Formation of phytocoenotypes in soils of different degree of erosion

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Abstract. The paper focuses on issues related to problems of eroded soils and subsequent processes of development of serial communities aimed at formation of a stable climax phytocoenosis. A series is considered as a set of species that briefly inhabit a given territory replacing each other. Soil erosion development is caused by anthropogenic and natural factors; hence, this process is of a mixed natural-anthropogenic type. Soil erosion on slopes with elemental landscapes of any exposure affects the environmental conditions for the formation of phytocoenotypes and species composition of plant communities due to secondary successions and variation in dominants and subdominants. In this case, plant communities of herbaceous phytocoenoses of eroded soils exhibit both sequential and rapid changes in species composition with the appearance of species adapted to decreased soil fertility. The orientation, rate and number of successional changes depend on the intensity of erosion development. Severely eroded soils significantly increase the heterogeneity of the soil environment, creating optimal conditions for introduction of species that are often nontypical of the considered phytocoenoses; the number of assectators therefore increases in soils of this type. In case weakly eroded soils are used as the control, the number of assectators in severely eroded soils increases two to three fold, with possible fluctuation changes aimed at reducing assectators due to ecotopic and phytocoenobiotic selections.

1 Introduction

The nature of erosion processes in the exogenesis system of (endogenetic successions) necessitates constant study, monitoring, and forecasting of damage to the landscape environment, in general, and to the soil cover, in particular [1].

Annual global loss in agricultural lands attains tons of fertile soil layer due to erosion processes, which significantly decreases the yield [1]. The erosion of slope soils with elemental landscapes of any exposure affect the environmental conditions for phytocoenotype formation. The processes of degradation of natural and cultivated meadows and pastures mirror the species composition of plant communities [2] changed due to secondary successions, and changed pattern of the formation of aboveground and underground plant parts. To pass through the stages of secondary successions, plant species

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need an additional factor, a sufficient supply of seeds to enhance their distribution, germination and rooting. First, they appear as single individuals, then form agglomerations to eventually fit into the structure of the plant community and ensure its spatial and temporal uniformity [3, 4] in line with the patterns of consistent filling of the environment – edaphotope.

The aim of the study was to analyze the stability of phytocoenoses with regard to the biomorphological spectrum of phytocoenoses in different elemental landscapes with a differentiated degree of erosion.

2 Object and methods of study

The study object was natural phytocoenoses of secondary origin that grow in the areas of carved out forests in the southwestern part of the Warmian Upland with sampling point gradation by the profile of elementary landscapes as proposed by B.B. Polynov and M.A. Glazovskaya [5] (Table 1).

Table 1. Elemental landscapes at the key site.

Elemental landscape	Degree of soil erosion	Moisturing, wash, drain
Plakors, or proper eluvial watersheds with a slight slope (1–2^0)	weak	Minor wash; atmospheric moisture prevails
Transeluvial upper relatively steep slopes (not less than 2–3^0)	severe	Intensive runoff, slope wash and flow erosion with significant microclimatic variations
Eluvial-accumulative or transaccumulative lower slopes and foothills	medium	Deposition of alluvium caused by flow waters; abundant moisture

The study employed the materials of research and observations of the authors performed within the framework of the research topics: Plant and forage resources of the Kaliningrad region: inventory, environment, production, management (No. 13.16.021.2); Resource potential of agricultural plants in the context of symbiotic population interactions (No. 01-33001-2).

3 Study Results

Perennial grasses play the key role in the formation of grassy-soddy covering due to their abundant tillering, long-term ability to shoot with constant renewal of above-ground organs.

The floristic composition of polycarpic species of meadow communities is presented in Table 2. The involvement of species in the formation of phytocoenotypes is uneven and depends on the degree of soil erosion downward along the topography of the key site.

Secondary succession can take place due to a sufficient seed supply for plant distribution, germination and rooting, first as single individuals, then forming agglomerations and populations, which ultimately fit into the plant community structure and ensure its spatial and temporal uniformity with regard to the patterns of consistent filling the environment.

Table 2. Species composition for the geomorphological profile of the eroded brown forest sandy loamy soil of the northern slope.

