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Carbon stock assessment through above-ground biomass of trees at different forest composition in Mt. Malindawag, Lubilan, Naawan, Misamis Oriental, Philippines

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ABSTRACT

It is documented that the amounts of carbon stored and its level of degradation in different forests compositions and different types of forest is mostly unknown, Philippines is no exemption as little was done in some places of this country. This study was conducted to assess carbon stock through above ground biomass of trees at different forest composition in Mt. Malindawag. There were three (3) 20m x 20m sample plots (quadrats) (400m^2 equivalent to 0.04 ha) established as replicate plots provided with 50m intervals. Forest composition such as the Agroforestry area, mixed forest area and the Plantation forest were assessed in terms of the number of individuals, number of species, diameter, and height to calculate the biomass, tree biomass density as well as the carbon stock. Based on the results of the study conducted in different forest compositions of Mt. Malindawag, plantation forest has the highest carbon stocking rate. However, these results were not significantly different from the other forest composition. This was associated with a higher accumulated diameter, which resulted in higher biomass and eventually carbon stock. Species found in this forest composition are productive and have lesser number of individuals; therefore, there is lesser competition for resources such as light. Such a mechanism might contribute to the higher biomass and carbon stock. However, the result may not be right to other areas due to uncontrollable factors, anthropogenic and environmental factors. Hence, it is recommended to have further studies on areas where trees have similar age, species diversity index as well as stand development and site productivity for a more accurate and quantifiable carbon stock.

Key Words: *Carbon storage, Forest composition, Agroforestry, Mixed forest, Plantation forest, Tree biomass and Species diversity index.*

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I. Introduction

Carbon in the form of carbon dioxide that primarily exists in the atmosphere plays an essential role in aiding existence on earth, as plants form themselves from it (Vashum and Jayakumar, 2012) through photosynthesis. Forest ecosystem is considered as sinks and sources of CO_2 and plays an essential factor in mitigating global climate change (Trexler and Haugen, 1994). The world's tropical forests are a net source of C due to anthropogenic activities, including deforestation with the emission of 1.6 Gt (1 Gt = 10 tons), in 1990 alone. Through massive deforestation, Philippine forests were found to have contributed about 3.7 Pg (1 Pg = 10 tons) of C to the atmosphere from the year 1500 to the modern era (Lasco and Pulhin, 1998). Other factors may be primarily human-induced practices, including the combustion of fossil fuels and land use and land cover changes (IPCC, 1995).

Currently, forest biomass studies have increased in the past several years as primary ecosystem data that are needed to develop sound ecological land management and predict the dynamics and productivity of the forests (Melillo et al., 1993). Moreover, the estimation of biomass is critical nowadays because of a need for the assessment of carbon stocks present in a forest stand. Further, carbon budgets, especially in the forest ecosystem, are significant to assess because it is considered a major sink for storing carbon in the biomass and soil and can emit carbon in the cases of deforestation and degradation. Lasco et al. (2004) also recommended that carbon stocks assessment must be done in different forest areas in the Philippines to have more comprehensive and accurate information about the carbon density of the areas.

Some studies have been conducted to determine stocking characteristics and carbon storage in other countries (Munishi et al., 2010; Shirima et al., 2011) as deforestation and forest degradation are closely linked with low levels of carbon stock increasing greenhouse gas (GHG) emissions. Carbon stored amount in different forests and the extent of forest degradation on carbon storage are largely unknown for many forest types (Burgess et al., 2007). However, little was done in some places in the Philippines and Mt. Malindawag is no exemption as there is no scientific data available to determine carbon stock density as well as its stocking characteristics. This type of forest also can mitigate climate change by absorbing carbon dioxide and storing it in their biomass. Thus, the study was conducted to assess the carbon stock in the above-ground biomass of trees from different forest compositions using a non-destructive method to make sure that the study will not compromise the forest's condition. Furthermore, data gathered was used to quantify carbon stock, which will help track changes in the carbon stock.

II. Materials and Methods

Area and duration of the study

The study was conducted during February - April, 2019, to identify and measure trees present in Mt. Malindawag, Lubilan, Naawan, Misamis Oriental (Figure 01). It has an elevation of 1,000 meters above sea level. In addition, according to the respondents that were interviewed, Mt. Malindawag is classified as secondary forests since the area is disturbed with logging activities and was previously burned during the year 1982, 1985 and 2002.

Mt. Malindawag as classified by PAG-ASA is under Type III of the Modified Corona's Classification Scheme. The areas falling beneath this category is articulated with no extreme rain period and is characterized by means of a short dry season lasting from one to three months. The location and elevation of the area were determined using a GPS receiver.

