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STRUCTURE AND LIVE BIOMASS OF GREEN FOREST FLOOR IN MIXED DECIDUOUS-CONIFEROUS FORESTS DURING REFORESTATION IN TAIGA ZONE

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Abstract

Forest cutting and natural reforestation essentially affect the species diversity, structure and live biomass of trees and green forest floor (GFF). Spruce forests, different-aged mixed deciduous-coniferous stands, and birch young forest in the taiga zone of northeastern Russia (Komi Republic) have been studied. Tree species are represented by *Betula pendula, B. pubescens, Populus tremula, Pinus sylvestris, Picea obovata, Abies sibirica.* Soil types at study objects are weakly peaty-weakly podzolic gley soil and illuvial-humus-iron podzol. Before cutting instead of today's deciduous forests there grew a 150–190-year-old spruce forest. GFF live biomass vary from 0.4 upto 3.9 $t.ha^{-1}$ and reaches its highest values in spruce forest and the lowest values in 37-year-old birch-aspen forest. High resistant of phytomass in spruce forest and 90 years old birch-aspen forest, low resistant phytomass characterizes middle-aged deciduous-coniferous forests. Weight proportion grasses/mosses makes 1:1 in middle-aged deciduous-coniferous forests, 3:5 in birch young forest and 90-years-old birch-aspen forest, and 1:8 in spruce forest.

Key words: deciduous-coniferous stands, phytomass, species diversity, taiga.

Introduction

Formation of secondary mixed deciduous-coniferous stands at large areas after clear cutting during the 20th century became a characteristic feature of northern forests. These stands are represented by aspen and birch in over story and by coniferous tree species, mainly spruce, in understory. A specificity of reforestation in northwestern Russia is a combination of natural regeneration and artificial reforestation (Leinonen et al. 2009). The cut areas of 1950–1990 on the territory of Komi Republic are now secondary spruce-birch and pine-birch forests. Most of them are result of natural regeneration.

The studies of succession processes in mixed deciduous-coniferous forests are important for understanding the dynamics of taiga forests. Phytomass structure is one of the most important characteristics of vegetation cover. For the Republic of Komi, species composition and structure of deciduous and deciduous-coniferous stands were studied by Degteva (2002), reforestation processes by Ilchukov (2003) and Pautov and Ilchukov (2001).

Anthropogenic impact and following natural reforestation substantially change composition, structure, and phytomass of trees and vegetation cover. Species composition of GFF after cutting initial forest is formed under influence of a series of factors. Grasses at cut areas actively respond to changes of ecological conditions. Estimating of plant phytomass is of a high practical and theoretical significance. The type of secondary forest depends on the mode of cutting, initial forest characteristics, on climatic, soil, and biotic factors (Melekhov 1954). The aim of the study was to reveal the principle characteristics of GFF in forests at different succession stages.

Materials and Methods

Mixed deciduous-coniferous and spruce forests have been studied for 10 years at the Lyali Forest-Ecological Station on the North-West of Russia (Komi Republic).

The studied objects are ranked by age from youngest to oldest (Table 1).

Birch-spruce young forest and middle-aged birch-aspen forest replaced once felled haircap-moss bilberry spruce forest and bilberry spruce forest, relatively, with tree stand composition 80% spruce and 20% birch, undergrowth composition 10% spruce, age 150–190 years. Studying of GFF in sphagnum bilberry spruce forest and bilberry spruce forest provides us the information on live biomass, species composition and structure before cutting.

Estimation of GFF live biomass was made by hay-harvest method at the area of 400 cm^2 in a 40-fold replication and at area 878.9 cm^2 in a 20-fold replication. Species composition and live biomass were measured at each test plot for 3 years.

Results and Discussion

GFF of the studied forests is mosaic, especially in deciduous young forest and middle-aged birch-aspen forest. The studied forests differed by species composition and species number in GFF. Total number of plants in the studied phytocenoses was 65 species, among them 52 vegetation cover species. North and south taiga subzones of Komi Republic may count up to 361 plant species in birch forests. Mixed deciduous-coniferous forests had as many as 1.4 times more plant species than spruce forests. Species number in deciduous stands of Komi Republic was sometimes higher than one in spruce forests by 1.5–2 times, and it increased due to perennial grasses (Degteva 2002).

The most amounts of species were found in deciduous-coniferous forest (No 3) and the least amounts in pine-deciduous forest (No 4) (Fig.1). Species composition of GFF during reforestation depends on type of cutting. GFF at clear cuttings is most dynamic (Melekhov 1954). Species composition formation in secondary deciduous forests is a very special process and is influenced by number of factors. Several reforestation principles, well-known in forestry that are appropriate for the species composition of study forests could be mentioned:

1. Grass plants at cuttings with different types of technogenic disturbance actively respond to changing of ecological conditions. Ten years after cutting the number of grass species increased by 1.6 times on logger-roads and by 2.3 times on timber-loading areas. Thirty-five years after tree cutting, species number increased by 6 and 20%, respectively, compared to the 10-year-old cutting (Ilchukov 2003). According to our results, species number in GFF of birch young forest and spruce forests was about the same, while in deciduous-coniferous stand it was about 1.5 times more than that in the spruce forest.

