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Specifisity of phytocoenotic structure and biomass of ground cover in northern boreal forests of Middle Siberia

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Abstract. We measured biomass of living ground cover and analyzed specificity of carbon accumulation in the litter in different types of larch forests in northern boreal subzone of Middle Siberia.

1 Introduction

Living ground cover is an extremely important structural element of forest ecosystems [1-3]. Along with tree stand, plants of the ground cover participate actively in the production process. By assimilating carbon dioxide from the atmosphere to build their own biomass, they take carbon out of circulation for the period of their life. Moreover, ground cover vegetation (shrubs, dwarf shrubs, herbs, mosses, lichens) forms a reserve of combustible forest materials [4, 5]. After a dieback, biomass of understory vegetation enters the pool of forest litter which, in turn, serves as a bridge between aboveground and underground forest storeys. Forest litter provides plants with mineral nutrients [6, 7], takes part in humus formation processes [8] and largely defines hydrothermal and chemical properties of the root zone [9-12].

The role of living ground cover is particularly important in boreal forests, including forests of Central Siberia permafrost zone, where phytomass of understory vegetation and its annual turnover are comparable with those of tree stand [13-15]. As a result, litterfall and understory vegetation die-off contribute significantly to dead organic matter entering the soil [16]. However, there are practically no quantitative estimates of living ground cover biomass and its contribution to a forest litter formation for different types of forest ecosystems in the Central Siberia permafrost zone.

The most dramatic climate changes are expected to happen in high latitudes of the Asian continent. Therefore, studies on the forest ecosystems of boreal subzone are becoming increasingly relevant. In this context, biospheric functions of the regional larch ecosystems are acquiring a global significance.

The aim of our research was to reveal eco-geographical peculiarities of carbon accumulation in the biomass of living ground cover and in forest litter for different types of

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larch forests in northern boreal subzone of Middle Siberia. The data obtained would help to understand structural and functional specificity of the ecosystems studied.

2 Materials and methods

The study was conducted in the forest ecosystems of Central Evenkia. The research area is located on the Central Siberian Plateau (64° N, 100° E), in basin of the Nizhnaya Tunguska River, near Tura settlement. The territory has low- and middle-mountain relief, characterized by erosion-denudation processes, with shallow slopes and flat-topped watersheds. The elevation varies from 120 to 650 m a.s.l. Traps that dominate the geological structure are the basis of pedogenesis. The research area lies entirely within the permafrost zone. Podburs, lithozems and cryozems forming on loamy eluvium dominat in the soil cover.

The region has a continental, moderately humid climate, with the mean annual air temperature -8.9°C. The average January and July temperatures are -36°C and +16°C correspondingly. The sum of air temperatures for a period with average daily values above 10 °C is 1000 °C, the annual amplitude of air temperature is 52°C. The average annual sum of precipitation amounts to 370 mm. The quantity of rain is comparatively regular in all the seasons. The height of the snow cover amounts to 50-60 cm. The length of vegetation period is 70-80 days. Climate parameters are changing with absolute height because of altitude climate inversions [17].

Temporary sampling plots of 25×25 m were established in different types of larch forests. On each plot, biomass of living ground cover and forest litter were taken in 5-10 replicates using round frame 20-cm diameter. Inside the frame shrubs, herbs, lichens and living parts of mosses were cut; forest litter was extracted entirely, up to the mineral soil horizon.

The samples of living ground cover were divided into four biomorphs: shrubs, mosses, lichens and herbs. Living roots of herbs and shrubs, extracted from the litter, were summed with the aboveground biomass of the corresponding biomorphs of living ground cover. The samples were dried at 60 °C for 24 hours and then weighted. The data obtained were converted into the mass per unit area.

Carbon content in the biomass of living ground cover and in forest litter was determined using CN analyzer (Vario Isotope Cube, Elementar, Germany) (Table 1).

Table 1. Carbon content in the biomass of living ground cover components and in forest litter, g/100g.

Component	Mean	SD	CV, %
Herbs	37.3	1.0	2.6
Shrubs	49.4	0.7	1.3
Mosses	43.6	0.2	0.5
Lichens	42.0	0.6	1.5
Forest litter	37.8	4.7	12.5

Note: **SD** – standard deviation, **CV** - coefficient of variation.

