Blume) Rchb. & Zoll.	LC	–
13	Fabaceae	*Bauhinia purpurea* L.	LC	–
14	Fabaceae	*Cassia fistula* L.	LC	–
15	Fabaceae	*Erythrina variegata* L.	LC	–
16	Fabaceae	*Gliricidia sepium* (Jacq.) Kunth	LC	–
17	Fabaceae	*Intsia bijuga* (Colebr.) Kuntze	NT	VU
18	Fabaceae	*Pongamia pinnata* (L.) Pierre	LC	–
19	Fabaceae	*Pterocarpus indicus* Willd. forma *echinatus* (Pers.) Rojo	EN	VU
20	Fabaceae	*Pterocarpus indicus* Willd. forma *indicus*	EN	VU
21	Fabaceae	*Samanea saman* (Jacq.) Merr.	LC	–
22	Fabaceae	*Tamarindus indica* L.	LC	–
23	Lamiaceae	*Gmelina arborea* Roxb. ex Sm.	LC	–
24	Lamiaceae	*Vitex negundo* L.	LC	–
25	Lauraceae	*Persea americana* Mill.	LC	–
26	Lecythidaceae	*Barringtonia racemosa* (L.) Spreng.	LC	–
27	Malvaceae	*Ceiba pentandra* (L.) Gaertn	LC	–
28	Malvaceae	*Hibiscus tiliaceus* L.	LC	–
29	Meliaceae	*Azadirachta indica* A. Juss.	LC	–
30	Meliaceae	*Sandoricum koetjape* (Burm. f.) Merr.	LC	–
31	Meliaceae	*Swietenia macrophylla* King	VU	–
32	Moraceae	*Artocarpus blancoi* (Elmer) Merr.	LC	–
33	Moraceae	*Artocarpus heterophyllus* Lam.	LC	–
34	Moraceae	*Ficus balete* Merr.	LC	–
35	Moraceae	*Ficus nota* (Blanco) Merr.	LC	–
36	Moraceae	*Ficus septica* Burm f.	LC	–
37	Moraceae	*Morus alba* L.	LC	–
38	Myrtaceae	*Psidium guajava* L.	LC	–
39	Myrtaceae	*Syzygium cumini* (L.) Skeels	LC	–
40	Phyllanthaceae	*Antidesma bunius* (L.) Spreng.	LC	–
41	Putranjivaceae	*Drypetes falcata* (Merr.) Pax & K. Hoffm.	–	OTS
42	Rutaceae	*Citrus maxima* (Burm.) Merr.	LC	–
43	Sapindaceae	*Nephelium lappaceum* L.	LC	VU
44	Sapotaceae	*Manilkara zapota* (L.) P. Royen	LC	–

Table 4

Taxonomic list of invasive species in the area

Family	Scientific Name
Lamiaceae	*Gmelina arborea Roxb*. ex Sm.
Meliaceae	*Swietenia macrophylla* King
Fabaceae	*Leucaena leucocephala* (Lam.) de Wit

