

Biomass Characterization and Allometric Model Development for Aboveground Carbon Stock of Benguet Pine (*Pinus kesiya*)

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INTRODUCTION

Carbon sequestration refers to the removal of carbon from the atmosphere and its deposition in a reservoir. It has been identified as one way to offset or mitigate global warming and climate change (OECD 2001) and was suggested as the only option for controlling climate change considering that no sign of long-term reduction of anthropogenic carbon emission exists (Nature Geoscience 2009). Its implications for the Philippines, as a developing country, could be better appreciated in the context of emission trading and carbon credits which involve giving monetary value to pollutants in the atmosphere and the reduction thereof. Carbon sequestration however requires precise quantification of forest biomass or carbon stock as stipulated in the Kyoto Protocol.

Carbon sequestration studies in Benguet pine forest and other forest types in the Philippines generally used generic mixed-species allometric models to estimate the biomass and carbon stock (Sakurai *et al.* 1994; Lasco *et al.* 2004; Lumbres *et al.* 2012). This method is non-destructive and easier to conduct but the accuracy of the models is often questionable and limited (Ketterings *et al.* 2001; Segura & Kanninen 2005; Tinker *et al.* 2008; Ebuy *et al.* 2011). Experts generally agree that the harvest method is the most accurate and direct method in estimating the aboveground biomass and the carbon stocks stored in the forest ecosystems (Vashum & Jayakumar 2012). Additionally, Vieilledent *et al.* (2011) concluded that generic models that have been calibrated at a particular site would unlikely yield accurate tree biomass estimates at other sites.

ABSTRACT

Experts generally agree that allometric models generated from destructively sampled trees is the most accurate and direct method of estimating carbon stock. However, carbon sequestration studies in the Philippines generally used generic mixed species models; thus, this study was conceptualized – to generate a more accurate and direct estimate of the aboveground carbon and organic matter content of Benguet pine (*Pinus kesiya*). A total of 24 best-fit allometric models were generated for total aboveground carbon and organic matter content and its different compartments based on 15 destructively sampled trees. These models have high r^2 and adjusted r^2 values of 0.79 to 0.99 and are thus deemed highly accurate in estimating the carbon stock and, subsequently, the carbon sequestered by Benguet pine forest. Diameter at breast height (D) was found to be the primary predictor variable and total tree height (H) as the secondary predictor variable. Tree biomass was also characterized in terms of biomass partitioning pattern, wood-bark proportion and organic matter content. The main trunk contains the bulk (60 to 77%) of the aboveground biomass, followed by branches, needles and twigs, respectively. However, in small pines, needles have greater biomass than the branches. Larger pines generally have greater wood proportion than smaller trees while the bark is greatest on the basal portion and decreases apically in trunk sections. High OM ranging from 72 to 99% were recorded in the different components with higher percentages in woody components than in needles and bark; and in smaller pines than in larger ones. Having these species-specific allometric models and a clear understanding on biomass and carbon distribution in Benguet pine could help local forest managers accurately account for pine forest carbon stock and guide them on how to enhance the pine tree's carbon sequestration capacity.

Keywords: allometric model, carbon sequestration, *Pinus kesiya*

To attain a more accurate accounting of the carbon stock in the Philippines, there is a need to develop models based on local forest biomass. Hence, this study was conceptualized and aimed to develop allometric models that can accurately estimate the aboveground carbon and organic matter content of Benguet pine. Additionally, it sought to document the biomass characteristics of this tree species in terms of partitioning pattern, wood-bark proportion and organic matter content.

Benguet pine dominates the montane rainforests or pine forests in the Cordillera Region in Northern Philippines (Lasco *et al.* 2004; Lumbres *et al.* 2012). Being the dominant species, it could be inferred that this tree contains the bulk of carbon in the forest.

