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SPATIAL-FUNCTIONAL HETEROGENEITY OF POST-CUTTING COMMUNITIES IN THE CENTRAL FOREST STATE BIOSPHERE RESERVE

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The article contains the results of a case study devoted to spatial and functional heterogeneity of post-cutting vegetation during early succession stages in southern taiga subzone. The study is based on large scale mapping of clear-cutting area and its vegetation communities. Post-cutting communities and their phytomass surveys were carried out within overgrowing cutting in buffer zone of the Central Forest Biosphere State Reserve (Tver region). In order to compose a schematic map of local vegetation, we implemented a classification of communities, grouping them by the regenerating layer of trees and shrubs and taking into account ground cover dominants. For the first time for this territory the analysis of ecotopic differentiation of post-cutting vegetation was conducted on the base of L.G. Ramensky ecological scales. The maps of average humidity and average nutrient status in post-cutting ecotopes had been composed. The correlation connections between projective cover, height, and plants increments and their phytomass were discussed. The phytomass stocks were accounted within studied cutting area as total and for each type of communities. The map of phytomass distribution within cutting area was made, where average phytomass values were showed for different types of communities. Maximal phytomass values were observed in forb and great willow herb communities and in communities with aspen and birch undergrowth near forest edge. Received data on plants increments and phytomass and their distribution would be used for conjugative analysis of pulsar measurements data on carbon balance parameters in cutting area which had obtained by meteorologists. Thus, it can be possible to evaluate the contribution of each communities' type and dominating plants in carbon sequestration.

Keywords: post-cutting communities, spatial structure, functional structure, ecotopic differentiation, vegetation phytomass.
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The study of the vegetation restoration on clear-cutting has a long tradition in the Russian scientific community (Melekhov, 1980; Kryshen, 2006; Ulanova, 2012). At the present stage, the surveys on the afforestation and deforestation contribution to the carbon balance are becoming more and more important (Isaev et al., 1995; Molchanov et al., 2017; Kudejarov, 2017; Amiro, 2001; Kimball, 1997). Russian forests play the most significant role in the carbon deposition, however, under cutting the forest land becomes the source of carbon emission, and then these emissions can last for more than 20 years (Isaev et al., 1995). While studying temporal variability of CO_2 flows within clear-cutting, C.A. Williams et al. (2014) have detected that the severest changes in those flows happened in the early years after cutting was performed, when the ecosystem became a steady source of CO_2 emission into the atmosphere. Forest felling results in considerable changes in biogeochemical and biogeophysical processes. In order to understand them better, the detailed survey of vegetation communities' structure is necessary to be made.

Scientific researches on the way the forests and cutting contribute into carbon balance within the Central Forest Biosphere Reserve have been carried out by the scientists of the A.N. Severtsov Institute of Evolution and Ecology Problems of the Russian Academy of Sciences (Laboratory of Biogeocoenology) for several years (Kurbatova, Olchev, 2017). There are observations on the heat flows, water vapor and carbon balance compounds, carried out with the method of turbulent pulsations with the usage of chamber gas analyzers, made several times during the season. The measurements within the studied cutting have begun in 2016, just after the logging works were finished. The results of CO_2 flows' measurements for the vegetation period of 2016 have affirmed that studying cutting area served as the CO_2 source for the whole period of our observation (Kurbatova, Olchev, 2017; Mamkin, 2017; Molchanov et al., 2017). The obtained data testify that at first the cutting area became a source of CO_2 emission, but as vegetation was restoring, photosynthesis was increasing, and living phytomass was accumulating, these emissions started to decrease. It is obvious that vegetation renewal and dynamics of phytomass production in different vegetation communities have the main role in forming carbon balance structure. However, studying of vegetation structure and phytomass accumulation has not been conducted within this territory yet. Hence, *the purpose of this survey* was to detect the spatial and functional heterogeneity of vegetation in the cutting area on the early successions stages, and to put it on the large scale maps for the further analysis, conjugated with carbon balance parameters.

Materials and Methods

The research area is located within the protective zone of the Central Forest State Natural Biosphere Reserve. The reserve is located in the southwestern part of the Valdai Upland, within the Main (Caspian-Baltic-Black Sea) watershed of the East European Plain (fig. 1 a). The reserve was established on December 31, 1931, in order to preserve the integrity of the unique southern taiga forests of the Central Russia and to study natural ecosystems processes. The nature of the relief and underlying rocks contributes to the formation of moistened soils and ecosystems' bogging in the entire reserve, as well as within the studied site. The combination of hydrothermal characteristics determines predominance of wet peatland spruce forests. Due to disturbances these forests are usually replaced by small-leaved forests with common birch, aspen and grey alder. Responding to the significant global warming tendency, the renewal of broad-leaved tree species is increasing here (The Central Forest …, 2007).

The zonal position of the reserve is interpreted differently in botanical, geographic, and geobotanical literature. According to the map "Zones and Types of Altitudinal Zonality of Vegetation of Russia and Adjacent Territories" (1999), this is a sub-taiga subzone with Eastern European spruce-broad-leaved, pine-broad-leaved and pine forests and with ridge-pool sphagnum upland bogs and grass bogs. According to the "Geobotanical Division of Non-Chernozem European Part of the Russian Soviet Federative Socialist Republic" (1989), the reserve is located in the Severodvinsk-Verkhnedneprovsky sub-province of the North European taiga province, *in the range of southern taiga forests*. Southern taiga is characterized by the spruce being replaced with birch and aspen due to the logging. The nature of reforestation depends not only on the zonal position of cutting, but also on a number of other factors, such as relief features, moisture soil regime, composition and age of the original tree stand, structures of the lower stories of the felled forest, logging techniques, degree of the undergrowth preservation, etc. (Melekhov, 1980; Kryshen, 2006). Monitoring studies on cuttings in different regions indicate a similar picture of vegetation restoration: increase in species richness in the first stage, its gradual decrease and replacement of the introduced meadow species with the original forest ones; at the same time the intensity of the undergrowth formation depends on the specific forest conditions within a particular territory (Kryshen, 2007; Leonova, 2000; Leonova, Gorjainova, 2011; Ulanova, 2007).

The studied cutting is located within the protected zone in the southern part of the reserve (fig. 1 b, photo 1). The geographic coordinates of the cutting center are N 56° 30', E 32° 53'. The protected zone is designed to reduce the anthropogenic pressure on the territory of the reserve, to study the dynamics of changes in natural complexes under the influence of human economic activity; this zone tends to transition into the regime of the rational use of biological resources. Felling was carried out on the site of the secondary aspen-birch-spruce forest in 2016, its area is about 4.5 hectares and has an overall oval shape. The relief is leveled, with a slight slope from west to east. The soil here is soddy, slightly podzolic and gleyous. The surveys of vegetation restoration were conducted in the summer of 2019.

Fig. 1a. Location (red) of the Central Forest State Biosphere Nature Reserve in the East European Plain.

To study the vegetation and phytomass production within the cutting area, we made 6 transects (fig. 2). The first transect was laid in south-north direction, and all the following ones were laid under 30° angle from the starting point (meteorological mast), except for the one which was oriented to the south. The length of the transects was determined by the distance from the starting point to the border of the forest, and lasted another 50 meters into the forest (photo 2). The full geobotanical releves were composed along each transect, within the test sites with area of 10x10 meters. The standard methodic of geobotanical releve compilation was used with indication of species cover as Braun-Blanquet scale. Releves were carried out twice a season, in June and in the early August. For this study we used 48 releves for the cutting area and 20 for the forest communities.

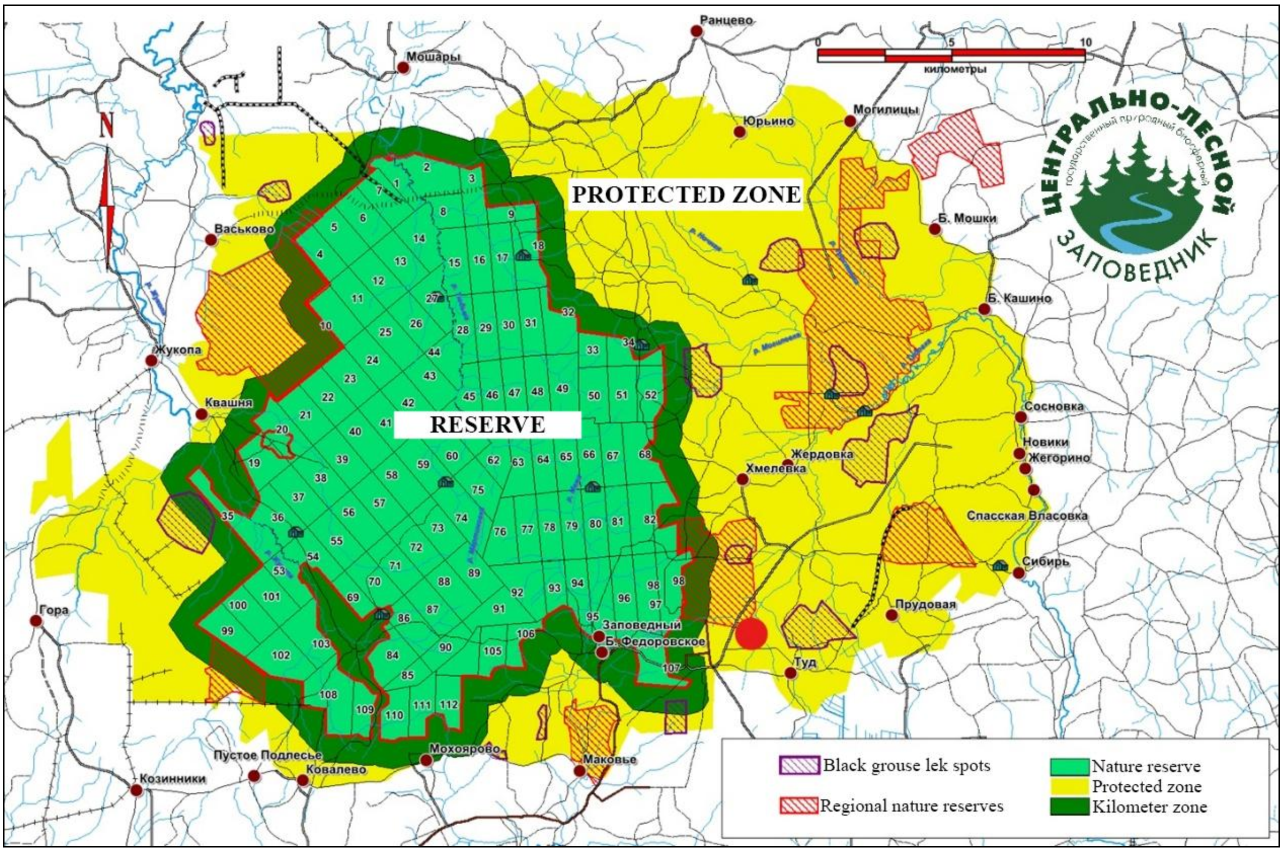

Fig. 1b. Functional zoning of the Reserve, red circle marks the location of studying clear-cutting (The Central Forest …, 2005).