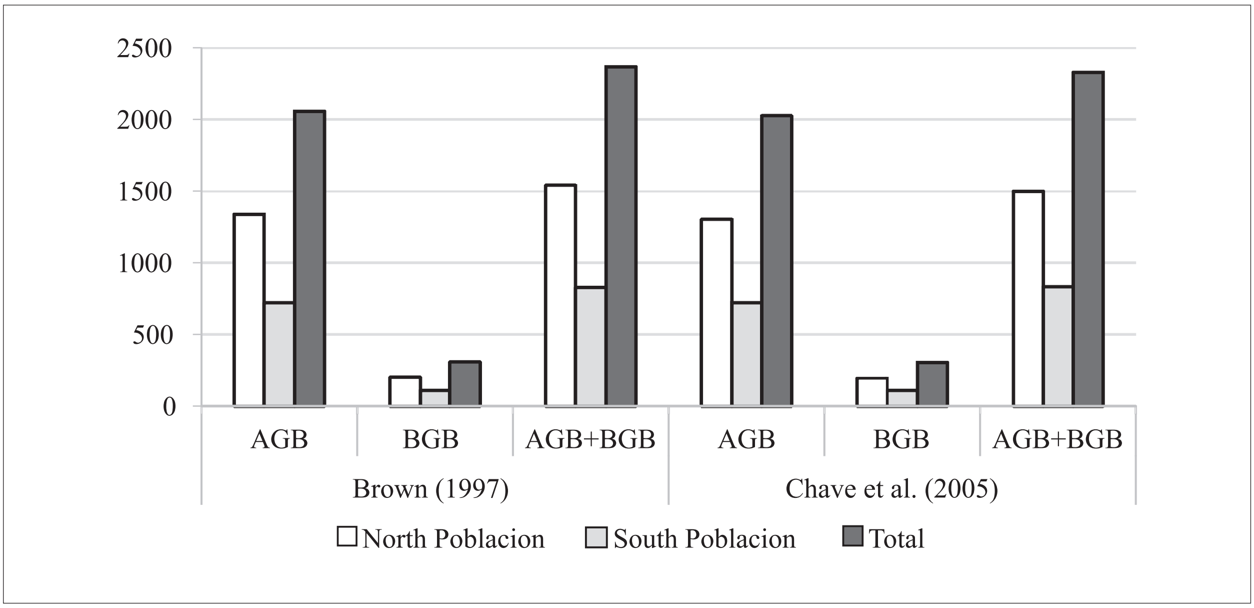

Fig. 5. Tree biomass (in tons) estimates for North Poblacion and South Poblacion

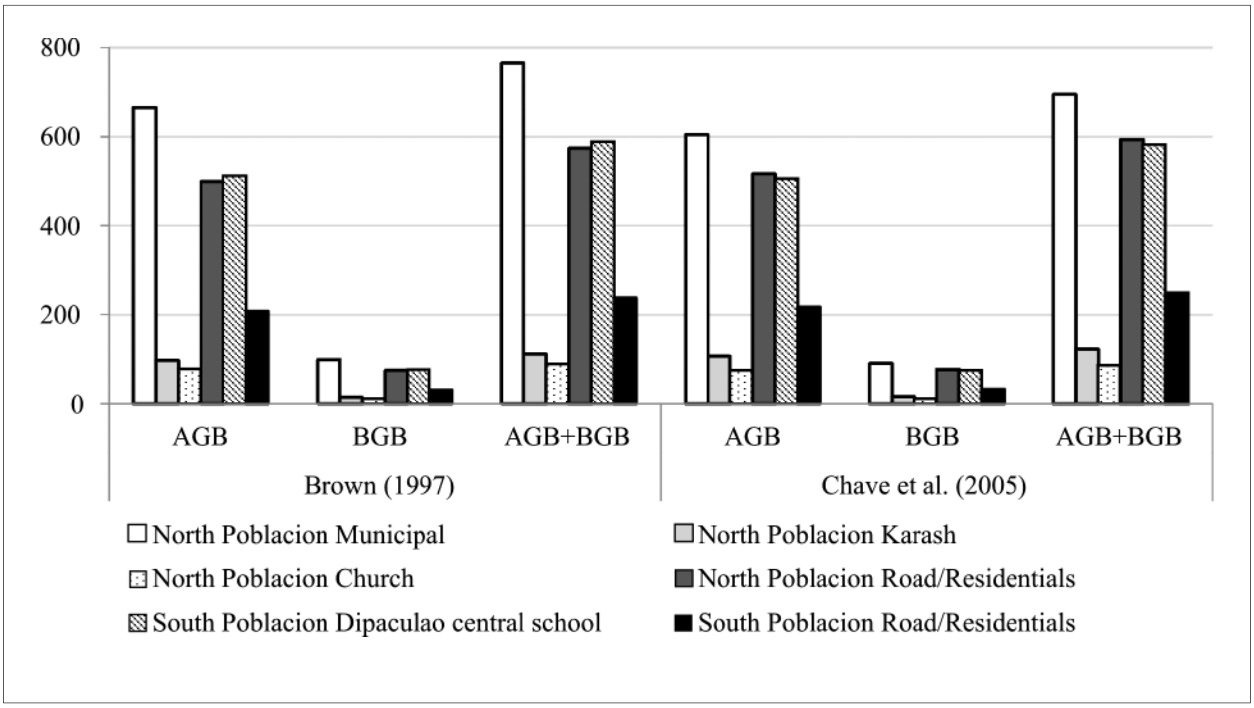