The pine forest or montane rainforest is common in Cordillera Administrative Region. It is dominated by *Pinus kesiya* (synonym: *Pinus insularis*), commonly known as Benguet pine

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and locally called “*saleng*” in Benguet and Nueva Vizcaya, “*bariat*” or “*batang*” in Bontoc, Mountain Province, “*palompino*” in Isabela, and “*sahing*” in Southern Luzon. This most popular of all pine species in the Philippines is a moderately fast-growing, medium-sized to large tree with a diameter reaching up to 140 cm and a height of up to 40 m. It has a thick and flaky bark, a straight cylindrical bole usually 15 m long and with no pronounced buttress, and a crown that is conical when young, gradually turning dome-shaped as the tree matures. Benguet pine thrives well in high elevations, usually between 500 and 2,700 masl. Found mostly in Benguet, Ifugao, Pangasinan, Nueva Vizcaya, Nueva Ecija, Kalinga, Cagayan, Ilocos Norte, Mountain Province, and Abra, Benguet pine is endemic to mainland Asia, Taiwan and the Philippines, but there have been reports of this species being grown in Burma and Indochina (Philippine NSCB n.d.).

Efforts have already been made to estimate the biomass and carbon stored in Benguet pine forests. Studies of Lasco *et al.* (2004) showed that old-growth pine forest stored 90.1 tons C ha⁻¹ and is greater than in pine plantation. However, Lumbres (2012) had a much lower estimate at 59.11 tons C ha⁻¹ in a pine forest at La Trinidad, Benguet. The variation could be attributed to lot of factors such as the age of the tree stand and the tree density. Variation could also be attributed to the generic allometric equations used in these studies which, though stratified for ecological zones, may not accurately reflect the tree biomass in a specific area or region (Segura & Kanninen 2005). Thus, the accuracy of the biomass and carbon estimates for Benguet pine needs further validation.

METHODOLOGY

The study sampled a total of 15 pine trees in a communal pine forest in Tadian, Mountain Province (17.054851° N, 120.814811° E). Based on recommendation of the Benguet State University’s College of Forestry, three diameter class ranges were determined; namely, 5–10 cm for saplings, 11–30 cm for young trees, and 30–50 for adult trees. Five trees for each diameter class were felled. Diameter at breast-height (D) and total tree height (H) of each tree were first determined before the tree parts were compartmentalized into main stem, primary branches, secondary branches, twigs, and needles. The respective biomasses of these compartments were summarized to get the total aboveground biomass. Samples from these compartments were gathered for determination of moisture content, wood density, wood-bark proportion, organic matter (OM), and carbon (C) content. Moisture content and wood density were reported in an earlier article (Napaldet & Gomez 2015).

Cylindrical wood samples were derived from the trees’ woody components, such as the main trunk and branches, for determination of wood-bark proportion. For the main trunk, three cylindrical samples were derived – one each from the base, middle and apical portions. The proportion of wood and bark was measured in terms of biomass. Organic matter content was directly determined from the biomass by subjecting the samples in the furnace of varying temperatures to derive the ash content (TAPPI 2010). The remaining ash was deducted from the original weight of the sample to get the OM. Carbon content was also estimated from the biomass, though indirectly, using the accepted 49% carbon conversion factor for pine trees (Matthews 1993; Thomas & Martin 2012).

OM and C content (see Appendix Table 1A and B) were estimated by multiplying the OM and C percentages with the biomass. These were then subjected to correlation and regression analyses using SPSS to develop the allometric models. This method of estimating the aboveground carbon stock is different from the traditional way of first estimating the biomass before converting it into carbon using the universal 50% carbon conversion factor. This traditional method was the one used by Lasco *et al.* (2004) & Lumbres *et al.* (2012). However, Gao *et al.* (2015) discovered that this traditional method yielded the highest error in estimating the aboveground carbon stock of pines. They also found that allometric models that directly estimate carbon stock are the most accurate for *Pinus*.

Correlation analyses were first employed to establish the relationship between the variables, such as D, H and wood density with the tree OM and C stock. When found to be significant, regression analyses were used to fit in models that would determine which (independent) variable(s) would best predict OM and C content (dependent variables). Easily measurable variables such as D, H and wood density were often the independent variables to relate with the biomass (Ketterings *et al.* 2001). In the regression analyses conducted, these variables were either treated singly or in combinations to come up with the best models. Several combinations of variables such as D only, H only, D+H, D+H+wood density, and D²H values were explored in different regression types such as linear, power, polynomial, logarithmic and exponential. In particular, models with D as the independent variable only or in combination with H were generated as these were more easily gathered in the field. The coefficient of determination (adjusted r²) for each model was used to assess the accuracy of the model. The adjusted r² value is considered as the universal test of accuracy since it compares models that have varying number of independent variables (Kahane 2001). The higher the adjusted r² value, the higher the accuracy of the model, thus allometric models with the highest adjusted r² value were selected and proposed for OM and carbon stock estimation.

