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Root Biomass and Carbon Storage in *Abies nordmanniana* S. subsp. *bornmülleriana* (Mattf.) Stands (Western Black Sea Region)

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Abstract

The forests of the world contain 80% of all aboveground carbon (C) and 40% of the entire belowground terrestrial C. It has been estimated that substantial amounts of belowground C may be released into the atmosphere this century, contributing significantly to global warming. Although root biomass constitutes an important component of total carbon storage in a forest, the difficulties in measuring it often lead to the lack of this component in estimating carbon sequestration. In forests, where below-ground C biomass is more than twice than the aboveground components, it is important to study the below-ground system of fine roots that may greatly influence C dynamics and may be a key indicator of ecosystem response to global change. The coarse root component is comprised of larger, structural roots which provide support for the above-ground portion and can account for approximately 30% of total biomass in forest ecosystem. Fine roots have also been regarded as short-lived and recognized as the most important component contributing to belowground C fluxes in forest ecosystems, accounting for up to 75% of the annual net primary production.

The aim of this study is to quantify biomass and carbon storage in roots (fine, small and coarse roots) and to develop allometric equations to estimate root biomass from easily measurable tree parameters for *Abies nordmanniana* S. subsp. *bornmülleriana* (Mattf.) in western Black Sea region.

Key words: Root, biomass, carbon storage, allometry

Introduction

Forests comprise the largest carbon pool of all terrestrial ecosystems thanks to the potential to sequester carbon. This important role in regulating carbon cycle is of major concern in relation to the continuous increase of CO2 in the atmosphere which contributes to global warming (Malhi et al., 2002). In fact, as incited by the Kyoto protocol in relation with United Nations Framework on Climate Change, reducing the release of carbon stored in vegetation or establishing vegetation sinks are among several methods for reducing the net emissions of CO_2 in the atmosphere (IPCC, 2007). The Clean Development Mechanism in Kyoto protocol will allow afforestation and reforestation projects to be established and financed in the developing countries to assist industrialized countries reach their emission reduction targets. Thus, there is much interest in estimating biomass of forest and tree plantations and this implies a need to explore all biomass components. Biomass components are living trees, deadwood, understory vegetation, litter floor, and soil (Woodburry et al., 2007). A very limited part of the research was focused on root compartment because, as in any forest ecosystems, biomass of root systems is difficult to measure. This is mainly because excavating root systems is a difficult task (measurement are tedious and very time-consuming) but also because there is a lack of adequate methods to study the dynamics and functions of this part of ecosystem. In this research, we only estimated the carbon sequestration in root systems.

Material and Methods

The data used in this study were collected from fir natural stands in Bostan Forest District of Kastamonu Forest Enterprise. Total area of the study area is 8297.5 ha and forested area is 5764 ha. The mean altitude and slope of this area are 1,750 m and 60% respectively.

From the various age and site classes, 15 temporary sample plots were measured in 2012. The plot size was 600 sq.m. In each sample plot, diameter at breast height, stump diameter and bark thickness of all trees, and height of at least 30 trees with different sizes were measured. In each sample plot four soil samples were taken.

Methods

To estimate root biomass of trees we used the roots directly measured in the field. They were separated into three groups (fine, small and coarse). The biomass of fine (0-2 mm), small (2-5 mm) and coarse (< 5 mm) roots was assessed by collecting four 30 cm depth, 6.4 cm diameter cores per plot. The roots were separated from the soil by soaking in water and then gently washing them over a series of sieves with mesh sizes of 2 and 5 mm. The roots were sorted into the diameter classes of 0-2 mm (fine root), 2-5 mm (small root) and < 5 mm (coarse root) classes. The roots from each sizes category were oven-dried at 65 °C for 24 h and weighed.

Results

Fine root biomass ranged from 1684.5 kg/ha to 9214.1 kg/ha. Small and coarse roots biomass were 4097 kg/ha and 11762 kg/ha as an average in *Abies nordmanniana* S. subsp. *bornmülleriana* (Mattf.) natural stands in Western Black Sea region. Fine, small and coarse root carbon storages ranged from 485 kg/ha to 3566 kg/ha, 392 kg/ha to 2673 kg/ha and 1049 kg/ha to 6428 kg/ha respectively. Total root biomass and carbon storage were 39628 kg/ha and 9365 kg/ha (Table 1).

