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Successional Dynamics of Forest Ecosystems Composition and Productivity.

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ABSTRACT

Forest vegetation of modern landscapes is a complex of successional systems, including communities at different stages of degressively recovered dynamics. Changes affect composition of species, forming forest stand and ground cover. The primary production and stocks of forest ecosystem biomass vary depending on the environmental conditions of the habitat and successional stages. During the research, we have identified three types of succession systems formed under conditions of territorial complexes studied: a succession system of linden-oak nemoral forests in the NTC (natural territorial complex) of high interfluvial plains, succession system of spruce-oak-linden nemoral forests in the NTC of high interfluvial plains and succession system of Raifa spruce moos forests in the NTC of indigenous valley slopes. Birch and linden-tree forests are the most productive.

Keywords: successional system, recovered dynamics, primary production, biomass

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INTRODUCTION

Full and long-term functioning of natural communities is possible only when maintaining their inherent biological diversity, taking into account natural and anthropogenic dynamics of communities. Therefore, the study of the dynamics of plant cover in its various time and spatial scales is of particular importance at the present stage of development of the natural sciences. The plant cover dynamics shall mean different variants of gradual changes that may be caused by both internal and external factors and, as a rule, are irreversible [1].

S. Razumovsky identifies three categories of dynamic phenomena such as changes (the phenomena occurring within the association), succession (substitution of one association with another) and conversion (the emergence of new, previously not existing units of vegetation under the influence of the macro environment varied), stressing their fundamental difference. He defines the concept of “change of plant cover” as a direct replacement occurring in time in a particular area of a community with the dominance of one species with the community of other species [2]. Gradual change of phytocenoses occuring vectorized or cyclically, under the influence of reasons internal or external to the phytocenosises is called succession [1].

From the standpoint of structuralism, the one and sufficient thing to consider a community to be the climax one is the lack of internal reasons for its change [3]. Different authors mention a number of additional properties and attributes of a climax community [4-6]. In terms of real communities, despite the fact that the vegetation has a significant amount of time to complete the ecogenetic transformation of ecotopes, the climax usually does not occupy large territories, rarely prevails in the area of other communities, and is almost absent in many areas [7, 8].

Theoretically, each type of successional series can have its climax. Problems of numbers of climaxes, the presence and nature of the internal dynamics in climax communities are topical subjects of special studies [9, 10]. One of the most important indicators of climax is the production. According to Whittaker [11], climax communities can be identified by the maximum height and biomass inherent to this series and the presence of self-regenerating populations of cenosis-forming species. The rate, at which the ecosystem producers capture solar energy, determines the productivity of communities. Organic mass created by plants per unit of time, is called the primary community production. Production is expressed quantitatively in damp or dry weight of plants or units of energy - equivalent to the number of joules [12]. It would be ideal to measure the flow of energy through the system when determining the productivity. However, it is usually impossible in practice. Therefore, the indirect indicators are used such as the amount of the substance produced, the amount of raw material used, the amount of by-products generated.

Characteristic of habitat

The total area of the Raifa zone of Volga-Kama natural biosphere reserve is 3450 thous. ha. This site is within Zelenodolsky District of the Republic of Tatarstan, located within the West Kazan terrace valley region Eastern European pine and broad-leaved pine subtaiga forests on high terraces above the floodplain of the Volga.

Raifa forests represent on their flora and vegetation the biogeocenoses of mixed forests of Eastern European part of the former Soviet Union, which they are adjacent geographically to [13]. A small area comprise almost all major forest types of the Volga-Kama region. It combines the formation of three forest zones of the European part of the USSR such as the southern taiga, mixed and broad-leaved forests. The age of some pine, fir and oak forests of Raifa reaches 250-280 years. Pine predominates in forests (68% of forest area), much less birch (13%), linden (11%), oak (5%) and spruce (3%). Spruce and fir are here on the southern border of their spread zone, oak is close to the northern boundary of the area.

