Species Composition and Carbon Stock of Selected Secondary Growth Forest Patches in Ilog-Hilabangan Watershed Forest Reserve

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ABSTRACT

A tree species composition and carbon stock assessment was conducted in selected secondary growth forest patches at Ilog Hilabangan Watershed Forest Reserve in Barangay Buenavista, Himamaylan City, Negros Occidental. The study aimed to (1) identify and enumerate the various tree species, (2) characterize the community structure of tree species in terms of species composition, diversity, evenness and richness, and (3) estimate the carbon stock of the remaining forest patches. In each sampling site, three 100-m transects were laid out, from which three 20m x 20m plots were established. The data collected from each sampling plots include tree count, species identification, and diameter at breast height. A total of 66 species of trees, belonging to 47 genera and 28 families were identified. The dominant species found were *Parashorea malaanonan* (pi=0.14) in NIDCO, *Ficus variegata* (pi=0.20) in Cansirmon and *Shorea contorta* (pi=0.39) in Candi-is. Forest patches in Cansirmon had the highest species richness (Dmg=12.75), while NIDCO had the highest tree species diversity (H'=3.01) and evenness (D=0.12). The highest carbon stock was estimated from NIDCO forest patches, with an average of 194.56 tons/hectare. This can be attributed to the dominance of old and larger trees in the sampling site. The study concluded that the level of disturbance of the site influences its diversity and carbon stock.

Keywords: *Diversity indices, Carbon Stock, Forest Patches, Watershed Forest Reserve*

INTRODUCTION

Tropical forests are among the natural ecosystems that are both directly and indirectly threatened by anthropogenic activities. The destruction of these ecosystems has led to depletion of natural resources that are essential to human survival (Khan et al. 1997). Even the carbon cycle is disrupted due to destructive human practices such as deforestation. Trees absorb and retain enormous amounts of carbon in its above- and below-ground biomass (Gibbs et al. 2007), and thus overexploitation of trees releases abundant amount of carbon to the atmosphere. Another pressing concern in tropical forest management is the loss of biodiversity. Vast areas of natural forests have been transformed to man-made plantation forests for the production of timber, in order to meet the demands of an ever-increasing human population (Pandey and Shukla 1999).

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The Ilog-Hilabangan Watershed and Forest Reserve (IHWFR), located in the cities of Kabankalan and Himamaylan in Negros Occidental, is one of the "highly-challenged" watershed forest ecosystems in the country. A number of research studies have already been conducted in the watershed, however these were limited to species diversity analysis. The carbon stock of the remaining forest patches in the watershed had not yet been estimated.

The amount of carbon contained in forest stands can be estimated using the above-ground biomass of trees. Likewise, plant growth, condition, and yield potential can all be predicted using above-ground biomass in forest stands (Krisnawati,2014). The changes in above-ground biomass and carbon stock in forest stands can be determined through series of tree inventories in permanent sampling plots. This study was conducted to generate baseline assessment of tree species diversity and carbon stock of forest patches in IHWFR, to serve as benchmark for conservation policies and management schemes towards improvement in count of trees, number of tree taxa, aboveground biomass, and carbon stock.

METHODOLOGY

Description of the Study Site

The study was conducted in three selected areas (i.e., NIDCO, Cansirmon, and Candi-is) in Barangay Buenavista, Himamaylan City, Negros Occidental. These areas encompass the forest patches located within the 10,211-hectare IHWFR. The NIDCO sampling site, located at Sitio Isi Daku, is a logged-over secondary growth forest with *Swietenia macrophylla* (Mahogany) as the major reforestation species. Significant portions of the previous logging site were planted with corn and cassava, whereas the abandoned log pond was planted with rice. Another large portion was developed into a pastureland. On the other hand, the Cansirmon sampling site is situated at the base of a mountain in Sitio Madaja. The area had few prominent secondary growth forest patches, which were found on high elevation and steep terrains of the mountain. Croplands planted with rice and corn were also found within the moderately sloping areas. Several newly burnt clearings were observed on the site during the site visit. Finally, the area of Candi-is is a reforestation site within Sitio Candi-is. The site was being managed by the Department of Environment and Natural Resources (DENR) and the local residents. The Candi-is forest patch was dominated by *Shorea contorta* (White Lauan), which were remnants of the original stand. Several exotic species, including *S. macrophylla* (Mahogany) and *Gmelina arborea* (Gmelina), were also found in the site. The location of the three sampling sites are presented in Fig. 1.