Average carbon pool in roots represented 3.9 % of total biomass, varying from 1.7% to 5.3% in *Abies nordmanniana* S. subsp. *bornmülleriana* (Mattf.) natural stands in western Black Sea region. The carbon content of fine, small and coarse roots ranged from 25.8% to 33.6%, 20.6% to 37.4% and 16.7% to 31.4% respectively (Table 2).

Conclusions

The total carbon pool of *Abies nordmanniana* S. subsp. *bornmülleriana* (Mattf.) natural stands in western Black Sea region was on average 6.2 t/ha. This estimate includes only carbon in roots. We analyzed the carbon content in root with a CHNS analyzer and we found a mean value of 34.1% with 95% of carbon content varying between 31.4% and 37.4%.

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Table 1. Root biomass in sample plots

Sample Plot	Sample No	Root biomass (kg/ha)			
		Fine	Small	Coarse	Total
1	1	2701.3	1863.0	4641.5	9205.8
1	2	1397.2	568.2	3943.3	5340.6
1	3	1614.6	434.7	7358.8	9408.1
1	4	1024.6	1831.9	1956.1	4812.7
2	1	3943.3	3663.9	11053.8	18661.1
2	2	3850.2	621.0	4160.7	8631.9
2	3	3663.9	2825.5	12420.0	18909.4
2	4	4284.9	6893.1	10898.5	22076.5
3	1	1707.7	807.3	14966.1	17481.2
3	2	12295.8	3446.5	24871.1	40613.4
3	3	2949.7	6955.2	19934.1	29839.1
3	4	3726.0	1987.2	19033.6	24746.8
4	1	2577.1	2794.5	3539.7	8911.3
4	2	4812.7	5278.5	3384.4	13475.7
4	3	4905.9	3105	5464.8	13475.7
4	4	3943.3	2794.5	7948.8	14686.6
5	1	11395.3	10308.6	14562.4	36266.4
5	2	11271.1	3198.1	3353.4	17822.7
5	3	2670.3	2732.4	9439.2	14841.9
5	4	11519.5	10370.7	12699.4	34589.7
6	1	1552.5	2328.7	807.3	4688.5
6	2	2639.2	1894.1	2018.2	6551.5
6	3	9563.4	11364.3	11612.7	32540.4
6	4	2452.9	2390.8	2755.1	7398.9
7	1	3260.2	5775.3	8383.5	17419.1
7	2	3011.8	3415.5	2049.3	8476.7
7	3	7420.9	8911.3	10557.0	26889.3
7	4	3105.0	2701.3	99918.9	105725.3
8	1	5061.1	4502.3	17046.4	26609.8
8	2	1676.7	4191.7	26206.2	32074.6
8	3	1521.4	1583.5	12482.1	15587.1
8	4	4222.8	2763.4	14686.6	21672.9
9	1	3322.3	3229.2	6661.5	13213.0
9	2	5061.1	3539.7	4325.5	12926.3
9	3	4843.8	2732.4	4905.9	12482.1
9	4	4191.7	4502.2	8228.2	16922.2
10	1	1148.8	3663.9	3415.5	8228.2
10	2	5589.0	2856.6	2574.1	11019.7
10	3	13289.4	4657.5	5347.4	23294.3
10	4	3819.1	6893.1	3258.2	13970.4
11	1	1179.9			1179.9
11	2	3757.1	3726.0	8383.5	15866.5
11	3	4347.0	6644.7	9749.7	20741.4
11	4	3291.3	3508.6	558.9	7358.8
12	1	3105.0	4626.4		7731.4
12	2	1148.8			1148.8
12	3	3167.1	403.6	4471.2	8041.9
12	4	496.8	2949.7	8041.9	11488.5
13	1	993.6	2297.7	14593.5	17884.8
13	2	1428.3	3260.2		4688.5
13	3	4160.7			4160.7
13	4	5899.5	6178.9	27238.6	39317.1
14	1	5775.3	16487.5	88709.8	110972.7
14	2	4750.6	1707.7	8787.2	15245.5
14	3	7389.9	3446.5	7079.4	17915.8
14	4	5682.1	3073.9	4378.1	13134.2
15	1	2515.1	3042.9	22418.1	27976.1
15	2	3105.0		9687.6	12792.6
15	3	3881.2	1304.1		5185.4
15	4	3415.5	2670.3	4843.8	10929.6

Table 2. Carbon storage of fine, small and coarse roots (kg/ha)

	Minimum	Maximum	Mean	Standard deviation
Fine roots	485.12	3565.85	1620.35	731.52
Small roots	392.15	2672.70	1644.78	664.17
Coarse roots	1048.50	6428.31	2949.01	1520.37