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Carbon Stock; Kurucaşile Forest Sub-District Directorate

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Abstract: Carbon dioxide, which accumulates in the atmosphere as a result of human activities, is one of the most important causes of global warming. Carbon as the main component of carbon dioxide in the atmosphere is stored in forests, oceans and on the earth. Any country must determine the content of carbon stocks and carbon stock change in the forest ecosystems in order to combat global change. There are various methods developed for this purpose. In this study, the biomass equation method based on the biomass equations of tree species and the EFFMP method based on the tree volumes were compared with each other. Evaluated as a result of the study, the biomass equation method was determined to bear higher results than the EFFMP method does in determining the stand carbon.The content of carbon stocked in the Kurucaşile Forest Sub-district Directorate was calculated to be 27.7 tons/ha by the biomass equation method and 197.3 tons/ha by the EFFMP method.

Keywords: Carbon stock, global warming, biomass, Kurucaşile Forest Sub-district Directorate

1. Introduction

Climate change as a result of global warming is seen as a serious threat to the earth. As the predominant factor, the effect of carbon dioxide (CO_2) on global climate change is stated to be 53.2% according to [1] while it ranges from 55% to 80% according to [2] and [3].The measurements made on the earth display that the amount of global carbon dioxide (CO_2) in the atmosphere has increased by 36% in the last 250 years and 275-285 ppm of CO_2 in the pre-industrial era rose up to 379 ppm in 2005 (Figure 1) [4].

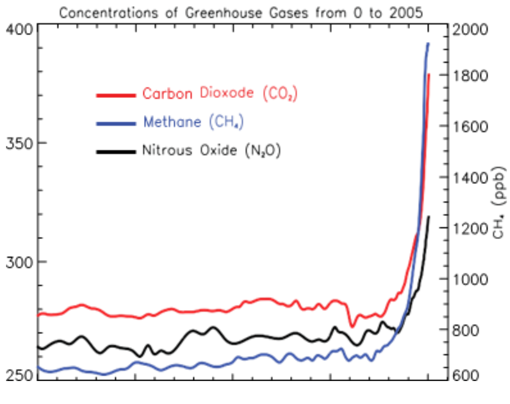

Figure 1: Atmospheric greenhouse gas changes [4].

Increasing the carbon dioxide sequestrated from the atmosphere and decreasing carbon emission are effective methods for preventing global warming and important terrestrial ecosystems [5]. The study by Le Quere et al. [6]reports that 25% of the emissions from fossil fuels have been absorbed from the atmosphere in the last 20 years. Atmospheric CO_2, considered as the most effective greenhouse gas, should be sustainably reduced [7]. It is important to know the carbon content stored by the forests accurately, playing an important role in combating climate change. The carbon in forest ecosystems are stored in the living biomass, the residues of sapwood and deadwood and forest soils[8-10]. Several studies have been carried out in order to determine the amount of carbon stock in the forest ecosystems [11-15].

In determining the carbon accumulated in forest ecosystems, it is a commonly-held approach to measure the carbon stock in the residues of sapwood and dead wood and forest soil through the carbon accumulated in the stand biomass. Many of the studies have tended to determine above-ground biomass ignoring the underground biomass. The results are obtained through a transformation from the above-ground biomass into underground. However, tree roots play an important role in terms of storing carbon in forest ecosystem [16-18]. It is significant to determine underground biomass since it is able to involve biomass up to one fourth of that of above-ground [17], [19]. In calculating biomass is benefited from allometric equations developed by using independent variables such as the diameter, height and weight density of tree [20-23]. The lumbers cause forest destructions as well as the financial difficulty while obtaining these equations [24-25]. However, this method gives more accurate results because it involves regional data about the tree species. In the other method used as the carbon computation method was made use of log volumes which are are obtained from forest inventory and later transformed into biomass carbon multiplied by biomass expansion [26-28].

The first computations in Turkey were made in forest lands for carbon determination by Asan[11], [29]. The carbon value computation for forests was made with the coefficients and formulas proposed for the forests of coniferous and broad-leaved trees. The degraded forest lands were not included in the computations for the determination of carbon stock in the forest lands with the use of coefficients from the studies over time. Today, based on FRA 2010, the computations are made with the methods proposed in Ecosystem-based Functional Forest Management Plans (EFFMP), where BEF coefficients developed by Tolunay and Çömez[30], and Tolunay[31-32] are used. As stated above, carbon stock values are obtained also by using the biomass equations developed for tree species. It was evaluated how the differences between the results were monitored in the computations made with different computation methods specific to 2011-2030 planning period by BartınKurucaşile Forest Sub-district Directorate, and the differences were revealed.