2. During the reforestation the green mosses decreased in amount because of changing of illumination (Melekhov 1954, Ilchukov 2003). Six green moss species were found in the studied spruce forests and 2–4 species in the deciduous forests.

3. The typical indicator-species of cut areas was *Chamerion angustifolium*. There is some this species in deciduous

Table 1. Characteristic of plots.

No	Tree stand composition	Forest age, years	Forest type	Type of soil
1	Birch 80% Spruce 20%	12	Grassy	peaty-weakly-podzolic gley soil
2	Aspen 50% Birch 40% Spruce 10% Fir (*Abies*) – singly	37	Grassy	peaty-podzolic-weakly gley soil
3	Aspen53% Birch 40% Pine 4% Spruce 3%	45	grassy-bilberry	illuvial-humus-iron podzol
4	Pine 51% Birch 24% Aspen 23% Spruce 2%	45	bilberry	illuvial-humus-iron podzol
5	Aspen 70% Birch 20% Spruce 10% Fir (*Abies*) – singly	90	Grassy-green moss	typical podzolic soil
6	Spruce 90% Birch 10% Pine <1% Fir (*Abies*) – singly	106-200	bilberry-sphagnous	peaty-podzolic-weakly-gley soil
7*	Spruce 80% Fir (*Abies*) 10% Birch 10% Pine <1%*	80-150	bilberry moisture	illuvial-humus-iron podzol

* Bobkova (2006)

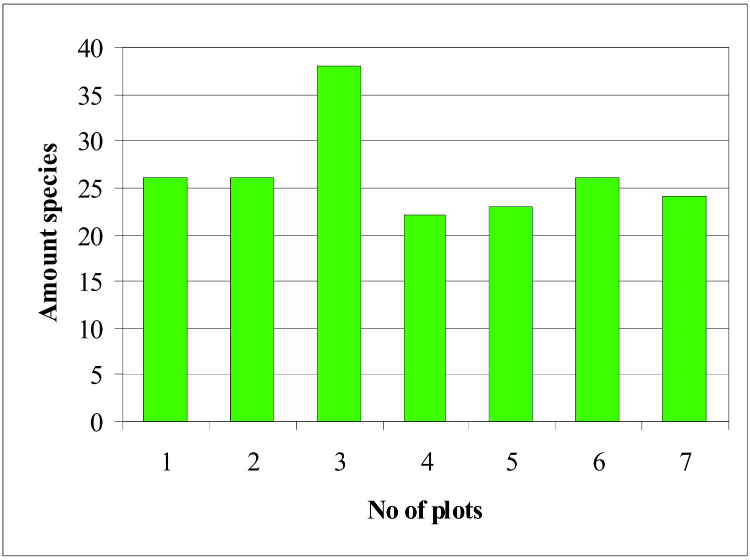

Fig. 1. Amount of plant species on the sample plots.

stand but does not bloom (Melekhov 1954). We did not found *Chamerion angustifolium* only in the spruce and mixed pine-deciduous forests.

We have applied the Stugren-Radulesku coefficient for comparing the species composition. The highest values of this coefficient were obtained when comparing between birch-aspen and pine-deciduous forests (0.27). There was almost no similarity between spruce forest and young forest and middle-aged deciduous forests.

Specific similarity between plots was estimated by the Jaccard's coefficient (K_J). The maximum similarity value (K_J>70%) was observed for birch-spruce young forest and aspen-birch stands (37- and 90-year-old stands). The high degree of similarity is attributed to the fact that they grow on the same soil type.

High similarity values (K_J>50%) were found among all middle-aged stands and young forest. In this case, it is related to similar composition, age and origin of tree stands. A high similarity degree between spruce forests and young forest (K_J=58%) is due to the fact that cut area (now young forest) remained with some spruce undergrowth, spruce trees and typical spruce forest plants. This is one of important reforestation and vegetation cover formation factors (Melekhov 1954).

The differences between sample plots in terms of species composition were estimated also by the differentiation coefficient (K_D). The highest differentiation degree (K_D>60%) was found between middle-aged deciduous and spruce forests due to essentially different species composition, and forest site quality. High degrees of differentiation (K_D>50%) were found between 90 years old birch-aspen and spruce forests, 90 years old birch-aspen and middle-aged forests. This indicates that 90-year-old stand has a special species composition different from both spruce forest and middle-aged deciduous forests.