RESULTS AND DISCUSSION

Biomass Partitioning Pattern

The distribution of aboveground biomass in Benguet pine is presented in Table 1. The main trunk contains the bulk (60 to 77%) of biomass in all of the diameter classes. In 11–30 and 31–50 cm D trees, primary and secondary branches account for 27% and 29% of the total aboveground biomass, respectively—much higher than combined twig and needle biomass (15% and 10%). However, in the 5–10 cm D class, the combined twig and needle biomass (12.99%) is significantly greater than the biomass of the branches (9.34%). Small (5–10 cm D) pines generally have no secondary branches; instead, twigs arise directly from the primary branch. The twigs contain the least biomass in all diameter classes while needles constitute 7 to 10% of the total aboveground biomass. This result supports the findings in other studies (Nilsson & Albrekston 1993; Tinker *et al.* 2008; Russell *et al.* 2009) that pine needles contain significant biomass and, therefore, should be included in formulating tree allometric models.

The biomass partitioning pattern of Benguet pine is consistent with the findings of Kaufmann and Ryan (1986), Nilsson and Albrekston (1993), and Tinker *et al.* (2008) on lodgepole pine. In pines, the main trunk biomass is greater than the combined

Table 1. Biomass partitioning patterns.

Tree Components	Mean Biomass Proportion (%)		
	5–10 cm	11–30 cm	31–50 cm
Main Trunk	77.68 ^b	60.85 ^{a,b}	61.57 ^a
Primary Branch	9.34 ^a	13.39 ^{a,b}	18.67 ^b
Secondary Branch	n/a	13.61	10.05
Branch Sub–Total	9.34	27.01	28.71
Twigs	4.42 ^a	4.73 ^a	2.82 ^a
Needles	8.57 ^a	10.13 ^a	6.89 ^a
Sub–Total (Foliage)	12.99	14.86	9.71
Total	100.00	100.00	100.00

Means with the same letter in a row are not statistically different at $\alpha = 0.05$ DMRT

biomasses of branches, twigs and needles particularly for competitively suppressed trees – the same condition of the Benguet pine in the study. Also, the higher foliage biomass (twigs and needles) than branch biomass in 5–10 cm D trees agrees with the findings of Tinker *et al.* (2008) which suggest that young pines allocate more resources in foliage or needles than in branch components. Russell *et al.* (2009) added that production of needles is the top priority in physiologically young trees.

Wood–Bark Proportion and Organic Matter Content

Table 2 summarizes the biomass proportion of wood and bark across the diameter classes. Results showed that wood constitutes 80 to 91% of the biomasses of the main trunk and branches. Large pine trees have significantly greater wood proportions and barks than small trees. Between the trunk sections, the bark is greatest at the base and decreases apically. The apical decrease is significant in 5–10 cm and 11–30 cm diameter classes. This is expected since the base is the oldest part of the tree and as such it accumulates the most bark. Also, it provides protection for the tree against fire, pest and diseases (Alen 2000; Prota n.d.). The same trend is also observed in branches: branches of larger trees have greater wood proportion and larger branches have greater wood than smaller ones.

Table 2. Biomass proportion of wood and bark.

Tree components	Wood–Bark Proportions (%) of the Tree Diameter Classes					
	5–10 cm		11–30 cm		31–50 cm	
	Wood	Bark	Wood	Bark	Wood	Bark
Main Trunk						
Base	80.54	19.46 ^b ^{II}	82.74	17.26 ^b ^{III}	90.05	10.09 ^a ^I
Middle	86.07	13.93 ^b ^I	88.48	11.52 ^{a,b} ^{I,II}	91.49	8.58 ^a ^I
Apex	88.38	11.62 ^b ^I	89.19	10.81 ^{a,b} ^I	91.62	8.44 ^a ^I
Average	85.00	15.00 ^b	86.80	13.20 ^b	91.05	9.04 ^a
Primary Branch	79.65	20.35 ^b ^{II}	88.00	12.00 ^a ^{I,II}	90.90	9.10 ^a ^I
Secondary Branch	n/a	n/a	84.57	15.44 ^{II,III}	85.17	14.83 ^{II}
Average	79.65	20.35 ^b	86.09	13.91 ^a	88.03	11.97 ^a

Note: Means with the same letter in a row are not statistically different at sig. =0.05 DMRT

Means with the same number in a column are not statistically different at sig. =0.05 DMRT

For its part, Table 3 presents the OM content in the different compartments of the Benguet pine. Results showed high OM content of every tree component ranging from 72 to 99%. Larger trees (31–50 cm D) generally have lower OM across the different tree compartments. This could be attributed to the greater inorganic constituents that accumulated in the older trees over time (Forrest & Ovington 1970). Needle OM is also lower in larger trees but not significantly different.