Description of sampling site

The sampling site was selected based on different forest composition area. There were three sites: an agroforest area, mixed forest area and plantation forest area (Figure 02). The Agro forest area (sampling site 1) is an area that is broadly dominated by combining agricultural crops with forest tree species. Mixed forest (sampling site 2) comprises naturally grown species that compete between trees of different species such as light. Plantation forest (sampling site 3) is composed of one species or few species with even spacing and/or even-aged stands.

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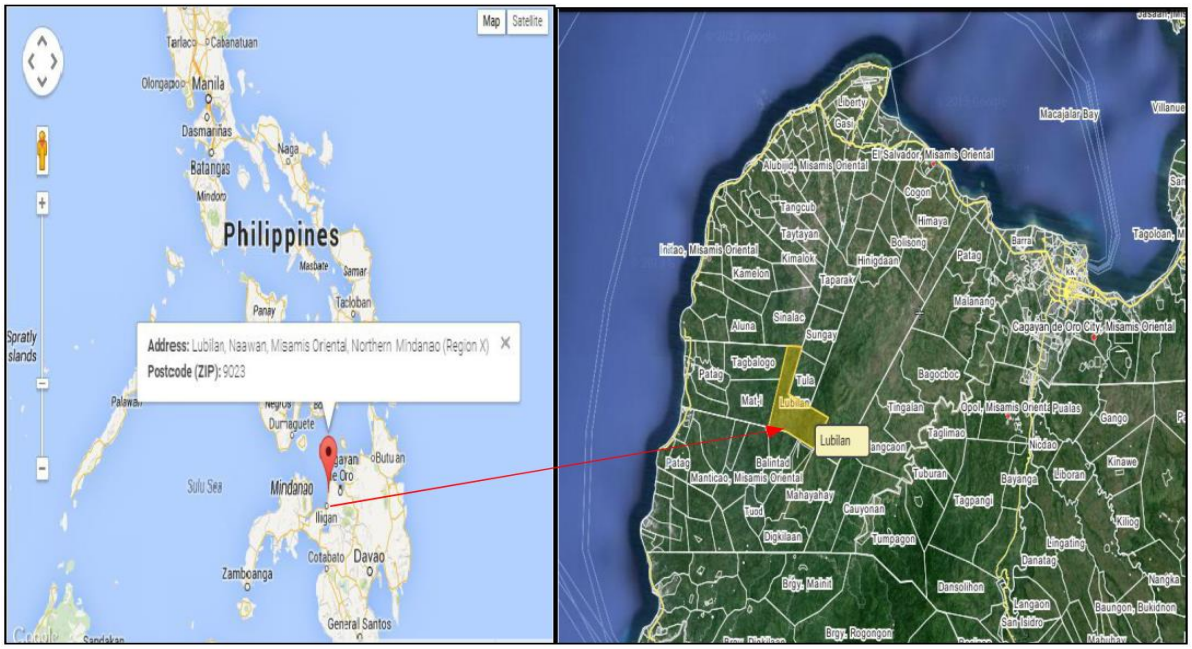

Figure 01. Map showing sampling areas

Sampling layout and collection of data

For above-ground measurement, the field sampling protocol was adapted from Hairiah et al. (2001). Sample plots (quadrats) were established to provide quantitative and qualitative descriptions of the tree species present. The baseline was positioned in the north direction. The north direction is perpendicular to the east of the mountain when tracking or climbing the mountain using the main road.

There were three (3) sampling sites selected within different forest compositions established in an agroforest area, mixed forest area and plantation area (Figure 02). In each sampling site, three (3) 20m x 20m sample plots (quadrats) (400 m^2 equivalent to 0.04 ha) were established as replicate plots which were provided with 50m intervals.

Species of trees with a diameter of more than 10cm DBH were identified and recorded within the 20m x 20m sample plots (quadrats). Circumference of the tree was the measured diameter at breast height (DBH) using a one meter tape measure. For trees of an unusual shape, a standard forestry practice was adopted (Karky and Banskota, 2007) and diameter at breast height (DBH) at 1.3 m was used as this is the primary measurement standard for trees.