There are more than 60 plant associations belonging to 7 formations, allocated on the basis of dominance in the main layer, and the presence of diagnostic species in subordinate layers [14]. Formation of pine forests is represented by Pineto-cladinosa associations in dry ecotopes, Pineto- Vaccinioso- Myrtilloso-Hylocomiosa in sufficiently moist soils and Pineto-Sphagnosa in waterlogged substrates. Derived types of pine plants including the number of pine reed grass, fern, raspberry and pine cultures of different ages are also widespread along with indigenous ones. Formation of spruce forests is represented by small fragments of derived plants not exceeding 30 hectares in area of the whole forestry. Formation of spruce forests is represented by two groups of associations. The first group is represented by nemoral spruces (Piceeto-Aegopodioso- Mercurialiosa, Caricosa pilosae-Aegopodiosa, Oxalidoso-Nemorosa Struthiopteridosa, Urticosa), the second is represented by Piceeto- calamagrostidosa, and Piceeto- Saxatile-Rubosa mainly with pine and lindentrees. There is a widespread formation of linden trees of different typology. Degressive recovered changes of primary and nominally primary forests under the impact of cutting and fires resulted resulted in the formation of short-derived plants of birch and aspen. Formation of alders is represented by floodplain forb alder. Alder forest stand comprises elm, aspen, birch, and the ground cover is represented by both hygrophilous and nemoral species, the species of ruderal flora also becomes widespread, coming to the reserve along floodplains with the river runoff.

Derivative types in place of primary forest plants include different associations of meadow formation. Dry meadows, forming individual fragments among forest stands of different typologies, include species of different eco-cenotic groups with a predominance of light-demanding forest-meadow and meadow species. Nemoral species, including seedlings of woody species, are also observed in the meadow herbage, while boreal species are extremely rare.

TECHNIQUE

We created the permanent test sites of 50 × 50 meters in phytocenoses belonging to different forest types and at different stages of successional development, where a detailed description of the plant communities structure was then carried out. Studies carried out during the field phase of work consider the basic characteristics of the forest stand layers (trunk height and diameter, the living condition of the trees, etc.), geobotanical description of each site, biomass of ground cover, ground cover map of each site at a scale of 1:100, and coordinates of the site in the WGS 84. Total 12 sites were created in quarters 39, 40, 41, 42, 56, 57, 66, 87, 88, 91, and two sites in the quarter 83 of Raifa area.

Different types of habitat were compared based on their environmental space on regional environmental scales. Environmental space shall mean the ranges of environmental factors that determine the specific environmental regimes of habitats. The simplest and most convenient way to assess the environmental space of habitat is the processing of geobotanical descriptions on environmental indicative scales containing ratings of the environmental properties of the various types of environmental factors.

Ratings are calculated for each geobotanical description. When using a point scale, the final rating of a certain factor is calculated as the average of the ratings of all kinds on this factor, weighted by the abundance of species. Calculation may be carried out on the range environmental scales as follows: 1) the extreme borders, 2) the intersections of the majority of intervals, and 3) the weighted average interval midpoint. The more gradations are in scale, the more detailed differentiation of habitat is.

MAIN BODY

Using the classification approach by V. Porfiriev, we identified types of successional systems that comprise the above communities, and described their relationship as a series of demutational successional changes. Plant communities represented at the sites, can be grouped into eight series due to composition of species and their abundance estimate: Myrtillosa, Caricosa pilosae-Aegopodiosa, Mercurialioso-Caricosa pilosae, Aegopodioso- Struthiopteridosa, Aegopodiosa, Aegopodiosa - Mercurialiosa, Myrtilloso - Hylocomiosa, Gramineo - Hylocomiosa; and five cycles: Hylocomiosa, Aegopodiosa, Caricosa pilosae, Struthiopteridosa, Mercurialiosa.

Diversity of series and cycles, combining the series, depends on the spectrum of landscape conditions. Based on the results of landscape and geobotanical studies [14, 15] and analysis of field data, we can assume that certain types of successional systems, which can be marked with the name of the formation, forms within the certain types of NTC (rank of complex tracts or areas).

Communities were merged into recovered ranks and assigned to certain types of successional systems. When forming such systems, we have considered the estimation of phytocoenotic role of forest forming species included into communities and features of the age spectrum of their populations. A hypothetical climax state is in the center of the figure, the inner circle unites secondary permanent variants of communities, similar in their properties to the climax, and the outer circle indicates primary permanent states resulting from intensive violations of plant cover in the past. Since none of the investigated phytocenoses is a climax community due to its characteristics, the most stable phytocenoses were chosen as a terminal stage community, according to V. Porfiriev, which can be referred to the terminal stage of the development of vegetation in this area.