Between the tree components, woody components have greater OM than twigs, needles and bark. This could be attributed to the resinous nature of pine wood, that is, it contains volatile organic compounds (Russell *et al.* 2009; Prota n.d.). Also, twigs and needles are metabolically active organs (site of photosynthesis); thus, biologically they contain more inorganic ions and minerals such as Mg, Co, and Fe (Mauseth 1988; Stern 2000). These results show that OM content could differ significantly between

biomass compartments and between ages of tree stand in the same species, thus supporting the findings of other studies (e.g., Matthiessen *et al.* 2005) that emphasize the importance of OM as a major parameter in biomass characterization.

Table 3. Organic matter content of Benguet pine.

Tree Components	Diameter class		
	5–10 cm	11–30 cm	31–50 cm
Main trunk wood			
Base	89.34 ^b ^{I, II}	90.72 ^b ^{III}	84.76 ^a ^{I, II}
Middle	90.18 ^a ^{I, II}	90.27 ^a ^{III}	87.66 ^a ^{II}
Apex	90.04 ^{ab} ^{I,II}	93.11 ^b ^{III, IV}	84.67 ^a ^{I, II}
Mean	89.85 ^b	91.37 ^b	85.70 ^a
Primary Branch	91.63 ^b ^{II}	99.41 ^c ^{IV}	85.25 ^a ^{I, II}
Secondary Branch	n/a	88.72 ^{ns} ^{II, III}	85.64 ^{ns} ^{I, II}
Twigs	86.63 ^b ^{I, II}	86.41 ^b ^{I, II, III}	79.62 ^a ^{I, II}
Needles	90.95 ^a ^{II}	79.24 ^a ^I	72.31 ^a ^I
Main trunk bark	76.65 ^a ^{I, II}	81.61 ^a ^{I, II}	72.52 ^a ^{I, II}
Branch bark	73.39 ^a ^I	80.61 ^a ^I	75.04 ^a ^{I, II}

Means with the same letter in a row are not statistically different at $\alpha = 0.05$ DMRT

Means with the same numeral in a column are not statistically different at $\alpha = 0.05$ DMRT

Allometric Model Development for Organic Matter and Carbon Stock

Pearson correlation analysis showed a very high correlation (sig.=0.00) between D and H with the aboveground biomass and its compartments (Table 4). This finding and the scatter plots (Figure 1) firmly established D and H as the independent variables in the study.

The best–fit allometric models for the total aboveground OM, C and the different compartments are presented in Table 5. Two equations per biomass component were selected. The 1st models have D as the sole independent variable while the 2nd models have combined effect of D with H (D²H). Best–fit allometric models for total aboveground OM (TAGOM) were:

Table 4. Pearson correlation analyses between independent and dependent variables.

Dependent Variables	Independent Variables		
	D	H	D ² H
Total Aboveground C	0.919**	0.840**	0.992**
Main Trunk C	0.926**	0.851**	0.995**
Primary Branch C	0.884**	0.750**	0.964**
Secondary Branch C	0.891**	0.888**	0.948**
Twigs C	0.883**	0.791**	0.965**
Needles C	0.859**	0.826**	0.949**
Total Aboveground OM	0.923**	0.844**	0.992**
Main Trunk OM	0.929**	0.854**	0.995**
Primary Branch OM	0.888**	0.755**	0.963**
Secondary Branch OM	0.892**	0.889**	0.947**
Twigs OM	0.885**	0.793**	0.963**
Needles OM	0.860**	0.828**	0.947**

** significant correlation at 0.01 level

(1st) TAGOM = 0.065D^{2.440}
(2nd) TAGOM = 0.000000315(D²H)² + 0.02(D²H) + 5.058.

