

Estimation of carbon stocks in ground cover in the oak, pine forests

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Abstract. This paper presents studies on the structural elements of biogeocenosis – living ground cover vegetation for carbon cycle assessment. The ground cover is an extremely important component of forest ecosystems. Plants growing under the canopy of a forest actively participate in the production process: by assimilating carbon dioxide from the atmosphere, they create their biomass and for life remove carbon from circulation. The article carried out an assessment of carbon stocks in the living ground cover of forest ecosystems of oak and pine trees in the forest conditions of Voronezh region. The structure of the ground vegetation in oak (*Quercus robur* L.) and pine (*Pinus silvestris* L.) forests is shown to be quite specific. With the underground biomass stock exceeds the above-ground stock on all test sites laid in different plantations and conditions. The amount of carbon deposited by ground vegetation covers is 2.35 t ha⁻¹ for moss in pine plantations and 3.80 t ha⁻¹ for grass. Results show that the largest amount of living ground cover carbon stock in pine plantations is observed in April (32.24 t ha⁻¹), and the smallest in May (13.15 t ha⁻¹). The highest carbon values in oak plantations are found in underground biomass. The highest total carbon stock is in April (25.1 t ha⁻¹) and the lowest in May (10.8 t ha⁻¹).

1 Introduction

Russia's forests play a significant role in the carbon cycle [3-4,11]. The role of forests in carbon sequestration is important, as forest ecosystems put carbon in the atmosphere into a non-active state and remove it from the cycle [2,5]. Carbon cycle assessment in forest ecosystems requires data on carbon content, storage and distribution in individual biogeocenosis structures. One of the most dynamic components of forest biogeocenosis, which is sensitive to any changes in the tree conditions (fertility, moisture) and the state of the plantations (light regime, specific influence of edificators tree species) is the living ground cover vegetation. Therefore, the formation of a species composition of ground cover is usually derived from main trees, forest understory and forest growing conditions. The species composition of grasses, mosses and lichens and the phytomass they produce are important components characterizing the biogeochemical carbon cycle. The characteristic feature of horizontal distribution of grass cover is its mosaic, which results from different

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density and compaction of the tree crown, microrelief, human impact etc. Living ground vegetation biomass largely determines carbon deposition, the amount of forest litter, fire hazard, its organic matter contributes greatly to the overall carbon and nitrogen cycles in forest ecosystem [8-10]. Carbon is the shell of organic matter and therefore predominates in the dry matter. For example, in dry biomass of plants (phytomass) contains from 45 to 53% carbon. Therefore, wherever there are large reserves of organic matter, carbon reservoirs (pools) are formed. The carbon flows associated with each pool form a final balance figure, which determines the direction of change in the size of this pool. The most obvious carbon balance in biomass [1].

The aim of these studies is to estimate carbon stocks in the living ground vegetation of forest ecosystems of oak and pine trees in the forest conditions of Voronezh region.

2 Materials and methods

To study and monitor the carbon cycle in natural and anthropogenic ecosystems of Voronezh region under conditions of global climate change, the most typical forest conditions for this region have been selected test sites, then established and describes permanent sample plots (PSP). Taking into account the requirements of special standard OST 56-69-83[6]. The research was conducted in the territory of the Suburban Forestry of Voronezh region (Fig.1) - in Levoberezhnii district (forest block №60, allotment №2, PSP №3) and Pravoberezhnii district of the Suburban Forestry (forest block №47, allotment №3, PSP №6; forest block №28, allotment №18, PSP №13 and forest block №34, allotment №11, PSP №14).

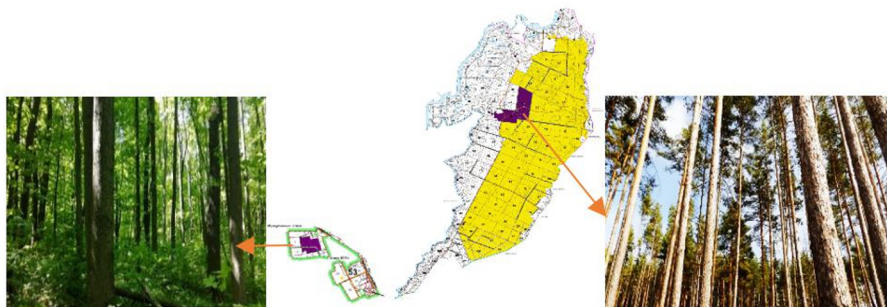


Fig. 1. Thematic forest map of the spatial arrangement of Permanent sample plots (PSP).