Fig. 6. Tree biomass (in tons) estimates in specific areas of the two barangays

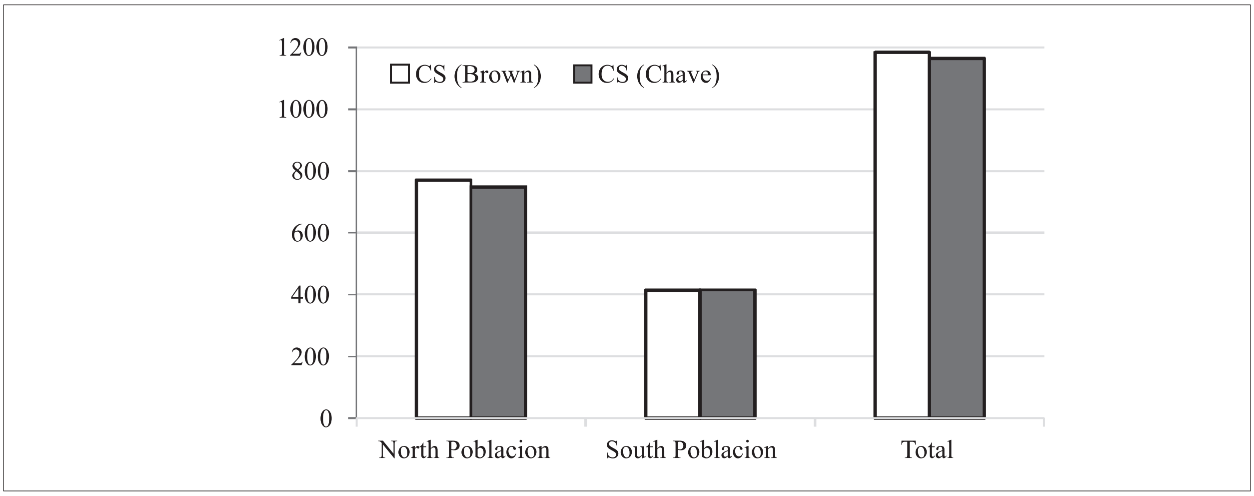

Fig. 7. Tree carbon stock (in tons) estimates in North Dipaculao and South Dipaculao