On the other hand, best-fit allometric models for total aboveground C (TAGC) were:

(1st) TAGC = 0.033D^{2.471}
(2nd) TAGC = 0.0000001973(D²H)² + 0.011(D²H) + 1.83

These models have high r² and adjusted r² values ranging from 0.87 to 0.99, indicating very good fit. These equations also have low p-values and high F-values, thus complying with the requirement for goodness of fit for allometric models (Kahane 2001).

For models with D as sole variable, power regression models (with a form: Y = aX^b) estimate and fit best all the tree compartments except for secondary branch. The r² values of these models were slightly lower than the more complex D²H models, but still suggest that D of Benguet pine is accurate enough to estimate its aboveground OM and C stock with 79 to 99% accuracy. This is a very advantageous case since D is easier and more accurately measured in the field than tree height and other variables. According to Montagu *et al.* (2005) as cited in Litton and Kauffman (2008), the measurement error of D in trees is only 3% while for tree height the measurement error is 10 to 15%.

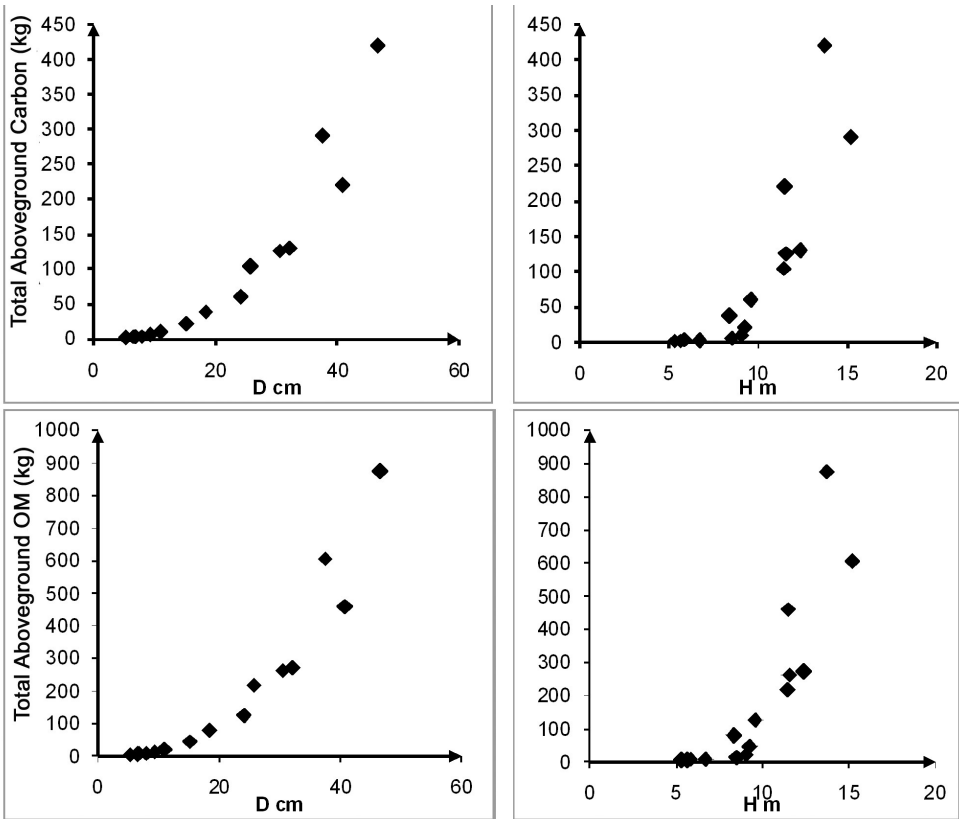


Figure 1. Scatter-plot showing the relation between the D and H with total OM and C content.

Table 5. Allometric models for the estimation of Benguet pine OM and C stock.