For the comparison of above-ground and underground biomass of living ground vegetation and further analysis, completely different plots were taken, which differ in composition and conditions of forest growth. In the Levoberezhnii forested area, the research was carried out in pine tree forest with a little mixture of oak and birch (*Betula pendula* Roth.), and in the Pravoberezhnii forested area - in mixed foliage plantations of an oak with admixture of *Tilia cordata* Mill. and *Fraxinus excelsior* L. Measurements of living ground cover were carried out at peak seasonal plant growth at the end of the vegetation season before the change in colour (yellowing/browning of grasses and leaves) began. The growing season dates are consistent with the geobotanics estimations adopted for this study region. In biogeocenosis with domination of perennial ephemerooids, two estimations are needed - at the peak of the ephemerooids growth and then at the peak of the other perennial grasses growth [7-11].

The biomass of the understorey vegetation on Permanent sample plots was carried out taking into account the area occupied by the species. The area of the species was occupied on the test sites measuring with special metal frame 25x25 cm. Thus, the area of the

monolith and the cutting of grasses were respectively on area 0.0625 m². Plants were sorted by species and weighed with determination of raw biomass. To determine the absolute dry mass, samples were dried in a drying chamber at 105 °C and re-weighed. The underground part was selected on each test site at a depth of 0.14 m, weighed in field conditions, then also transferred to the laboratory where an absolutely dry biomass was determined and again weighed.

3 Results and discussion

Comparative analysis of organic matter accumulation in the biogeohorizon of living ground vegetation in different habitats in old pine and oak stands showed that biomass stocks of mosses, grasses including grains vary according to in which month the material was collected.

On the PSP №3 (forest block №60, allotment №2) represented by pine tree stands at age 111 years, were identified reserves of above-ground and underground part of ground cover during the period April - July. The analysis of the data on the grass biomass reserve of ground vegetation shows that in April, the underground plant biomass is 3.7 times higher than the above-ground plant biomass. In May, the underground biomass is 1.6 times less than the above-ground one. In June, the stock of underground biomass is twice as much as the stock of above-ground biomass, in July - 2.7 times. The largest stock of aboveground phytomass is observed in May, and the smallest - in June. In the biogeohorizon of understorey vegetation, the largest biomass reserves of mosses are observed in April (0.81 t ha⁻¹), and the largest biomass reserves of grasses - in July (7.6 t ha⁻¹).

On the PSP №6 (forest block №47, allotment №3) in the oak tree forest the highest stock of ground vegetation is observed in June (12.18 t ha⁻¹), underground biomass - in April (45.13 t ha⁻¹). The underground biomass stock exceeds the aboveground - in April by 9 times, in May - by 20 times, in June - by 1.7 times, in July - by 3 times.

On the PSP №13 (forest block №28, allotment №18) in July, the stock of underground phytomass is 5 times greater than the stock of aboveground one.

On the PSP №14 (forest block №34, allotment №11) in July, the stock of living vegetation cover varies from 1.6 g/m² to 40 g/m², underground - from 83.2 g/m² to 276.8 g/m². Total understorey vegetation biomass - above ground 200.4 g/m², underground - 1448.0 g/m². In translation of one-hectare total biomass - above ground is 3.2 tons; underground - 23.17 tons. Thus, for the ground cover vegetation, the underground biomass stock 7 times higher than the aboveground.

When calculating the carbon stock of above- and underground phytomass in ground cover vegetation, the following was found. Carbon deposited by the for the moss ground cover in pine plantations on the PSP №3 (forest block №60, allotment №2) is 0.40 t ha⁻¹ in April, for grasses - 0.12 t ha⁻¹; in May - for moss cover 0.20 t ha⁻¹, for grass - 0.30 t ha⁻¹; in June - for moss - 0.24 t ha⁻¹, for grass - 0.10 t ha⁻¹; in July - for moss - 2.35 t ha⁻¹, for grass - 3.80 t ha⁻¹. The highest values are for moss and grass cover in July.

Deposited carbon by ground cover vegetation in April – in aboveground biomass 6.84 t ha⁻¹, underground - 25.4 t ha⁻¹, total stock - 32.2 t ha⁻¹; in May – aboveground 8.19 t ha⁻¹, underground - 4.96 t ha⁻¹, total stock - 13.15 t ha⁻¹; in June – aboveground - 5.49 t ha⁻¹, underground - 10.16 t ha⁻¹, total - 15.65 t ha⁻¹, in July – aboveground biomass - 6.19 t ha⁻¹, underground - 16.54 t ha⁻¹, total stock - 22.74 t ha⁻¹. Results show that the largest amount of carbon stock in living ground cover vegetation in pine plantations is observed in April (32.24 t ha⁻¹), and the smallest in May (13.15 t ha⁻¹).