Name in Latin	Plakor	Transeluvial	Trans-accumulative
Eriophorum vaginatum L.	-	sol	-
Poa pratensis L.	cop_2	sp	cop_1
Elytrigia repens (L.) Beauv.	cop_2	sol	sp
Anthriscus sylvestris (L.) Hoffm.	cop_1	cop_1	sol
Sonchus arvensis L.	cop_1	sp	cop_1
Equisetum arvense L.	cop_1	cop_1	cop_2
Calamagrostis epigeios Roth.	sp	sp	sp
Urtica dioica L.	-	-	sol
Bromus inermis Leyss.	cop_1	cop_1	cop_1
Lupinum polipholia	sp	-	cop_3
Taraxacum officinale Wigg.	sol	sol	sp
Selinum carvifolia L.	-	sp	-
Achillea millefolium L.	cop_3	cop_3	sol
Artemisia abisnthium L.	sp	sol	sp
Alopecurus pratensis L.	cop_3	sp	cop_1
Phleum pratense L.	cop_1	cop_1	sp
Galium mollugo L.	sol	-	sp
Dactylis glomerata L.	-	cop_1	-
Scirpus lacustris L.	-	cop_3	-
Heleoharis acicularis R. Br.	-	sp	-
Carex vesicaria L.	-	cop_2	-
Calla palustris L.	-	sp	-
Juncus effusus L.	-	sp	-
Iris pseudacorus L.	-	cop_2	-
Polytrichum communis	-	sp	-
Projective cover, %	50	70	70
Basal cover, %	10	60	40

The grass stand of the upper third of the slope in slightly eroded soil comprises a significant number of various species, including representatives of the legume family – *Lupinum polipholia*. Table 3 summarizes polydominant communities revealed in the study.

Table 3. Phytocoenotypes in soils with different degree of erosion

Elemental landscape	Phytocoenosis
Plakors, or actually eluvial watersheds with a slight slope (1–2^0)	*Poa pratensis - Elytrigia repens + Alopecurus pratensis + Achillea millefolium*
Transeluvial, relatively steep upper slopes (not less than 2–3^0)	*Carex vesicaria + Iris pseudacorus - Achillea millefolium + Scirpus lacustris*
Eluvial-accumulative or transaccumulative, lower slopes and foothills	*Equisetum arvense Sonchus arvensis Alopecurus pratensis - Lupinum polipholia*

Due to increased erosion, species with rhizomatous (Alopecurus pratensis.) and tap (Achillea millefolium, Anthriscus sylvestris) root systems predominate in the grass stand. At the base of the slope, near the base level of erosion, it forms a plant community typical of a lowland bog (Figure 1). The obtained results indicates parallel changes in plant communities confined to eroded soils, which are caused by both syngenetic and exoecogenic processes. Therefore, the vegetation cover of severely eroded soils can be defined as completely unformed due to the transition of cultivated soils to fallow soils and associated changes in the plant community composition. At the same time, this can be characterized as a transition to an avalanche-like change in the phytocoenosis due to severe erosion of part of the geomorphological profile with the predominance of rhizomatous and taproot species that exhibit high adaptation to changes in the degree of erosion [6].

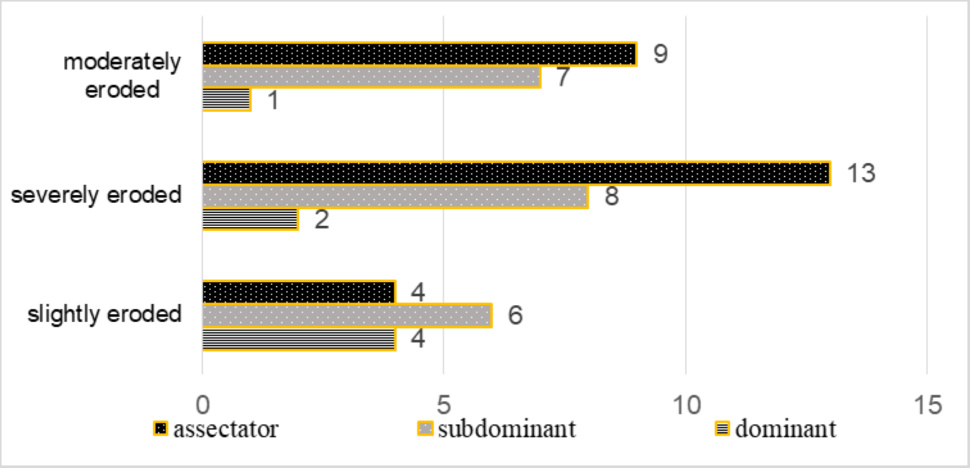

Fig. 1. The dominance system in soils of different degrees of erosion

The distribution of plant communities in eroded soils depends on the soil-geomorphological conditions, the stage of phytocoenosis evolution, and the rate of changes of dominant species under different erosion orientation and intensity (Figure 2). In severely eroded soils, the species composition is observed to increase with a predominance of assectators, which form secondary steps in plant communities. In the studied conditions, all assectators are degressive since they have invaded and ecized in the disturbed soil cover. At the same time, autochthonous, edificator-phobic assectators are not found at the key site.

