ROOT BIOMASS AND CARBON STORAGE FOR *Fagusorientalis*Lipsky. (NORTHEASTERN ANATOLIA)

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Abstract

Data on the biomass and C storage capacity of northeastern Anatolian forest are rare, making it difficult to evaluate the role of these forest ecosystems in the global carbon cycle for this region in Turkey. In particular, more precise information on size and dynamics of tree root systems is needed. In thirty natural oriental beech (*Fagusorientalis*Lipsky.) forest stands from Ormanüstü Planning Unit in northeastern Anatolia, we determined below-ground biomass and C storage, and compared the results to literature value from other northeastern Turkey natural forests. In this study, influence of slope position on fine (0-2 mm), small (2-5 mm) and coarse (5-10 mm) root biomass and carbon storage of oriental beech was investigated.

The mean total root biomass of natural oriental beech stands was 17585 Kg ha^{-1} on north-facing slopes and 18511 Kg ha^{-1} on south-facing slopes. Mean below-ground C storage of natural oriental beech stands was 978, 987 and 2618 Kg ha^{-1} of fine, small and coarse root biomass on north-facing slopes, and 1059,1051and 2829 Kg ha^{-1}, respectively on south-facing slopes, respectively. Fine and small root biomass and total root biomass and C storage of natural oriental beech stands were significantly higher in south-facing slopes than in north-facing slopes. While fine root biomass and C storage decrease with age, coarse root biomass and C storage increase with age. Below-ground biomass and C storage for natural oriental beech stands were found to be lower than these of oriental spruce and oriental fir natural forests in Black sea region.

Key words: Root, biomass, carbon storage, oriental beech

1. Introduction

Many nations count on coal, oil and natural gas to supply most of their energy needs, but reliance on fossil fuels presents a big problem. Fossil fuels are a finite resource. Eventually, the world will run out of fossil fuels, or it will become too expensive to retrieve those that remain. Fossil fuels also cause air, water and soil pollution, and produce greenhouse gases that contribute to global warming. One of the most important global environmental problem is global warming refers to the current rise in the average temperature of Earth's atmosphere and oceans and its projected continuation. In the last 100 years, Earth's average surface temperature increased by about 0.8 °C (1.4 °F) with about two thirds of the increase occurring over just the last three decades (Ravindranath and Ostwald, 2008). Scientists are more than 90% certain most of it is caused by increasing concentrations of greenhouse gases (GHG) produced by human activities such as deforestation and burning fossil fuels(Carnesale and Chameides, 2011). GHG absorb and emit radiation within the thermal infrared range in an atmosphere. By their percentage contribution to the greenhouse effect on Earth's atmosphere the major gases are water vapor (36-70%), Carbon dioxide (9-26%), methane (4-9%) and ozone (3-4%) (Kiehl and Trenberth, 1997).

Carbon dioxide (CO_2) is the most important anthropogenic GHG. Its concentration in Earth's atmosphere is approximately 392 ppm (parts per million) by volume as of February 2012 and rose by 2.0 ppm/yr during 2000–2012 (Tans, 2012). The present level is higher than at any time during the last 800 thousand years and likely higher than in the past 20 million years (Amos, 2006), (IPCC, 2001).

Forest ecosystems which cover 30% of terrestrial ecosystems play very important role in the global C cycle. They store 86% of the planet's terrestrial above-ground C and 73% of the planet's soil C (Sedjo, 1993). The major C pools in forest ecosystems are live biomass, dead biomass, soil, and wood products; each of these pools can be subdivided further (e.g., live biomass may include leaves, twigs, branches, stems, roots of trees, herbaceous plants, shrubs, and vines) (IPCC, 2000). Live biomass consists of above-ground and below-ground biomass. Aboveground biomass and C storage in forest ecosystems is usually found within the tree biomass components (stem, branches, and foliage). Below-ground biomass is defined as the entire biomass of all live roots, although fine roots less than 2 mm in diameter are often excluded because these cannot easily be distinguished empirically from soil organic matter. Below-ground biomass is an important carbon pool for many vegetation types and landuse systems and accounts for about 20% (Santantanio et al., 1977) to 26% (Cairns et al., 1997) of the total biomass. Since below-ground biomass could account for 20–26% of the total biomass, it is important to estimate this pool for most carbon mitigation as well as other landbased projects (Ravindranath and Ostwald, 2008). Although root biomass constitutes an important component of total carbon storage in a forest, the difficulties in measuring its often lead to the mission of this component in estimating carbon sequestration(Laclau, 2003). In forests, where below-ground C biomass is more than twice that of its above-ground components, it is important to study the below-ground system of fine root 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 below-ground C fluxes in forest ecosystems, accounting for up to 75% of the annual net primary production(Miller et al., 2006; Gower et al., 1992 andHelmisaari et al., 2002). A very limited part of the research was focused in root component 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 method to study the dynamics and functions of this part of the ecosystem. Moreover oriental beech (*Fagusorientalis*Lipsky.) is considered one of the most important species for Turkey, due to its valuable wood and ecological function.The aim of this study is to estimate biomass and C storage of this pools (fine, small and coarse roots) of forest ecosystems for *Fagusorientalis*Lipsky. in northeastern Anatolia.