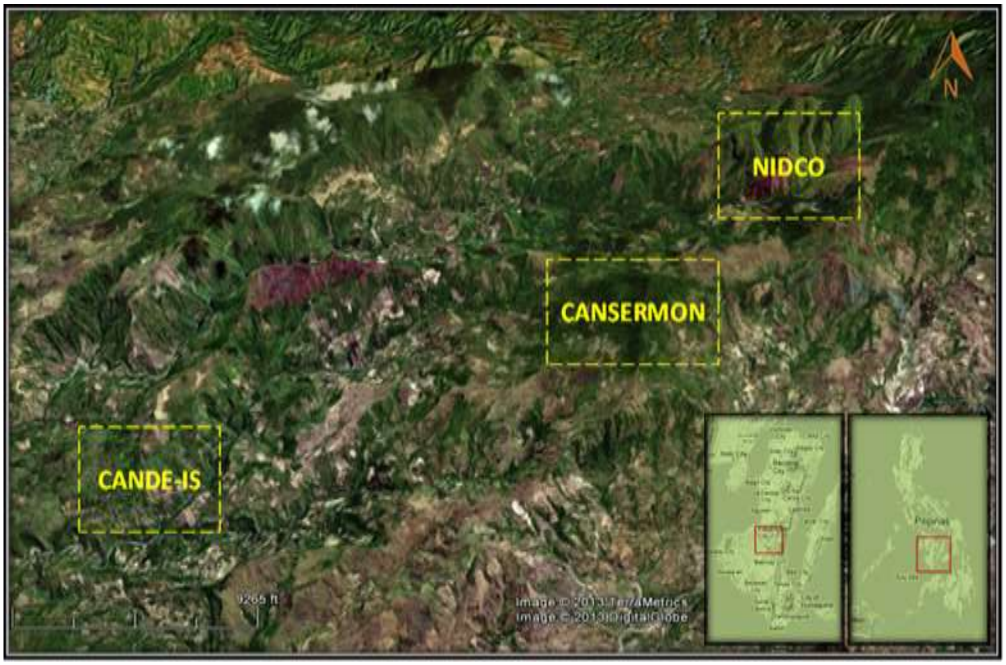

Figure 1. Map showing the location of sampling sites in Brgy. Buenavista, Himamaylan City, Negros Occidental (Google Maps, 2013).

Field Sampling and Gathering

The three sampling sites were purposively selected based on the presence of forest patches. In each sampling site, three 100-meter transect lines where laid out, from which three 20m x 20m quadratic plots were established. Hence, a total of 24 quadrats, 9 in NIDCO, 9 in Cansirmon, and 6 in Candi-is, were laid-out for the tree inventory. The inventory included all woody tree species with a Diameter at Breast Height (DBH) of 10cm and above. The 10-cm specification was based on the minimum requirement for the computation of carbon stock. The data gathered include tree count, species identification, and DBH.

Data Analysis

The data on species identification and tree count were used to assess the tree species composition and diversity of the sampling sites. The tree species composition was assessed based on the relative density (RD) and the relative abundance (pi) of each species. These measures indicate the proportion of the number of trees of a species out of the total number of trees in the forest stand.

Relative Density is the number of a given species expressed as a percentage of all species present and was estimated by dividing the density by the total of the densities of all species of trees that are present in the research locations. Furthermore, they were categorized based on the classification below with their corresponding value.

Classification	Relative Density Value
Abundant	5.00
Frequent	$4.00 \leq RD \leq 4.99$
Occasional	$3.00 \leq RD \leq 3.99$
Rare	1.00 RD 2.99

RD (Equation 1) is expressed in percentage while Pi (Equation 2) is expressed in fraction.

Importance Value Index (IVI) was determined by adding together the relative frequency, relative density, and the relative dominance. The importance value index might be anything between 0 and 300. Frequency is then computed as the number of observations where a species is recorded divided by the total number of survey plots. The density of a species is measured as the total number of individuals of that species. To assess dominance, it is necessary to know the total basal area of all species.