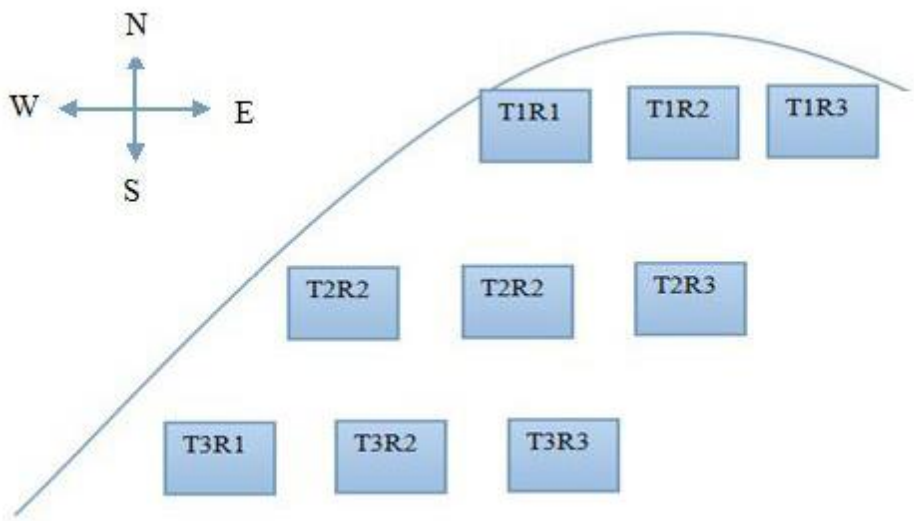

Figure 02. Sampling layout of the study

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Inventory of trees

Local residents were the collaborators in providing the local name of the tree species. Each tree was recorded individually; diameter and common name of trees having a diameter-at-breast height (dbh) of 10 cm and above were recorded. The tree species' analysis and identification were based on the standard taxonomic classification of tree species (Appendix 01).

Mathematical equation analysis

The biomass is assessed through the use of allometric equations generally derived from tree diameter to biomass since destructive sampling is not suggested for trees due to practical concerns. The carbon in trees is then calculated through biomass value (Brown, 1997).

A generic power fit biomass regression equation (Banaticla et al., 2007) using existing data from studies involving destructive sampling for biomass determination of trees conducted in several localities in the Philippines. The following general equation was derived using a non-linear estimation procedure by fitting the pooled biomass data to the power function with potential broader applicability.

Brown (1997) and Banaticla et al. (2007) equations were used as high and low estimates for this study's tree biomass. Tree biomass density and carbon stored were calculated using the following formula, as shown in Table 01.

Table 01. Parameters and the formula in computing the biomass and the carbon stock per tree.

Parameters	Formula
Diameter at breast height	DBH= Girth/3.1416
Height	Ht= tan ø * distance
Biomass	$Y= 0.342D^{2.073}$
Tree biomass density	Tree biomass (Mg)/Sample area in hectare
C stored (MgC ha-1)	Tree biomass density * C content

A default value of 45% was used to determine the carbon stored in tree biomass, which is an average carbon content of wood samples collected from secondary forests from several locations in the Philippines (Lasco and Pulhin, 2000).

Statistical analysis

Data from agroforest, mixed forest and plantation area were computed using Excel 2007. Simple descriptive statistics were employed to describe the data gathered. Data were analyzed using analysis of variance (ANOVA) and was used to differentiate the biomass estimated out of the allometric equation applied and the mean carbon stock estimates were computed. Mean separation was done using the DMRT at 5% level of significance.

III. Results and Discussion

Number of individuals

The number of individuals per forest composition is shown in table 02 below. Mixed forest area (T2) and agroforestry area (T1) have a higher mean number of individuals with 25.33 and 16.33 trees, respectively. The difference is significantly observed between the mixed forest (T2) and the plantation forest (T3). Thus, forest composition has an impact on the number of individuals found per quadrat. According to Bartelink and Olsthoorn (1999), trees found in the mixed forest are composed of naturally grown species that compete between trees of different species. Thus, the mixed forest obtained the highest number of individuals.

Plantation forest is established through planting or seeding, with few species, even spacing and/or even-aged stands (FAO, 2006a). With this, plantation forest obtained the lowest number of species because it is mainly intended to produce wood on a commercial basis and enhance environmental benefits (Nambiar, 1997 and Kile et al., 1998). Agroforestry area is a combination of agronomic crops and trees; thus, fruit trees such as Jack fruit, Coconut and timber trees were found in this forest

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composition. Also, species found in agroforests were planted for economic purposes with spacing per species of trees indicated.

Table 02. Analysis of tree assessment inventory

Treatment	Number of individuals/Quadrat (400m²)	Number of species/ Quadrat (400m²)	Diameter at breast height (cm)	Height (m)
Agroforest (T1)	16.33[ab]	5.33[a]	435.72[a]	267[a]
Mixed Forest (T2)	25.33[b]	9.5[a]	546.8[a]	823.33[b]
Plantation Forest (T3)	12.33[a]	1[b]	515.39[a]	310.83[a]

* Means with the same superscript are not significantly different at 5% level using DMRT.

Number of Species

Table 02 shows the number of species according to forest composition. There were more species in Agro forest (T1) and Mixed forest (T2) than the Plantation forest (T3). Only one species is found in Plantation forest (T3) and significantly different from the other treatments. Therefore, forest composition affects the number of species found.

