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Carbon stock assessment of the undisturbed forest in the heavily mined Island of Nonoc, Surigao City, Philippines

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Abstract

Forest serves as a significant carbon sink that helps minimize carbon concentrations in the atmosphere through the process of carbon sequestration. The purpose of this study was to determine the total carbon storage of the forest reserve area in Nonoc Island, Surigao City, as one of the areas in Surigao del Norte facing threats of forest degradation from mining and anthropogenic activities. Non-destructive and destructive sampling methods were used to determine the total aboveground (TAG) and belowground (BG) biomass density (BD) and carbon stock of the natural forest's various carbon pools. Results revealed a total BD of 606Mg ha^{-1} composed of 484Mg ha^{-1} TAG while BG is 122Mg ha^{-1}. The forest has an estimated carbon stock value of 368Mg ha^{-1}. *Artocarpus blancoi* has the highest carbon stock value of 41Mg ha^{-1} among the 19 species of trees recorded in the area. This implies that the Nonoc Island Forest reserve stored a significant amount of carbon, similar to the reports of other natural forests in the country that may help reduce carbon concentration. As a result, this study would like to recommend preserving and improving the island's remaining forest areas, not only for forest resource conservation but also for climate change mitigation measures.

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Introduction

Global warming has become one of the major concerns since human civilization started the industrial revolution (Bahadur *et al.*, 2010; Watson *et al.*, 2001). According to IPCC (2007, 2001), there is strong evidence that human activities have increased the amount of greenhouse gases (GHGs) in the atmosphere, causing a gradual increase in temperature and, thus global warming. Carbon dioxide (CO^2) is one of the GHGs that can trap heat that mainly causes the rising of temperature on the earth's surface (Uejio *et al.*, 2015). Although the emission of atmospheric CO^2 is a product of both natural and human activities, the significant contribution of CO^2 in the atmosphere comes from anthropogenic activities such as the combustion of fossil fuels, deforestation, and other land-use changes (Henderson *et al.*, 2018; Peters *et al.*, 2013).

Carbon sequestration is a natural and deliberate process of removing CO^2 and storing it in different carbon sinks like the ocean, terrestrial environments (soil and forest), and geologic formation (Sunquist *et al.*, 2008). Aside from ocean sinks, terrestrial biomes also sequestered a significant amount of carbon where around 500 GtC are stored aboveground in plants and other living organisms (Prentice, 2001) and approximately 1,500 GtC in soil (Rice, 2002). Because of the natural ability of forest ecosystems to remove the excess amount of atmospheric CO^2, forest carbon sequestration is recognized as one of the most effective measures for reducing the amount of carbon in the atmosphere (Pan *et al.*, 2011; Eric *et al.*, 2008; Pregitzer and Euskirchen, 2004). However, global forest cover is continuously declining over the past decades due to massive deforestation and major land conversions. If these circumstances are not mitigated, it will impose more adverse impacts not only on humans but on the balance and distribution of carbon that accelerates the process of global warming.

Philippines is one of the countries in Southeast Asia where forest covers depleted significantly over time (Lasco and Pulhin, 2009; Pulhin *et al.*, 2007; Dolom and Dolom, 2006). Along with logging and other deforestation activities, mining is also one of the driving forces that significantly decrease forest cover accounting for more than 12 million ha (Camacho *et al.*, 2009) since the 1930s.

Nonoc Island in Surigao City is one of the areas in the province of Surigao del Norte where one of the biggest mining companies is operating. With rich nickel deposits, the mining operation has long been operating since late 1974. The previous company on the island was shut down due to storm after storm disasters in the late 1980s. However, since most of the areas in the province are declared mineral reserves including Nonoc Island, mining operations are still permitted to operate. Given the situation of the island and the whole province as a typhoon belt and its vulnerability to the potential hazards of climate change, it is a major challenge to the local government to manage the remaining forest covers without hampering economic development. Thus, baselining on the characteristics and importance of the forest is one of the critical steps in managing the remaining forest resources for natural hazard and climate change mitigation.