Equation 1. Relative density of a species (RD) = $\frac{Number\ of\ individuals\ of\ a\ species}{Total\ number\ of\ trees} X100$

Equation 2. Relative abundance of Species (*pi*) = $\frac{Number\ of\ individuals\ of\ a\ species}{Total\ number\ of\ trees}$

Tree diversity was analyzed using three indices, namely Margaleff's species richness (Dmg), Simpson's index of Dominance (D), and Shannon-Wiener index (H'). The formula for each diversity indices are shown below:

Equation 3. Margalef's index of richness' (Dmg) $= \frac{S-1}{\ln{(N)}}$

where: S = Total number of species;
N = Total number of individuals

Equation 4. Simpson index of Dominance (D) = $\sum (pi)^2$
where: pi = ni/N
ni = number of individuals of a species
N = total number of individuals sampled

Equation 5. Shannon-Wiener index (H') $= -\sum_{i=1}^{s}[\left(\frac{ni}{N}\right)\ln\left(\frac{ni}{N}\right)]$

where: s = total number of species
ni = number of individuals of a species
N = total number of individuals sampled

The variability of species diversity among study sites was compared using cluster analysis. This was performed using an open-access computer program and biodiversity professional software, that was run on a Windows operating system.

Finally, the carbon stock in sampling sites was estimated based on the above-ground biomass (AGB) of trees. The data on the DBH of trees were used to estimate AGB, following the generic allometric equation (Equation 6) that was modelled by Brown (1997) for humid tropical forests.

Equation 6. AGB = 0.118 x D2.53

where: B = aboveground biomass of each tree in kilograms

D = DBH of the tree in centimeters

By multiplying the aboveground biomass by a carbon fraction factored at 0.5, the carbon stock was calculated (IPCC, 2003).

RESULTS

Tree Species Composition

A total of 66 species of trees, distributed among 47 genera and 28 families, were recorded across the three sampling sites. Table 1 shows the species identified in each sampling sites, as well as the corresponding frequency, relative density, relative abundance for each species. At NIDCO sampling site, 35 tree species were identified with *Parashorea malaanonan* as the most abundant, representing 13.79% of all trees. The Cansirmon sampling site, with 38 tree species, was dominated by *Ficus variegata*, constituting 19.66% of all trees. The least number of identified tree species was recorded at the Candi-is sampling site with only 27 tree species. The site was dominated by *Shorea contorta*, with a relative density of 38.98%.

Based on the number of individuals and the computed relative densities, the species reported in the study sites were classified as abundant, frequent, occasional, and uncommon. Site 3 has 12 species, including *Shorea contorta* and two others; Site 2 has *Ficus variegata* at the top of the list, with *Parashorea malaanonan* and five other species in abundance; and Site 3 has *Ficus variegata* at the top of the list with five other species found to be abundant (RD 5.00). Just three species are classified as frequent (4.00 ≤ RD ≤ 4.99) in the study area, while ten species are classified as occasional (3.00 ≤ RD ≤ 3.99).Furthermore, a large number of species (44) were classified as rare (1.00 RD 2.99) using the scoring system (Morris, 1995). He asserted that these methods are ideal for obtaining a rough estimate of species abundance in a given area (quadrat). They are not, however, precise or objective measurements.

Table 1. *List of species recorded in the three sampling sites from Brgy. Buenavista, Himamaylan City, Negros Occidental.*