The study conducted in different forest composition in Mt. Malindawag showed that mixed forest obtained the highest number of species and same results were obtained by Spiecker (2003) that mixed forest has more diverse fauna and flora due to variation in tree age and dimension that will help increase in diversity than pure, single species stands. These areas are naturally grown, which means that it has various types of trees found therein. Moreover, Mixed forest is advantageous over the other forest composition because of the greater diversity of forest products provides economic certainty for local communities, which promotes land use stability that has subsequent beneficial effects for biodiversity conservation (Paquette et al., 2009 and Lamb, 2011).

Plantation Forest (T3) expectedly has the least number of species because of its less diversified systems, such as monoculture practice (Drever et al., 2006). It contains one species with even spacing and/or even-aged stands (FAO, 2006a) and designed with spacing within and between rows (Paquette and Messier, 2011).

Diameter

Mixed forest (T2) obtained the highest diameter since it also obtained the highest number of trees per quadrat with different and varying diameters (Table 02). On the other hand, tree species possessing different diameters and heights may have their own set of habitat requirements for nutrients and coverage (Wang et al., 2011). As forests grow, competition for resources also increases and this may favour the elimination of suppressed individuals (usually small ones) thus, reduce the number of diametric classes according to Keddy (2005) and Healy et al. (2008). Studies were conducted by Buongiorno et al. (1994), Staudhammer and Le May (2001) and Zhang and Chen (2015) on the significant variations in tree DBH, which resulted in a multilayered forest structure with enhanced structural complexity, allowing for more efficient light capture at the stand level. Hence, the result is only valid exclusive of the study sites.

On the other hand, diameter obtained in the Plantation forest (T3) is slightly similar to the mixed forest due to the presence of fast growing and productive species, although lesser in number. The tree species found in this forest composition had more prominent and more even diameter compared to other forest composition. This is due to the partitioning of the resources they have for optimal growth since trees have enough space and less resources. Also, this plantation stand is already mature, considering that trees have almost the same diameter. This result agrees with Gibbs et al. (2007) that mature forests are likely to have a greater incidence of large trees with large diameters.

Height

As shown in Table 02, mixed forest (T2) obtained the highest value for the mean total height with 823.33 meters. This even agrees with Sterba and Monserud (1993) that height is dominant for species in uneven-aged mixed stands. Basically, it is known that in the mixed forest, there is much more competition for resources such as light due to the presence of large number of individuals with limited

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resources needed for their growth and survival. This is also reported by Canham et al. (2004) and Uriarte et al. (2004) that species compete mainly for light as juveniles and nutrients as adults thereby contributing to their apical growth which is the height. Moreover, Bartelink and Olsthoorn (1999) observed the same results that stands composed of different tree species, leading to competition between trees of different species as the main factor influencing growth and management thereby influencing plants to have higher heights as compared to other forest composition.

It is reasonable to say that Plantation forest (T3) probably was not the highest because it will depend on spacing. However, it is still the second to the highest because all species found in this treatment were fully matured and had bigger diameter and height. The majority of AGB in the study was found within taller trees and trees with a larger diameter. The species found in the agroforest had varying diameters but not as big as compared to Plantation forest (T3) with almost the same diameter and height. This is the reason why trees in this treatment generally had the lowest value for height.

Biomass

In terms of biomass, different forest composition is statistically the same (Table 03). Even so, Plantation forest (T3) has the highest numerical value with 10,569.48 kg, respectively. This study is consistent with Nizami et al. (2009), showing that the tree biomass increases with the increasing stem diameter. Lasco et al. (2005) agree that more than 90% of biomass is commonly found in more giant trees, such as trees found in the plantation forest.

Table 03. Biomass and carbon stored of trees at different forest composition

Treatment	Biomass (kg)/ Quadrat	Tree Biomass Density (Mg ha $^{-1}$)	Carbon Stored (Mg C ha $^{-1}$)
Agroforest (T1)	6280.04^{a}	157^{a}	70.65^{a}
Mixed Forest (T2)	6420.85^{a}	160.52^{a}	72.24^{a}
Plantation Forest (T3)	10569.48^{a}	264.24^{a}	118.91^{a}

* Means with the same superscripts are not significantly different at 5% level using DMRT.

Tree biomass density

As shown in Table 03, tree biomass density of different forest compositions didn't statistically different. However, the plantation forest has the highest numerical value of 264.24 Mg ha^{-1}, respectively since the plantation forest has bigger and more even in diameter. This result is consistent with Lasco et al. (2006) who reported that the bigger the biomass, the bigger is the tree biomass density. Gibbs et al. (2007) also agree with the findings and reported that mature forests have more giant trees with large diameters, thereby contributing to a higher biomass density. In the present study, having small sizes of different trees is therefore associated with having a relatively low biomass density.