Several studies of carbon stock assessments have been conducted in some parts of the Philippines already. However, most of the studies conducted are in the agroforestry system and, or forest plantations. Based on the reports and available literature, only a few studies (Coracero *et al.*, 2022; Origenes and Lapitan, 2021; Bobon-Carnice and Lina, 2017; Tulod, 2015; Ebasan *et al.*, 2016; Lasco *et al.*, 2002) conducted carbon stock assessment in the natural forest ecosystems in the country. This study believes that measuring the carbon stock of a natural forest aside from plantations is an essential step to having reliable estimates of carbon accounts and determining its carbon-carrying capacity for the protection and management of the remaining forest covers, especially in dealing with the impacts of climate change. This study generally aimed to measure the carbon stock of the forest reserve in Barangay Talisay of Nonoc Island, Surigao City. Specifically, it aimed to compute the biomass density of the above and below ground, determine the carbon stock of the different carbon pools, and identify the species of tree that has the highest carbon stored in the area.

Materials and methods

Study area

Surigao City is located in the northeastern part of Mindanao adjacent to Leyte, Dinagat Islands, and Siargao Islands (Fig. 1). Nonoc is one of the major islands in Surigao City consisting of 3 barangays namely: Nonoc, Cantiasay, and Talisay. According to the Surigao City Municipal Office, the whole island has a total land area of 66.4527 km^2 of which 1.6 km^2 was declared as a Special Economic Zone for heavy industries due to the high deposition of Nickel. The 3 barangays within the island were classified as rural island barangays. The island falls under climate type II condition with no definite dry season but with a pronounced maximum rainfall from January to March and October to December. Annual average rainfall on a 12-year spread is 3,021mm. The forest reserve has a total land area of 30 hectares (0.3km^2) with geographic coordinates of 9˚50'6.587" north and 125˚36'12.431" east. The whole forest is under the jurisdiction of the private mining company operating on the island.