Along transect with the 10 m step test sites 50 x 50 cm in size were laid for measurement of plant height and phytomass (68 sites). The entire vascular plants list was composed for every accounting test site and the height of each plant species was measured at least 10 times (if the number of specimens was less within the test site so all plants were measured). Measurements performed in triplicate – in the second half of June (July, 15-26), in early August (August, 1-4) and at the end of August (August, 28-31).

The stock of above-ground phytomass was determined by the method of mowing at the accounting sites (photo 3). Grass plants and dwarf shrubs were cut at the level of green and brown moss parts. Lichen-moss turf was cut with a knife. In laboratory conditions, the cuts were sorted by species, if cut material couldn't be identified it was sorted by life forms (trees, shrubs, their fractions: stems, branches, leaves) and by fodder groups: cereals, sedges, forbs, dwarf shrubs, mosses, lichens. Dead biomass was also weighed. The material was dried to an air-dry state and weighed on electronic scales with an accuracy of 0.1 g. According to the laboratory (A.N. Severtsov Institute of Evolution and Ecology Problems RAS) work plan a quadcopter cutting was performed, and the image of the study area with a resolution of 2 cm/pixel was received. Then this image was used for mapping of vegetation communities.

The classification of secondary post-cutting vegetation communities was carried out by the dominants of the above-ground grass and undergrowth of trees and shrubs. The names of classification units show the herbaceous layer composition and the forming tree undergrowth. At first, we compiled a schematic map for a single sector of cutting area, according to the field releves and visual decryption of the photos of the area with the ArcGIS software package. In order to create the map of the entire cutting area, we used the ArcMap teachable classification tool. We selected the reference plots with correctly established vegetation communities and used them as standards to make an auto-decryption of the cutting communities, with the following manual generalization. Created vegetation map served as the base for the maps of total phytomass distribution, of individual dominant species phytomass, and ecotopic regimes. The phytomass and plant growth data was processed in Microsoft Office Excel. Taxonomic affiliation and life forms of plants were specified according to the "Open On-line Key to Plants and Lichens of Russia and Neighboring Countries" (2007). Ecological ordination of communities and assessment of ecotopes were carried out on the basis of L.G. Ramensky (1956) scales by the two parameters: soil richness according to plant nutrition and moisture.

Photo 1. General view of the clear-cutting area and meteorological observation site (all photos by T.Yu. Ivleva).

Results of Research

Vegetation communities structure. The spatial structure of post-cutting vegetation is characterized by inner mosaic due to the differences in microrelief, soil moisture, initial forest tree stand and distance from the forest edge.

The canopy closeness of the most typical communities of the surrounding forest is about 0.6. The tree stand dominants are *Picea abies* (L.) H. Karst. and *Betula pendula* Roth. The main shrubs dominants are *Sorbus aucuparia* L. and *Rubus idaeus* L. The sparse ground cover is formed by *Oxalis acetosella* L., *Stellaria holostea* L. and *Luzula pilosa* (L.) Willd. Usually, its projective cover is not higher than 60%.

The vegetation classification by the dominants of the grass and shrubs layer allowed us to determine 7 groups of secondary communities by their ground cover dominants, and 3 groups by the undergrowth dominants (table 1). Thus, 12 types of vegetation communities were identified, with specific combination of herbaceous and undergrowth dominants each.

The distribution of vegetation communities was shown in the compiled schematic map, according to the Legend, created on the bases of the classification we made (fig. 3). The color contours mark the ground cover dominants, the hatching marks the dominants of renewal undergrowth.

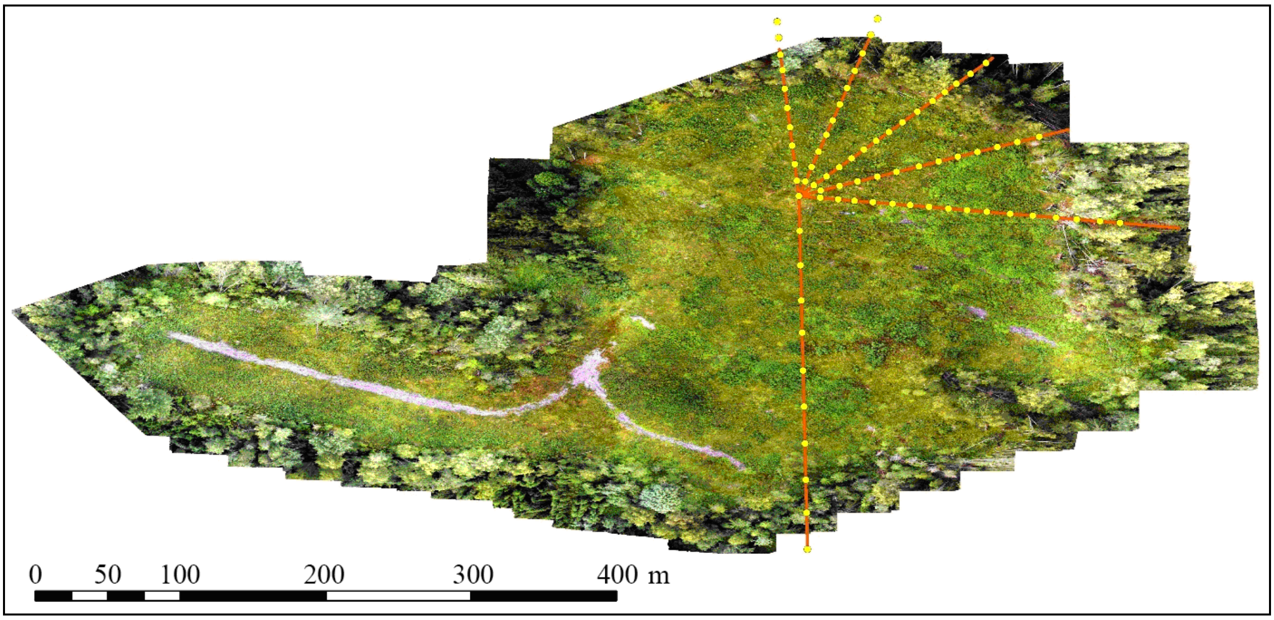

Fig. 2. Transects and accounting sites locations within clear-cutting area.

Based on the map, the areas occupied by each type of vegetation communities were calculated (table 2). On the following pages we provide a description for each community of the recovering cutting area.

A – group of communities with undergrowth of aspen and birch.

1a. Forb and forb plus willow-herbs communities with undergrowth of aspen and birch are mostly located close to the forest edge, but can also be found in the center of cutting area. They primarily occupy the western half of the cutting area, which is more elevated. Their area is 15919.5 m^2, or 32% of the total area. These are the most prevalent communities within the studying territory (fig. 3, table 2).

The average canopy closeness of undergrowth is 35%, in some places it is 60% and higher. The prevailing tree species is *Populus tremula* L., its height varies from 1 to 1.5 m near the forest edge. The aspen forms dense undergrowth, which makes the occurrence of the other plant species very sporadic, so in total they occupy only 5% of the area. The average projective cover of herbaceous layer is 88%. Its main dominants are *Chamaenerion angustifolium* (L.) Scop., *Hypericum maculatum* Crantz, *Veronica chamaedrys* L., *Fragaria vesca* L. and *Stellaria holostea* L. The average height of this layer is about 50-60 cm, *C. angustifolium* is 110 cm high. The average species richness is 33 species per 100 m^2. Lichen and moss cover is absent.

2a. Forb and *Juncus* communities with undergrowth of aspen and birch are distributed as small fragments over the entire cutting area, mainly in the wet habitats. They occupy 3419 m^2, or 6.8%.

The average canopy closeness of undergrowth is 35%, in some places it is 80% (photo 4). Its average height varies from 1 to 1.5 m. The most common species are *Betula pendula* Roth and *Rubus idaeus* L., which was found in the most releves. The average projective cover of herbaceous layer is 80%, its height is 60-70 cm, with *Chamaenerion angustifolium* reaching 120 cm high. The dominants are *Juncus effusus* L., *Hypericum maculatum* Crantz, *Stellaria holostea* L., *Cirsium heterophyllum* (L.), *Carex leporina* L. Hill and *Luzula pilosa* (L.) Willd. The average richness is 35 species per 100 m^2. Lichens and mosses are absent.

3a. Willow-herbs and *Juncus* communities with undergrowth of aspen and birch are located in the western part of cutting area, where a lot of felling residues are concentrated. They occupy 2195 m^2, or 4.4%.

Photo 2. Initial birch and fir forest.

This type of communities has the thinnest canopy of aspen and birch undergrowth – only 30%. The average projective cover of herbaceous layer is 90%, its height is 40-50 cm, with *C. angustifolium* reaching 120 cm. The dominant species are *Juncus effusus* L. and *Chamaenerion angustifolium* (L.) Scop., the occurrence of *Hypericum maculatum* Crantz, *Luzula pilosa* (L.) Willd. and *Fragaria vesca* L. is also high. The average richness is 32 species per 100 m^2. Some releves include mosses and lichens layer, but its cover is only 6%.

4a. Tussock-grass and *Juncus* communities with undergrowth of aspen and birch are rather scanty in the group of communities with aspen and birch undergrowth. They occupy only 263 m^2, or 0.5%, and are presented only on two small spots in the northern and southern parts of the cutting area.