Carbon stocks

There is no significant difference among different forest compositions in terms of carbon stock, as shown in table 03. However, plantation forest of Mt. Malindawag numerically is the highest with a value of 118.91 Mg C ha^{-1}. The result was consistent with Noordwijk et al. (2002) who reported his study in Claveria, although not the same species were used. He reported that generally, plantation forest held much higher carbon than agroforest in above ground tree biomass. Corona et al. (2012) also agree that plantations have a high carbon uptake potential and Mangium stand has no exemption.

Plantation forest of Mt. Malindawag is already mature, with trees having even and bigger diameters as compared with other forest compositions. It was noted in this study that the bigger the diameter, the more significant is the biomass. The bigger the biomass, the more significant is the carbon stock of trees. Findings were consistent with Gibbs et al. (2007) reported that mature forests are likely to have a greater incidence of large trees. Trees with large diameters often make the largest contribution to above ground biomass (Kirby and Potvin, 2007; Baishya et al., 2009; Djuikouo et al., 2010). These findings were even more supported by Brakas and Aune (2011) that mature stands will have high carbon stocks, but low carbon accumulation rates since they have reached maturity while young plantations will have low carbon stocks, but higher accumulation rates since the plantation will be in an active growth phase. Moreover, diameter may affect above ground C stock directly as tree diameter

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increases when the forest becomes mature (Lohbeck et al., 2015). Furthermore, mature stands typically contain large old trees (Slik et al., 2013 and Stephenson et al., 2014).

Similar findings were reported by Sales et al. (2005) in Leyte's plantations that the biomass and carbon stock varied with diameter. As trees grow bigger and reach standard sizes, no significant variation exists anymore in terms of their CO_2 stocking because the growth rate (change in DBH) will gradually slow down for mature trees (Terakunpisut et al., 2007). Additionally, the diameter and carbon stock are consistent with the idea that the carbon stock increases with larger trees' presence (Vanninen et al., 1996 and Baraloto et al., 2011).

The lowest carbon stock was observed in agroforest with 70. 65 Mg C ha-1, this is the same in the carbon stocks in the agroforestry systems study in the Philippines, particularly in Mindanao (Brakas and Aune, 2011). Furthermore, Lasco and Pulhin (2000) reported some agroforestry farms such as alley cropping with emphasized spacing among crops and reported to have little biomass carbon (Figure 03).

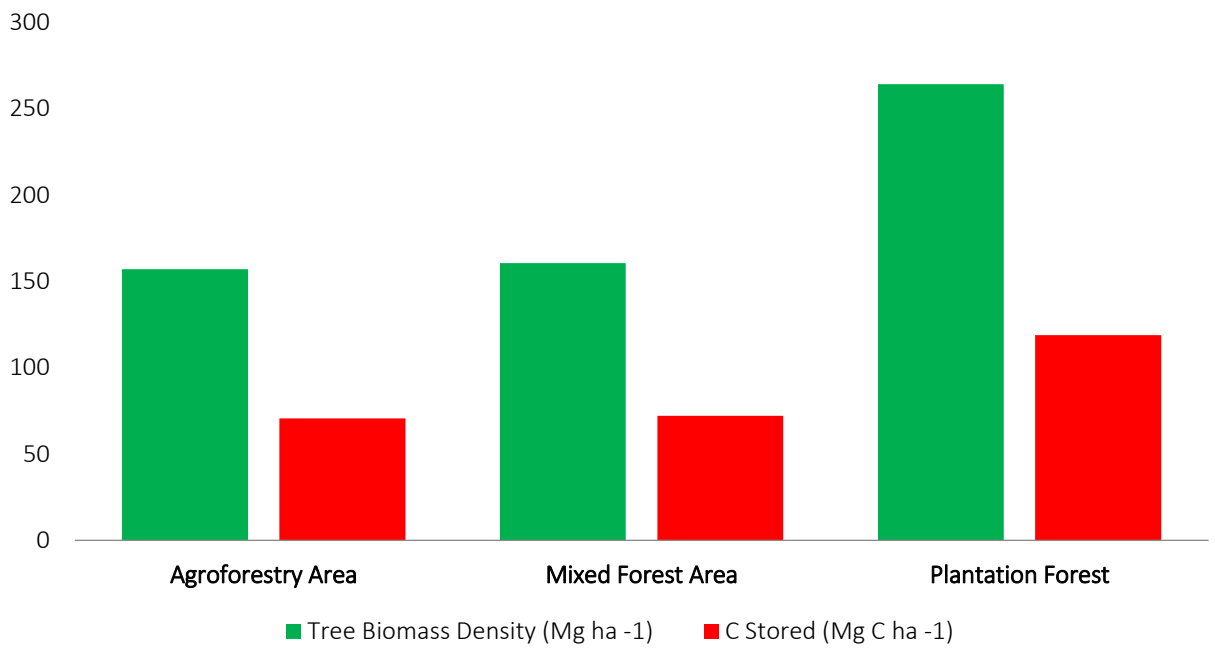

Figure 03. Tree biomass density (Mg ha^{-1}) and carbon stored (Mg C ha^{-1}) by forest composition