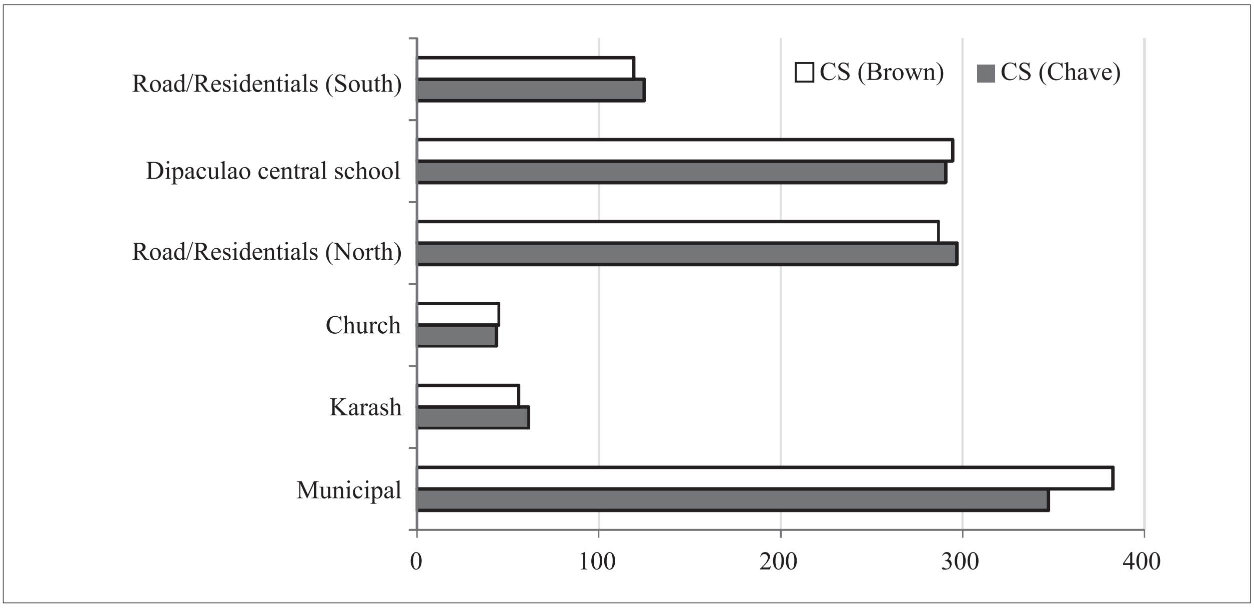

Fig. 8. Tree carbon stock (in tons) estimates in specific areas of two barangays

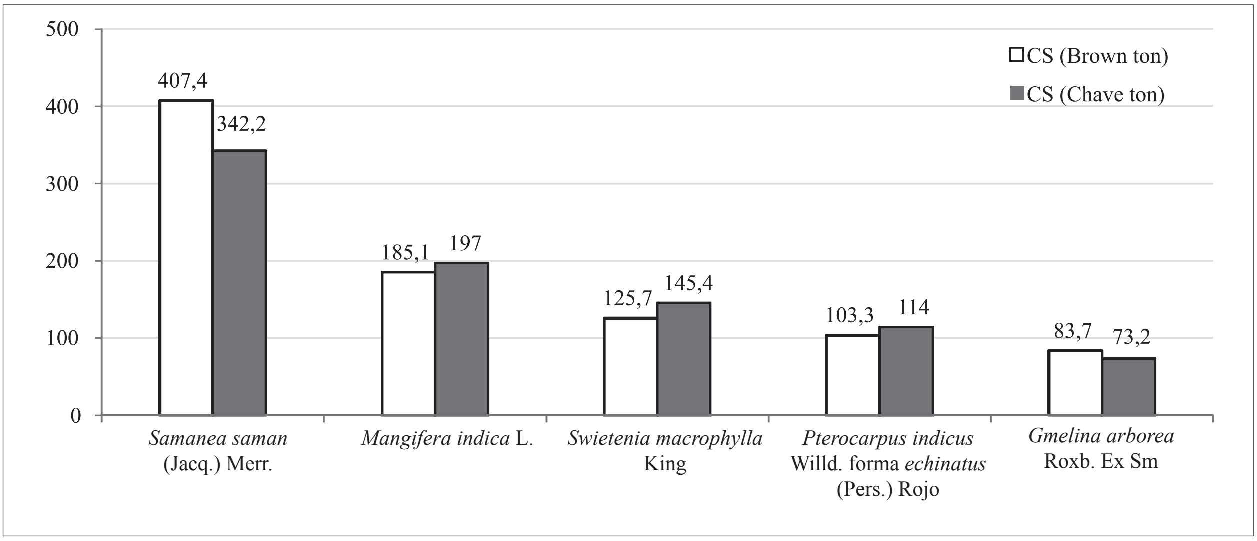

Fig. 9. Top 5 species in terms of carbon stock using [20, 21]

The results were compared with studies conducted in similar or closely similar areas in the Philippines. A study in Isabela State University Wildlife Sanctuary (ISUWS), Cabagan, Isabela revealed a carbon stock estimate of 47.50 t/ha [25]. Another study at the University of San Carlos – Talamban Campus' (USC-TC) Nature Park, Cebu City obtained a tree carbon stock of 36.21 t/ha for *Vitex parviflora* while 207.76 t/ha for *S. macrophylla* trees [26]. A in the urban areas of Cebu City revealed carbon stock value of 87.81 t/ha. Generally, the carbon stock in North Poblacion and South Poblacion are far lower than the urban areas mentioned [27].

