Conference Paper

Century-long Dynamics of Meadow Steppes in the Privolzhskaya Uplands

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Abstract

Information on the structure and dynamics of the zonal Central Russian meadow steppes is presented in terms of the example of the Privolzhskaya forest-steppe state nature reserve (Penza region, Russia). The cenotic diversity of the herbaceous vegetation of the reserve is represented by 91 associations, of which 48 refer to steppes and 43 to steppe meadows. It has been revealed that the vegetation of the studied placer sites under the influence of an absolutely reserved regime undergoes mesophyticization and silvatization, which are more intensively manifested in the forest-steppe landscapes of the secondary moraine plains (areas of the Poperechenskaya steppe and Ostrovtsovskaya forest-steppe reserve) than in the eroded denudational plains of forest-steppe landscapes (areas of the Kuncherovskaya steppe and Ostrovtsovskaya forest-steppe reserves). The study of the dynamics of zonal meadow steppes in the Volga Uplands testifies to the inevitability of their transformation in modern climatic conditions into meadow, shrubby and even forest communities.

Keywords: forest-steppe, meadow steppes, structure, dynamics, succession, reserve, geobotanical mapping, protection of steppe vegetation

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Received: 12 September 2018
Accepted: 15 October 2018
Published: 29 October 2018

Publishing services provided by Knowledge E

Selection and Peer-review under the responsibility of the Ecology and Geography of Plants and Plant Communities Conference Committee.

1. Introduction

Meadow steppes, being the most northern steppe type of vegetation and occupying an ecotone position, react to climatic and anthropogenic changes [1–3]. In the Privolzhskaya Uplands, meadow steppes, as a zonal type of vegetation, have been preserved fragmentarily [4]. The largest areas of meadow steppes in the territory of the Volga Uplands have been preserved only in the territory of the Privolzhskaya forest-steppe state natural reserve (Penza region), which consists of several clusters

– the Kuncherovskaya steppe (190 ha), the Poperechenskaya steppe (252 ha) and the Ostrovtsovskaya forest-steppe (352 hectares).

The purpose of this work is to identify the dynamics of zonal Central Russian meadow steppes in the conditions of the protected regime in the Volga Upland, to assess the impact of climatic and geoecological conditions on dynamic processes and to identify changes in the ratio of the main types and subtypes of vegetation.

2. Methods

Many works have been devoted to studying the dynamics of meadow steppes under climatic and anthropogenic factors [5–9, etc.]: however, few studies contain specific information on the change in the structure of plant communities, especially over a long period. We have at our disposal unique material [10–13, etc.] which makes it possible to trace the progress of the succession of meadow steppes over more than a century and to propose some measures for their conservation.

Studies on the structure and dynamics of vegetation cover in protected steppe areas were carried out via repeated geobotanical mapping. The first detailed mapping of the reserve sites was carried out immediately after its creation in 1989, the second – after ten years in the absence of anthropogenic interference. The investigations were carried out in the Ostrovtsy site in 1990 and 2000, the Kuncherovsky site in 1991 and 2002 and the Poperechensky site in 1992 and 2003. Vegetation mapping was carried out by a selective-statistical method [14, 15] with some changes. As a result, two geobotanical maps were created for each site on a scale of 1:5000 [16–19]. Classification of grass vegetation was carried out on a dominant basis, taking into account the ecological-phytocenotic groups of species.

3. Results

The cenotic diversity of grassy vegetation in all areas of the Privolzhsky forest-steppe nature reserve is represented by 91 identified associations, 48 of which belong to the steppes (8 to real steppes and 40 to meadow steppes) and 43 to steppe meadows. A variety of real and marshy meadows, lowland bogs and shrub vegetation are also described (Table 1).

As a result of periodic geobotanical mapping, it was established that on the territory of the reserve there are associations of meadow steppe dominated by *Stipa tirsa*, *S. pennata, Bromopsis riparia* and mezoxerophilic herbage and an association of steppe

meadows with a predominance of *Calamagrostis epigeios, Poa angustifolia, Elytrigia intermedia* and xeromesophilic herbage.

Table 1: Changes in the ratio of the main types and subtypes of vegetation in the steppe areas of the Privolzhskaya forest-steppe reserve, in terms of area percentage.