IV. Conclusion

Based on the results, mixed forest consistently has the highest number of individuals, number of species, diameter, and height in the tree assessment inventory gathered. This result is largely driven by much more competition in the mixed forest due to the number of individuals competing for resources such as light and nutrients. Moreover, it can also be explained by the random arrangement of trees in these forest types where some patches may only be dominated by understory vegetation. While on the other hand, Plantation forest has the least number of individuals due to the particular spacing required for certain species found in this forest composition. In terms of biomass, tree biomass density and carbon stock, the plantation forest of Mt. Malindawag consistently has the highest value, numerically. This is reasonable because of the matured stand with trees having larger and bigger diameter, which also explains why plantation forest has this much carbon stock. The required spacing for the plantation forest species provides enough resources that will be used by plants for its lateral growth. Carbon accumulation rate is low when fast growing species matures. There is relatively low carbon stock for trees with smaller diameter sizes because of high carbon accumulation rate however; plants will use this carbon during their active growth phase. Furthermore, carbon stocks varied significantly with DBH growth, but as trees grow bigger and reach standard sizes, no significant variation exists anymore in terms of their carbon stocking, because the growth rate (change in DBH) will gradually slow down for mature trees (Terakunpisut et al., 2007).

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The study conducted in different forest composition of Mt. Malindawag shows that plantation forest has the highest carbon stock, numerically. Therefore, among different forest composition, plantation forest has the highest potential in carbon stocking in Mt. Malindawag. However, the findings were not conclusive and may not be accurate in other areas due to uncontrollable factors such as anthropogenic and environmental factors. To get more accurate and precise data on the carbon stock in different forest composition, the following are recommended to have further studies on:

- Areas which have the same age and uneven age stand of trees.
- Relationship of species diversity to carbon stock not just in Mt. Malindawag but also in other forest areas in the Philippines.
- Soil fertility and other possible factors affecting plant growth.
- Carbon sequestration rate of the different forest composition in Mt. Malindawag.

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Appendix 01

List of species at different forest composition

Agro forest area	
Name of Species	**Description**
Coconut (14) Scientific name: *Cocos nucifera* Family : Arecaceae	Coconut is found throughout the tropics and is most popular in the Philippines. It is the most important commercial Palm in the world as referred as the tree of life due to its various uses and benefits to mankind (Chan and Elevitch, 2006). http://www.malatumbaga.com/tree.html
Jackfruit (7) Scientific name: *Artocarpus heterophyllus* Family : Moraceae	Jackfruit is a species of tree of the mulberry family (Moraceae), it produces heavier yield than any other tree species, and bear the largest known edible fruit (up to 35 kg). Its wood is used for making musical instruments, furniture, cabinets, frames, and tool handles. The tree produces one of the most popular fruits in the country (Prakash et al., 2010). http://www.malatumbaga.com/tree.html
Ani-I (1) Scientific name: *Erythrina fusca* Family : Fabaceae	*Erythrina fusca* is a medium to large, much-branched, spreading, soft-wooded, deciduous tree with a rounded crown. The tree is strongly recommended as a multipurpose tree for agroforestry. http://www.worldagroforestry.org/
Mahogany (8) Scientific name: *Sweitenia macrophylla* Family : Meliaceae	Mahogany is a tropical evergreen or deciduous tree that can attain heights of 150 feet. It is the most important timber tree in neo-tropical forests and has become the flagship species in debates about the feasibility of sustainable tropical forest management (Gullison et al., 1996).
Atis (1) Scientific name: *Annona squamosal* Family : Annonaceae	*Annona squamosal* is a small, semi-deciduous tree about 3-5 meters tall, produces its first branches near the base of the trunk. Its fruits are normally eaten fresh. https://www.cabi.org/isc/datasheet/5820, http://www.stuartxchange.org/Atis
Avocado (1) Scientific name: *Persea americana* Family : Lauraceae	Avocado is a medium to large tree, 9-20 meters in height. It is classified as an evergreen, although some varieties lose their leaves for a short time before flowering. http://www.tropical.theferns.info/viewtropical.php?id=Persea+americana
Gmelina (13) Scientific name: *Gmelina arborea* Family : Verbenaceae	*Gmelina arborea* is deciduous and fast growing tree belongs to family Verbenaceae. The plant height of *G. arborea* is approximately 40 m and 140 cm in diameter and the tree is growing deep, well drained, base rich soil and PH level maintain 5-8 (Jensen, 1995).
Falcata (1) Scientific name: *Paraserianthes falcataria* Family : Fabaceae	Falcata is a large tree that can grow up to 40 m tall with the first branch at a height of up to 20 m. Also, it is a fast growing species and has an important role in both commercial and traditional farming systems (Krisnawati et al., 2011)
Antipolo (1) Scientific name: *Artocarpus blancoi* Family : Moraceae	Antipolo is an endemic species, found throughout the Philippines at low and medium altitudes. It is a large tree, growing up to 30 meters tall. Its wood is used for house posts and other purposes requiring durability; for paneling furniture and cabinet work, and musical instruments as substitute for Jackfruit. The bark of this tree is retted and used by highland folks for making clothes. http://www.malatumbaga.com/tree.html,
Lago (1) Scientific name: *Prinus grisea*	Lago is a small to fairly large tree, up to 35 m tall and its bole is crooked or straight and cylindrical, branchless for up to 15 m, with diameters of 100 cm. Its wood is used for making boxes, crafts and for other purposes that