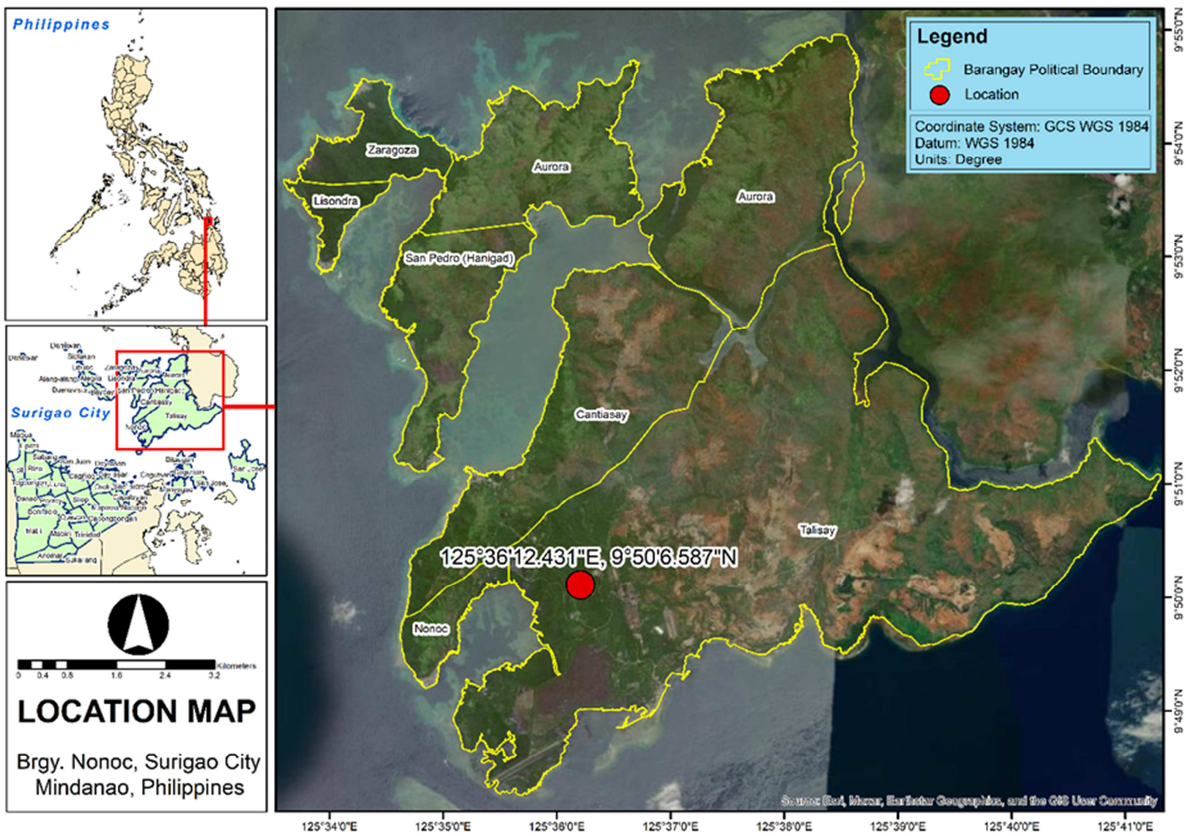

Fig. 1. Map of Nonoc island, Surigao City showing the study site.

Establishment of the study sites

As suggested by Hairiah *et al.* (2010) for natural forest or heterogeneous vegetation, two (2) 5m x 40m plots (200m^2) were established randomly for measuring tree biomass density (TBD) with a distance of 50 m away from each other (Fig. 2). An additional extension of a 20m x 100m plot (2000m^2) was applied for every sampling plot for the identification and measurement of trees greater than 30cm diameter at breast height (DBH). Within the 5m x 40m sample plot, six (6) sampling frames were alternately established measuring 1m x 1m for collecting the understory biomass. Inside each 1 m x 1 m subplot, another subplot measuring 0.5m x 0.5m was established to collect the litter layer and soil organic matter.

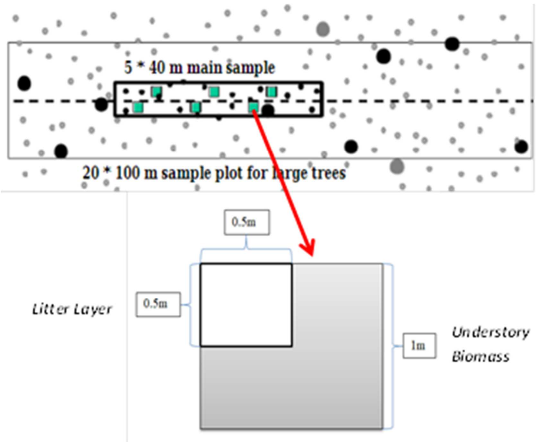

Fig. 2. Design and layout of nested sampling plot technique (Hairiah *et al.*, 2010).

Data gathering

Total aboveground biomass (TAGB)

Tree biomass (TB)

Non-destructive sampling was applied for measuring the aboveground (AG) biomass of living trees. Inside the 5 m x 40 m plots, only trees with stem diameters ranging from 5cm to 30cm were counted and measured using a tree caliper or tape measure at 1.3 m above the soil surface. While, in the extension plot of only 20m x 100m, trees with greater than 30cm DBH were counted and measured.

Understory biomass (UB)

Within the 5m x 40m plot, destructive technique was applied to the understory layer. All vegetation with less than 5cm DBH was harvested within the six (6) alternate established 1 m x 1 m quadrats. Bolo was used for cutting the shrubs and understory biomass. The total fresh sample was weighed in the field, after which a sub-sample of about 300g was only taken. Then, the sub-sample was subjected to oven-drying and weighed to determine the total dry weight of the understory biomass.

Litter biomass (LB)

All the decomposed plant materials like leaves and branches were collected inside the 0.5m x 0.5m sub-plot. The same procedure was applied in the understory, decomposed materials were weighed, and then a sub-sample of 300g was only being taken. The samples from two sampling plots were over-dried.