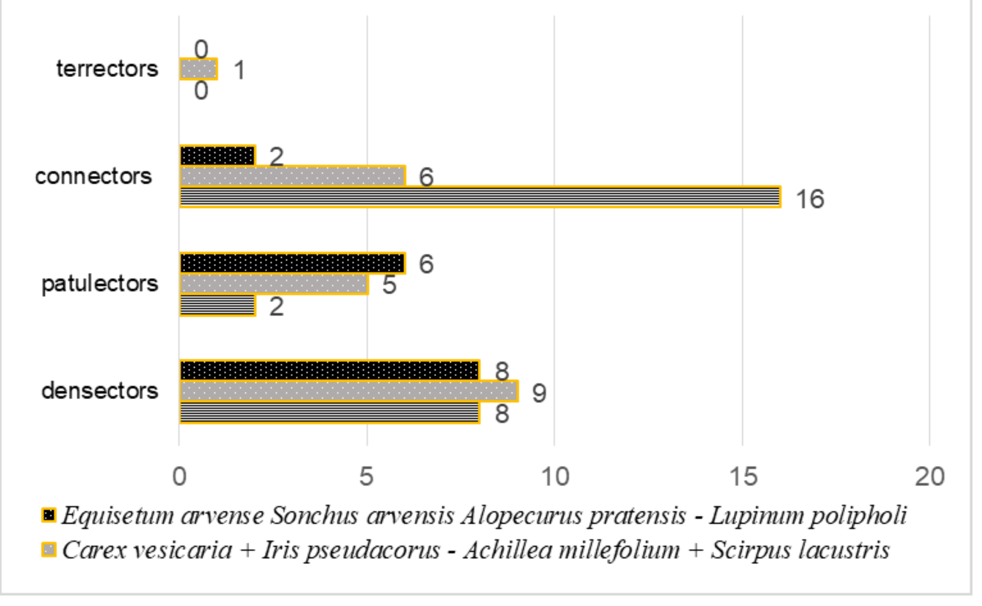

Fig. 2. Biomorphological spectrum of species with regard to their dominance during restoration of plant communities in soils of different degree of erosion.

In terms of the biomorphological spectrum, the community of yarrow-foxtail-couch grass-bluegrass phytocoenosis includes patulectors, connectors, and densectors.

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The data analysis shows the predominance of connectors with a close interweaving of rhizomes and stolons. The forecast of this type of phytocoenosis is aimed at preventing and slowing down erosion since plants serve as a factor structuring the soil surface and preventing leaching of soil particles and their colloids even during surface runoff events.

A heterogeneous environment is formed in moderately eroded soils. These conditions can induce introduction of species to provide the ecological stability and reliability of the habitat. Reed-yarrow-iris-sedge phytocoenosis is characterized by atmospheric humidification and surface runoff. In this case, populations typical of coastal aquatic vegetation are formed. Densectors growing in dense standing predominate, but not interwoven into a network of rhizomes. In the plant community, terrectors, *Polytrichum communis*, are found to support the soil surface structure.

4 Conclusion

The study yields the conclusion that plant communities of herbaceous phytocoenoses confined to eroded soils are characterized by a successive rapid change in the species composition and increased abundance of species with rhizomatous and taproot systems, which are highly adapted to the deterioration of soil fertility.

During erosion events, the number of herbaceous edificators that predominate in phytocoenoses decreases from 7.4 to 1.8%. The species composition of plant communities in eroded soils has a relatively low and unstable phytomass production, depending on the degree of erosion, and can be characterized as completely unformed. At the base of the slope with a moderate degree of erosion, the number of assectators is slightly higher (16.6%) compared to subdominants (12.69%). These phytocoenoses are distinguished by a small area of basal and projective cover. The evolution of plant communities by landscape elements increases the erosion intensity.

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