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Diversity, Species Composition, and Carbon Stock Assessment of Trees in Aurora, Philippines: Variations between Preserved and Developed Ecosystems †

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Abstract: Forest and tree cover loss decreases the ecosystem services that they may provide such as food and livelihood, protection from calamities, oxygen to breathe, and storing of carbon. This study assessed the diversity, species composition, and carbon stock potential of trees located in Aurora, Philippines. Two areas were surveyed to represent preserved and developed ecosystems. The preserved ecosystem was represented by the ultramafic forest in Baler, Aurora while the developed ecosystem was represented by the urbanizing portion of Dipaculao, Aurora. The sampling site in Baler included 27 400-m^2 plots while the site surveyed in Dipaculao had a total of 72.72 hectares of developed area. Results showed a higher tree diversity in Baler (H′ = 4.096) than in Dipaculao (H′ = 3.278). Species composition assessment also revealed a higher number of ecologically important species in Baler. Ecologically important species in Baler included 100% natives, 34.5% endemics, and 20.86% threatened. Dominant species in Baler were the native, endemic, and threatened *Xanthostemon philippinensis* Merr. and the native *Teijsmanniodendron ahernianum* (Merr.) Bakh. On the other hand, the developed ecosystem had 54.4% native, 4.41% endemic, and 11.76% threatened. Dipaculao was dominated by introduced and invasive species such as *Swietenia macrophylla* King and *Gmelina arborea* Roxb. ex Sm. For the tree carbon stock assessment, a tremendous difference was found wherein the preserved ecosystem had 272.28 tons/ha carbon while the developed ecosystem had 16.28 tons/ha carbon. This study revealed ideal forest ecosystem characteristics in preserved forests with high diversity, the presence of many important species, and a large amount of carbon stock. This calls for immediate action from the government to continuously protect the natural forests and prioritize proper land use planning and the right choice of species to be integrated with developed areas to improve the ecosystem's capacity to provide vital ecological services.

Keywords: carbon stock; forest management; natural forest; urban forest; tree diversity

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1. Introduction

The world's forests continue to decrease at an alarming rate. The Food and Agriculture Organization of the United Nations report estimated a loss of 420 million hectares of forests since the 1990s, with a net loss of 7.8 million hectares per year [1]. This was mainly brought about by anthropogenic activities such as deforestation, illegal logging, land

conversion, forest and environmental degradation, and other destructive activities [2]. These events shall be controlled to prevent the total loss of the forests and the biodiversity therewith. Forests and biodiversity, particularly the trees, provide infinite ecosystem services such as food, livelihood, protection against calamities, and carbon storage and sequestration which are all beneficial to humans [3].

In the Philippines, forest ecosystem damages were exacerbated by rapid deforestation, excessive commercial timber harvesting, and agricultural and human settlement expansion [4]. This calls for immediate action to conserve and improve the remaining forest cover for the forest to continue the provision of valuable ecosystem services. However, to implement protection and conservation measures towards the forests, an assessment of the status and ecology of the resources within shall be conducted. For the forests, flora and fauna resources shall be inventoried and assessed. The data to be collected in these assessments can serve as a useful basis for the sustainable management of the resources [5].

As mentioned above, one of the major reasons for forest loss is the expansion of human settlements and commercial spaces. These are brought by continuous urbanization. Urbanization is unstoppable [6] but this shall not stop us from saving the forests. This is when the concept of urban forestry enters, which integrates tree-based resources in cities and developing towns [7]. However, the inclusion of these resources in urban areas shall be appropriate and science-based such as planting native species instead of invasive alien species to promote a diverse urban forest [8].

This current study aims to assess the tree species composition, diversity, and carbon stock potential in a preserved natural forest and in an urbanizing area in Aurora, Philippines. This study is significant especially because Aurora is a part of the Sierra Madre Mountain Range, a protected area considered the backbone of Luzon Island in the country. Thus, the results of this study may show the major differences between a preserved natural forest and an urban forest which can be used as a baseline for implementing appropriate management plans in the area.

2. Methodology

The study was conducted in two sites, the municipalities of Baler and Dipacualo in Aurora, Philippines. The study areas in Baler belong to a privately-owned forest ecosystem with strict monitoring regarding its resources (Figure 1). Meanwhile, the study sites in Dipaculao, Aurora (South Poblacion and North Poblacion) were the urbanizing portions of the municipality where residential areas, commercial spaces and infrastructures are dense (Figure 2).

The preserved natural forest was surveyed through the 9-plot 2-km transect line method. Three transect lines were established in three locations. Thus, a total of 27 400-m plots were surveyed equating to 1.08 hectares. On the other hand, the urbanizing area was 100% surveyed.

Trees with a diameter at breast height of at least 5 m were recorded from both areas. Plant identity, total height, and merchantable height were also collected from each individual tree. Data on endemism, nativity/indigeneity, and conservation status (local and international scales) were also collected [9-11]

Data were encoded and processed for the data analysis. The diversity indices were computed using the PAST software 3.14. Meanwhile, the carbon stock potentials of trees were estimated using a series of computations. The aboveground biomass was obtained first using the Brown formula [12] being a suitable model in tropical countries like the Philippines. Then belowground biomass was estimated at 15% of the aboveground biomass [13]. Lastly, carbon stock was estimated to be 50% of the sum of the computed biomass [13].

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

$$BGB = Y * 15\% \quad (2)$$

$$CS = (Y + BGB) * 50\% \quad (3)$$

where Y is the aboveground biomass in kilograms, D is the diameter at breast height, BGB is the belowground biomass in kilograms, and CS is carbon stock in kilograms.