Belowground (BG) biomass

Root biomass (RB)

No sampling procedure was applied in gathering the RB. This was determined on a purely equational basis because it is based on the above-ground tree biomass (see data analysis for the computation).

Soil organic carbon (SOC)

The same plot for the litter layer, soil samples were taken from each of the sample plot at 0-30cm depth. The soils were sieved through a 5-mm mesh screen and mixed to a uniform color and consistency then a subsample of 500g was taken for carbon analysis. The collected samples were delivered to the Regional Agriculture Office in Butuan City for the determination of organic carbon content using Walkley-Black method (Mac Dicken, 1997).

In one of the four subplots, an undisturbed soil was taken through core sampling to determine the bulk density with an aluminum cylinder with a diameter of 5.3cm and length of 10cm. Soil samples were initially air-dried or oven-dried at 105-110°C for at least 24 hours or until stable weight.

Data analysis

In measuring the biomass of the different carbon pools, the following equations were used:

Tree Biomass (TB)

The TB density of was calculated using the allometric equation for natural forests and plantations by Brown (1997):

Y (Kg) = exp(-2.134+2.530*In*D) for natural forest and plantation (Eq. 1)

Where;

Y	=	Tree biomass, kg/tree
exp {…}	=	"raise to the power of (…)"
In	=	"natural logarithm of (…)"
D	=	tree DBH (cm)

After measuring TBD, equations were used as high and low estimates for the tree biomass in this study. Tree biomass density and carbon stored were calculated using the formula:

Tree biomass density = Tree biomass (Mg)/Sample area in hectare (Eq. 2)

In estimating the carbon stored, a default value of 46% (Hairiah *et al.*, 2001) of carbon content was used using the formula:

Carbon Stored (Mg ha^{-1}) = aboveground tree biomass (Mg) x Carbon content (0.45) (Eq. 3)

UB

After measuring the TBD, understory biomass was followed. The first step in any harvesting method is to measure the Total dry weight (TDW). TDW was calculated using the formula (Hairiah *et al.*, 2001):

TDW (kg/ m^2) = (Total fresh weight (kg) x subsample dry weight (g))/(Subsample fresh weight (g) x sample area (m^2)) (Eq. 4)

After the determination of TDW, the carbon content of the understory was measured using this formula:

C stored (Mg ha^{-1}) = TDW x Carbon Content (Eq. 5)

RB

Lastly, the measurement of root biomass is not simple (Hairiah *et al.*, 2010; Hairiah *et al.*, 2001; Smit *et al.*, 2000) because harvesting is the traditional and most accurate method of measuring the biomass of the root system. For the purpose of this research without destructing the forest ecosystem, this study applied a non-destructive technique suggested by Van Noordwijk and Mulia (2002). This approach uses AGB (Chave *et al.*, 2005) and allometric equations using default assumptions that are normally used for the shoot: root ratio (Van Noordwijk *et al.*, 1996; Cairns *et al.*, 1997; Mokany *et al.*, 2006). Although the root biomass of live trees is not yet standardized, the equation of Cairns *et al.* (1997) as cited by Tulod (2003) was used to compute the root biomass using the formula:

RB = Exp[-1.0578+0.8836 x In(AGB)] (Eq. 6)

Where:

RB	=	Root Biomass (Mg ha^{-1})
Exp	=	e to the power of
In	=	Natural Logarithm
AGB	=	Aboveground Biomass

After measuring the RB, the carbon stored was measured using the formula:

Carbon Stored (Mg ha^{-1}) = Root Biomass x Carbon content (Eq. 7)

LB

The same formulas in the understory were applied for measuring the TDW, biomass density, and carbon content for the litter layer.