3 Results and discussion

The general floristic composition of phytocoenoses studied doesn't change significantly from one landform to another, but the dominants vary among different forest types. *Vaccinium uliginosum* L. and bushy lichens genera *Cladonia* P. Browne and *Cetraria* Ach. dominate on the uplands. Tall dwarf shrubs *Ledum palustre* L. and *Chamaedaphne* *calyculata* (L.) Moench. prevail in the lowlands, with a continuous cover of *Pleurozium schreberi* (Brid.) Mitt and species of the genus *Sphagnum* L. under them. On the northern slopes, the dominants of living ground cover are *Ledum palustre* L., *Pleurozium schreberi* (Brid.) Mitt and *Hylocomium splendens* (Hedw.) Bruch. et al., but *Vaccinium vitis-idaea* L. becomes abundant on the upper parts of the slopes and *Carex globularis* L. – on the lower parts of the slopes. On the slopes of southern exposition, *Vaccinium vitis-idaea* L. prevails everywhere except for the lower parts of slopes, where *Ledum palustre* L. co-dominates. The hydrophilic moss *Aulacomnium palustre* (Hedw.) Schwagr. also makes up a significant part of living ground cover vegetation on the lower parts of slopes of all expositions. The names of vascular plants and mosses are according to [18, 19].

The blueberry-lingonberry-green moss birch forests cover the most drained, relatively warm uplands; flat convex places and slopes of different exposure (usually north-eastern, 3-10°) on altitude 470-650 m a.s.l. Density of tree canopy varies from 25 to 55%; *Betula tortuosa* Ledeb dominates in the tree layer, always with an admixture of *Larix gmelinii*. The shrub layer with 10-40% coverage is dominated either by *Duschekia fruticosa* or by undergrowth of *Betula pubescens*. The herb-dwarf shrub layer with 15-50% coverage is dominated by *Ledum palustre* L., *Vaccinium uliginosum* L. and *Vaccinium vitis-idaea* L. in various combinations. *Vaccinium vitis-idaea* L. usually forms the lower sub-layer. The coverage of the moss-lichen layer is 70-90%; lichens genus *Cladonia* P. Browne, *Pleurozium schreberi* (Brid.) Mitt, *Hylocomium splendens* (Hedw.) and, sometimes, *Polytrichum commune* Hedw. are prevalent. The mean carbon stock is 0.69 kg/m^2 and 2.89-3.02 kg/m^2 in the biomass of living ground cover and in the forest litter, respectively (Fig. 1).

On even landforms of the uplands and on the uppermost parts of the slopes of different exposition (W, E, N), with 3-7° steepness and 500-600 m a.s.l. elevation, there grow blueberry-herb-green moss birch forests. These habitats are more precipitated (less drained) compare to the previous subassociation. Tree layer is dominated by *Betula tortuosa* Ledeb, always with an admixture of *Larix gmelinii* and *Picea obovata*. Tree canopy density varies from 45 to 70%. The coverage of the shrub layer is 5-30%; *Duschekia fruticosa* and the undergrowth of *Betula tortuosa* are prevalent. The herb-dwarf shrub layer with 15-25% coverage is usually dominated by *Vaccinium uliginosum* L. and boreal small grasses. The moss-lichen layer is well developed (65-90% coverage). It is dominated either by *Hylocomium splendens* (Hedw.) or by *Pleurozium schreberi* (Brid.) Mitt, co-dominated by lichens genus *Cladonia* P. Browne or *Polytrichum commune*. Carbon stock in the biomass of living ground cover in these ecosystems is lower than in previous ones and varies from 0.21 to 0.32 kg/m^2. Carbon stock in forest litter ranges between 1.78 and 5.82 kg/m^2 (Fig. 1).

The ledum-green moss larch forests cover middle transit, even or slightly convex, parts of the slopes, usually northern, eastern or western expositions (200-400 m a.s.l.), with very stony soils. The tree stand is sparse (canopy density 20-35%) and is composed entirely of *Larix gmelinii*. The shrub layer with 5-20% coverage is dominated by *Duschekia fruticosa*. The only dominant of the herb-dwarf shrub layer with 20-60% coverage is *Ledum palustre* L. The moss-lichen layer forms a practically continuous cover (90-100% coverage), with an absolute predominance of *Pleurozium schreberi* (Brid.) Mitt. In the larch forests of this type carbon stock in the living ground cover biomass increases again and reaches 0.35-0.42 kg/m^2. The carbon stock in the forest litter varies substantially: from 3.17 to 6.08 kg/m^2 (Fig. 1).