During the research, we have identified three types of succession systems formed under conditions of territorial complexes studied: a succession system of linden-oak nemoral forests in the NTC (natural territorial complex) of high interfluvial plains, succession system of spruce-oak-linden nemoral forests in the NTC of high interfluvial plains and succession system of Raifa spruce moos forests in the NTC of indigenous valley slopes. All quarters studied differ in a number of indicators, the main of which are soil fertility and soil moisture.

Comparison of sites on environmental scales [16], considering regional features, has revealed major differences between the quarters. There is an expected increase of soil fertility in the "pine - mixed coniferous-deciduous - broad-leaved forests”. Soil moistening also increases in this series, although less significantly. Analyzing the data in Table 1 we can define conifers (quarter 39-42) among the areas studied, the conifers such as spruce and pine dominate in the forest stand. The participation of these species is disproportionate: spruce is more widespread, pine is presented only by mature generative individuals occupying the entire first layer. Communities of these sites, originating from the Raifa spruce-pine moss forests in the NTC of primary valley slopes composed of fluvioglacial sands and sandy loams belong to successional system of spruce-oak-linden nemoral forests. The state of all communities does not meet a climax, which is the result of intensive economic impact in the past. A significant amount of herbaceous vegetation is represented by ruderal species. These communities are characterized by the largest stockpiles of wood. According to the taxation descriptions, age of pine in the quarters studied ranges from 60 to 250 years, which points directly to the vast reserves of timber. However, despite the excellent condition and large stocks, the population of pine raises a red flag. During the study no young pine trees were found in any of the studied quarters. This indicates that pine due to its aging and die-back will give way to spruce, the population of which is represented by all age states.

The next type of community is mixed forests (quarter 56, 57, 66). Deciduous tree species certainly dominate in this community, however, conifers are also quite abundant and fall within a formula of forest stand by both the number of trunks and the total cross-sectional area. Successional ratio of these areas makes a recovered series of spruce-oak-linden nemoral forests. Ecotopes are represented by the NTC of interfluvial high plains composed of eluvial-diluvial loams on sod-podzolic loamy soils.

The third group of communities is deciduous forests (quarter 83, 87, 88, 91) represented by linden and birch. All birch communities are secondary forests grown after cutting and burning out the primary communities. Linden forest have been formed in place of oak forests. The figure shows ratios of this group of communities in the NTC of interfluvial high plains composed of eluvial-diluvial loams on sod-podzolic loamy soils, which have been attributed to the succession system of linden-oak nemoral forests. The community of quarter 87 - linden-tree forest with plant cover of mercurialis and aegopodium - has the closest to climax state. The most distant variant of this type is the community of quarter 88 represented by birch forest with plant cover of mercurialis and aegopodium and with linden trees.

The lowest biomass of ground cover was recorded in quarters composed of conifers, a little more - in mixed communities, the highest one - in the broad-leaved forests. This distribution is the result of complex of biotic and abiotic conditions prevailing in each community. Coniferous communities, despite a higher level of illumination, are rather dry and the soil is much poorer than in phytocenoses with hardwood. In addition, the presence of a specific edificator - *Piceae fennica* - has a very strong influence on the vegetation, its species composition and biomass. Therefore, a high level of light under such conditions neither promotes an increase in biomass, nor exacerbates the lack of moisture caused by high drainage capacity of the soil.