RANK	SCIENTIFIC NAME	FAMILY NAME	FREQ	RELATIVE DENSITY	RELATIVE ABUNDNCE
		SITE 1 (NIDCO)			
1	*Parashorea malaanonan*	Dipterocarpaceae	24	13.79	0.138
2	*Hopea foxwothyi*	Dipterocarpaceae	20	11.49	0.115
3	*Shorea almon*	Dipterocarpaceae	19	10.92	0.109
4	*Palaquium pinnatinervium*	Sapotaceae	18	10.34	0.103
5	*Myristica philippinensis*	Myristicaceae	9	5.17	0.052
6	*Neotrewia comingii*	Euphorbiaceae	7	4.02	0.04
7	*Nephelium mutabile*	Sapindaceae	6	3.45	0.034
8	*Paraserianthes falcataria*	Mimosaceae	6	3.45	0.034
9	*Macaranga tanarius*	Euphorbiaceae	5	2.87	0.029
10	*Neonauclea bartlingii*	Rubiaceae	5	2.87	0.029
11	*Pangium edule*	Flacourtiaceae	5	2.87	0.029
12	*Hopea foxworthyi*	Dipterocarpaceae	4	2.3	0.023
13	*Celtis luzonica*	Ulmaceae	4	2.3	0.023
14	*Polycias nodosa*	Araliaceae	4	2.3	0.023
15	*Ficus congesta*	Moraceae	4	2.3	0.023
16	*Ficus nota*	Moraceae	4	2.3	0.023
17	*Bischofia javanica*	Euphorbiaceae	4	2.3	0.023
18	*Shorea gisok*	Dipterocarpaceae	3	1.72	0.017
19	*Shorea contorta*	Dipterocarpaceae	3	1.72	0.017
20	*Chisocheton cumingianus*	Meliaceae	2	1.15	0.011
21	*Toona calantas*	Meliaceae	2	1.15	0.011
22	*Terminalia copelandii*	Combretaceae	2	1.15	0.011
23	*Sandoricum vidalii*	Meliaceae	2	1.15	0.011
24	*Artocarpus blancoi*	Moraceae	1	0.57	0.006
25	*Artocarpus ovata*	Moraceae	1	0.57	0.006
26	*Litsea Philippinensis*	Lauraceae	1	0.57	0.006
27	*Drypetes longifolia*	Euphorbiaceae	1	0.57	0.006
28	*Ficus saxophila*	Moraceae	1	0.57	0.006
29	*Calophyllum inophyllum*	Guttiferae	1	0.57	0.006
30	*Swietenia macrophylla*	Meliaceae	1	0.57	0.006
31	*Shorea polita*	Dipterocarpaceae	1	0.57	0.006
32	*Pometia pinnata*	Sapindaceae	1	0.57	0.006
33	*Cratoxylum celebicum*	Guttiferae	1	0.57	0.006
34	*Ficus variegata*	Moraceae	1	0.57	0.006
35	*Pouteria macrantha*	Sapotaceae	1	0.57	0.006
		Total/Average	174	2.86	0.290
		SITE 2 (CANSIRMON)			
1	*Ficus variegata*	*Moraceae*	35	19.66	0.197
2	*Diospyros mindanaensis*	*Ebinaceae*	20	11.24	0.112
3	*Parashorea malaanonan*	Dipterocarpaceae	10	5.62	0.056
4	*Macaranga tanarius*	*Euphorbiaceae*	10	5.62	0.056
5	*Neotrewia comingii*	*Euphorbiaceae*	8	4.49	0.045
6	*Ficus nota*	*Moraceae*	8	4.49	0.045
7	*Myristica philippinensis*	*Myristicaceae*	7	3.93	0.039
8	*Shorea gisok*	Dipterocarpaceae	7	3.93	0.039