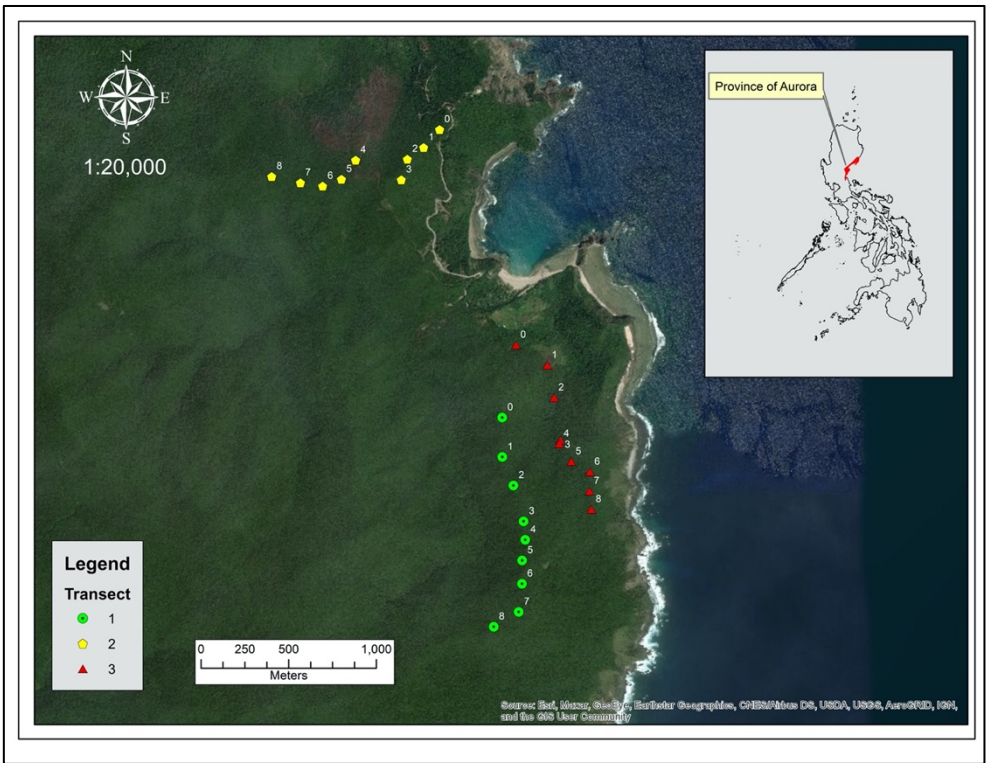

Figure 1. Location map of the study site in Baler, Province of Aurora in the Philippines

Figure 2. Location map of the study site in Dipaculao, Province of Aurora in the Philippines

3. Results and Discussion

3.1. Tree Species Composition and Diversity

The assessment revealed higher values for all diversity and importance parameters in the preserved ecosystems than in the developed or urbanizing area (Table 1). There were greater counts of families, species, and individuals of trees in Baler with 46, 139, and 2239 respectively. Also, critically important species such as the natives, endemics, and threatened were higher in the preserved ecosystem with 139, 48, and 16 respectively. Lastly, the Shannon diversity was 4.096 in Baler, Aurora which is a very high diversity value.

Table 1. Values of diversity and importance parameters of trees in Baler and Dipaculao

Parameters	Preserved (Baler)	Developed (Dipaculao)
Number of Families	46	23
Number of Species	139	68
Number of Individuals	2239	1290
Number of Native Species	139	37
Number of Endemic Species	48	3
Number of Threatened Species	16	7
Shannon Diversity	4.096	3.278

The species composition assessment also found an overwhelming abundance of *Teijsmanniodendron ahernianum* (Merr.) Bakh. and *Xanthostemon philippinensis* Merr. in the preserved forest of Baler, Aurora with 168 and 129 individuals, respectively. However, the opposite was observed in the developed areas of Dipaculao, Aurora wherein the dominating species were introduced and naturalized species namely *Swietenia macrophylla* King, *Mangifera indica* L., and *Gmelina arborea* Roxb. ex Sm. with individual counts of 191, 172, and 102, respectively. To add to that, two of these species (*S. macrophylla* and *G. arborea*) are considered prominent alien invasive species in the Philippines [14].

3.2. Tree Carbon Stock Potentials

Overall, the carbon stock potentials obtained in the studies were 272.28 tons/ha (a total of 294.06 tons in the entire study area of 1.08 ha) and 16.28 tons/ha (a total of 1183.88 tons in the entire study site of 72.72 ha) for the preserved and developed ecosystems, respectively. The obtained carbon stock values per hectare can be attributed to the number of trees in the areas. As observed, there was a very high difference in the number of tree individuals between the preserved forest (2239) and the developed/urbanizing area (1290). Thus, the presence of dense residential areas diminished the number of tree individuals in the area contributing to the area's low carbon stock relative to its size.

4. Conclusions and Recommendations

The study revealed that the natural/preserved forests are generally more diverse than developed areas. Also, more ecologically important species are present in the preserved forest including the natives, endemics, and threatened. Furthermore, there were larger amounts of carbon stock, in relation to the size of the area, in the preserved forest. The results of the study call for immediate action from the government to prioritize proper land use planning and the right choice of species to be integrated into the developed areas. Also, IEC campaigns must be conducted by the local government in partnership with the academe to educate people of the benefits that the forest trees offer.

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gathering, data processing, and data analysis. M.J.A. Suniega and E.E. Coracero created the maps. All the authors helped in writing and finalizing the research paper.

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