2. Materials

The study area is Kurucaşile Forest Sub-district Directorate (FSD) located within the borders of Bartın Forestry Operation Directorate (FOD) affiliated to Zonguldak Regional Directorate of Forestry (RDF) (Figure 2). This region, according to Greenwich prime meridian, is located between 320 32′56″- 320 46′37″ east longitudes and 410 43′18″- 410 51′01″ arctic circles. Kurucaşile FSD is of a total of 14.455,6 ha forest lands, 70% of which is covered by forests; 8.801,3 ha of which is fertile land, 951,5 ha of which is degraded, and where 362,6 ha is forest land and 4.340,5 ha are other areas. The forests in the planning unit are owned by the state [33]. In this study were utilized 2011-2030 management plans of Kurucaşile FSD.

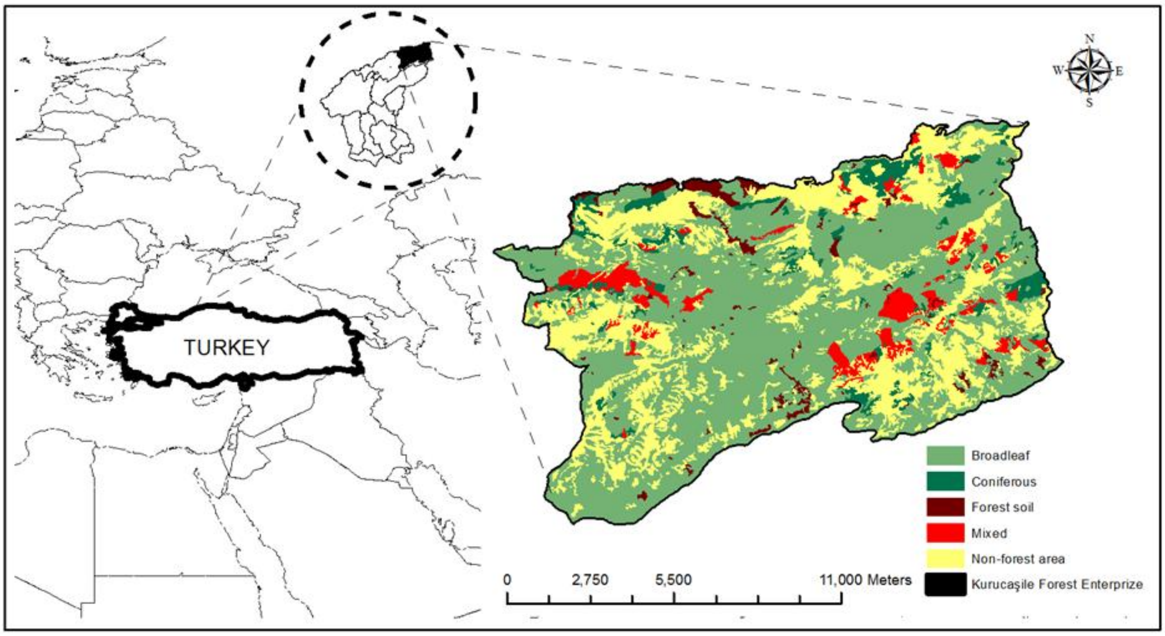

Figure 2: Kurucaşile Forest Sub-district Directorate

3. Method

This study was prepared by using 2011-2030 management plans of Kurucaşile FSD. With this aim, two different methods were used in carbon computation. The formulas belonging to the methods used were obtained from several studies and the results were achieved with the computations in the Excel. In the study were used the biomass equations method and the method in the Procedures and Principles regarding the arrangement of Ecosystem-based Functional Forest Management Plans (EFFMP).