SOC

Walkley-Black method (MacDicken, 1997) was used in determining organic carbon content in every soil sample. To calculate the weight of SOC per hectare, the following formula was used (Patricio and Tulod, 2010):

Carbon density (Mg ha^{-1}) = weight of soil * %SOC (Eq. 8)

Where:

Weight of soil (Mg) =bulk density * volume of 1 hectare

Bulk density (g/cc) = Oven-dried weight of soil / Volume of canister

Volume of canister = π r2 h

Volume of one ha = 100m * 100m * 0.30m

Once the biomass and carbon potential of every sampling area is estimated, descriptive statistics was applied using mean, median, mode, and standard deviation to describe the set of data of every study site. For correlation and regression analysis, R Studio and Microsoft excel were applied.

Results

Biomass density (BD)

Biomass is the total amount of organic matter in a given area (Krug and dos Santos, 2004). When biomass is presented as mass per unit area, the term biomass density is used. Results revealed an estimated total mean BD of the forest reserve is 606Mg ha^{-1} composed of 442Mg $ha^{-1}$of TB, 30Mg ha^{-1} of UB, 13Mg ha^{-1} of LB, and 122Mg ha^{-1} of RB (Table 1). The importance of measuring biomass density is it provides estimates of the productivity of the ecosystem.

The estimation of BD provides information about the nutrients, carbon stored, and, or the amount of extractable products in a given area.

Table 1. Biomass density (BD) of total aboveground (TAG) and belowground (BG).

Carbon Pool		BD (Mg ha^{-1})
TAG	TB	442
	UB	30
	LB	13
		484
BG	RB	122
Total		606

TB=tree biomass, UB=understory biomass, LB=litter biomass, RB=root biomass

The result of total aboveground biomass (TAGB) (484Mg ha^{-1}) in the study area is within the range (446-1126Mg ha^{-1}) of secondary or old-growth forests in other parts of the Philippines reported by Lasco *et al.*, (2000, 2002). It is lower than the TAGB (690Mg ha^{-1}) of the secondary forest in Lake Danao National Park, Ormoc, Leyte, Philippines (Bobon-Carnice and Lina, 2017) but higher than the TAGB (251Mg ha^{-1}) in the second growth forest in Maramag, Bukidnon, Philippines (Tulod, 2015).

The mean TB (442Mg ha^{-1}) of the study area is lower to the mean TB (641Mg ha^{-1}) in the secondary forest in Panaon, Misamis Occidental, Philippines (Ebasan *et al.*, 2016) but higher compared to the tree BD result (161Mg ha^{-1}) in the mixed forest of Mt. Malindawag, Lubilan, Naawan, Misamis Oriental, Philippines (Origenes and Lapitan, 2021) and the result (298Mg ha^{-1}) in the second growth forest of Maramag, Bukidnon, Philippines (Tulod, 2015). The high BD of the tree is associated with high population density in the study area. A total of 59 standing trees were counted in the study area, including the trees with greater than 30cm DBH outside the 200 m^2 sampling plots. The average number of counts of standing trees in every plot is 30 individuals and the mean number of individuals per species is 3 with a standard deviation of ± 1. The mean individuals per quadrat result in this study is higher compared to the report (25 individuals) of Origenes and Lapitan (2021) in the mixed forest of the mixed forest in Mt. Malindawag, Lubilan, Naawan, Misamis Oriental, Philippines.

The average DBH of every species is 21cm ranging from 6cm to 47cm with a standard deviation of ± 13cm. Using the correlation coefficient, results revealed that the number of individuals per species has a very high positive correlation (r = 0.928964; p value= 1.483 x 10^{-08}) to the total biomass density in the study area. While average DBH showed a positive negligible correlation with an only r value of 0.09678884 with a p-value of 0.6934.

This implies that the number of counts per species is the major contributing factor to the TBD instead of the DBH of the different individuals of every species. Despite the relatively small tree DBH in the study area (21cm), the high population density contributes to the high accumulative TBD result in the forest reserve. Using regression analysis, the model predicts that each additional number of individuals is associated with an additional 5.8348 TBD (Fig. 3). R^2 value revealed 86% (0.8554) of the variability of the total TBD is explained by the number of individuals per species while only 3% (0.0292) in mean DBH.