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Agro forest area	
Name of Species	**Description**
Family : Rosaceae	do not require durability and strength. http://www.malatumbaga.com/tree.html
Narra (1) Scientific name: *Pterocarpus indicus* Family : Fabaceae	Narra is the national tree of the Philippines, a majestic tree typically growing to 25-35 meters in height. It is durable when exposed to all kinds of weather or in contact with the ground. It can be used for making almost any articles where strong and beautiful wood is needed. Also, it is a nitrogen-fixing tree that nodulates readily (Thomson, 2006). http://www.malatumbaga.com/tree.html, http://www.stuartxchange.org/Narra.html

Mixed Forest Area	
Name of Species	**Description**
Malakauayan (2) Scientific name: *Podocarpus rumphii* Family : Podocarpaceae	*Podocarpus rumphii* is an evergreen tree, usually growing from 12 - 45 meters tall with a fairly open, slender crown. The tree is harvested from the wild for its timber and there is evidence decline due to logging, especially in the Philippines. The extent of the decline may be approaching 30% over the past 75 years, so almost qualifies for listing as threatened. The plant is classified as 'Near Threatened' in the IUCN Red List of Threatened Species (2013). http://www.iucnredlist.org/
Red Lauan (33) Scientific name: *Shorea negrosensis* Family : Dipterocarpacea	Red lauan is a large evergreen tree that can grow up to 50 meters tall. It is a found at elevations from sea level to 1,000 meters. The tree is becoming rare in the wild due to habitat loss and overexploitation and has been classified as 'Critically Endangered' in the IUCN Red List of Threatened Species (2010). http://www.iucnredlist.org/
Mahogany (1) Scientific name: *Sweitenia macrophylla* Family : Meliaceae	Mahogany is a tropical evergreen or deciduous tree that can attain heights of 150 feet. It is the most important timber tree in neo-tropical forests and has become the flagship species in debates about the feasibility of sustainable tropical forest management (Gullison et al., 1996).
Red Nato (7) Scientific name: *Palaquium luzoniense* Family : Sapotaceae	Red nato is an evergreen tree that can grow up to 40 meters tall. It is the best source of gutta-percha in the Philippines and its population has seriously eroded in the past due to destructive harvesting. The tree is listed as 'Vulnerable' in the IUCN Red List of Threatened Species (2010). http://www.iucnredlist.org/
Paguringon (6) Scientific name: *Cratoxylum sumatranum* Family : Hypericaceae	Paguringon is a deciduous to semi-evergreen tree; it can grow up to 51 meters tall. It is harvested from the wild for local use of its timber. It is also an emergent tree, often in disturbed open sites in mixed dipterocarp and scrub vegetation at elevations up to 500 meters and most commonly found on hillsides and ridges with clay to sandy soils, but also on limestone. http://www.asianplant.net
Binukaw (2) Scientific name: *Garcinia binucao* Family : Clusiaceae	*Garcinia binucao* is endemic and widely distributed in the Philippines, particularly in the Visayas region, including Negros Occidental, Iloilo, Samar, Leyte (Quevedo et al., 2015). It is grown as a home garden tree and its fruits maybe eaten raw or used for souring local dishes (Coronel, 2011).
Dugoan (8) Scientific name: *Myristica philippensis* Family : Myristicacea	*Myristica philippensis* is native to the Philippines and it is locally known as Duguan which means bloody because of the exudation of red sap when the bark is injured (Ragasa et al., 2013). Its wood is used for temporary construction and for making boxes, crates and molding. This is not very durable, unless treated and should not be used in permanent structures. http://www.malatumbaga.com/tree.html
Piling liitan (1) Scientific name: *Canarium luzonicum* Family : Burseraceae	*Canarium luzonicum* is endemic in the Philippines having a large tree reaching a height of more than 30 meters, the trunk a meter or more. It is common in primary forests at low and medium altitudes. The tree seeds are edible and the bark yields tannin of satisfactory quality. It is classified as 'Vulnerable' in the IUCN Red List of Threatened Species (2011). http://www.iucnredlist.org/
Bagtikan (1) Scientific name: *Parashorea malaanonan*	*P. malaanonan* belong to the "Philippine Mahogany" group specifically categorized as "Light Red Mahogany" (De Guzman et al., 1981). Presently, this species are depleted and have been considered by the IUCN Red List of