Biomass equation method: The study area consists of coniferous and broad-leaved tree species. The existent biomass equations belonging to these species were used[34-41]. For the other species not having biomass equations, the computations were made with the mean values (coniferous and broad-leaved separately). Above-ground dry-weight (above-ground biomass) in the hectare of the tree species was reached by correlating the single tree dry-weight values with diameter and tree numbers in the middle of maturity stages of tree species in the stand identification tables of management plans. The total of above-ground biomass of the stand type was multiplied by the total area of the stand type and the above-ground biomass value was reached in the area of Sub-district Forest Directorate for the given stand type. The underground biomass was achieved multiplying the above-ground biomass by coefficients 0,29 for the coniferous species and 0,24. Assuming that 50% of the above-ground and underground biomass is carbon, the total carbon was calculated multiplying it by 0,5. Because the diameters for tree species were not specified in the stand type identification tables for the degraded stands, the computations were made only in fertile forest lands. The columns in the EFFMP method were used in calculating carbon in deadwood, litter layer and the organic soil and total carbon in all forest lands in Kurucaşile FSD.

EFFMP method: The coefficients and formulas for calculating carbon content in forest lands in the Procedures and Principles regarding Ecosystem-based Functional Forest Management Plans were used [42]. The computations in this method are made multiplying the areas by several coefficients (separately for coniferous and broad-leaved trees) in determining the litter and soil carbon content. However, the coefficients for the species mixtures were not determined. So, the mean rates of the coefficients of broad-leaved and coniferous trees were used in determining the litter carbon and soil carbon. In the computation of litter carbon of mixed stands, (7,46+3,75)/2=5,61 for the fertile lands and (1,86+0,93)/2=1,40 for the degraded lands were used. In this method, the computations were made by utilizing the tree species stocks in the stand type.

Table 1. Carbon computation according to the EFFMP

	Productive forest	**Degrade forest**
Above Ground Biomass (AGB) (Coniferous)	Vx0,446x1,212	Vx0,446x1,212
Above Ground Biomass (AGB) (Broadleaf)	Vx0,541x1,31	Vx0,541x1,31
Above Ground Carbon (AGC)	AGB x 0,51	AGB x 0,51
Below Ground Biomass (BGB)(Coniferous)	AGB x 0,29	AGB x 0,40
Below Ground Biomass (BGB) (Broadleaf)	AGB x 0,24	AGB x 0,46
Below Ground Carbon (BGC)	BGB x 0,51	BGB x 0,51
Woody Debris Carbon (WDC)	AGB x 0,01 x 0,47	AGB x 0,01 x 0,47
Litter Cover Carbon (LCC) (Coniferous)	Area x 7,46	Area x 1,86
Litter Cover Carbon (LCC) (Broadleaf)	Area x 3,75	Area x 0,93
Litter Cover Carbon (LCC) (Mixed)	Area x 5,61	Area x 1,40
Soil Carbon (Coniferous)	Area x 76,56	Area x 19,14
Soil Carbon (Broadleaf)	Area x 84,82	Area x 21,20
Soil Carbon (Mixed)	Area x 80,69	Area x 20,17
TOTAL CARBON	**AGC+BGC+WDC+LCC+Soil Carbon**	

V: Volume (m^3)

4. Findings

As a result of the study, the findings obtained through two methods after the computations using the data for 2011-2030 management plans belonging to Kurucaşile FSD are given in Table 2.

Table 2: The biomass and carbon stock amount in 2011-2030 management plans according to the Biomass equation method and the EFFMP method.

		Biomass Equation		**EFFMP**	
		Biomass (t)	**Carbon (t)**	**Biomass (t)**	**Carbon(t)**
Stand Above Ground	Coniferous	61.492,7	30.746,4	45.246,1	23.010,2
	Broadleaf	2.328.239,0	1.164.119,5	1.917.381,0	920.707,3
	Mixed	1.289.66,6	64.483,3	101.607,9	50.153,8
	Total	2.518.698,4	1.259.349,2	2.064.235,0	993.871,3
Stand	Coniferous	17.832,9	9.094,8	13.012,5	6.620,7
	Broadleaf	573.058,5	277.553,0	460.778,9	221.279,5

Below Ground	Mixed	37.400,3	19.074,2	26.689,2	13.211,6
	Total	628.291,8	305.722,0	500.480,6	241.111,9
Stand Total	Coniferous	79.325,6	39.841,1	58.258,7	29.630,9
	Broadleaf	2.901.297,6	1.441.672,5	2.378.159,8	1.141.986,9
	Mixed	166.366,9	83.557,5	128.297,1	63.365,4
	Total	3.146.990,1	1.565.071,1	2.564.715,6	1.234.983,2
Woody Debris Carbon			11.837,9		9.701,9
Above Ground Litter-Living Cover Carbon			37.892,682		37.892,7
Soil Carbon			695.593,9		695.593,9
Total Carbon			2.004.673,7		1.737.059,9