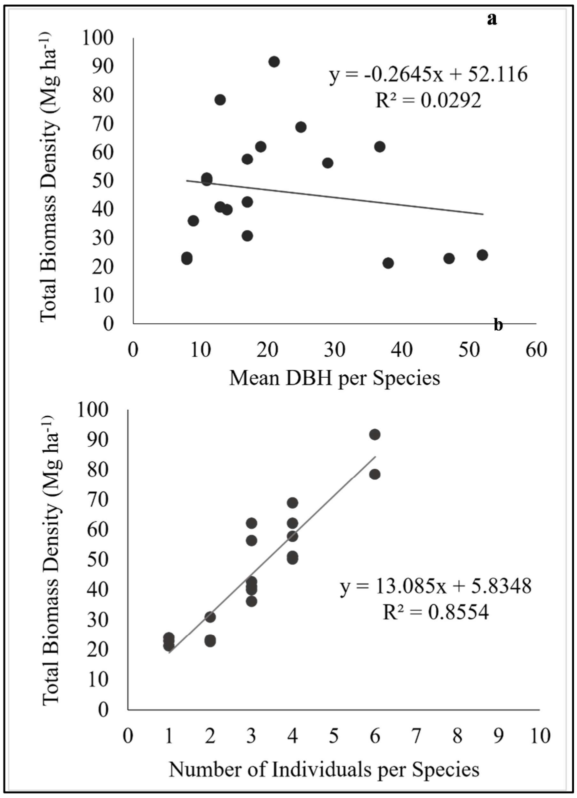

Fig. 3. Scatter plot and regression analysis of the total tree biomass density values in every species in relation to the number of individuals per species (a) and average DBH of every species (b).

As emphasized by Kara *et al.* (2008), trees with relatively large canopy covers have strong effects to the litter accumulation and it decreases the understory vegetation by blocking the light (Sigurdsson *et al.*, 2005). Majority of the species found in the study area belong to family Moraceae (Table 2) which are known to have most species having dome shaped and dense canopy (Somashekhar *et al.*, 2013) resulting to low UB (30Mg ha^{-1}) and LB (13Mg ha^{-1}). Despite the low BD values of UB and LB in the whole study area, results are still higher compared to the report of Tulod (2015) in the second growth forest in Maramag, Bukidnon, Philippines.

RB is one of the significant components of carbon stocks in terrestrial ecosystems, and it is also a critical means of understanding the ecophysiology of vegetation communities (Qi *et al.*, 2019; Macinnisng *et al.*, 2010; Mokany *et al.*, 2006). According to most studies, root biomass accounts for around 20% of aboveground forest carbon stocks in most forest types; however, it can be less than 10% or more than 90% in certain vegetation types. (Houghton *et al.*, 2001, Achard *et al.*, 2002, Ramankutty *et al.*, 2007; van Noordwijk *et al.*, 1996; Cairns *et al.*, 1997, Mokany *et al.*, 2006). Moreover, several studies also claimed that the ratio of AG to BG biomass is approximately 4:1 (van Noordwijk *et al.*, 1996; Houghton *et al.*, 2001; Ramankutty *et al.*, 2007). In extremely wet conditions, the ratio can reach 10:1, whereas in dry conditions, it can fall to 1:1. The computed estimated RB value of the area showed 122Mg ha^{-1} accounting for 28% of the total TBD. Results revealed a ratio of approximately 8:2 AG to BG and BG ratio. The RB result is also higher than the report of Tulod (2015) (39Mg ha^{-1})