The lingonberry-green moss larch forests cover the lower gentle parts of the slopes of different exposition (S-E, S-W, N-E, N-W), with 2-5° (rarely up to 10°) steepness and 160-230 m a.s.l. elevation. The density of tree canopy is 20-40%; the tree stand is composed entirely of *Larix gmelinii*. The sparse shrub layer with 5-15% coverage is dominated by

Duschekia fruticosa, *Betula exilis*, willows and the undergrowth of *Larix gmelinii*. In the herb-dwarf shrub layer, with 30-45% coverage, *Vaccinium vitis-idaea* L. prevails, *Vaccinium uliginosum* L., *Carex globularis* and *Arctous alpina* (L.) Nied. can co-dominate. The moss-lichen layer is always continuous (100% coverage), with a predominance of *Pleurozium schreberi* (Brid.) Mitt, *Hylocomium splendens* (Hedw.), *Aulacomnium palustre* (Hedw.) Schwagr. and lichens genus *Cladonia* P. Browne in different combinations. These forest ecosystems are characterized by medium carbon stock in the biomass of living ground cover (0.30-0.40 kg/m^2) and by high variability of carbon stock in the forest litter (2.77-6.03 kg/m^2) (Fig. 1).

On the low waterlogged floodplains of Nizhnaya Tunguska and Kochechum rivers there grow the dwarf shrub-sphagnum larch forests. These communities occupy the habitats with flat or shallowly inclined (2-3°) relief on the slopes of different expositions. The elevation is 122-150 m a.s.l. Tree canopy density varies from 10 to 50%; forest stand is composed entirely of *Larix gmelinii*. The shrub layer with 5-20% coverage is composed of willows, *Betula exilis* or *Duschekia fruticosa*. The coverage of the herb-dwarf shrub layer is 25-40% (dominated by *Chamaedaphne calyculata* (L.) Moench and *Ledum palustre* L.). The moss-lichen layer with 95-100% coverage is dominated by *Pleurozium schreberi* (Brid.) Mitt., *Hylocomium splendens* (Hedw.) and species of the genus *Sphagnum* L. These waterlogged larch forests demonstrate no significant difference in regard of carbon stock in the living ground cover (0.39 kg/m^2); but carbon stock in the forest litter is relatively high – 6.13 kg/m^2 (Fig. 1).

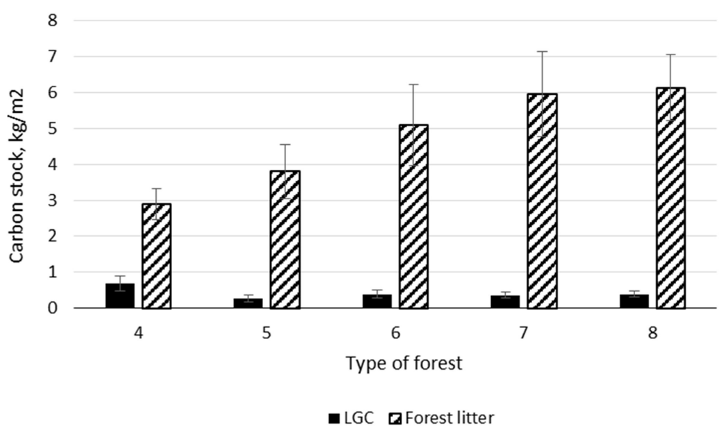

Fig. 1. Carbon stock in the biomass of living ground cover (LGC) and in the forest litter: **4 –** the blueberry-lingonberry-green moss birch forest; **5** – the blueberry-herb-green moss birch forest; **6** – the ledum-green moss larch forest; **7** – the lingonberry-green moss larch forest; **8** – the dwarf shrub-sphagnum larch forest.

4 Conclusions

Harsh climate conditions and the presence of permafrost define low decomposition rate of dead organic matter on the soil surface. As a result, the larch forests in northern taiga have well-developed living ground cover and accumulate a significant amount of forest litter.

The analysis of the ratio between carbon stock in living ground cover biomass and in forest litter of the associations studied demonstrates the following. The birch forests (forest type is blueberry-lingonberry-green moss) occupy the most drained conditions of the uplands, where environment is favorable for the formation of high biomass of living ground cover and for relatively high decomposition rate of dead plant material. The ratio between carbon stock in living ground cover biomass and in forest litter is 1:4.

On the upper and lower parts of the slopes the living ground cover biomass is declined and the amount of forest litter is increased, that can be a consequence of lower drainage of the habitat. As a result, the ratio between living ground cover biomass and forest litter increases up to 1:13-1:14 (forest types include blueberry-herb-green moss birch forests and ledum-green moss larch forests).

Larch forests growing on the lower parts of the slopes and on waterlogged low floodplains (lingonberry-green moss and dwarf shrub-sphagnum larch forests) are tend to accumulate forest litter without any significant changes in living ground cover biomass.

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