Table 1: Characteristics of vegetation and environmental conditions in the test sites

ID	Quarter No	Type of soil	Forest site type (for 2013)	Type of forest	Forest stand formula	Species richness	Total grass biomass on the site, kg	Wood biomass, kg	Total biomass, kg	Rating of soil fertility	Rating of soil moistening
1	39	Sandy-loam podzolic soils	C2	Pine forest with spruce with plant cover of *Convallaria majalis* and *Chelidonium majus*	5S3P1L1B+Elm	26	1705	213617.9	215322.9	4	5
2	40	Sandy-loam podzolic soils	B3	Pine forest with spruce and birch with plant cover of *Convallaria majalis* and *Chelidonium majus*	5S2P1B+L	31	1282.5	158740.7	160023.2	4	5
3	41	Sandy podzolic soils	C2	moss-covered pine forest (*Vaccinium myrtillus* and *Chelidonium majus*) with linden tree and spruce	5S2B2L1P	17	2265	174566.0	176831.0	4	5
4	42	Sandy podzolic soils	A2	moss pine forest with plant cover of *Convallaria majalis* and *Chelidonium majus*	5P5S+L	25	2025	284999.5	287024.5	4	5
5	56	Sod-podzolic sandy-loam soils with clay-loam illuvial horizon	C2	linden-tree forest with spruce with plant cover of *Carex pilosa* and *Aegopodium podagraria*	8L1M+B+S	29	2882.5	115348.3	118230.8	5	5
6	57	Sod-podzolic sandy-loam soils with clay-loam illuvial horizon	C2	linden-tree forest with spruce with plant cover of *Mercurialis perennis* and *Carex pilosa*	7L2M+Elm+S	30	2860	100642.1	103502.1	5	5
7	66	sod-podzolic loam soils	C2	linden-tree forest with spruce with plant cover of *Aegopodium podagraria* and *Matteuccia struthiopteris*	4L2M2Elm1S1H	24	3912.5	178384.1	182296.6	5	6
8	83_1	sod-podzolic loam soils	C2	birch forest with linden trees with plant cover of *Matteuccia struthiopteris* and *Aegopodium podagraria*	3M3Elm2L1B+H+S	27	12275	92337.4	104612.4	5	6
9	83_2	sod-podzol loam soils	C2	linden-tree forest with birch with plant cover of *Matteuccia struthiopteris* and *Aegopodium podagraria*	5L3M1B1Elm+S	24	8235	129542.1	137777.1	5	5
10	87	sod-podzol loam soils	C2	linden-tree forest with plant cover of *Mercurialis perennis* and *Aegopodium podagraria*	5L3Elm2M+O	14	6425	133639.6	140064.6	6	6
11	88	Gray forest loamy soils	C2	birch forest with plant cover of *Mercurialis perennis* and *Aegopodium podagraria* and with linden trees	5L4B+Elm	23	5110	164201.6	169311.6	5	5
12	91	Gray forest loamy soils	C3	linden-tree forest with birch and oak with plant cover of *Mercurialis perennis* and *Aegopodium podagraria*	7L2M+B+O+Asp	34	1792.5	115891.4	117683.9	6	6