When examined the Table 2, it is seen that stand biomass and carbon computations were calculated to have higher values. The biomass equation gives the following results relatively for coniferous, broad-leaved and mixed stands in the computation of stand above-ground carbon: 30.746,4 tons, 1.164.119,5 tons and 64.483,3 tons. The EFFMP method estimates 23.010,2 tons, 920.707,3 tons and 50.153,8 tons of the stand above-ground carbon content. The biomass equation method similarly gives higher results than the EFFMP method in the underground stand values. The highest difference is seen in the mixed stands. While the underground carbon is determined to be 19.074,2 tons in the biomass equation method, it is 13.211,6 with the EFFMP method. When considered the whole stand, it is seen that the biomass equation method is better than the EFFMP method. The carbon was calculated to be 39.841,1 tons for the coniferous stands with the biomass equation considering the both above-ground and underground carbon content whereas it was found to be 29.630,9 tons with the EFFMP method. The difference between these two is 21% (higher results in the biomass equation). It was seen that this difference becomes smaller in the broad-leaved stands. The carbon is calculated 1.441.672,5 tons in the biomass equation method and 1.141.986,9 tons in the EFFMP method. In total, stand carbon was determined 1.565.071,1 tons in the biomass equation and 1.234.983,2 tons in the EFFMP (Table 2).

The deadwood carbon stock in the area is calculated from the above-ground biomass. As for the biomass equation method having higher above-ground stand biomass values (2.518.698,4 tons), higher values were obtained than it was in the EFFMP method with 11.837,9 tons. The same values were achieved in the biomass equation method and the EFFMP method because the processes were carried out using the same coefficients and areas for the above-ground litter-understory carbon and the carbon values in the soil.

In the planning period, the carbon currently stored in the Kurucaşile FSD was calculated 2.004.673,7 tons with the biomass equation method while it was 1.737.059,9 tons with the EFFMP method. The difference between these two methods was 267.613,82 tons. This amount corresponds to a 13% decline in the EFFMP method compared to that in the biomass equation method.

5. Results and Discussion

The carbon computation stored in the forests should be made in the most accurate and reliable way. It is highly significant for combating global climate change. Forests, like oceans, absorb carbon from the atmosphere and store it for a long term. Therefore, different methods were developed depending on the several coefficients. The biomass equation, one of the two methods used in the study, made its computations based on the tree biomass equations and the EFFMP method made computations depending on the tree stocks. In this regard, it is thought that especially biomass equation method gives more accurate results in determining the stand carbon values. The stand computation was made in the biomass equation and the other computations expect for the deadwood carbon were made in the EFFMP conducted in the practice.

When Table 2 was examined, it is seen that stand biomass and carbon computations had higher results with the biomass equation method. The computations for the above-ground carbon value in the EFFMP method had low values with %25 for coniferous trees, %20 for broad-leaved trees, %22 for the mixed tree species and 21% for the above-ground. The EFFMP method gives similarly 21% lower results compared to the biomass equation method in the underground total stand carbon. 39.3841,1 tons of carbon was calculated in the area for the coniferous stands with the biomass equation method in terms of the total of stand underground and above-ground values while it was calculated as 29.630,9 with the EFFMP method and a difference of 25% was found in favor of the biomass equation method. This difference for the broad-leaved stands had 20% lower values. For the total stand, the stand carbon was calculated 21% lower in the EFFMP method (Figure 3 and Figure 4).