Main syntaxa	The Kuncherovsky site			The Poperechensky site			The Ostrovtsovsky site		
	1991	**2002**	**Balance**	**1992**	**2003**	**Balance**	**1990**	**2000**	**Balance**
STEPPES	**84.6**	**84.7**	**+0.1**	**44.5**	**24.6**	**–19.9**	**80.0**	**55.0**	**–25.0**
Genuine steppes:	15.3	17.6	+2.3	0.0	0.0	0.0	0.6	2.1	+1.5
Cereal grass	10.0	17.0	+7.0	0.0	0.0	0.0	0.6	1.7	+1.1
Mixed grass	5.3	0.6	–4.7	0.0	0.0	0.0	0.0	0.4	+0.4
Meadow steppes:	69.3	67.1	0.2	44.5	24.6	–19.0	79.4	52.9	–26.5
Cereal grass	46.0	48.7	+2.7	11.2	4.4	–6.8	6.0	10.4	+4.4
Rhizome cereal	10.7	11.8	+1.1	1.1	1.7	+0.6	0.0	1.5	+1.5
Turf sedge	0.0	0.6	+0.6	0.0	0.0	0.0	0.0	0.0	0.0
Mixed grass	12.6	4.8	–7.8	20.5	16.2	–4.3	55.4	35.3	–20.1
Shrub	0.0	1.2	+1.2	11.7	2.3	–9.4	18.0	5.7	–12.3
MEADOWS	**15.4**	**15.3**	**–0.1**	**55.2**	**73.8**	**+18.6**	**20.0**	**45. 0**	**+25.0**
Steppe meadows:	15.4	15.3	–0.1	52.9	61.8	+8.9	2.4	32.5	+30.1
Cereal grass	0.0	0.0	0.0	0.0	0.6	+0.6	0.0	0.0	0.0
Rhizome cereal	15.4	14.1	–1.3	29.0	23.7	–5.3	2.4	23.1	+20.7
Mixed grass	0.0	1.2	+1.2	16.1	29.5	+13.4	0.0	6.9	+6.9
Shrub	0.0	0.0	0.0	7.8	8.0	+0.2	0.0	2.5	+2.5
Genuine meadows:	0.0	0.0	0.0	2.0	9.2	+7.2	7.1	5.5	–1.6
Cereal grass	0.0	0.0	0.0	2.0	0.0	–2.0	7.1	4.9	–2.2
Rhizome cereal	0.0	0.0	0.0	0.0	0.6	+0.6	0.0	0.0	0.0
Mixed grass	0.0	0.0	0.0	0.0	7.4	+7.4	0.0	0.6	+0.6
Shrub	0.0	0.0	0.0	0.0	1.2	+1.2	0.0	0.0	0.0
Swampy meadows:	0.0	0.0	0.0	0.3	2.8	+2.5	10.5	7.0	3.5
Cereal grass	0.0	0.0	0.0	0.3	1.1	+0.8	10.5	7.0	3.5
Mixed grass	0.0	0.0	0.0	0.0	1.7	+1.7	0.0	0.0	0.0
SWAMPS	**0**	**0**	**0.0**	**0.3**	**1.6**	**+1.3**	**0**	**0**	**0.0**
Total, %	100	100	–	100	100	–	100	100	–
Area, ha	190	190	–	252	252	–	207	142	–

Source: Authors' own work.

The greatest cenotic diversity was found in the Poperechensky and Ostrovtsovsky plots (61 synctaxa), which is associated with inhomogeneous habitat conditions and a greater degree of afforestation. However, typical for these areas are the associations of steppe meadows with the dominance and participation of *Bromopsis inermis*, as well as shrubby meadow steppes and shrub steppe meadows involving *Spiraea crenata, Chamaecytisus ruthenicus, Amygdalus nana, Cerasus fruticosa, Prunus spinosa, Rosa majalis*, etc. This reflects process of silvatization of the vegetation cover of protected areas. At the same time, on the southern steep slopes of the Ostrovtsovskaya forest–steppe section associations of the present steppes with the dominance of *Stipa capillata*, *Helictotrichon desertorum* and xerophyllic herbage are preserved, although they almost completely vanished from the vegetation cover of the Poperechenskaya steppe section.

The vegetation of the Kuncherovsky area is distinguished by a smaller level of variety (26 synctaxa), which is associated with more homogeneous relief and poor sandy soils. In contrast to watershed surfaces, associations of meadow steppes with the dominance of *Helictotrichon desertorum*, *Stipa dasyphylla* and *Carex supina*, are completely absent in other areas. On the slopes of predominantly southern exposure, associations are currently developing with the participation of *Stipa anomala, Koeleria glauca, Festuca polecica* and xerophilic (psammophilic) herbage.