9	*Hopea foxwothyi*	Dipterocarpaceae	7	3.93	0.039
10	*Shorea almon*	Dipterocarpaceae	6	3.37	0.034
11	*Bischofia javanica*	*Euphorbiaceae*	6	3.37	0.034
12	*Koordersiodendron pinnata*	*Anacardiaceae*	5	2.81	0.028
13	*Neonauclea bartlingii*	*Rubiaceae*	5	2.81	0.028
14	*Palaquium pinnatinervium*	*Sapotaceae*	4	2.25	0.022
15	*Ficus saxophila*	*Moraceae*	3	1.69	0.017
16	*Neonauclea formicaria*	*Rubiaceae*	3	1.69	0.017
17	*Shorea contorta*	Dipterocarpaceae	3	1.69	0.017
18	*Syzygium vidalianum*	*Myrtaceae*	3	1.69	0.017
19	*Homalanthus populneus*	*Euphorbiaceae*	2	1.12	0.011
20	*Chisocheton cumingianus*	*Meliaceae*	2	1.12	0.011
21	*Litsea leytensis*	*Lauraceae*	2	1.12	0.011
22	*Calophyllum inophyllum*	*Guttiferae*	2	1.12	0.011
23	*Nephelium mutabile*	*Sapindaceae*	2	1.12	0.011
24	*Polycias nodosa*	*Araliaceae*	2	1.12	0.011
25	*Sandoricum vidalii*	*Meliaceae*	2	1.12	0.011
26	*Ficus congesta*	*Moraceae*	2	1.12	0.011
27	*Albizia acle*	*Caesalpiniaceae*	1	0.56	0.006
28	*Securinega flexuosa*	*Euphorbiaceae*	1	0.56	0.006
29	*Artocarpus ovata*	*Moraceae*	1	0.56	0.006
30	*Radermachera pinnata*	*Bignoniaceae*	1	0.56	0.006
31	*Diospyros pilosanthera*	*Ebinaceae*	1	0.56	0.006
32	*Ficus minahassae*	*Moraceae*	1	0.56	0.006
33	*Macaranga bicolor*	*Euphorbiaceae*	1	0.56	0.006
34	*Ficus ulmifolia*	*Moraceae*	1	0.56	0.006
35	*Clausena laxifolia*	*Rutaceae*	1	0.56	0.006
36	*Aporosa symplocifolia*	*Euphorbiaceae*	1	0.56	0.006
37	*Cratoxylum celebicum*	*Guttiferae*	1	0.56	0.006
38	*Strombosia philippinensis*	*Olacaceae*	1	0.56	0.006
	Total/Average		178	2.63	0.26
		SITE 3 (CANDI-IS)			
1	*Shorea contorta*	Dipterocarpaceae	69	38.98	0.39
2	*Sandoricum vidalii*	*Meliaceae*	18	10.17	0.102
3	*Cratoxylum celebicum*	*Guttiferae*	16	9.04	0.09
4	*Swietenia macrophylla*	*Meliaceae*	7	3.95	0.04
5	*Ormosia Calavensis*	*Fabaceae*	6	3.39	0.034
6	*Clausena laxifolia*	*Rutaceae*	6	3.39	0.034
7	*Dipterocarpus grandiflorus*	Dipterocarpaceae	5	2.82	0.028
8	*Celtis philippinensis*	*Ulmaceae*	5	2.82	0.028
9	*Polycias nodosa*	*Araliaceae*	5	2.82	0.028
10	*Sterculia montana*	*Sterculiaceae*	5	2.82	0.028
11	*Parashorea malaanonan*	Dipterocarpaceae	4	2.26	0.023
12	*Bischofia javanica*	*Euphorbiaceae*	4	2.26	0.023
13	*Neotrewia comingii*	*Euphorbiaceae*	3	1.69	0.017
14	*Macaranga tanarius*	*Euphorbiaceae*	3	1.69	0.017
15	*Artocarpus nitidus*	*Moraceae*	3	1.69	0.017
16	*Pangium edule*	*Flacourtiaceae*	3	1.69	0.017
17	*Antidesma bunius*	*Euphorbiaceae*	2	1.13	0.011
18	*Garcinia binucao*	*Guttiferae*	2	1.13	0.011

19	*Myristica philippinensis*	*Myristicaceae*	2	1.13	0.011
20	*Hopea foxwothyi*	Dipterocarpaceae	2	1.13	0.011
21	*Shorea almon*	Dipterocarpaceae	1	0.56	0.006
22	*Radermachera pinnata*	*Bignoniaceae*	1	0.56	0.006
23	*Mussaenda multibracteata*	*Rubiaceae*	1	0.56	0.006
24	*Canthium dicoccum*	*Rubiaceae*	1	0.56	0.006
25	*Acacia mangium*	*Mimosaceae*	1	0.56	0.006
26	*Pterocarpus indicus*	*Fabaceae*	1	0.56	0.006
27	*Syzygium vidalianum*	*Myrtaceae*	1	0.56	0.006
	Total/Average		177	3.7	0.37

Diversity Indices and Dominance

Table 2 shows the diversity indices and relative dominance profile of tree species from each of the three sampling sites. NIDCO had the highest species diversity (H'=3.01), followed by Cansirmon (H'=3.00), and Candi-is (H'=2.36). The relatively low species diversity in Candi-is can be attributed to the high relative density of *Shorea contorta,* covering 38.98% of all trees in the site. On the other hand, Cansirmon, with the most number of species identified (T=38), had the highest species richness (Dmg = 12.75) among the sampling sites. The most even species distribution was found at NIDCO sampling site (D = 0.12) where the four most abundant species had comparatively similar relative densities.