Carbon stock

The term "terrestrial carbon stocks" refers to the carbon stored in terrestrial ecosystems as living or dead plant biomass (aboveground and belowground) and soil, as well as usually negligible amounts as animal biomass (Hairiah *et al.*, 2010). The forest reserve revealed an estimated carbon stock of 368Mg ha^{-1}. The result in this study area is higher compared to the carbon stock time-averaged (250Mg ha^{-1}) for the natural forest ecosystem reported by Palm *et al.*, (2004). If the result of the mean C stored will be compared to other studies in the Philippines where all the carbon pools are computed, having the same or relative type of vegetation patterns (natural/ secondary forest), the result (368Mg ha^{-1}) is lower to the report of Lasco *et al.* (2004) in the secondary forest in Mount Makiling Forest Reserve, Philippines (418Mg ha^{-1}), and Lasco *et al.* (2002) in the natural forest of watershed area in Geothermal plant in Leyte with carbon stored value of (393Mg ha^{-1}) but higher compared to the report of Coracero *et al.* (2022) in the preserved natural forest of Baler, Aurora (272Mg ha^{-1}), Bobon-Carnice and Lina (2017) in forest park of Lake Danao National Park, Ormoc, Leyte (311Mg ha^{-1}). In a forest ecosystem, there are five different pools namely aboveground biomass, belowground biomass, deadwood, litter, and soil (Hoover and Riddle, 2020; Hairiah *et al.*, 2010). The carbon pools in various forest ecosystems are strongly influenced by different environmental factors such as temperature, rainfall, topography, forest type and structure, tree species composition, species diversity, land-use changes, and human-induced disturbances (Meena *et al.*, 2019; Wei *et al.*, 2013; Vayreda *et al.*, 2012). Fig. 4 shows the amount of carbon stored in different carbon pools where AG has the highest carbon stock value of 217Mg ha^{-1} accounting 59% of the estimated total carbon stored followed by soil organic content (SOC) (89Mg ha^{-1}, 24%), RB (56Mg ha^{-1}, 15%), and litter layer (6Mg ha^{-1}, 2%) respectively. The C stored value in tree biomass is higher compared to the report of Origenes and Lapitan (2021) (72Mg ha^{-1}).

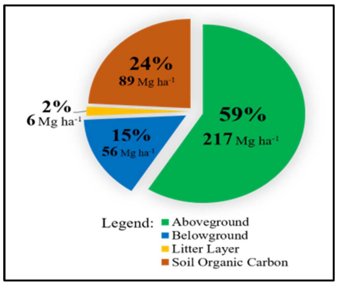

Fig. 4. Percentage of carbon in the different carbon pools in the Forest Reserve in Nonoc Island, Surigao City, Philippines.

The amount of SOC content is determined by the rate of organic matter inputs, accumulation, rate of mineralization in different organic carbon pools, stand type, and stand age (Meena *et al*., 2019; Cao *et al*., 2018; Post and Kwon, 2000). The SOC result is lower to the report of Lasco *et al.* (2002) (193Mg ha^{-1}). Although SOC is lower to other study reports, the relatively high carbon stored in the soil in the study area (24% of the total C stored) reflects high plant residues and other organic solids stored and retained as soil organic matter (SOM) in the study area (Olson, 2013). Moreover, the high SOC in the forest reserve is also due to the less disturbances from human activities from adjacent communities and mining company operating in the island. Several studies emphasized that anthropogenic activities particularly the conversion of natural vegetation (Post and Kwon, 2000) and poor land use and soil management practices (Bobon-Carnice and Suzette, 2017; Tıan *et al*., 2002) can significantly influence the soil organic dynamics and carbon flux of the soil. Aside from disturbances and land use management, climate and vegetation type (Baker *et al*., 2007; Six and Jastrow, 2002) are also the possible factors that influence the soil organic dynamics of an area. According to PAG-ASA, Caraga (Region 13) has a climate of type II, with no distinct dry season but a pronounced maximum rainfall from January to March and October to December. Mani *et al.* (2018) claimed that rainfall has a strong influence to the SOM of a given area.