Allometric Models		r^2	Adjusted r^2
Tree OM (kg)			
Total Aboveground OM	$= 0.065D^{2.440}$	0.991	0.991
	or $= 0.000000315(D^2H)^2 + 0.02(D^2H) + 5.058$	0.993	0.992
Main Trunk OM	$= 0.065D^{2.294}$	0.990	0.989
	or $= 0.0000001308(D^2H)^2 + 0.013(D^2H) + 1.969$	0.995	0.994
Primary Branch OM	$= 0.002D^{2.918}$	0.952	0.949
	or $= 0.0000001429(D^2H)^2 + 0.002(D^2H) + 1.929$	0.964	0.958
Secondary Branch OM	$= 0.031D^2 + 0.285D - 4.219$	0.825	0.796
	na or $= -0.00000009653(D^2H)^2 + 0.003(D^2H) - 0.716$	0.898	0.881
Twigs OM	$= 0.005D^{2.187}$	0.942	0.937
	or $= 0.00000002(D^2H)^2 + 0.0003(D^2H) + 0.9022$	0.966	0.960
Needles OM	$= 0.009D^{2.228}$	0.954	0.950
	or $= 0.003(D^2H)^{0.923}$	0.959	0.955
Tree C (kg)			
Total Above-Ground C	$= 0.033D^{2.471}$	0.991	0.990
	or $= 0.0000001973(D^2H)^2 + 0.011(D^2H) + 1.83$	0.995	0.994
Main Trunk C	$= 0.034D^{2.318}$	0.989	0.988
	or $= 0.00000007985(D^2H)^2 + 0.007(D^2H) + 0.519$	0.995	0.994
Primary Branch C	$= 0.001D^{2.951}$	0.952	0.948
	or $= 0.00000008735(D^2H)^2 + 0.001(D^2H) + 0.808$	0.971	0.967
Secondary Branch C	$= 0.018D^2 + 0.128D - 2.208$	0.825	0.796
	na or $= 0.002D^2H - 0.196$	0.899	0.891
Twigs C	$= 0.002D^{2.233}$	0.945	0.941
	or $= 0.001(D^2H)^{0.921}$	0.943	0.938
Needles C	$= 0.004D^{2.352}$	0.956	0.954
	or $= 0.001(D^2H)^{0.974}$	0.962	0.960

The 2nd models with combined effects of D and H as independent variables yielded higher r^2 values than the 1st models. However, D was squared first before multiplied with H (D^2H) signifying D as the primary predictor and H only as secondary. This result is consistent with the study of Tinker *et al.* (2008) on lodgepole pine (*Pinus contorta* var. *latifolia*) where D was identified as the primary morphological predictor of all the trees' biomass compartments and H only as secondary.

Total tree height as sole independent variable was also explored but yielded models with much lower r^2 values. Additionally, wood density of Benguet pine, which ranges from 0.34 to 0.59 g cm⁻³ (Napaldet & Gomez 2015), was explored as an independent variable. Several studies suggested that inclusion of wood density would generate more accurate models (Baker *et al.* 2004; Chave *et al.* 2005; Basuki *et al.* 2009; Ebuy *et al.* 2011). However, this was not the case in the present study as wood density (both the main trunk and branch) yielded poor correlation with the OM and C, and models that include wood density have low r^2 values and therefore they were not included in the best-fit allometric models. Nonetheless, similar studies showed that wood density is more aptly used in mixed species models but not on species-specific models like the ones generated in the study (Tinker *et al.* 2008 on lodgepole pine; Litton & Kaughman 2008 on *Metrosideros* sp.).

CONCLUSION

The study was conducted to develop allometric models for the aboveground carbon and organic matter content of Benguet pine (*Pinus kesiya*) based on 15 destructively sampled trees. The study generated 24 allometric models for trees' aboveground OM and carbon stock and the trees' different compartments using D and H as independent variables. These models have high r^2 and adjusted r^2 values of 0.79 to 0.99, thus they were concluded to be highly accurate in quantifying the trees' aboveground carbon. This finding, in turn, will accurately guide the monetization of aboveground carbon under carbon sink and emission trading schemes/programs. With these r^2 values, the study's author is confident that the estimated carbon of these models is less than the 20% error set in the emission trading scheme under the Clean Development Mechanism defined in the Kyoto Protocol (IPCC 2007).

Additionally, the biomass characteristics of Benguet pine were documented. The biomass partitioning pattern of the tree showed that the main trunk contains the bulk (60 to 77%) of the aboveground biomass, followed in descending order by branches, needles, and twigs. However, in small pines, needles have greater biomass than the branches. In terms of wood-bark proportion, larger pines generally have greater wood proportion

than in smaller ones while on the main trunk, the bark is greatest on the basal portion and decreases apically. Lastly, the different tree compartments contain high OM ranging from 72 to 99% with higher percentages in wood components than needles and bark. OM is also higher in smaller pines.