Table 2. *Diversity indices and dominance of tree species in Brgy. Buenavista, Himamaylan City, Negros Occidental.*

SITE	**Shannon's index (H')**	**Margaleff's index (Dmg)**	**Simpson's index (D)**	**No. of taxa (T)**	**Average Relative Abundance (Pi)**
NIDCO	3.01	11.90	0.12	35	0.29
Cansirmon	3.00	12.75	0.14	38	0.26
Candi-is	2.36	7.60	0.37	27	0.37
Average/Total	2.79	10.75	0.21	33.33	0.31

The graph in Fig.2 shows that Cansirmon was significantly more diverse in terms of tree species than Candi-is ($P<0.05$). Overlapping of diversity profile means that the samples are not-comparable. NIDCO and Cansirmon appears to have similar diversity profile. Changes in biodiversity influences ecosystem structure and function, and consequentially affects ecosystem stability and resilience, as well as the provision of ecosystem services (Chapin et al. 2000; Loreau et al. 2001; Duffy 2009; Thompson et al. 2011; Boykin et al. 2013). It is also associated with the provision of both market and non-market ecosystem services including crop pollination (Klein et al. 2003), wood production, fisheries' yield stability, and carbon sequestration (Cardinale et al. 2012).

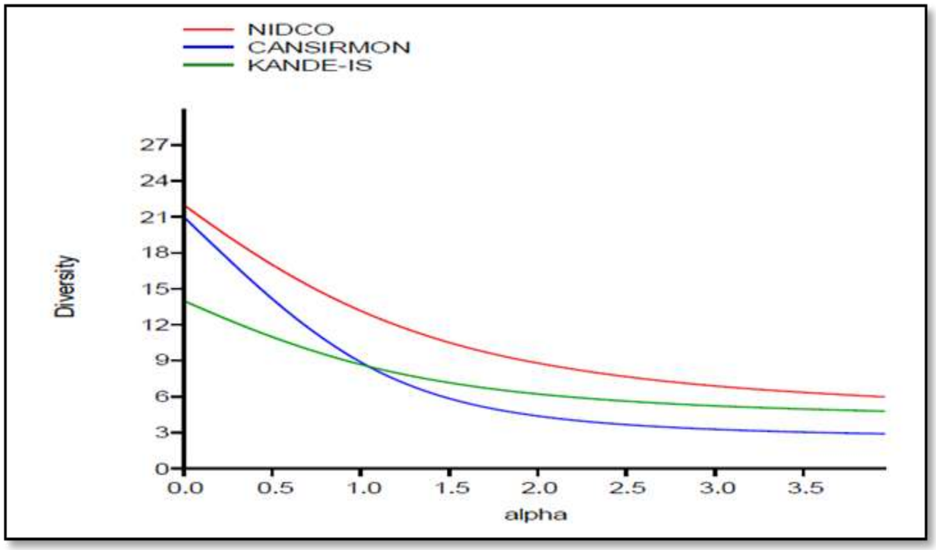

Figure 2. Diversity profile in Brgy. Buenavista, Himamaylan City, Negros Occidental.

The species accumulation curve presented in Figure 3 reveals that the number of taxa (species) identified increases with increasing sampling (P>0.05). The curve, however, is not reassuring as it indicates that further sampling might have recovered a lot more taxa, hence this study might have underestimated the tree diversity in the study sites.