The average undergrowth closeness is 25%, and 50% in some places, its average height is 1-1.5 m. The average herbaceous cover is 92%, its height is 40-50 cm. The dominants are *Deschampsia caespitosa* (L.) P. Beauv. and *Juncus effusus* L., the occurrence of *Calamagrostis arundinacea* (L.) Roth, *Chamaenerion angustifolium* (L.) Scop., *Cirsium heterophyllum* (L.) Hill and *Carex leporina* L. is also high. The average richness is 33 species per 100 m^2. Lichens and mosses are absent.

Photo 3. Phytomass accounting site.

B – group of communities with broad-leaved undergrowth.

3б. Great willow herb and *Juncus* communities with broad-leaved undergrowth are distributed as small fragments in this group, without undergrowth, and occupy only 662 m^2, or 1.3%.

This type has low undergrowth closeness, which is about 10%. Its dominants are *Acer platanoides* L. and *Corylus avellana* L., its height is 1.5-2 m (photo 5). The average herbaceous cover is 78%, its average height is 40-50 cm, with *C. angustifolium* reaching 140 cm high. Like the communities of this group, this one has *Juncus effusus* L., *Chamaenerion angustifolium* (L.) Scop., *Hypericum maculatum* Crantz), *Fragaria vesca* L., *Veronica* *chamaedrys* L. as its dominants. The average richness is 36 species per 100 m^2. Lichens and mosses are absent.

C – group of communities with raspberry and buckthorn undergrowth.

1c. Forb and forb plus willow-herbs communities with raspberry and buckthorn undergrowth are distributed within more depressed and moistened parts than the same communities with aspen and birch undergrowth. They are concentrated near the eastern forest edge and in some central parts of the cutting area. They are rather widespread, occupying 11838 m^2, or 23.7%.

Table 1. Secondary vegetation communities of early stage of cutting succession.

Index in the map legend	**Types of post-cutting communities**
	By dominants of ground cover
1	Forb and forb plus willow-herbs: *Chamaenerion angustifolium* (L.) Scop, *Hypericum maculatum* Crantz, *Veronica chamaedrys* L., *Fragaria vesca* L., *Stellaria holostea* L.
2	Forb and *Juncus*: *Juncus effusus* L., *Hypericum maculatum* Crantz, *Stellaria holostea* L., *Cirsium heterophyllum* (L.) Hill, *Carex leporina* L. Hill, *Luzula pilosa* (L.) Willd.
3	Great willow-grass and *Juncus*: *Juncus effusus* L., *Chamaenerion angustifolium* (L.), *Stellaria holostea* L., *Carex leporina* L. Hill, *Luzula pilosa* (L.) Willd.
4	Tussok-grass and *Juncus*: *Deschampsia caespitosa* (L.) P. Beauv., *Juncus effusus* L., *Hypericum maculatum* Crantz, *Carex leporina* L., *Luzula pilosa* (L.) Willd.
5	Forb and tussock-grass: *Deschampsia cespitosa* (L.) P. Beauv, *Melampyrum nemorosum* L., *Luzula pilosa* (L.) Willd., *Fragaria vesca* L., *Stellaria holostea* L.
6	Tussok-grass and wood-reed: *Calamagrostis arundinacea* (L.) Roth, *Deschampsia cespitosa* (L.) P. Beauv., *Stellaria holostea* L., *Potentilla erecta* (L.) Raeusch., *Luzula pilosa* (L.) Willd.
7	*Juncus* and wood-reed: *Juncus effusus* L., *Calamagrostis arundinacea* (L.) Roth, *Hypericum maculatum* Crantz, *Chamaenerion angustifolium* (L.) Scop., *Luzula pilosa* (L.) Willd.
	By dominants of tree-shrubs' undergrowth
а	With aspen and birch undergrowth: *Populus tremula* L., *Betula pendula* Roth
б	With broad-leaved species undergrowth: *Acer platanoides* L., *Corylus avellana* L.
в	Raspberry with rowan and buckthorn: *Rubus idaeus* L., *Sorbus aucuparia* L., *Frangula alnus* Mill.

The undergrowth closeness is about 50%, it reaches 80% near forest edge, its average height is 1-1.5 m. Its dominants are *Sorbus aucuparia* L., *Frangula alnus* Mill. and *Rubus idaeus* L., its height doesn't exceed 75 cm. The average herbaceous cover is 70%, its average height is 50-60 cm. The dominants are *Chamaenerion angustifolium* (L.) Scop., *Luzula pilosa* (L.) Willd., *Hypericum maculatum* Crantz and *Stellaria holostea* L. The average richness is 30 species per 100 m^2. Only one releve has a moss-lichen layer, its cover is not higher than 5%.

4c. Tussock-grass and *Juncus* communities with raspberry and buckthorn undergrowth occupy the minimal area of 395 m^2, or 0.8%, in the south-eastern part of the cutting area, where a small amount of felling residues is presented.

The dominants of undergrowth layer are *Sorbus aucuparia* L., *Frangula alnus* Mill. and *Rubus idaeus* L. The closeness of tree and shrub canopy doesn't exceed 30% and is mainly formed with *R. idaeus*. The dominants of herbaceous layer are *Deschampsia cespitosa* (L.) P. Beauv., *Juncus effusus* L. *Chamaenerion angustifolium* (L.) Scop., *Cirsium heterophyllum* (L.) Hill), *Carex leporina* L., *Stellaria holostea* L. and *Luzula pilosa* (L.) Willd.

Herbaceous communities without formed undergrowth are presented by the following types.

3. Willow-herbs and *Juncus* communities occupy 3262 m^2, or 6.5%. They are mostly located near the forest edge, and thus, grow in more shadow habitats.

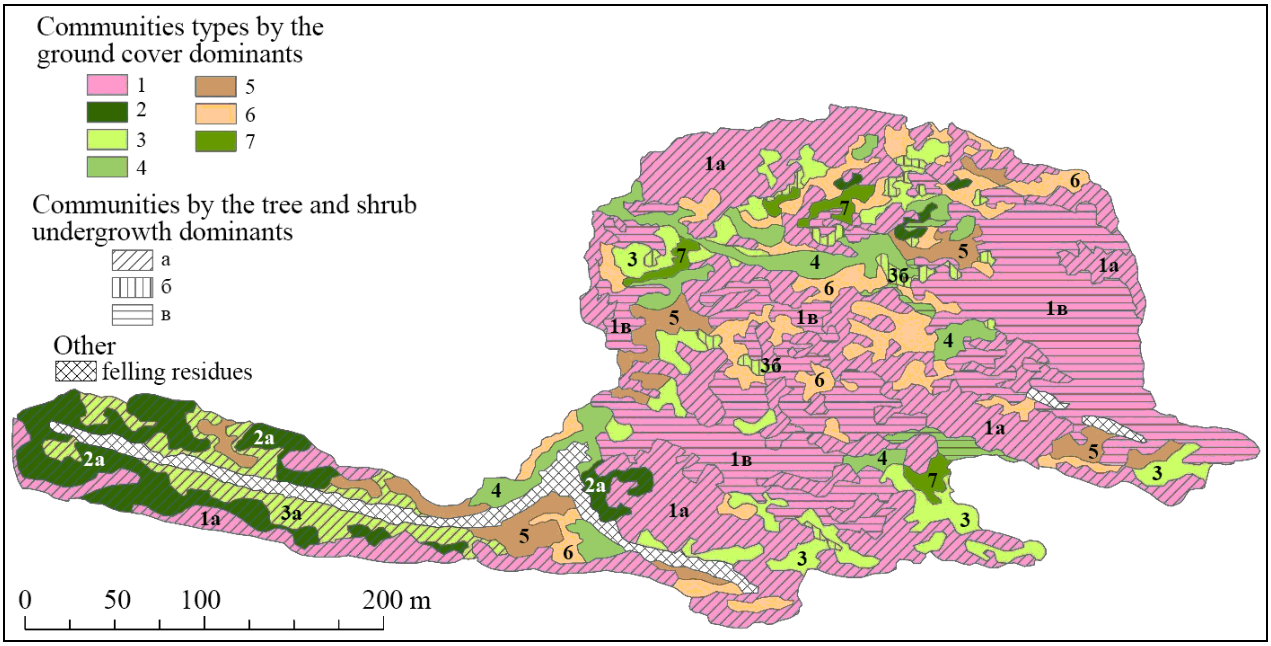

Fig. 3. Schematic map of secondary post-cutting communities on the early succession stage. *Legend.* Communities types by the ground cover dominants: 1 – forb and forb and great willow herb, 2 – forb and *Juncus*, 3 – great willow herb and *Juncus*, 4 – tussock-grass and *Juncus*, 5 – forb and tussock-grass, 6 – tussock-grass and wood-reed, 7 – *Juncus* and wood-reed; communities types by the tree and shrub undergrowth dominants: a – with *Betula pendula* and *Populus tremula*, b – with broad-leaved undergrowth, c – with raspberry and buckthorn undergrowth.

The cover of herbaceous layer is more than 90%. Its dominants are *Juncus effusus* L. and *Chamaenerion angustifolium* (L.) Scop., with a lot of *Hypericum maculatum* Crantz, *Fragaria vesca* L. and *Veronica chamaedrys* L. The average height of the herbaceous layer is 50-60 cm. The richness is 25 species per 100 m^2. Mosses and lichens are absent.

4. Tussock-grass and *Juncus* communities. According to the image, these communities tend to grow on the dense soils, disturbed by the logging vehicles. They occupy 2511 m^2, or 5%.

The herbaceous cover is 95%, its average height is 40-50 cm. The dominants are *Deschampsia cespitosa* (L.) P. Beauv., *Juncus effusus* L., *Stellaria holostea* L., *Hypericum maculatum* Crantz and *Luzula pilosa* (L.) Willd. The average richness is 27 species per 100 m^2. Mosses and lichens are absent. The undergrowth is very sparse, its closeness is less than 10%, and its height is less than 1 m. It is mostly presented with *Frangula alnus* Mill. and *Rubus idaeus* L.

5. Forb and tussock-grass communities occupy the most disturbed and dense soils and distributed near felling residues storages. Their area is 2484 m^2, or 4.9%.