Tree Carbon Stock per Species. Among the species, only five had obtained carbon stock potential or more than 50 tons (Fig. 9). *Samanea saman* (Jacq.) Merr or Rain Tree had the highest carbon storage potential of 407.4 tons using [20] and 342.2 tons using [21]. This was possible due to the large diameter of individual trees of *S. saman*. The largest tree in the whole area was Rain tree with DBH of 188.15 cm. Also, 49 out of 72 individuals of trees had DBH of more than 50 cm signifying the relatively large diameter composition of Rain Trees in the area.

Conclusion

The barangays were found to be highly diverse species home to a number of Philippine native, threatened, and endemic species. However, the overwhelming abundance of invasive species, particularly Mahogany and Gmelina poses serious threats to the remaining native species in the area. The carbon storage potential of trees in the area were generally lower than in other similar areas in the Philippines. The results of this study can be used as guide for the government to create management plan relating to species conservation and protection prioritizing the native, threatened and endemic species.

References

1. Nowak D., Hoehn R., Crane D. Oxygen Production by Urban Trees in the United States // Arboriculture & Urban Forestry. 2007. V. 33. No. 3. P. 220–226. doi: 10.48044/jauf.2007.026

2. Bütler R., Lachat T., Larrieu L., Paillet Y. Habitat trees: key elements for forest biodiversity // Integrative approaches as an opportunity for the conservation of forest biodiversity. Germany: European Forest Institute, 2013. P. 84–91.

3. Wahlström M. The critical role of trees and forests in disaster risk reduction // Unasylva. 2015. V. 66. No. 1–2. P. 3–5.

4. Reed J., van Vianen J., Foli S., Clendenning J., Yang K., MacDonald M., Petrokofsky G., Padoch C., Sunderland T. Trees for life: The ecosystem service contribution of trees to food production and livelihoods in the tropics // Forest Policy and Economics. 2017. V. 84. P. 62–71. doi: 10.1016/j.forpol.2017.01.012

5. Food and Agriculture Organization of the United Nations. The State of the World's Forest. FAO 2020 [Internet resource] https://www.fao.org/state-of-forests/en/ (Accessed: 11.20.21).

6. Lüttge U., Buckeridge M. Trees: structure and function and the challenges of urbanization // Trees. 2020. V. 2020. No. 34. P. 1–8. doi: 10.1007/s00468-020-01964-1

7. Smail R.A. Forest land conversion, ecosystem services, and economic issues for policy: A review. Darby, Pennsylvania: DIANE Publishing, 2010. P. 1–40.

8. Chacalo A., Aldama A., Grabinsky J. Street tree inventory in Mexico City // Journal of Arboriculture. 1994. V. 20. P. 222–226.

9. Assefa G., Mangstu T., Gelu Z., Zewdie S. Forest carbon pools and carbon stock assessment in the context of SFM and REDD+. Wondo Genet, Ethiopia: Awassa University Wondo Genet College of Forestry and Natural Resources Training Manual, 2013. P. 1–69.