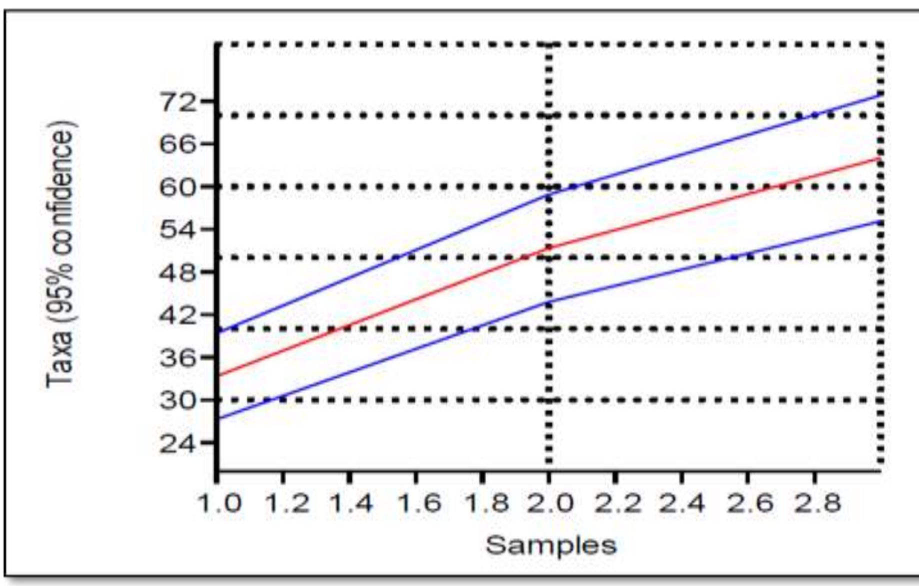

Figure 3. Species-accumulation curve in Brgy. Buenavista, Himamaylan City, Negros Occidental

Tree Carbon Stock

The average diameter at breast height (DBH), basal area and above ground biomass from the three sampling sites is presented in Table 3. Madaja had the highest average DBH, while NIDCO had the highest basal area and AGB.

Table 3. *The average diameter at breast height, basal area and above ground biomass in Brgy. Buenavista, Himamaylan City, Negros Occidental.*

SITE	AVERAGE DBH (cm)	BASAL AREA (m2)	AGB (Kg)
NIDCO	22.52	11.98	70.04
Madaja	25.44	11.27	55.44
Kandiis	19.17	7.2	34.59
Total/Ave.	**22.38**	**30.45**	**160.07**

Table 4 revealed that NIDCO had the highest carbon stock at 194.56 tons/ha, followed by Mt. Cansirmon with 154.0 tons/ha, while Candi-is had the lowest average stock at 96.08 tons/ha. The variation on the results was influenced by the variety and diversity of forest trees in the respective sites.

Forest lands constitute the biggest and long-term potential in carbon sequestration, and as such should be conserved by slowing deforestation, reforestation and agroforestry (Brown et al. 1996). However, at present, the world's forests are estimated to be a net source of 1.8 Gt of carbon per year, primarily because of deforestation, harvesting and forest degradation (Watson *et al* 2000). At least 20% of all atmospheric carbon dioxide emissions are from tropical deforestation as cited from the study of Lasco, et al in 2000.

Table 4. *Computed carbon stock in Brgy. Buenavista, Himamaylan City, Negros Occidental*.

SITE	AREAS, ha				CARBON STOCK, TONS				CARBON STOCK, TONS/ha			
	T1	T2	T3	Total	T1	T2	T3	Total	T1	T2	T3	Ave.
NIDCO	0.12	0.12	0.12	0.36	33.98	17.26	18.80	70.04	283.17	143.83	156.67	194.56
Cansermon	0.12	0.12	0.12	0.36	15.74	16.82	22.88	55.44	131.17	140.17	190.67	154.00
Candi-is	0.12	0.12	-	0.24	24.59	10.00	-	34.59	204.92	83.33	-	96.08
Total/Ave.	0.36	0.36	0.24	0.96	74.31	44.08	41.68	160.07	206.42	122.44	115.78	148.21

Legend: T = Transect

DISCUSSION

Over the last century, studies of the species composition and community structure of assemblages of land plants and their dependent heterotrophs have helped the global delineation of distinct biomes (Smith et. al. 2008). In this study, diversity indices and relative dominance profile of tree species were used in assessing tree diversity in the study sites. The highest species diversity was found in NIDCO (H’=3.01), followed by Cansirmon (H’=3.00), and

Candi-is (H'=2.36). In comparison to the other sites, Cansirmon had the highest species richness (Dmg=12.75), while NIDCO has the most evenly distributed tree species (D=0.12). Cansirmon had the most number of species (T=38); while Candi-is had only one dominant species (*Shorea contorta*), resulting in low diversity. Pausas and Austin (2001) documented similar cases, that was the study that gives baseline information on the effects of anthropogenic disturbance on forest species distribution and diversity. Austin et al. (1996) discovered that species diversity and ecosystem establishment are significantly influenced by edaphic or soil characteristics. At the same time, competition for nutrients, reduced light by canopy trees, and damage to understorey species during tree harvesting can all be factors in the poor establishment of some species. Similar incidents were found in disturbed and natural regeneration forests in Korup National Park, according to Egbe et al. (2012), and Coley and Barone (1996).