The herbaceous cover is 90%, its height 30-40 cm. The dominants are *Deschampsia cespitosa* (L.) P. Beauv., *Melampyrum nemorosum* L., *Luzula pilosa* (L.) Willd., *Fragaria vesca* L. and *Stellaria holostea* L. The undergrowth closeness is about 15% due to *Rubus idaeu*s L., its height is not higher than 1 m. The average richness is 32 species per 100 m^2. Mosses and lichens are absent.

6. Tussock-grass and wood-reed communities are widespread in the inner parts of the cutting area; they occupy more elevated places, less disturbed by logging vehicles. These are the most extensive herbaceous communities of the area, occupying 4278 m^2, or 8.6%.

The undergrowth closeness is about 15%, mainly due to *Rubus idaeus* L. The herbaceous cover is 95%, its height is 40-50 cm. The dominants are *Calamagrostis arundinacea* (L.) Roth, *Deschampsia cespitosa* (L.) P. Beauv., *Stellaria holostea* L. *Potentilla erecta* (L.) Raeusch. and *Luzula pilosa* (L.) Willd. The average richness is 27 species per 100 m^2. Moss-lichen cover is absent.

Table 2. Areas of post-cutting communities.

Index in the map legend	Post-cutting vegetation communities	Area, m^2	Area share within cutting, %
1a	Forb and forb-great willow-grass with aspen and birch undergrowth	15919.5	31.9
2a	Forb and *Juncus* with aspen and birch undergrowth	3419.5	6.8
3a	Great willow-grass and *Juncus*, with aspen and birch undergrowth	2195.3	4.3
4a	Tussok-grass and *Juncus* with aspen and birch undergrowth	263.3	0.5
3б	Great willow-grass and *Juncus* with broad-leaved species undergrowth	662.6	1.3
1в	Forb and forb-great willow-grass raspberry with rowan and buckthorn	11838.8	23.7
4в	Tussok-grass and *Juncus* raspberry with rowan and buckthorn	395.2	0.7
3	Great willow-grass and *Juncus*	3262.9	6.5
4	Tussok-grass and *Juncus*	2511.2	5.1
5	Forb and tussock-grass	2484.2	4.9
6	Tussok-grass and wood-reed	4278.3	8.5
7	*Juncus* and wood-reed	649.5	1.3
	Logging residues	2062.2	4.1
	Total:	49943.2	100.0

7. *Juncus* and wood-reed communities are presented by some fragments in the inner part of cutting area in more depressed and wet microrelief forms. They occupy 649 m^2, or 1.3%. The undergrowth closeness is not higher than 10%, formed by single exemplars of *Sorbus aucuparia* L., *Populus tremula* L. and *Salix cinerea* L. The average herbaceous cover is 88%, its height is 40-50 cm. Its dominants are *Juncus effusus* L., *Calamagrostis arundinacea* (L.) Roth, with numerous *Hypericum maculatum* Crantz, *Chamaenerion angustifolium* (L.) Scop., *Luzula pilosa* (L.) Willd and *Deschampsia cespitosa* (L.) P. Beauv. The average richness is 30 species per 100 m^2. Moss-lichen cover is absent.

It can be seen that biological diversity of post-cutting communities is rather high. Species richness of described communities varies from 27 to 36 vascular plants species per 100 m^2, which is higher than in the forest communities. According to the investigations of different authors, post-cutting communities reach the maximal level of species diversity in the second year after felling (Ulanova, 2012; Leonova, 2000). The diversity of ecotopes, forming due to disturbance of initial vegetation cover and logging equipment activity, allows numerous plant species which are uncommon to the forest habitat to settle there (photo 5).

The species differentiation for dominants and subordinate species is not complete yet. However, there are characteristic species, playing a significant role in vegetation cover and occurring all over cutting area: *Juncus effusus* L., *Calamagrostis arundinacea* (L.) Roth, *Chamaenerion angustifolium* (L.) Scop., *Deschampsia cespitosa* (L.) P. Beauv. Undergrowth characteristic species are *Populus tremula* L., *Betula pendula* Roth, *Sorbus aucuparia* L. and *Frangula alnus* Mill. These species have III-V constancy classes, according to Braun-Blanquet scheme (table 3).

Photo 4. Birch undergrowth in the clear-cutting area.

Mosaic ground cover of cutting area is determined by ecotope's diversity, and thus it affects tree and shrub species renewal. As mentioned above, the *forb and forb plus willow-herbs communities* with and without undergrowth; they occupy the largest areas, which is 56% of the total cutting area. Near the forest edge they have the closest and tallest undergrowth, which indicates that this habitat has the most favorable conditions for birch and aspen renewal. Large areas are occupied by communities with dominating *Juncus*: it's tussock-juncaceous, forb and *Juncus*, willow-herbs and *Juncus* communities. Together they occupy 25% of the cutting area, while being located mostly in its inner parts. Forb plus tussock-grass and tussock-grass plus wood-reed communities occupy 5 and 9% area, respectively, growing on the most disturbed and dense soils, where undergrowth renewal is obstructed.

Photo 5. *Corylus avellana* L. undergrowth.

The composition and nature of the undergrowth is also mosaic. It reaches its greatest height and closeness near the forest edge, where the microclimatic conditions are most favorable and the seed sources are close. Communities with undergrowth of aspen and birch occupy the largest areas in the studied cutting area (44%), raspberry communities with rowan and buckthorn occupy a quarter of the area (25%). Broad-leaved species undergrowth is very fragmented, occupying only 1.3%. Therefore, distribution and development of trees and shrubs undergrowth are heavily determined by growth conditions in different types of ground cover (table 4).

The table data confirms that the most closed (up to 80% closeness) and various undergrowth forms in forb and forb plus willow-herbs communities, where *Populus tremula* L., *Sorbus aucuparia* L., *Frangula alnus* Mill. and *Rubus idaeus* L. prevail. The low undergrowth closeness (20%) is observed in willow-herbs and *Juncus* communities, and the main dominant is *Populus* *tremula* L. Approximately, the same closeness was registered in the tussock-grass and *Juncus* communities, where *Populus tremula* L. is numerous, but *Rubus idaeus* L. is prevailing. In forb and tussock-grass communities the closeness does not exceed 15%, the undergrowth is formed by *Rubus idaeus* L. The renewal of tree species is very weak. The same picture was registered in the tussock-grass plus wood-reed and *Juncus* plus wood-reed communities (with more aspen participation).

Photo 6. *Sussica pratensis* in the forb community of the clear-cutting area.

Table 3. Constancy classes of the most distributed plant species in some post-cutting communities.

Plant species / Communities	1a*	2a	3a	1в	4	Total
Tree and shrubs layer						
Sorbus aucuparia L.	**IV******	**V**	**V**	**V**	**V**	V
Betula pendula Roth	**IV**	**IV**	**V**	**V**	**V**	V
Populus tremula L.	**V**	**V**	**V**	**IV**	**III**	IV
Rubus idaeus L.	**IV**	**IV**	II	**V**	**V**	IV
Corylus avellana L.	**V**	**IV**	**IV**	**III**	II	IV
Frangula alnus Mill.	**III**	**III**	**IV**	II	**V**	III
Herbaceous layer						
Chamaenerion angustifolium (L.) Scop.	**V**	**V**	**V**	**V**	**V**	IV
Juncus effusus L.	**V**	**V**	**V**	**V**	**V**	IV
Hypericum maculatum Crantz	**V**	**IV**	**V**	**V**	**V**	IV
Stellaria holostea L.	**V**	**V**	**V**	**V**	**IV**	V
Deschampsia cespitosa (L.) P. Beauv.	**V**	**V**	**V**	**III**	**V**	IV
Luzula pilosa (L.) Willd.	**III**	**V**	**V**	**V**	**V**	V
Fragaria vesca L.	**V**	**V**	**V**	**IV**	**IV**	V
Cirsium heterophyllum (L.) Hill	**V**	**V**	**V**	**IV**	**IV**	IV
Veronica chamaedrys L.	**V**	**IV**	**IV**	**IV**	**IV**	IV
Dryopteris filix-mas (L.) Schott	**III**	**IV**	**IV**	**V**	**IV**	IV
Potentilla erecta (L.) Raeusch.	**III**	**IV**	**III**	**IV**	**V**	IV
Solidago virgaurea L.	**IV**	**III**	II	**V**	**III**	IV
Agrostis tenuis Sibth.	**III**	**III**	**V**	**III**	**III**	IV
Carex leporina L.		**V**	**V**	**IV**	**III**	III
Ranunculus acris L.	**V**	**IV**	**IV**	**III**	**IV**	III
Calamagrostis arundinacea (L.) Roth	**III**	**III**	**IV**	**IV**	**IV**	III
Equisetum sylvaticum L.	**IV**	**IV**	**IV**	**III**	**III**	III
Maianthemum bifolium (L.) F.W. Schmidt	**IV**	**III**	II	**IV**	**III**	III
Epilobium montanum L.	**III**	**IV**	**V**	II	**III**	III
Campanula patula L.	II	**IV**	**IV**	**III**	**III**	III
Prunella vulgaris L.	**V**	**III**	II	II	II	III
Thalictrum aquilegiefolium L	**III**	**III**	II	**IV**	II	III
Carex vesicaria L.	II	**V**	**III**	II	**III**	III
Melampyrum nemorosum L.	**V**	**III**	II	I	II	III
Oxalis acetosella L.	**IV**	**III**	II	**IV**		III
Angelica sylvestris L.	**IV**	**III**	**III**	II		III
Circaea alpina L.		**IV**		**V**	**III**	III
Geranium pratense L.	V	**III**	I	I		II
Viola palustris L.	II	II	II	**III**	**IV**	II
Ajuga reptans L.	**IV**	II		II		I
Athyrium filix-femina (L.) Roth	**IV**	I		I		I
Vicia sepium L.	**IV**	II				I

Notes to table 3. *Communities indices are listed in table 2. **Constancy classes: I – specie was found in 0-20% of descriptions, II – 21-40%, III – 41-60%, IV – 61-80%, V – 81-100%.

Table 4. Undergrowth canopy density in different types of communities (%).