The maximum phytomass was accumulated in bilberry-sphagnum spruce forest (No 6) – 3858±369 kg.ha^{-1}, and the minimum in birch-aspen forest (No 2) – 406±62 kg.ha^{-1} (Table 2). Among deciduous forests, phytomass accumulation reached its maximum in birch-spruce young forest – 1950 ± 220 kg.ha^{-1} and its minimum in birch-aspen forest – 406 ± 62 kg.ha^{-1} (Table 2). GFF live biomass was dominated by *Vaccinium myrtillus* L., *V. vitis-idaea* L., *Agrostis tenuis* Sibth., *Geranium sylvaticum* L., *Chamerion angustifolium* (L.) Scop., *Melampyrum sylvaticum* L., *Solidago virgaurea* L., *Cirsium heterofillum* (L.) Hill., *Polytrichum commune* (Hedw.) Br., Sch. Et Gmb., *Plerozium schreberi* (Brid.). Mitt., *Hylocomium splendens* (Hedw.) Br., Sch. et Gmb., *Sphagnum magellanicum* Brid.

Phytomass of ferns, horsetails, and club-mosses was never above 5% of total GFF live biomass in study forests and never above 10% for gramineous plants. Dominating groups of plants are undershrubs, grasses, and mosses. In middle-aged deciduous-coniferous and birch-aspen forests we found about 40% of grasses, undershrubs – 20% and mosses – 40% of the total (Table 2). In birch-spruce young forest and birch-aspen (90 years old) forest, grasses had about 30% and mosses more than a half of the total mass. High live biomass of undershrubs (70%) was observed in pine-deciduous stand. The proportion between mosses and grasses depends on tree stand composition, age and soil type. For example, in middle-aged deciduous forests on illuvial-humus-iron podzols the ratio was 1:1, in birch young forest and birch-aspen (37 years old) forests on peaty weakly-podzolic weakly-gley soil – 1:2. In spruce

Table 2. GFF live biomass, kg dry matter ha^{-1}/%.

No	Forest type	Total phytomass	Moss	Subshrubs	Grass
1	Birch-spruce young forest	1951 ± 221 100	1119 ± 130 57	292 ± 33 15	540 ± 28 28
2	Birch-aspen (37 years)	407 ± 63 100	151 ± 16 37	79 ± 22 19	177 ± 14 44
3	Deciduous-coniferous	1033 ± 241 100	429 ± 165 42	221 ± 13 21	383 ± 88 37
4	Pine-deciduous	702 ± 131 100	120 ± 58 17	471 ± 207 67	110 ± 12 16
5	Birch-aspen (90 years)	681 ± 39 100	351 ± 35 52	64 ± 17 9	266 ± 26 39
6	Spruce forest	3858 ± 360 100	3190 ± 272 83	86 ± 8 2	583 ± 59 15
7	Spruce forest*	1837 ± 56 100	1498 ± 43 82	270 ± 12 15	69 ± 7 3

* Bobkova (2006)

forest mosses were dominant and so the proportion became 1:7.

We applied the coefficient of variation (V) for statistical analysis of phytomass. The data presented indicate relative stability of the studied phytocenoses in GFF live biomass (Table 3).

Table 3. The variation coefficient of GFF live biomass, %.

Forest type	Total phytomass	Moss	Subshrubs	Grass
Birch-spruce young forest	11.3	11.6	11.3	9.6
Birch-aspen (37 years)	15.5	10.5	27.7	10.6
Deciduous-coniferous	23.4	38.5	6.0	31.0
Pine-deciduous	18.7	48.2	43.9	18.7
Birch-aspen (90 years)	5.6	10.1	27.1	24.2
Spruce forest	9.3	8.5	9.8	16.8
Spruce forest *	3.1	2.9	4.6	10.3

* Bobkova (2006)

Spruce forests and birch-aspen forest (90 years old) were the most stable according to the total phytomass index of vegetation cover plants. Less stable were the middle-aged deciduous forests. On the whole the variation coefficient for GFF live biomass varied within a small range, except for some groups of plants. Mosses live biomass was stable in spruce forest, birch-aspen forests, and birch young forest. This stability is related to peaty weakly-podzolic weakly-gley soil and wide participation of sphagnum in the phytomass. *Polytrichum commune* and *Sphagnum* spp. mosses can develop instead of green mosses at cut areas (former spruce forests) under certain conditions. This is because green mosses are less tolerant to changing illumination (Melekhov 1954). The birch young forest was found on small wet plots (former logger-roads) dominated by sphagnum mosses.

Live biomass of moss cover in the middle-aged deciduous forests varied widely. Subshrub layer in deciduous-conifer and spruce forests was the most stable one. A high variation coefficient for subshrub phytomass in the pine-deciduous forest (43.9%) indicates a possible decrease of their share in the total phytomass. This stand was dominated by bilberry and cowberries, but they may decrease in phytomass because of the second spruce canopy formation and the consequent illumination change. The highest species diversity and mosaicity of grasses in GFF are typical for the deciduous and mixed deciduous-coniferous forests. Phytomass of grasses in the deciduous and mixed deciduous-conifer forests was 1.6–7.8 times higher as compared to the bilberry spruce forests. Mosses phytomass in the spruce forests was 2.9–12.5 times higher as compared to deciduous and deciduous-coniferous forests (Table 2).

Conclusion

The obtained results show that species composition and phytomass of GFF in the secondary deciduous forests depends on tree composition and age, soil type, and succession stage.

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