The analysis of species composition in all three sampling sites revealed that a total of 12 tree species, including *Shorea contorta (*RD=38.98%)*,* *Ficus variegata* (RD=19.66%) and *Parashorea malaanonan* (RD=13.79%) were abundantly distributed (RD ≥ 5.00). In addition, three species were found to have frequent distribution (4.00 ≤ RD ≤ 4.99), while 10 species were occasionally distributed (3.00 ≤ RD ≤ 3.99). A total of 44 tree species were categorized as rarely distributed (1.00 ≤ RD ≤ 2.99). *Parashorea malaanonan* (Bagtikan) predominates in NIDCO (IVI = 40.30) and *Shorea contorta* (White lauan) predominates in Candiis (IVI = 94.8) while *Ficus variegata* (Taloot) predominates in Mt. Cansirmon (IVI = 49.4). A high importance value (IVI) indicates that a species is well represented in the stand. IVI can be attributed to either the large number of individuals of a species or to the large basal area of a species, as compared with other species in the stand (Kimmerer, 2019). The presence of a dominant species may increase the primary production of an ecosystem, because it has higher ecological resource-use efficiency than sub-dominant individuals (Gong et al., 2018). One species may achieve dominance either by colonizing most of a large open patch and persisting thereafter, or by gradually replacing the existing residents. The most dominant species are also found to be the most resistant to deleterious physical or biotic conditions because it is superior in competition to all others (Connell,1989).

Forest diversity plays a vital role in supporting ecosystem processes, functions and services (Gebrewahid et al., 2020). Species diversity was found to be significantly influenced by forest structure and species composition (Huang et al, 2003). For trees, a positive relationship was expected because both tree diversity and above-ground carbon are known to be lower in regrowth forests compared to old-growth forests (Van de Perre et al.,2018). High species diversity is often connected to more complex vertical structure.

Furthermore, this study revealed that the carbon stocks in the three study sites were influenced by the diversity of forest trees and land use patterns. The logged-over sampling site had the highest diversity and carbon stock, as compared with the two sampling sites located in a secondary forest. Sintayehu et al. (2020) explained that the potential of natural vegetation's above ground carbon stock was higher than that of agricultural land. Conversion of uncultivated land into agricultural land found a 22% reduction in soil carbon stock. Thus, any human activities that have serious impact on soils would have major implications in declining carbon stock in the cultivated land. Conversion of natural vegetation to agricultural land was known to decrease soil carbon stock due to disturbance of the soil surface. In addition to edaphic condition, the biotic, topographic and disturbance factors may also influence the variation in carbon stocks of forests (Gebeyehu, 2019).

Understanding the relationship between carbon stock and biodiversity is very important in achieving the optimum balance between them because biomass is a significant component of forest stand productivity (Lasky et al., 2014). Moreover, understanding the dynamics of tree carbon stock in relation to key factors is of prime need for sustainable management of forest carbon sinks (Pragasan,2020). According to Kurniatun Hairiah, et al. (2001), carbon stock estimates may also be focused at a specific ‘area,' regardless of vegetation or land use, or a specific ‘activity,' or type of land use or land cover as found within a specific geographic domain. Brown et al. (1991) found that tropical forests in Asia with little human disturbance had aboveground biomass of more than 350–400 Mg ha-1, compared to 194–270 Mg ha-1 for forests exposed to human disturbance.

CONCLUSION

It is concluded in this report that Cansirmon had the highest diversity and carbon stock across all the three sampling sites. The type of vegetation present determines the amount of carbon and biodiversity found in a given area of land. In the study sites, various levels of disturbance have different effects on tree diversity, as well as carbon stock. The estimated carbon stock in the different study sites at the Ilog Hilabangan Watershed Forest Reserve can be used to prioritizing forest patches for protection and conservation. The results of the study suggest that the Ilog-Hilabangan Watershed Forest Reserve Management Council should include forest conservation and regeneration strategies in their forest resource management plan. These may include natural regeneration, planting of appropriate tree species that are rarely or not present on the site to increase species richness, and reforesting the open degraded portion of the watershed.

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