We have revealed a general trend in vegetation change at all three sites toward mesophytization (Table 1). The area occupied by meadow steppes decreased almost twice in the Poperechensky area, from 44.5% to 24.6%, while shrub vegetation was widespread. Steppes are retained only in those areas experiencing intense anthropogenic influence: plowing, steppe fires or grazing.

The most intensive process of sylvatization was manifested in the Ostrovtsovskaya forest-steppe section, where forest and shrubby vegetation occupied first a third and then almost half of the territory. Herbal vegetation has also undergone significant changes: the steppes have reduced in area from 80% to 55% and have survived only along the southern slopes, where intensive grazing conditions predominated prior to the organization of the reserve. The reserve regime contributed to the restoration of the steppes on the slopes, while the watershed vegetation almost completely lost its steppe character.

The process of sylvatization is manifested itself much more slowly in the Kuncherovskaya forest-steppe section. In ten years, the area covered with steppe vegetation has practically not changed (about 84%): however, the cenotic diversity has changed. On watershed surfaces, the turf-grass meadow steppes has been

replaced by rhizome–cereal steppe meadows dominated by *Calamagrostis epigeios*. In contrast, on the steep slopes of the southern exposition, where the grass cover was severely disturbed by grazing before the organization of the reserve, restorative successions occur, accompanied by the formation of real steppes dominated by *Stipa anomala*.

Associations of meadow steppes, formed with moderate anthropogenic impact, are zonal. In this case, the *Stipa tirsa+Heteroherbae* and *Stipa pennata+Heteroherbae* associations develop in a landscape of the secondary morainic plains on the watershed, while the *Stipa tirsa+Heteroherbae* and *Helictotrichon desertorum+Heteroherbae* associations develop in a landscape of erosion-denuded plains.

In the two landscapes, the processes of steppe transformation under the influence of intensive haymaking and grazing are similar: from the rhizome-cereal meadow steppes to the rhizome–cereal stage of demutation. However, the continued use of this regime could lead to the destruction of communities of meadow steppes because of the formation of a weed stage, represented by the herbage of genuine meadows or herbaceous steppe meadows. A very peculiar stage for the landscape erosion–denudation equinox is that of rhizome-sedge meadow steppes [*Carex supina–Heteroherbae*].

In the conditions of absolute reserve, the initial stages of the transformation of vegetation in the two landscapes are also very similar: the mixed meadow steppes are replaced first by rhizome–grassed steppe meadows and then by shrubby meadow steppes and shrub steppe meadows (as represented by various associations). The final stages in this series are the formation of arboreal and shrubby vegetation.

In a landscape of secondary morainic plains, the shrub vegetation type is formed with the participation of *Chamaecytisus ruthenicus*, *Cerasus fruticosa*, *Amygdalus nana*, *Rosa majalis*, *Spiraea crenata*, *Prunus spinosa*, etc., which is replaced by deciduous forests (*Acer tataricum* and *Padus avium*).

In the landscape of erosion–denuded plains, *Pinus sylvestris* is introduced into the shrub meadow steppes, which can form first sparse and then closed coniferous and mixed forests. Trees are periodically uprooted from the steppe, which inhibits these processes.

In the conditions of this landscape, the successions of steppe vegetation play out in a completely different way after intensive anthropogenic influence on the slopes of the southern exposure, where they are represented by the associations of the present steppes [*Koeleria glauca+Heteroherbae*, *Koeleria glauca+Heteroherbae*, *Festuca poleca+Heteroherbae* and *Stipa anomala–Heteroherbae*]. Similar processes have

occurred in the same sequence in the Kucherovskaya forest–steppe along very steep slopes where vegetation can be destroyed under the influence of slope erosion processes.

4. Conclusion

At present, there is a tendency to replace steppes with meadows followed by shrub and tree overgrowth: in other words, a forest–steppe is formed in the absence of any anthropogenic influence. This process manifests itself in different steppe areas differently depending not only on the natural conditions which orographic and edaphic factors determine, but also on the nature of the use of the steppes, the organization of the reserve and the period of time for which the reserve itself has existed.

The study of the dynamics of zonal meadow steppes in the Volga Uplands indicates the inevitability of their transformation in modern climatic conditions into meadow, shrubby and even forest communities. In the territory of the Privolzhskaya forest–steppe nature reserve, it is necessary to introduce a protection regime with elements of anthropogenic influence (haymaking, grazing, etc.) that can compensate for the effects of animals on vegetation. The organization of such events in the reserve will help preserve the floral and cenotic diversity of the meadow steppes of the Volga Uplands.

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