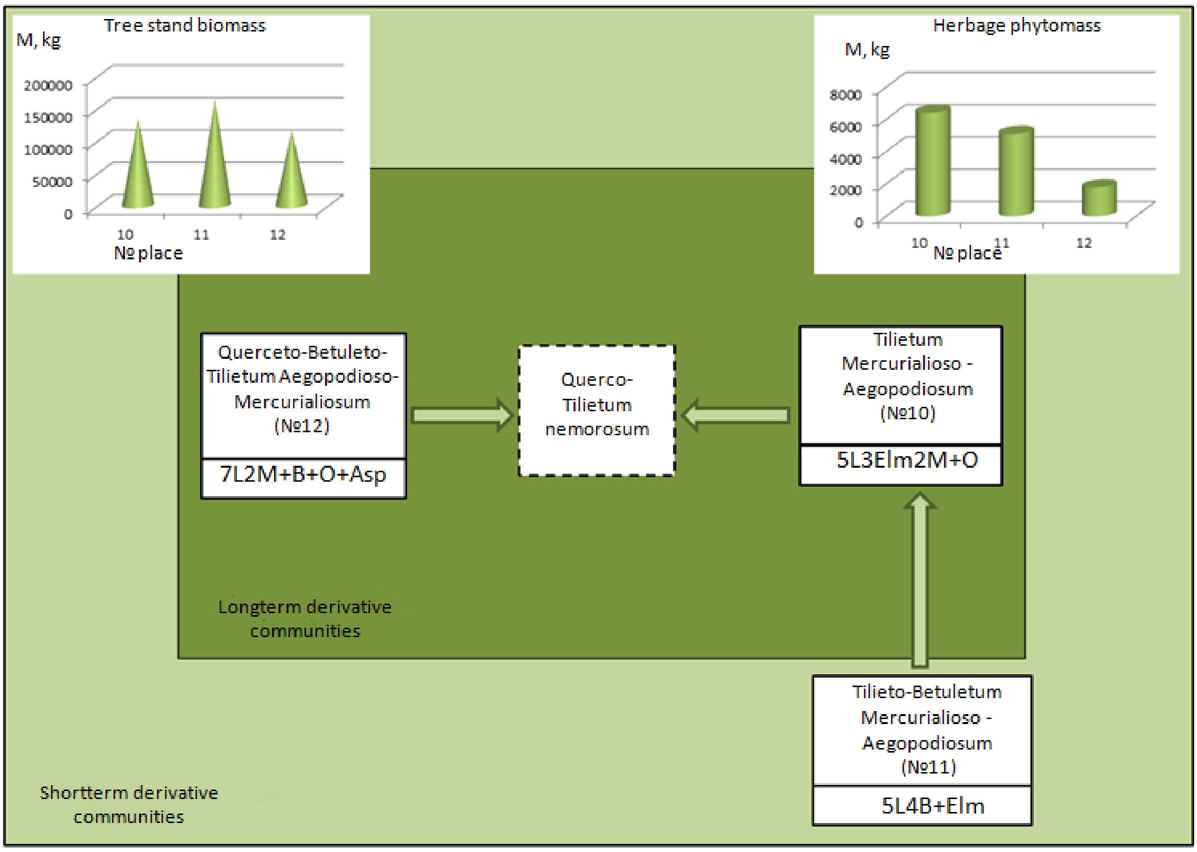

Figure: Recovered series of linden-oak nemoral forests.

CONCLUSION

Taking into account that the sites considered belong to the lands of specially protected natural areas, they have the potential for dynamic development in the direction of stabilization and improvement of the stability, but this can be done only in the case of careful and strict observance of the reserve status of the aforesaid territories. Natural or anthropogenic violations of the integrity of the plant communities, whether forest fires, illegal logging or regular trampling, become a factor that holds the community back in its recovered series that affects its animal world, the rate of development of soil, climatic characteristics, and the hydrological regime of the area, and, eventually, the most of the biogeocenose components. Restoration of balance lost may take decades or centuries. Given the fewness, small area and uniqueness of SPNR of the republic, they deserve the most careful treatment.

REFERENCES

[1] Mirkin B.M., Naumova L.G., Solomets A.I. M., Logos, 2001.
[2] Razumovsky S.M. Nauka, Moscow, 1981
[3] Zhirkov I.A. Partnership of scientific publications KMK, Moscow, 2010
[4] Connell J., Slatyer R. The American Naturalist, Vol. 111, No. 982, 1977.
[5] Legendre P , Fortin M-J. Kluwer Academic Publishers, Vegetatio, 107-138, 1989
[6] Odum E. P. Basic Ecology, 1983.
[7] Holling C. S. International Institute for Applied Systems Analysis, 1973.
[8] Kuuluvainen T. Finnish Zoological Publishing Board, Helsinki, 1994.
[9] Walker L.R, Roger del Moral. Cambridge University Press, 2003.
[10] Walker L.R., Walker J., Hobbs R.J. Springer Science Media, New York, 2007.
[11] Whittaker R.H. Communities and Ecosystems, Macmillan, 1975.
[12] Chernova N.M. N.M. Chernova, A.M. Bylova. - M.: Drofa, 2007.- 416 p.
[13] Porfiriev V.S. Proceedings VKGZ, Edition 1, 1968, Kazan, publ. hous of KSU, p. 106-136.

[14] Rogova T.V., Mangutova L.A., Lyubina O.E., Farkhutdinova S.S. Proc. of Volga-Cama State Reserve, edition 6. - Kazan, 2005.

[15] Porfiriev V.S. Bot. Journal, t.49, No2, 1964.

[16] Shagiev B.R. tPh.D. thesis in biological sciences. K. 2012 - p. 185