Plant species \ Communities	1*	2	3	4	5	6	7
Sorbus aucuparia L	10.3	1.5	1.6	1.7	1.0	1.8	2.0
Populus tremula L.	18.3	21.1	6.9	5.4	5.0	2.6	10.5
Betula pendula Roth	1.8	4.1	1.3	1.9	–	1.0	3.0
Acer platanoides L	2.1	1.6	1.0	1.0	–	–	–
Frangula alnus Mill.	10.6	2.6	5.8	2.7	–	1.3	1.0
Rubus idaeus L.	11.6	4.3	4.5	6.1	10.0	13.0	16.0
Corylus avellana L.	3.6	4.8	1.0	1.0	1.0	1.5	2.0
Salix cinerea L.	18.3	1.0	2.0	1.0	–	7.0	1.0
Viburnum opulus L.	1.0	1.0	–	1.0	–	–	–
Picea abies (L.) H. Karst	1.0	1.0	1.0	1.0	1.0	1.0	–
Daphne mezereum L.	–	–	1.0	–	1.0	1.0	–
Padus avium L.	–	1.0	1.0	–	–	–	1.0

Notes to table 4. *Communities types: 1 – forb and forb plus great willow herb, 2 – forb and *Juncus*, 3 – great willow herb and *Juncus*, 4 – tussock-grass and *Juncus*, 5 – forb and tussock-grass, 6 – tussock-grass and wood-reed, 7 – *Juncus* and wood-reed.

The results of our research show that the conditions for the renewal of tree and shrub species are closely connected to the ground cover composition, and the latter is a good indicator for ecotope conditions (Melekhov, 1980).

Ecotopic structure of cutting area. In order to identify the differentiation of ecotopic conditions within the cutting area, the releves were analyzed on the basis of L.G. Ramensky's scales (1956). The use of ecological amplitudes of plant species makes it possible to ordinate vegetation communities in ecological space. We used the scales of humidity and nutrient soil status. Ecological ranges have been built for some community groups (fig. 4, 5).

The widest ecological amplitude in relation to humidity was observed in the forb and forb plus willow-herbs communities with aspen and birch undergrowth (1a), and willow-herbs plus *Juncus* communities with broad-leaved undergrowth (3б). At the same time, only willow-herbs plus *Juncus* communities with broad-leaved undergrowth are adapted to the driest habitats (the scale of dry and fresh meadows and forests). The main part of the ecological ranges of all the communities under consideration is located in the stages of wet meadow moisturizing, which is typical for southern taiga. Such communities as forb and forb plus willow-herbs ones with aspen and birch undergrowth, forb and forb plus willow-herbs with raspberry and buckthorn undergrowth, tussock-grass and *Juncus* with undergrowth of aspen and birch, can also form under conditions of wet meadows. Regarding the soil richness, all communities correspond to not rich (mesotrophic) soils with a slightly acid reaction. At the same time, willow-herbs plus *Juncus* communities with broad-leaved undergrowth (3b), and forb and *Juncus* ones with undergrowth of aspen and birch (2a) are indicators of more trophic habitats.

Communities without undergrowth correspond to ecotopes with moist-meadow and wet-meadow humidity scale. *Juncus* and wood-reed communities form in the most wet habitats (they occupy small lowlands in the northern and south-eastern parts of cutting). Forb and tussock-grass communities form in the drier biotopes, and cannot be found in the wet meadows. The broadest ecological amplitude is found in tussock-grass plus wood-reed communities, because their formation is largely characterized by the high disturbance and density of soil cover. Regarding soil richness, all herbaceous communities are in approximately same conditions, within the steps of not rich mesotrophic, weakly acidic soils.

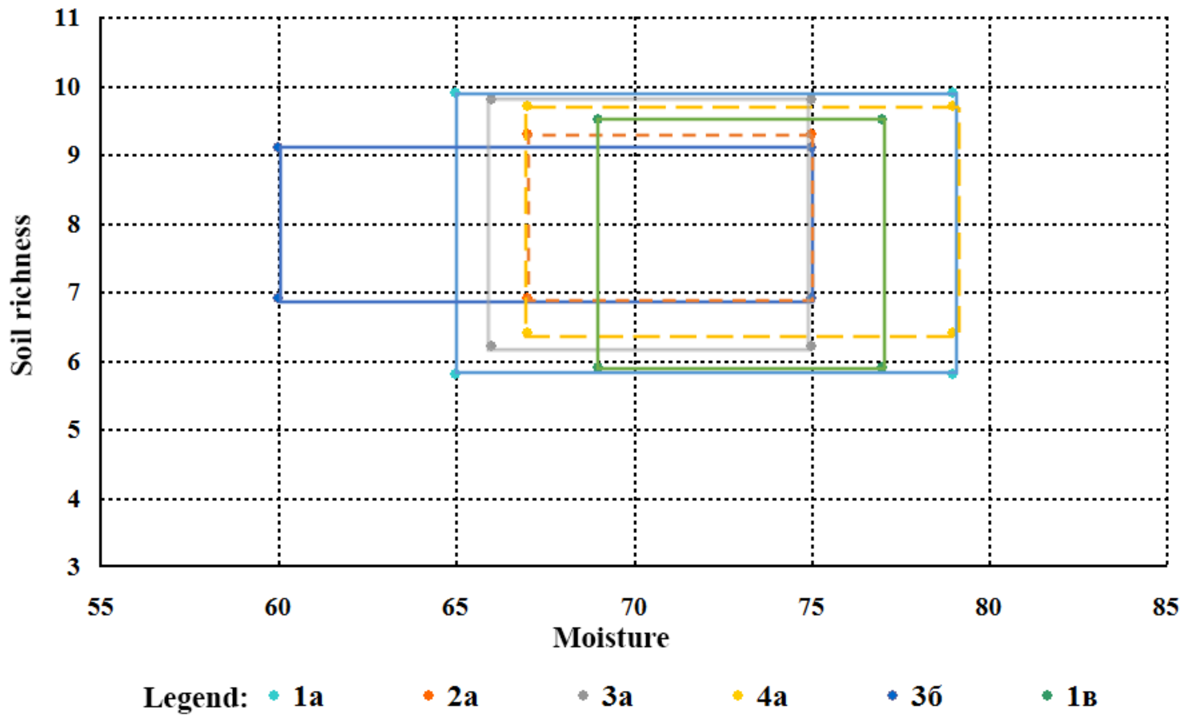

Fig. 4. Ecological ranges of post-cutting communities with tree and shrub undergrowth. *Legend:* 1a-3б – indices of community types are listed in table 2.

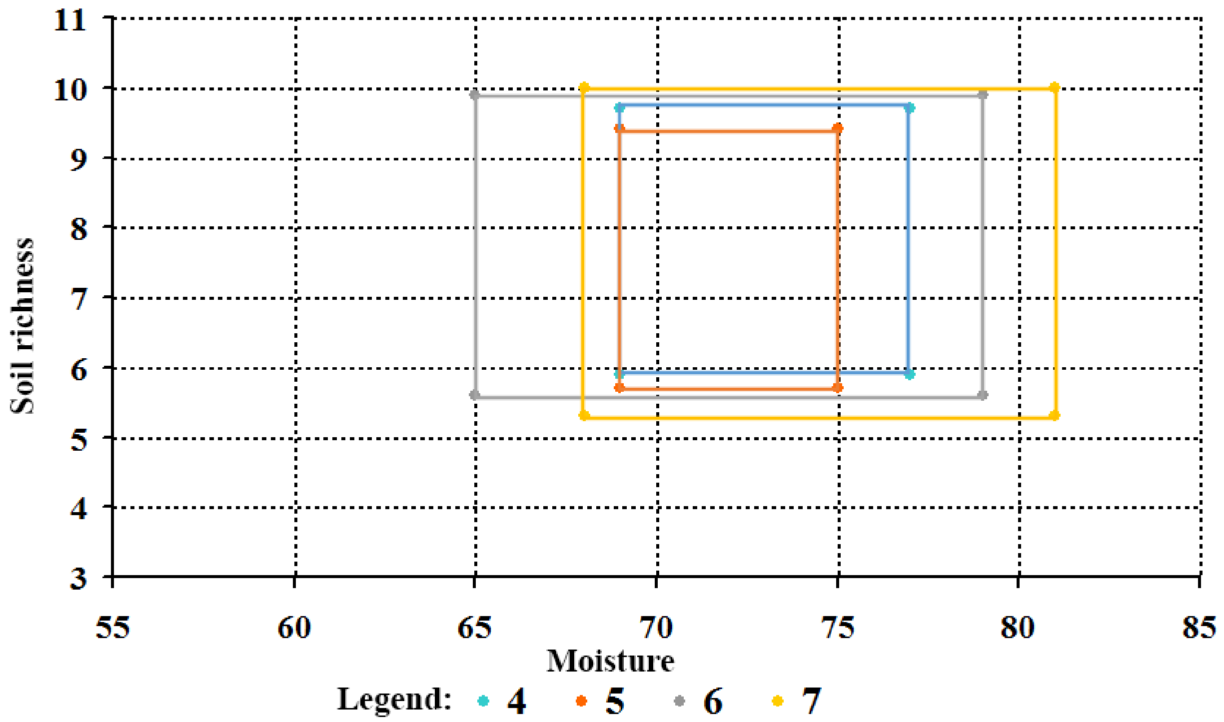

Fig. 5. Ecological ranges of post-cutting herb communities. *Legend:* 4-7 – indices of community types are listed in table 2.

The location of ecotopes that differ in the average score of moisture and soil richness is presented on cartographic schemes (fig. 6, 7), which were used to identify conditions for the production of organic matter in the cutting area.

Functional structure of post-cutting communities. The result of the functional activity of phytocenosis is the primary biological productivity, manifested in the accumulation of phytomass. In order to characterize production processes, information is needed on the mass of plants, their height, and the rate of phytomass accumulation (plants' increment, litter and mortmass). It is important to take into account the distribution of these parameters in the cutting area according to communities' types. This is a functional structure of post-cutting vegetation cover. Two approaches were used to study the dynamics of phytomass and the productivity of phytocenoses at the cutting: method of mowing with subsequent analysis of phytomass at the test sites, and three-fold measurements of plant height growth at the same sites.