Understanding the biomass characteristics of the Benguet pine trees gives us the idea on the distribution of the trees' carbon which in turn can serve as guide for forest managers on how to enhance the carbon stock or sequestration capacity of Benguet pine forests.

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Appendix Table 1–A. Biomass, and Carbon Content of Sampled Pines.

Diameter class	Tree #	Diameter (cm)	Total Tree Height (m)	Total Above-ground Biomass (kg)	Tree Biomass Compartments (kg)				
					Main trunk	Primary	Secondary	Twig	Needle
5–10 cm	1	5.26	5.29	5.50	3.60	0.84	0.00	0.45	0.60
	2	6.42	5.63	6.58	5.72	0.35	0.00	0.17	0.33
	3	6.74	6.71	8.63	6.73	0.79	0.00	0.29	0.82
	4	7.86	5.84	8.89	6.62	1.05	0.00	0.43	0.79
	5	9.31	8.51	14.18	11.84	0.71	0.00	0.44	1.20
11–30 cm	1	10.91	9.04	23.80	17.25	1.66	0.00	1.67	3.22
	2	15.08	9.23	50.57	35.49	2.75	5.69	2.08	4.58
	3	18.36	8.35	88.37	48.79	15.82	12.14	3.78	7.85
	4	24.07	9.57	139.49	71.68	20.50	23.15	7.27	16.90
	5	25.67	11.44	237.18	130.55	52.11	30.54	7.19	16.79
31–50 cm	1	30.49	11.55	309.75	205.31	48.27	30.03	8.65	17.50
	2	32.09	12.35	320.27	209.15	55.56	34.93	6.15	14.48
	3	37.48	15.19	720.88	426.00	103.51	97.21	21.63	72.53
	4	40.76	11.47	544.38	326.00	125.04	41.03	16.06	36.24
	5	46.53	13.72	1037.43	594.56	239.35	89.35	35.86	78.30

Appendix Table 1–B. Organic Matter and Carbon Content of Sampled Pines

Tree #	Total Above-ground OM (kg)	Main trunk	Tree Compartments OM (kg)				Total Above-ground C (kg)	Main trunk	Tree Compartments C (kg)			
			Primary Branch	Secondary Branch	Twig	Needle			Primary Branch	Secondary Branch	Twig	Needle
1	4.94	3.23	0.77	0.00	0.39	0.55	2.70	1.76	0.41	0.00	0.22	0.29
2	5.91	5.14	0.32	0.00	0.15	0.30	3.22	2.80	0.17	0.00	0.08	0.16
3	7.77	6.05	0.72	0.00	0.25	0.75	4.23	3.30	0.39	0.00	0.14	0.40
4	8.00	5.95	0.96	0.00	0.37	0.72	4.36	3.24	0.51	0.00	0.21	0.39
5	12.76	10.64	0.65	0.00	0.38	1.09	6.95	5.80	0.35	0.00	0.22	0.59
6	21.41	15.76	1.65	0.00	1.44	2.55	11.66	8.45	0.81	0.00	0.82	1.58
7	45.63	32.43	2.73	5.05	1.80	3.63	24.78	17.39	1.35	2.79	1.02	2.24
8	80.56	44.58	15.73	10.77	3.27	6.22	43.30	23.91	7.75	5.95	1.85	3.85
9	126.08	65.49	20.38	20.54	6.28	13.39	68.35	35.12	10.05	11.34	3.56	8.28
10	217.69	119.28	51.80	27.10	6.21	13.30	116.22	63.97	25.53	14.96	3.52	8.23
11	262.33	175.94	41.15	25.72	6.86	12.66	151.78	100.60	23.65	14.71	4.24	8.58
12	271.86	179.23	47.36	29.91	4.88	10.47	156.93	102.48	27.22	17.12	3.01	7.10
13	606.17	365.07	88.24	83.25	17.16	52.45	353.23	208.74	50.72	47.63	10.60	35.54
14	460.05	279.37	106.60	35.14	12.74	26.21	266.75	159.74	61.27	20.10	7.87	17.76
15	875.15	509.52	204.05	76.52	28.44	56.63	508.34	291.33	117.28	43.78	17.57	38.37