2. Material and methods

The study area is located in the Maçka State Forest Enterprise (40°43-40°48 N and 33°26-33°36 E) which covers part of Trabzon Province located in the eastern Black Sea region of Turkey (Fig. 1). The 6,000.5 ha study area is called the Ormanüstü Planning Unit (OPU) and contains a forested area of 3,886.5 ha. The altitude ranges from 400 to 2,280 m above the sea level and average slope is about 57%.

The Black Sea climate is characterized by mild winters and cool summers and is rainy during all four seasons. The average annual temperature is 12.2°C, reaching a maximum of 20.2°C in summer, a minimum of 4.5°C in winter and with an average annual precipitation of 640.9 mm (Altun, 1995). Forest vegetation is typical and the dominant tree species include oriental spruce (*Piceaorientalis* (L.) Link), scots pine (*Pinussylvestris* L.), Nordmann's fir (*Abiesnordmanniana* (Stev.) Spach subsp. *Nordmanniana*), oriental beech (*Fagusorientalis*Lipsky), oriental hornbeam (*Carpinusorientalis* L.) and alder (*Alnusglutinosa* (L.) Gaertner). The study area is also part of the Research Forest of Karadeniz Technical University Faculty of Forestry.

Data were collected from 30 sample plots. Sample plots were taken from pure oriental beech stands in OPU. All sample plots were between 0.04 to 0.10 ha in size. For each sample plots, all trees were measured diameter at breast height (*dbh*), total height, age. Mean stem diameter 1.3 above-ground (*dbh*) and tree height (*H*) for oriental beech were 27.0 cm and 18.6 m, respectively. Ages of these oriental beech stands ranged from 41 to 184 years (Table 1). To estimate belowground biomass we used the roots directly measured in the field. Root samples were taken with a cylindrical root sampler (30 cm depth and 6.4 cm diameter) at six random points with in the each sample plot. The roots were divided into three size classes based on diameter, namely fine (0-2 mm), small (2-5 mm) and coarse (5< mm). The root samples were separated from the soil by soaking in the water and then gently washing them over a series of sieves with mesh size 2 and 5 mm. To obtain oven-dried weight, the root samples were oven dried at 65°C for 24 hour.For calculating the carbon stored in root biomass, the C concentration of root was analyzed with a CHNS Elemental Analyzer (COSTECH, Italy) at the Karadeniz Technical University.

2.1. Statistical analysis

ANOVAs were used to test the effects of slopes and age on root biomass and carbon storage. Correlations between fine, small and coarse root biomass and carbon storage and various stand parameters (e.g. age, standing volume) were analyzed by correlation analysis. Statistical significance was defined as P<0.05. Statistical analysis was performed using SPSS Version 20.0 (SPSS Inc. Chicago, IL, USA).

3. Results and Discussion

Fine root biomass ranged from 1801 to 7669 kg ha^{-1}on north-facing and 2205 to 10153 Kg ha^{-1}on south-facing slopes. Small and coarse root biomass varied from3330to 9060Kgha^{-1}on north-facing slopes, and 3569 to 9752 Kg ha^{-1}on south-facing slopes, respectively innatural*Fagusorientalis*Lipsky. stands in northeastern Anatoliain Turkey (Table 2).

Fine, small and coarse roots carbon concentrations ranged from 20.1 to 37.8 %, 21.6to 36.2 % and 20.5 to 38.5 %on north-facing slopes, and 22.3to 39.1 %, 27.9 to 38.2 % and 26.7 to 41.6 % on south-facing slopes, respectively (Table 3).

Fine, small and coarse root carbon storage ranged from 361 to 2764 Kg ha^{-1}, 251 to 2360 Kgha^{-1} and 436 to 5628Kgha^{-1} on north-facing slopes, and 445 to 2764Kg ha^{-1}, 393 to 2559 Kg ha^{-1} and 1378 to 7629 Kg ha^{-1} on south-facing slopes, respectively (Table 4). These values are within the ranges reported byFogel (1983), Keyes and Grier (1981), Hendrick and Pregitzer (1993), Tüfekçioglu et al. (2002), Tüfekçioglu et al. (2004), Tüfekçioglu et al. (2005a) and Tüfekçioglu et al. (2005b), Mısır and Mıs r (2012).

Mean total root biomass and carbon storage were 17585and 4682Kg ha^{-1} on north-facing slopes, and 18511 and 5031 Kg ha^{-1} on south-facing slopes, respectively.

Fine, coarse and total root biomass and C storage of natural oriental beech stands were significantly higher in south-facing slopes than in north-facing slopes. This result was also confirmed by Tüfekçioğlu et al. (2005a) for oriental beech forest of Genya Mountain in Turkey.

Fine, small, coarse and total root biomass and C storage varied significantly between north-facing and south-facing slopes according to One-Way ANOVA (P<0.001). Fine, small, coarse and total root biomass and C storage values in south-facing slopes were significantly higher than in north-facing slopes. Our results indicated that the highest fine, small, coarse and total root biomass and C storage were obtained in south-facing slopes.