Analysis of data on changes in plant height allowed us to identify a group of species, which were found on the most test sites and which has the total growth for the season. The values of their average growth within each transect and cutting area are presented in the table 5.

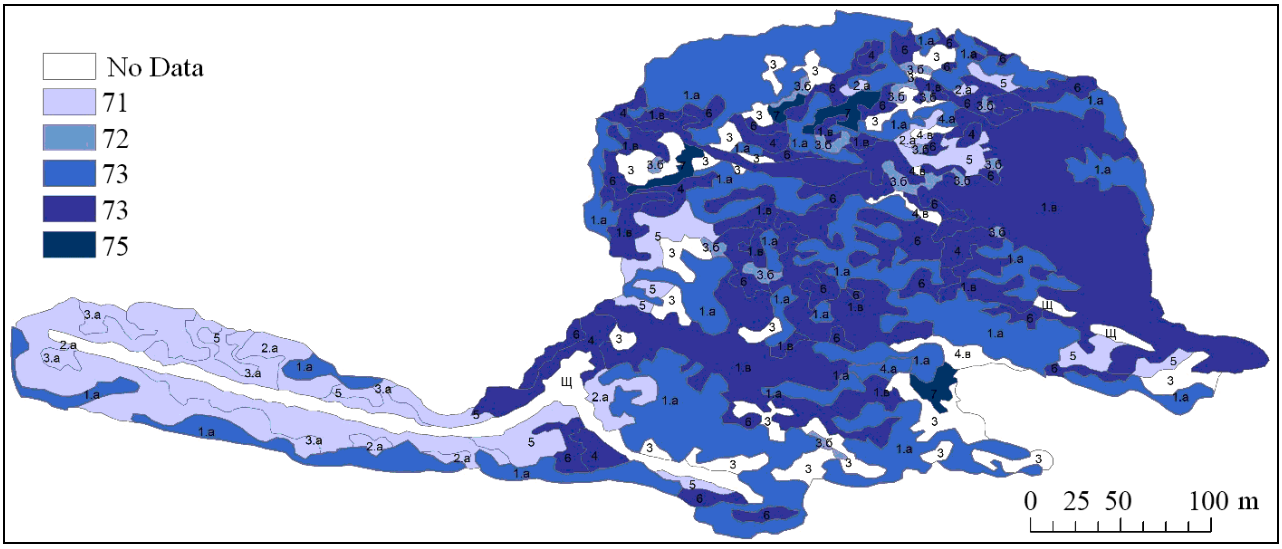

Fig. 6. Humidity in clear-cutting ecotopes according to L.R. Ramensky (1956) scale; indices of community types are listed in table 2.

A significant increase in height is given by two groups of plants: tree undergrowth and some herbaceous species. Moreover, the largest growth is observed in dominant species of post-cutting communities: *Calamagrostis arundinacea* (L.) Roth and *Chamaenerion angustifolium* (L.) Scop. The greatest importance for carbon storage will be the growth of tree species, such as *Betula pendula* Roth, *Populus tremula* L., *Frangula alnus* Mill. and *Sorbus aucuparia* L., since they produce enough phytomass to keep absorbed carbon for a longer time than one season, like the grasses do. It is important to note that some plants (*Frangula alnus* Mill., *Calamagrostis arundinacea* (L.) Roth) have a very strong scatter in growth values around the cutting, which is associated with a change in ecotopic conditions and is reflected in the spatial heterogeneity of phytomass accumulation.

The phytomass was cut at the test sites and sorted by species composition and by fractions: herbs, trees and shrubs (leaves, branches, stems), litter and dead phytomass. The diagrams, reflecting the change in the fractions phytomass by transects, allow us to detect the patterns of phytomass changes according to the distance from the forest edge (fig. 8). The closest the edge of the forest is, the highest the proportion of trees and shrubs in the phytomass fractions becomes. In forest communities, the weight of herbs decreases sharply and a significant amount of dead phytomass (uncomposed pieces of branches and bark) is observed.

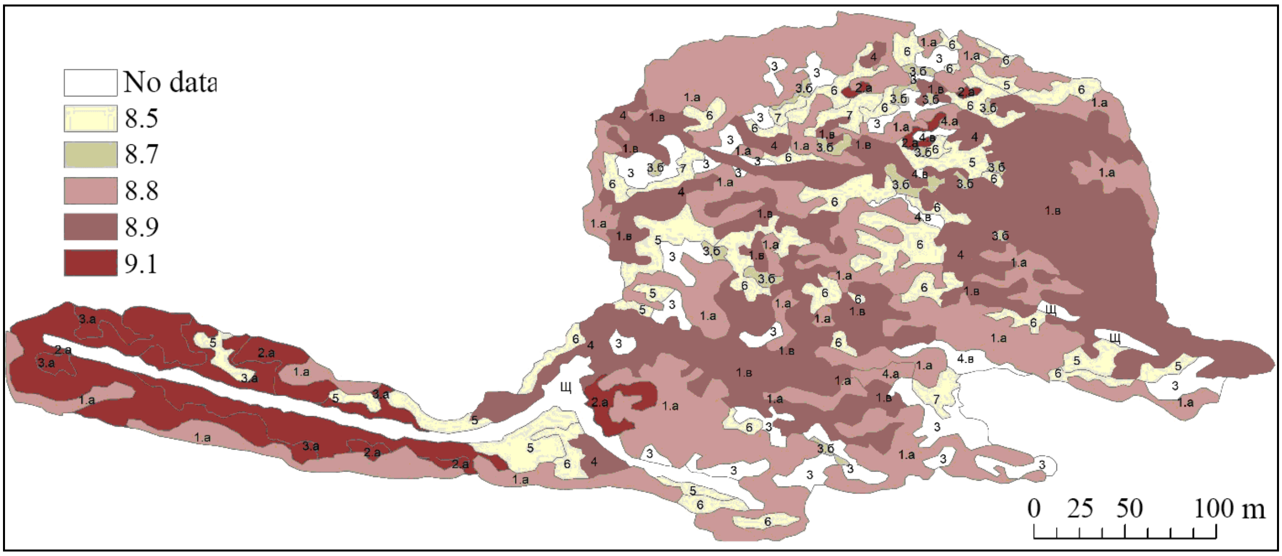

Fig. 7. Nutrient status of clear-cutting ecotopes according to L.R. Ramensky (1956) scale; indices of community types are listed in table 2.

Table 5. Increments of key plant species along transects from June to August (cm).

Transects / Plant species	T1	T2	T3	T4	T5	T6	Average increment	Standard deviation
Tree species and shrubs								
Betula pendula Roth	13.6	10.5	5.1	9.2	18.8	15.1	11.1	4.8
Frangula alnus Mill.	2	24.6	4.1	11.3	24.9	–	17.9	11.2
Rubus idaeus L.	3.4	10.5	-5.2	8.2	8.4	5.3	6.3	5.6
Populus tremula L.	9.7	7.1	5	20.8	–	1.5	8.3	7.5
Sorbus aucuparia L.	0.5	8	-5	12	1.9	7.5	2.7	6.1
Herbs								
Calamagrostis arundinacea (L.) Roth	7.2	–	8.6	23.5	21.3	3.6	11.1	9.5
Hypericum maculatum Crantz	11.4	13.1	8.4	0.02	7.4	8.5	8.3	4.5
Chamaenerion angustifolium (L.) Scop.	33.5	23.6	11.7	7.3	2.7	29.6	13.1	12.6
Poa annua L.	3.1	2.5	6.5	5	10.2	–	7.6	3.5
Luzula pilosa (L.) Willd.	-1.2	2.4	-0.01	3.4	3.2	0.2	2.2	1.9

The contribution of individual plant species to the phytomass is related to their abundance and height. Therefore, for *Rubus idaeus* L. the correlation coefficient between the height of the individual and the phytomass is 0.91, significant under $\alpha=0.001$ (fig. 9). Respectively, we can conclude that phytomass increases with height growth of individuals of trees and shrubs undergrowth and herbaceous plants in the post-cutting communities. This increase is clearly visible in many species when moving from the central part of the cutting area to the forest edge, for example, for *Rubus idaeus* L. (fig. 10). The similar data was obtained for other species too: *Chamaenerion angustifolium* (L.) Scop, *Calamagrostis arundinacea* (L.) Roth and *Betula pendula* Roth.

Among the dominant herbaceous species, there are various growth reactions in different parts of the cutting area. *Juncus effusus* L. in all releves has approximately the same height, but was found mainly in the central part of the cutting, growing in larger numbers not closer than 50 m from the forest edge. *Deschampsia cespitosa* (L.) P. Beauv. also has approximately the same height, but significantly reduces its presence closer to the forest. *Hypericum maculatum* Crantz is not dominant in any community, but it occurs throughout the whole cutting area with similar height parameters.

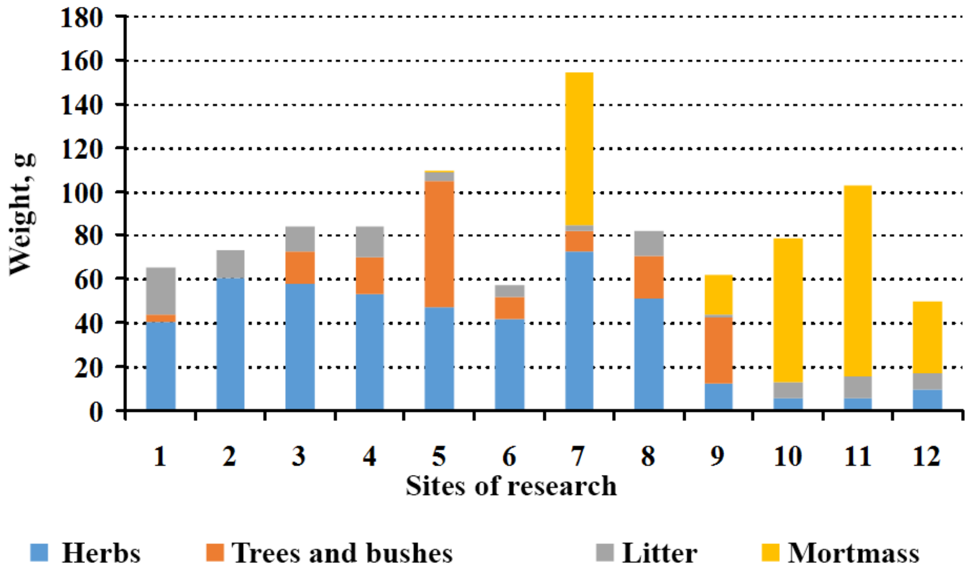

Fig. 8. Phytomass fractions within the accounting sites of the transect. *Legend:* sites 1-9 – clear-cutting, 10-12 – forest.