Species Composition and Carbon Stock (AG)

According to several studies, the composition of tree species influences the total biomass and carbon stock of a forest ecosystem (Solomon *et al*., 2018; Borah *et al*., 2015). Some tree species have relatively larger stem diameter and have dense canopy cover and wide crown compared to others. A total of 59 tree individuals were observed and counted in the study area composed of 19 species belonging to family: Anacardiaceae, Apocynaceae, Burseraceae, Combretaceae, Dilleniaceae, Dipterocarpaceae, Fabaceae, Favaceae, Lamiaceae, Lauraceae, Moraceae, Myrtaceae, and Verbenaceae (Table 2). The study has an average of 9.5 species per quadrat similar to the report of Origenes and Lapitan (2021). Among the tree species in the study area, *Artocarpus blancoi* generated the highest accumulated carbon estimate value of 41Mg ha^{-1}. *A. blancoi* is expected to have the highest AG carbon stored because it is one of the species with high number of individuals (6) and has an average DBH of 21cm ranging from 7cm to 47cm.

Table 2. Species composition, total tree biomass, and total carbon content of every species in the 2 sampling plots of the forest reserve of Nonoc Island, Surigao City, Philippines.

Species	Common Name	Family	Total Tree Biomass (Mg ha^{-1})	Total Carbon Content (Mg ha^{-1})
Aleurites moluccanus	Candlenut	Euphorbiaceae	62	28
Alstonia macrophylla	Batino	Apocynaceae	50	23
Alstonia scholaris	Dita	Apocynaceae	41	18
Artocarpus altilis	Breadfruit	Moraceae	31	14
Artocarpus blancoi	Tipolo	Moraceae	92	41
Buchanania arborescens	Balinghasai	Anacardiaceae	36	16
Canarium luzonicum	Manila Elemi	Burseraceae	23	10
Cinnamomum mercadio	Kalingag	Lauraceae	40	18
Dillenia philippinensis	Katmon	Dilleniaceae	23	10
Ficus benjamina	Balete	Moraceae	24	11
Ficus callosa	Kalukoi	Moraceae	69	31
Ficus pseudopalma	Lubi-lubi	Moraceae	78	35
Gmelina arborea	Gmelina	Lamiaceae	56	25
Leucaena leucocephala	Ipi-ipil	Favaceae	23	10
Pterocarpus indicus	Narra	Fabaceae	21	10
Shorea palosapis	Mayapis	Dipterocarpaceae	51	23
Terminalia microcarpa	Kalumpit	Combretaceae	43	19
Vitex parviflora	Molave	Verbenaceae,	62	28
Xanthostemon sp.	Mangkono	Myrtaceae	58	26
Total			883	396
Mean			46	21

Although in the study area, *Ficus benjamina* generated the largest DBH value of 52cm compared to other species, *A. blancoi* (6 individuals) outnumbered *F. benjamina* with only 1 individual resulting to high total BD and high carbon stock. Similar counts (6) were also observed in *Ficus pseudopalma*, however, its mean DBH (13cm) is 38% smaller compared to *A. blancoi* mean DBH (21cm).

Conclusions and recommendations

Results revealed that the forest reserve in Nonoc Island, Surigao City stored significant amount of carbon (368Mg ha^{-1}) which is comparable and even higher to other reports with relative type of vegetations in some areas in the country. Aside from tree biomass (217Mg ha^{-1}, 59%), SOC also account large portion (89Mg ha^{-1}, 24%) of the total C stored in the study area. Despite the high deposition of nickel, it also holds several species of trees within the island. Among the 19 species of trees found in the study area, *A. blancoi*, under family Moraceae, has the highest C stock value of 41Mg ha^{-1}.

To sustain and enhance the carbon stored and the remaining resources of the forest reserve in the area, this study would like to recommend to the mining company and the regional DENR-BMB together with the local government of Surigao City the following:

- Pursue the protection of the existing natural forest,
- Strictly monitor the land use boundaries between the forest reserve, community and mining site operation; and
- Provide sustainable livelihoods to the local community to prevent them from future forest encroachment.

The preservation and enhancement of the forest reserve in the island of Nonoc, Surigao City, is an essential step in mitigating climate change in local setting and conservation strategy of the remaining forest resources on the island.

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