There was no significant difference in root biomass and C storage among altitudes (P>0.05).Because all the samples were in collected tree fall, whether there were significant differences among sampling dates could not be tested.

Root biomass and C storage were no correlated with standing volume. But, fine root biomass and C storage was negatively correlated most highly with stand age (r=-0.56, P<0.001), while coarse root biomass and C storage was positively correlated with stand age (r= 0.38, P<0.001).While fine root biomass and C storage decreases with age, coarse root biomass and C storage increases with age. The same result was also reported by McQueen (1968) for scots pine stands.

Below-ground biomass and C storage for oriental beech natural stands were found to be lower than these of oriental spruce (Tüfekçioğlu et al., 2004) and oriental fir (Mıs rand Mıs r, 2012) natural forestsin Black sea region in Turkey.

4. Conclusions

The total carbon pool ofnatural*Fagusorientalis*Lipskystands in northern Anatolia was on average 4.7 ton ha^{-1} in north-facing slopes, and 5.0 $tonha^{-1}$ in south- facing slopes. This estimate includes only carbon in roots. We analyzed the carbon content in fine root with a CHNS analyzer and we found a mean value of 23.9 % with 95% of carbon content varying between 20.1 % and 37.8% in north-facing slopes, and 25.9 % with 95% of carbon content ranging from 22.3 % to 39.1% in south-facing slopes. The mean carbon content in small and coarse roots were obtained 27.7 % and 25.8 % in north- facing slopes, and 29.1 % and 27.7 % in south-facing slopes, respectively.

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Figures

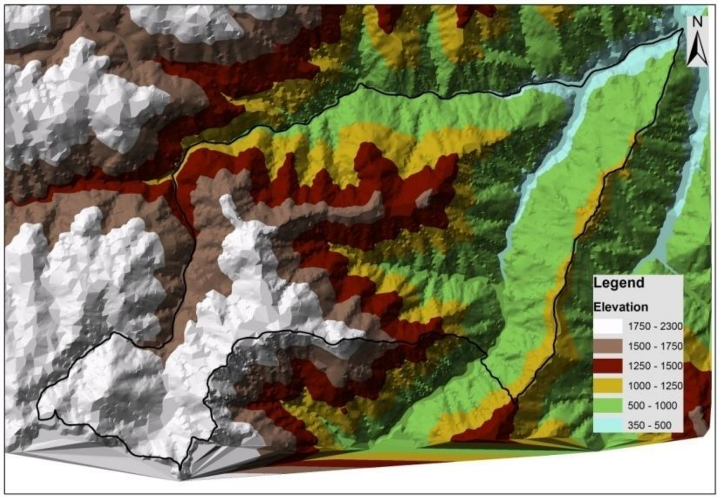

Fig.1 The study area (Ormanüstü Forest Planning Unit (OPU))

Tables

Table 1. Standcharacteristics of theresearchplot of *Fagusorientalis*forest

StandCharacteristics	Min	Max	Mean±*S.D.*
Meandiameter (cm)	10.2	63.7	27.0±6.8
Meanheight (m)	8.2	29.2	18.6±4.8
Age (year)	41	184	79±15.2
Volume (m^3/ha)	50	1105	571±158
Basalarea (m^2/ha)	12.0	68.6	32.9±18.2
Number of trees (*N*)	280	1800	607±221.7
Crownclosure	0.10	0.70	0.46±0.19
Slope (°)	22	56	35.5±18.01

Table 2. Root biomass (kg ha^{-1}) in sample plots

Root class	Minimum		Maximum		Mean		Standard Deviation	
	North-facing	South-facing	North-facing	South-facing	North-facing	South-facing	North-facing	South-facing
Fine	1801	2205	7669	10153	4042	5065	2169	1553
Small	1118	1708	7173	8259	3330	3569	1779	1741
Coarse	1118	6614	23567	24172	9060	9752	4083	4563
Total	4037	10527	38409	42584	16432	18386	8031	7857

Table 3. Carbon concentration (%) in root biomass in sample plots

Root class	Minimum		Maximum		Mean±S.D.	
	North-facing	South-facing	North-facing	South-facing	North-facing	South-facing
Fine	20.1	22.3	37.8	39.1	23.9±6.9	25.9±6.3
Small	21.6	27.9	36.2	38.2	27.7±4.9	29.1±5.1
Coarse	20.5	26.7	38.5	41.6	25.8±6.4	27.8±7.1

Table 4. Carbon storage of fine, small and coarse roots (Kgha^{-1})

Root class	Minimum		Maximum		Mean± Stand. Dev.	
	North-facing	South-facing	North-facing	South-facing	North-facing	South-facing
Fine	361	445	1626	2764	978±571	1059±393
Small	251	393	2360	2559	987±607	1051±636
Coarse	436	1378	5628	7629	2618±1576	2829±1764
Total	1742	2568	11841	13505	4682±2041	5031±2387