In addition, it is clearly seen that from the center of the cutting area to the edge of the forest, the projective cover of the herbaceous layer decreases as the undergrowth closeness increases (fig. 11).This also affects the contribution of species groups to the total phytomass and the heterogeneity of its distribution over the cutting area.

Plant height and rate of phytomass accumulation depend not only on distance from the forest edge, but also on belonging to different types of communities. According to the obtained data that reflects the height and growth of key species in different types of communities for season, *Betula pendula* Roth has maximal height in forb plus willow-herbs communities with aspen and birch undergrowth. *Calamagrostis arundinacea* (L.) Roth has maximal height and phytomass in forb plus willow-herbs and willow-herbs plus *Juncus* communities with aspen and birch undergrowth, as well as in tussock-grass plus wood-reed communities. *Hypericum maculatum* Crantz has the maximal growth in forb plus willow-herbs and willow-herbs plus *Juncus* communities with aspen and birch undergrowth, as well as in willow-herbs plus *Juncus* ones with broad-leaved species undergrowth. *C. angustifolium* (L.) Scop. reaches its maximal height in forb plus willow-herbs communities with aspen and birch undergrowth and in raspberry plus buckthorn and rowan ones. Generally, the obtained data confirms the assumption that plants have maximal height when they are dominant in communities, because they have the best conditions for their growth.

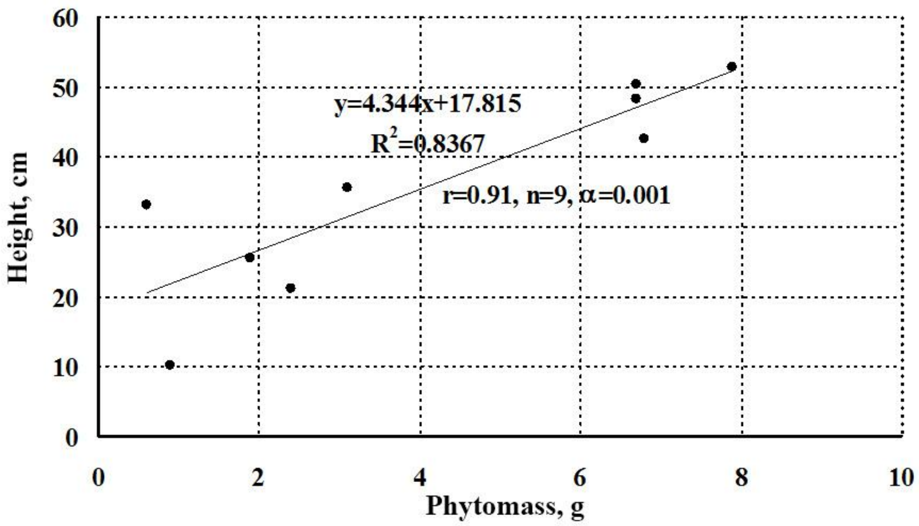

Fig. 9. Correlation between the height and phytomass of *Rubus idaeus* L. with its trend line and formula.

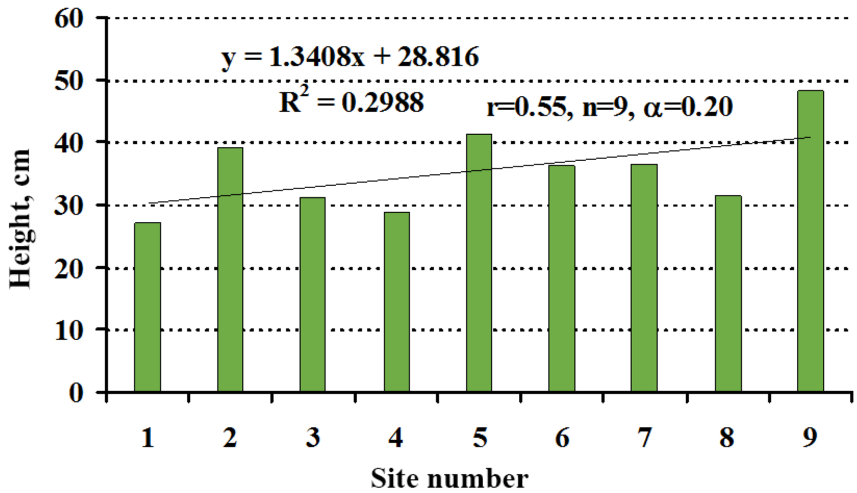

Fig. 10. Changing of *Rubus idaeus* L. height from the center of clear-cutting area (1) to the forest frontier (9), continuous line marks its trend line and formula.

The information obtained on the height, increments and phytomass of some plants allows us to draw conclusions about their contribution to the creation of organic matter and carbon deposition. Correlation relations can be detected, which will allow to determine the phytomass by the height and projective cover of some indicator plant species in different types of communities without additional measurements.

According to the data obtained during the analysis of phytomass, the average phytomass (g/m^2) was established for all detected communities (table 6). The largest phytomass are recorded in forb and forb great willow grass communities with undergrowth of aspen and birch (616 g/m^2) due to the contribution of the aspen and birch undergrowth phytomass. Among the communities with undergrowth, the least phytomass (377 g/m2) has tussock-grass and *Juncus* with raspberry, rowan, buckthorn and willow communities, because tussock grass forms unfavorable conditions for undergrowth renewal. Among the herbaceous communities without undergrowth, the great willow grass and *Juncus* communities are noticeably distinguished by phytomass, which is achieved through the participation of *Chamaenerion angustifolium* (L.) Scop. The least phytomass among herbaceous communities is observed in the *Juncus* and wood-reed communities, only 260 g/m^2.

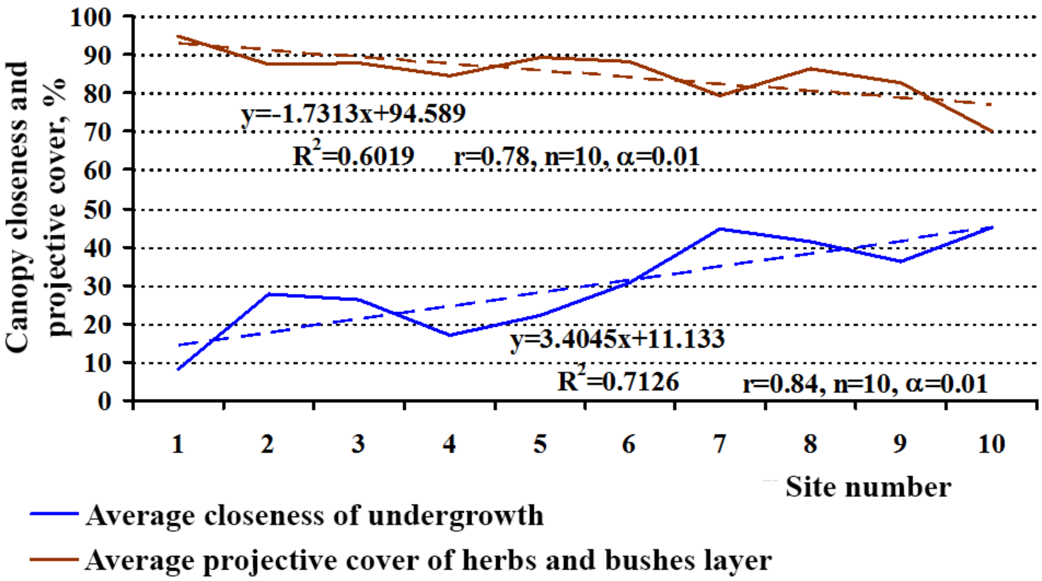

Fig. 11. Changing of undergrowth canopy density (blue line) and projective cover of herbs and bushes layer (orange line) along the transect, from the center of clear-cutting area (1) to the forest frontier (10) with their trend lines and formulas.

Table 6. Average phytomass in clear-cutting communities (g/m^2).

Index in the map legend	Post-cutting vegetation communities	Average phytomass, g/m^2
1a	Forb and forb plus willow-herbs with aspen and birch undergrowth	616
2a	Forb and *Juncus* with aspen and birch undergrowth	438
3a	Willow-herbs and *Juncus* with aspen and birch undergrowth	445
4a	Tussok-grass and *Juncus* with aspen and birch undergrowth	386
3б	Willow-herbs and *Juncus* with broad-leaved species undergrowth	445
1в	Forb and forb plus willow-herbs and raspberry with rowan and buckthorn	442
4в	Tussok-grass and *Juncus* raspberry with rowan and buckthorn	377
3	Willow-herbs and *Juncus*	335
4	Tussok-grass and *Juncus*	261
5	Forb and tussock-grass	285
6	Tussok-grass and wood-reed	285
7	*Juncus* and wood-reed	260

An integral expression of the functional structure of the studied cutting area is created map of the phytomass distribution (fig. 12), which reflects the average values of phytomass in different types of communities, in accordance with the map of post-cutting succession communities (fig. 3). According to the obtained map, communities located closer to the forest edge in more humid ecotopes have the largest phytomass. The lowest phytomass values are observed in communities without undergrowth, located in the central parts of the cutting area within dry and disturbed habitats. The range of phytomass values within the post-cutting communities is quite large – from 200 to 500 g/m^2.