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Mixed Forest Area	
Name of Species	**Description**
Family : Dipterocarpaceae	Threatened Species (2011) as critically endangered. This means that almost 80% of them were already gone in the natural forests. The species is common in lowland forests and occurs up to 1300 m altitude. http://www.iucnredlist.org/
Putian (4) Scientific name: *Alangium javanicum* Family : Cornaceae	Putian tree can grow up to 10-30 meters tall and found in dry land lowland forest on low hills at 250 meters altitude. Its flowering is on July and August and fruiting from July to February. Its wood is used for house construction, flowing and general framing in light constructions works. http://www.malatumbaga.com/tree.html
Magabuyo (1) Scientific name: *Celtiz luzonica* Family : Cannabaceae	*Celtis luzonica* is an evergreen tree that can grow up to 30 meters tall. The tree is harvested on a commercial basis from the wild for its wood. It is endemic to the Philippines and now threatened due to habitat loss through logging and shifting cultivation has led to considerable population declines. The tree is classified as 'Vulnerable' in the IUCN Red List of Threatened Species (2013). http://www.iucnredlist.org/
White lauan (1) Scientific name: *Shorea contorta* Family : Dipterocarpaceae	*Shorea contorta* is an evergreen tree that can grow up to 50 meters tall. The straight bole is usually unbranched for 15 - 20 meters; it can be 60 - 150cm in diameter with buttresses. It is commonly harvested from the wild for its wood, which is traded internationally. The tree is classified as 'Critically Endangered' in the IUCN Red List of Threatened Species (2013). http://www.iucnredlist.org/
Kalingag (1) Scientific name: *Cinnamomum mercadoi* Family : Lauraceae	*Cinnamomum mercadoi* Vidal is an endemic species in the Philippines that is locally known as kalingag. It is used for remedy for digestion disorder, flatulence, headache, rheumatism and diarrhea (Palis, 1995 and Langenberger et al., 2009).
Anilau (1) Scientific name: *Colona serratifolia* Family : Malvaceae	*Colona serratifolia* is a species of tree in the family Malvaceae. A tree grows up to 15 m tall, with densely hairy twigs. *C. serratifolia* is distributed from Peninsular Malaysia (eastern coast) through Borneo and throughout the Philippines. https://uses.plantnet-project.org/en/Colona_Cav._(PROSEA)
Pagsahingin (1) Scientific name: *Canarium asperum* Family : Burseraceae	Pagsahingin is a mid-canopy tree that can grow from 8 - 37 meters tall. It grows in undisturbed mixed dipterocarp forest at elevation up to 600 meters and usually present as a pre-disturbance remnant tree in secondary forests. The tree is classified as 'Least Concern' in the IUCN Red List of Threatened Species (2011). http://www.iucnredlist.org/
Dungon (2) Scientific name: *Heretiera sylvatica* Family : Malvaceae	Dungon is a large tree measuring up to 45 meters in height and 100 centimeters in diameter. It is found in forests at low and medium altitudes. The wood is used for building posts, beams, joists, rafters, foundation sills, piles, paving blocks, wharves, ship frames, keels, keelson and rudders and for making hubs, spokes, axels, capstan bars and other levers, tool handles, mallets and other wooden tools. http://www.malatumbaga.com/tree.html, http://www.caintaplantnursery.com/our-products/philippine-indigenous-plants/dungon/
Falcata (1) Scientific name: *Paraserianthes falcataria* Family : Fabaceae	Falcata is a large tree that can grow up to 40 m tall with the first branch at a height of up to 20 m. Also, it is a fast growing species and has an important role in both commercial and traditional farming systems (Krisnawati et al., 2011)
Bitaog (2) Scientific name: *Calophyllum Inophyllum* Family : Clusiaceae	Bitaog is a medium-sized tree that grows up to 25 meters tall, sometimes as large as 35 meters. Found in low and medium altitudes. Its wood is used for flooring, sheathings, ceilings, ship sterns, keels, knees and ribs, vehicle-wheel hubs; and for making fine furniture, cabinets, gunstocks and musical instruments. http://www.malatumbaga.com/tree.html

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Plantation Area	
Name of Species	**Description**
Mangium (37) Scientific name: *Acacia mangium* Family : Fabaceae	Mangium is a tropical tree species capable of colonizing difficult sites, it is also a fast growing species, has a good wood quality (for pulp, sawn timber and fuel wood), and tolerance of a range of soil types and pH (Hediyanti and Sulistyawati, 2010).

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