10. Coracero E.E., Malabrigo Jr. P.L. Diversity assessment of tree species in Sitio Dicasalarin, Barangay Zabali, Baler, Aurora, Philippines // Open Journal of Ecology. 2020. V. 10. No. 11. P. 717–728. doi: 10.4236/oje.2020.1011043

11. Dida J., Tiburan C. Aboveground biomass estimation of trees in the University of the Philippines Los Baños Campus, Philippines // Sylvatrop. 2020. V. 30. No. 2. P. 91–105. doi: 10.1093/jue/jux020

12. Kessler M., Keßler P.J., Gradstein S.R., Bach K., Schmull M., Pitopang R. Tree diversity in primary forest and different land use systems in Central Sulawesi, Indonesia // Biodiversity & Conservation. 2005. V. 14. No. 3. P. 547–560. doi: 10.1007/s10531-004-3914-7

13. Faridah-Hanum I., Philip L., Awang Noor A.G. Sampling species diversity in a Malaysian rain forest: The case of a logged-over forest // Pakistan Journal of Botany. 2008. V. 40. No. 4. P. 1729–1733.

14. Baynes J., Herbohn J., Chazdon R.L., Nguyen H., Firn J., Gregorio N., Lamb D. Effects of fragmentation and landscape variation on tree diversity in post-logging regrowth forests of the Southern Philippines // Biodiversity and conservation. 2016. V. 25. No. 5. P. 923–941. doi: 10.1007/s10531-016-1098-6

15. Fernando E.S. Forest formations and flora in the Philippines: Handout in FBS 21. Philippines: University of the Philippines College of Forestry and Natural Resources, 1998. (Unpublished).

16. Pelser P., Barcelona J., Nickrent D. Co's digital flora of the Philippines. 2020 [Internet resource] http://www.philippineplants.org (Accessed: 10.15.2021).

17. Joshi R.C. Invasive alien species (IAS): concerns and status in the Philippines // Proceedings of the International Workshop on the Development of Database (APASD) for Biological Invasion. China: FFTC, 2006. 23 p.

18. IUCN. The IUCN Redlist of Threatened Species. IUCN, 2021 [Internet Resource] www.iucnredlist.org (Accessed: 10.16.2021).

19. DENR. DAO 2017-11. Philippines: DENR, 2017. 30 p.

20. Brown S. Estimating biomass and biomass change of tropical forests: a primer. Rome: FAO, 1997. 87 p.

21. Chave J., Andalo C., Brown S., Cairns M.A., Chambers J.Q., Eamus D., Folster H., Fromard F., Higuchi N., Kira T., Lescure J.P., Nelson B.W., Ogawa H., Puig H., Riera B., Yamakura T. Tree allometry and improved estimation of carbon stocks and balance in tropical forests // Oecologia. 2005. V. 2005. No. 145. P. 87–99. doi: 10.1007/s00442-005-0100-x

22. Galias D.C., Guerrero J.J., General M., Bañares E., Serrano J. Diversity of tree species within an urban forest fragment in Albay Province, Eastern Philippines // Bicol University R & D Journal. 2018. V. 21. No. 1. P. 33–44.

23. Tutor J.A.A., Palijon A.M., Visco R.G., Castillo A.S., Militante E.P. Floristic composition, diversity of public green spaces in major urban cities in Western Visayas, Philippines // West Visayas State University Research Journal. 2017. V. 6. No. 2. P. 23–38.

24. Coracero E., Urriza H., Foster P. Species composition and diversity: baseline for tree conservation at Laguna State Polytechnic University, San Pablo, Philippines // International Research Journal of Advanced Science. 2021. V. 2. No. 1. P. 10–16.

25. Pascua J.G., Alfonso G.P., Galicia R.S. Carbon sequestration potential of tree species at Isabela State University Wildlife Sanctuary (ISUWS), Cabagan, Isabela, Philippines // Open Journal of Ecology. 2021. V. 11. No. 5. P. 462–473. doi: 10.4236/oje.2021.115030

26. Parilla R.B., Tamoso K.M.P., Jawad F.R.O. Carbon storage and sequestration by selected tree species in the University of San Carlos–Talamban Campus' (USC-TC) Nature Park, Cebu City, Philippines // CNU Journal of Higher Education. 2018. V. 12. P. 15–20.

27. Pansit N.R. Carbon storage and sequestration potential of urban trees in Cebu City, Philippines // Mindanao Journal of Science and Technology. 2019. V. 17. P. 98–111.