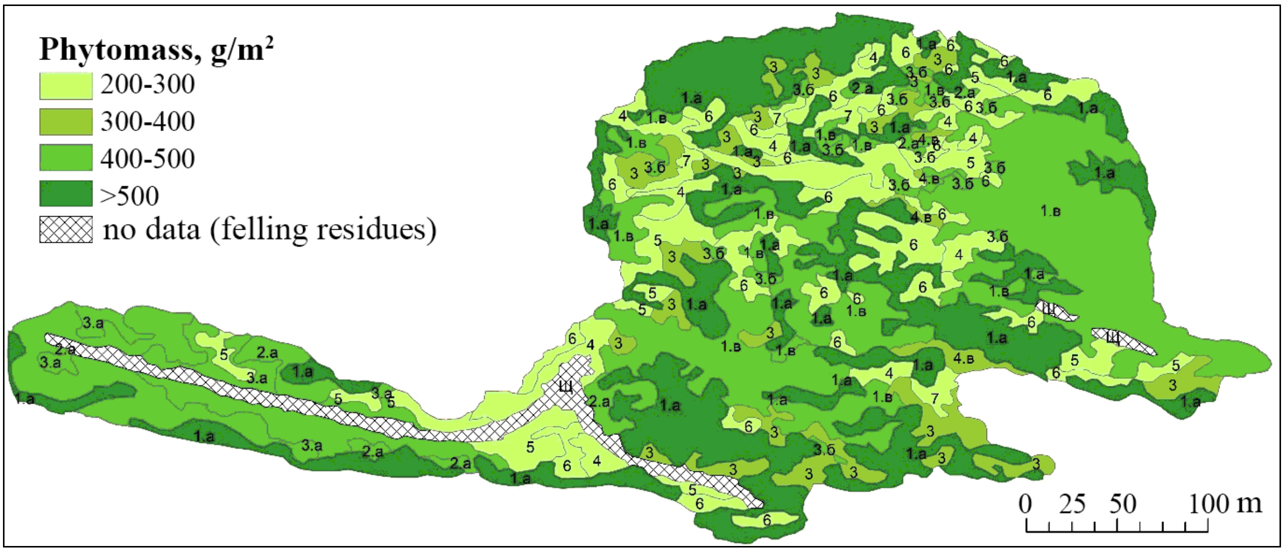

Fig. 12. Phytomass distribution within the clear-cutting area; indices of community types are listed in table 2.

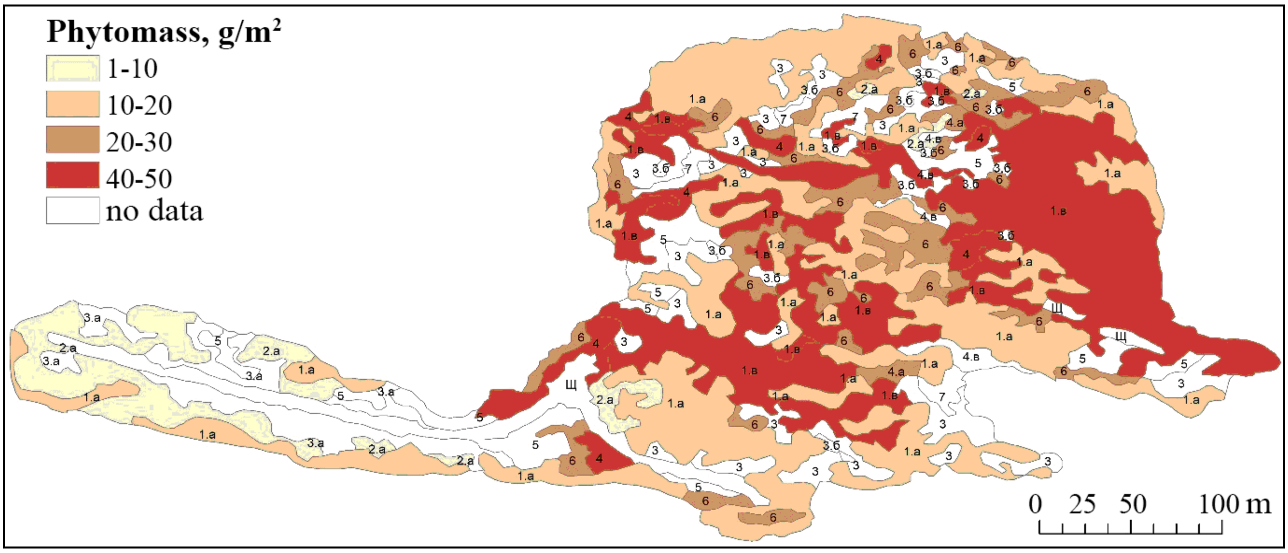

Fig. 13. Distribution of *Luzula pilosa* phytomass in the clear-cutting communities; indices of community types are listed in table 2.

Comparison of the phytomass distribution with maps of ecotopic conditions in the system of ecological ordination (fig. 6, 7) show that, the optimal conditions for phytomass accumulation are the 73th humidity step (moist meadow) and 8.8 nutrient status step (not rich soils with weak acid reaction). The proposed approach to study the phytomass distribution can be used to identify changes in individual species phytomass in different communities and also to compare these values with ecotopic conditions. So, on the map of the phytomass distribution *Luzula pilosa* (L.) Willd, (fig. 13), one can notice the dependence of its phytomass production on ecotopic conditions. This species reaches the maximal phytomass in the most moistened ecotopes, the 74th step (fig. 6), which does not coincide with the general phytomass distribution, since the ecological amplitudes of each species are individual.

Table 7. Phytomass stocks in clear-cutting communities (centner).

Index in the map legend	Post-cutting vegetation communities	Phytomass stocks, centner	Share in the total phytomass, %
1a	Forb and forb plus willow-herbs with aspen and birch undergrowth	98.06	44.8
2a	Forb and *Juncus* with aspen and birch undergrowth	14.97	6.8
3a	Willow-herbs and *Juncus* with aspen and birch undergrowth	9.76	4.5
4a	Tussok-grass and *Juncus* with aspen and birch undergrowth	1.01	0.5
3б	Willow-herbs and *Juncus* with broad-leaved species undergrowth	2.94	1.3
1в	Forb and forb plus willow-herbs and raspberry with rowan and buckthorn	52.32	23.9
4в	Tussok-grass plus *Juncus* and raspberry with rowan and buckthorn	1.49	0.7
3	Willow-herbs and *Juncus*	10.93	5.0
4	Tussok-grass and *Juncus*	6.55	3.0
5	Forb and tussock-grass	7.08	3.2
6	Tussok-grass and wood-reed	12.19	5.6
7	*Juncus* and wood-reed	1.68	0.8
	Total:	219.04	100.0

The obtained data made it possible to calculate phytomass values by the areas occupied by different types of communities, and the total phytomass stock within studied cutting (table. 7). Taking into account the occupied areas, the largest contribution to the phytomass is made by forb and great willow grass communities with aspen and birch undergrowth (45%) and forb and great willow grass raspberry communities with rowan, buckthorn and willow undergrowth (24%). The total stock of phytomass in the post-cutting communities comprises 219 centners of dry matter.

Conclusions

In the course of the study of post-cutting vegetation spatial-functional heterogeneity the following conclusions were made.

1. The combination of hydrothermal characteristics, the nature of the relief and underlying rocks contribute to the formation of bogging soils and the swamping processes within the whole reserve territory and within studied cutting. Moistened spruce forests predominate in the vegetation cover, under cutting they are changed by small-leaved forests formed by common birch, aspen, alder.

2. The nature of post cutting reforestation depends not only on the zonal position of territory, but also on a number of other factors: relief, humidity, tree species composition and its age, ground cover, logging technologies, undergrowth conservation, which determine inner renewal mosaic of vegetation.

3. Studies of the species composition in communities showed an increase in species richness at the first stage of overgrowth (more than 30 species per 100 m^2); at this stage the group of characteristic species with high classes of constancy forms. These species play an active role in the composition of vegetation.

4. Analysis of the spatial structure of post-cutting vegetation revealed 7 types of post-cutting communities by dominants of herbaceous layer and 3 types of forming undergrowth. The largest area (more than 60%) is occupied by forbs and great willow grass communities with aspen and birch undergrowth and *Juncus* communities without undergrowth.

5. The undergrowth height and closeness depend on forest conditions in a particular territory, namely, from the distance to the forest edge and the features of a ground cover. The most favorable conditions for the renewal of undergrowth are formed in the forbs and great willow grass communities near the forest edge.

6. Analysis of ecotopic conditions with the help of ecological scales L.G. Ramensky showed that the study area is characterized by moisture from fresh meadow to wet meadow steps and not rich mesotrophic weakly acidic soils. Differentiation of conditions is reflected in the distribution of communities: tussock-grass communities form in more dense and disturbed parts; great willow grass and juncaceous communities with broad-leaved undergrowth form in the driest ecotopes; tussock-grass and *Juncus* and *Juncus* plus wood-reed communities form in the most wet ecotopes.

7. The result of the phytocenosis functioning is the primary biological productivity, manifested in the accumulation of phytomass, the values of their height, increment, litter and dead phytomass. Two groups of plants make the greatest contribution to the phytomass production and carbon deposition: tree undergrowth (birch and aspen) and some herbaceous dominants (*Chamaenerion angustifolium* (L.) Scop. and *Calamagrostis arundinacea* (L.) Roth). These species can be used as indicators of a certain level of phytomass accumulation.

8. The map of the post-cutting communities total phytomass distribution is an integral expression of the functional structure of the study area. The largest phytomass was detected in forbs and great willow grass communities with aspen and birch undergrowth; the lowest – in forb and tussock-grass and tussock-grass and reed communities.

9. Composed maps of the plant communities distribution, phytomass, and ecological regimes show the spatial relationships between phytomass accumulation, ecotopic and coenotic conditions.

The data obtained can then be used for conjugate analysis with pulsation measurements for carbon balance components. Despite the fact that the process of accumulation of phytomass is actively ongoing at the cutting site, according to turbulent pulsation measurements, it is still a source of CO_2 for the atmosphere at this stage. Detailed information on the structure and course of production processes in different types of communities will help to study in more details the essence of carbon deposition processes, and evaluate the contribution of individual communities and species to carbon sequestration. The study of vegetation is the first step in the research of these relationships. In the future, it seems possible to establish more accurate correlations between the height, projective cover and phytomass of individual plant species in different types of communities.

Measurement of indicators for key dominant species will allow assessing phytomass reserves in the territory and, respectively, the rate of carbon deposition / emission.

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