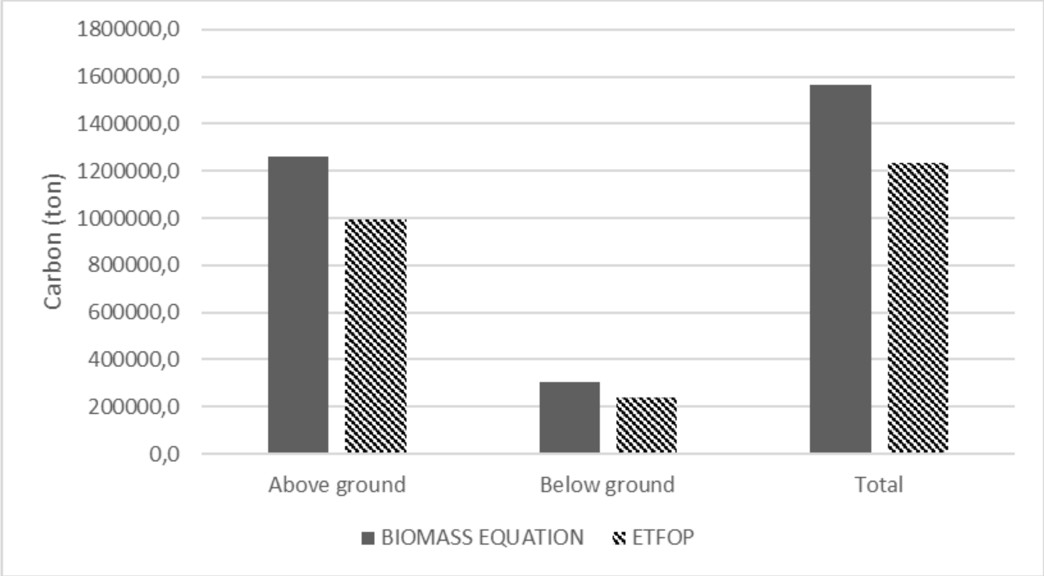

Figure 3. Stand carbon stock according to Kurucaşile 2011-2030 management plan

Carbon accumulation in the study area was calculated to be 2.004.673, 7 tons in the biomass equation method and 1.737.059, 9 tons in the EFFMP method. The accumulation amounts were determined as 227, 7 ton/ha in the biomass equation method; 197, 4 ton/ha in the EFFMP method. In 2011-2030 Kurucaşile FSD management plan prepared using Asan[11], [29] method, the carbon content determined in the hectare is 159,8 ton/ha [33]. It was understood, as a result of the study, that the best results were obtained from the biomass equation method among all three methods. In a similar study in which the biomass equation method was used, it was measured that 246.77 ton/ha of carbon was stored in the Bartın City Forest which is constituted by black pines [43]. It is thought that it is because of the lack of biomass equation method that the biomass equations of all tree species in the study area do not exist. It is understood that the computations made using the biomass equations to be developed for each tree species as a result of the study are real-like values.

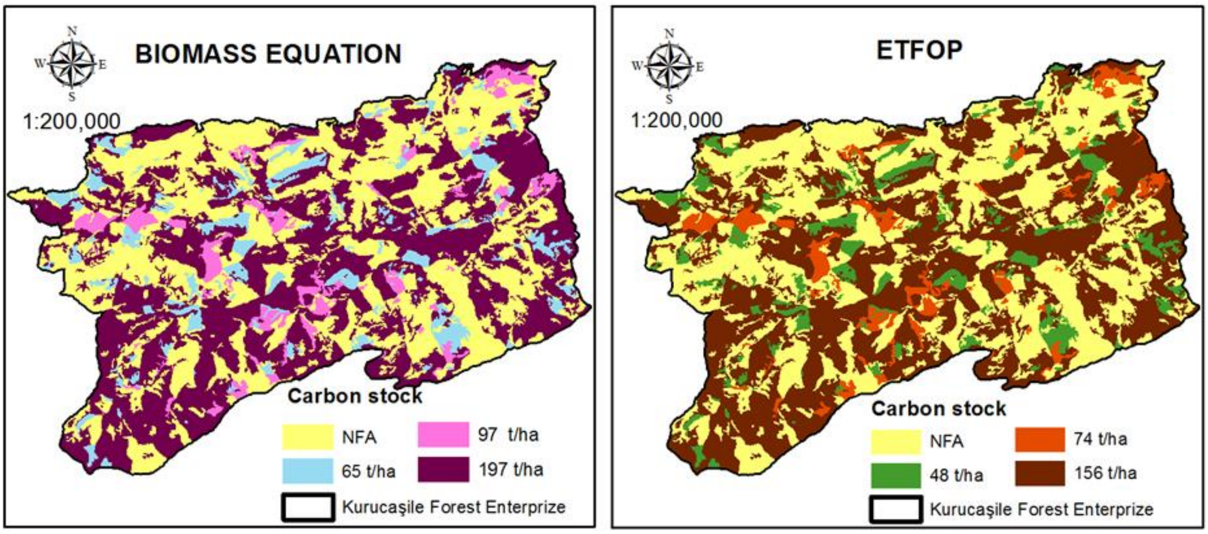

Figure 4. The content of carbon stock for the Biomass Equation and the EFFMP (NFA:Non-Forest Area)

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