On the PSP №6 (forest block №47, allotment №3) carbon deposited by living ground vegetation in oak forest in April in aboveground biomass is 2.53 t ha⁻¹, in underground - 22.57 t ha⁻¹, total stock - 25.1 t ha⁻¹; in May – aboveground 0.50 t ha⁻¹, underground – 10.32

t ha⁻¹, total – 10.82 t ha⁻¹; in June - aboveground 6,09 t ha⁻¹, underground – 10.67 t ha⁻¹, total – 16.76 t ha⁻¹; in July - aboveground 3.00 t ha⁻¹, underground – 9.04 t ha⁻¹, total – 12.04 t ha⁻¹. The highest carbon values are for underground biomass. The highest total carbon stock is in April (25.1 t ha⁻¹) and the lowest in May (10.82 t ha⁻¹).

On the PSP №13 (forest block №28, allotment №18) the amount of carbon deposited by ground cover vegetation in oak forest is 2.48 t ha⁻¹ in the aboveground biomass, 12.15 t ha⁻¹ in the underground. Total carbon stock - 14.63 t ha⁻¹.

On the PSP №14 (forest block №34, allotment №11) the amount of carbon deposited by ground cover vegetation in oak forest is 1.60 t ha⁻¹ in aboveground biomass, underground - 11.58 t ha⁻¹. Total carbon stock - 13.19 t ha⁻¹.

The maximum carbon stock in ground cover vegetation is observed in suburban forests in plantations growing in forest block № 60, allotment №2. For 1 hectare in aboveground and underground phytomass there are 6.84 and 25.4 tC ha⁻¹ respectively.

The comparative analysis of total carbon stocks of above and underground biomass of ground cover vegetation in different habitats showed that maximum values are typical for subsurface carbon stocks ranging from 10.67 to 25.40 t ha⁻¹. With the highest amount of carbon found in the underground layer of ground cover vegetation in pine plantations. The highest carbon stock in the aboveground level is observed in the oak stands in forest block №47, allotment №3 and is 6.09 t ha⁻¹ and in the pine stands is 6.84 t ha⁻¹ (Fig. 2)

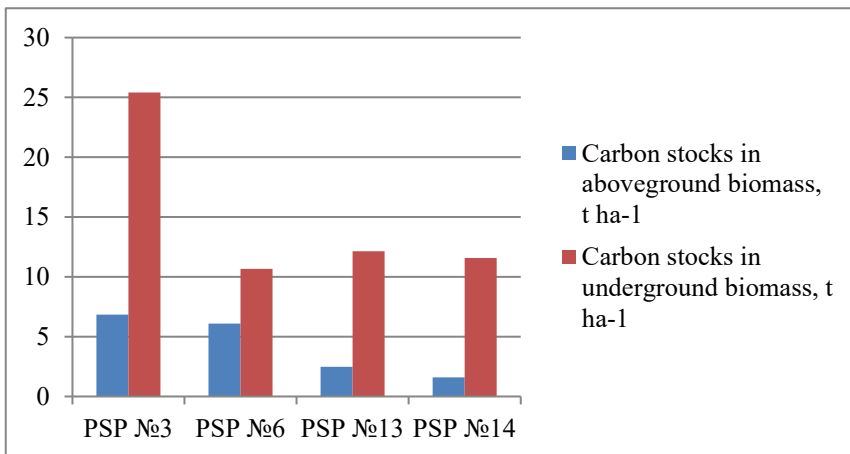


Fig. 2. Histogram of the ratio of the carbon stock (t ha⁻¹) of aboveground and underground phytomass in the ground cover vegetation on 4 PSP in Voronezh region.

Our research provides an idea of the ratio of carbon stocks in different fractions of aboveground and underground phytomass of ground cover vegetation. The resulting carbon content in tree components can be used to build a database on forest phytomass carbon stocks, which is needed as a basis for successful development of modern environmental programmes. Comparative analysis of the total above-ground biomass reserves of living overland cover in different types of forest showed that the biogeosphere of living overland cover has the largest reserve of underground phytomass during the period from April to July.

4 Conclusions

1. Comparative analysis of the total biomass reserves of ground cover vegetation in different types of forest showed that the biogehorizon of understorey vegetation has the largest reserve in underground phytomass during the period from April to July.

2. The largest stock of aboveground biomass in the period April - July is observed in the oak-tree forest with sedge and goutweed in June (12.18 t ha^{-1}), in the grass oak-tree forest in May (16.38 t ha^{-1}).

3. In pine forests in the biogehorizon of understorey vegetation, maximum biomass values of moss (4.7 t ha^{-1}) and grass (38.0 g/m^2) are observed in July.

4. In oak plantations in the the biogehorizon of understorey vegetation a grass layer is clearly expressed.

5. The comparative analysis of total carbon stocks of above and underground biomass of ground cover vegetation in different habitats showed that maximum values are typical for the carbon stocks in pine forest and accumulated in the underground layer - 25.4 t ha^{-1} . The highest carbon stock in the above-ground level is observed in the oak forest on PSP №6 and is 6.09 t ha^{-1} and in pine forest on PSP №3 is 6.84 t ha^{-1} .

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