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THE CURRENT STATE AND PROTECTION OF STEPPE LANDSCAPES IN THE VOLGOGRAD REGION OF RUSSIA

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Abstract: The anthropogenic activity creates a significant negative impact on the steppe biome of the Earth. Eurasian steppe is one of the most altered by human economic activity, particularly in Russia. These changes are especially vividly manifested in the Russian Plain, the old-developed territory of Russia. The most substantial damage on steppe landscapes of the Russian Plain was caused by the extensive agricultural use of natural grasslands, especially in the second half of the 20th century. The overwhelming majority of natural steppe landscapes are replaced here by agricultural landscapes which threaten the preservation of the unique soil, biological and landscape diversity of steppes. The main goal of the article is to analyze the current geoecological situation in the steppe zone of the Russian Plain from the regional aspect: by the example of its south-eastern part attributed to the Volgograd region. The described territory is characterized by the extraordinary landscape diversity and located within forest-steppe, steppe and semi-desert natural zones. The article deals with the analysis of the current agricultural structure in the south-east of the Russian Plain within Volgograd Region, of major geoecological consequences of economic activity typical of different types of agricultural lands, and also of pressing problems related to the preservation of the landscape, and of the biodiversity of steppe landscape. The results of this research are necessary to make decisions aimed at optimizing agriculture, at raising the quality of steppe landscape preservation, and at organizing ecologically-conscious recreational activity to preserve the unique variety of steppe landscapes.

Keywords: steppes of the Russian Plain; Volgograd Region of Russia; agricultural landscapes; nature preservation; natural parks

Introduction

Steppes are the biome most changed by economic activity in the world which primarily suffered damages from agriculture (Mordkovich, 2014). Steppe grasslands appear in 35 of the 83 regions or provinces of Russia that extend at least partly south of 55° northern latitude. These 35 provinces cover a massive area of 4,806,295 km^2 but only 2,300,000 km^2 are a part of the steppe geographical zone (including forest-steppe and semi-desert) (Smelansky & Tishkov 2012). In the oldest-developed European part of Russia, agricultural landscapes occupy 80% of the steppe territory. The

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critical situation in the steppe zone of the Russian Plain started to form since the second half of the 19th century and reached its peak by the end of the 20th century.

Historically, all the steppes of Russia were widely used by nomadic cattle breeders for raising sheep, horses, cattle and camels. Agricultural development of steppes of the Russian Plain was promoted by the expansion of the borders of Russia to the south and the east in the 17th century. The agricultural development of steppes began with the north-western part of the zone of Eastern European meadow steppes (now the Central Chernozem zone of Russia and the adjacent part of Ukraine). Since the end of the 18th century, the main areas of grain production from non-Chernozem regions and forest-steppe gradually shifted to the steppe zone. Until the late 19th century, this shift had a southward direction with the access to the Black Sea and Caucasus. During the 18th–19th centuries, rural population increased in the Chernozem zone of the Russian Plain, and so did the arable land area. By the end of the 19th century, almost all the steppes of the Central Chernozem zone, the Volga region, and the Northern Black Sea Region were plowed or turned into pastures. As a result, in the 1880s–1890s an ecological crisis occurred in a large part of the European part of Russia due to the degradation of pastures, destruction of forest cover, increased soil erosion. Since the beginning of the 20th century the agricultural development of the steppes of the Trans-Volga (Zavolzhye) and Trans-Ural regions, Northern Kazakhstan and southern Siberia began due to the resettlement of peasants from the central regions of European Russia and Ukraine where the agricultural overpopulation and the agrarian crisis took place. The consequences of the Revolution of 1917 and the Civil War of 1918–1922 worsened the economic situation of the country. In 1920–1930s, in the Soviet Union, the collective and state farms were organized, and the collectivization and large-scale agriculture mechanization was carried out. In the mid-1930s plowing of the steppe zone of the European part of the USSR reached its peak – the last virgin steppes of Eastern Europe were plowed (Chibilev & Levykin, 1998; Levykin & Kazachkov, 2009).

The Second World War severely undermined the agriculture in the European part of the USSR. In order to restore agriculture, to combat droughts and dry winds, to increase the productivity of agricultural production "The plan for planting field shelter belts, the introduction of field grass rotations, and the construction of ponds and reservoirs for ensuring high and stable harvests in the steppe and forest-steppe regions of the European part of the USSR" was adopted in 1948 (Shaw, 2015). However, after the death of Stalin in 1953, the agricultural policy was completely revised. In 1954–1963 virgin steppes of the Urals, Siberia, and Northern Kazakhstan were plowed ("The Virgin Lands Campaign"). Geoecological crisis involved almost the entire steppe zone of the USSR. The processes of water and wind erosion caused by irrational natural resources management led to the significant degradation of the soil cover (Elie, 2015; Levykin, Semenov, Chibilyov (jr.), & Petrishchev, 2018). Chemization of agriculture, the use of excessive amounts of pesticides adversely affected the fauna of the steppes. In the 1970s and 1980s, the irrigation of arable lands was actively introduced, including semi-desert in the Caspian Lowland, which eventually turned into a secondary saline soils. For example, in 1950 the irrigated land area in Russia was 1.1 million ha, followed by 1.9 million ha in 1970, 5 million ha in 1980, and reached its peak in 1990 with 6.1 million ha. The intensity of agricultural development in the steppe zone reached its maximum in the 1970–1980s. In 1991 the collapse of the USSR occurred, as well as the transition of the Russian economy from planned to market management model. Collective and state farms began to transform into private farms. Due to the economic crisis of 1990–2000s, the cultivation of plant crops decreased, the area of irrigated lands reduced (from 4.6 million ha in 2000 to 4.2 million ha in 2010), livestock population decreased, and there was a mass abandonment of unprofitable arable land. As a result of economic

transformations, the load on steppe landscapes decreased in terms of area scale, and secondary self-renewable steppes (fallow lands) started to form (Reinecke, Smelansky, Troeva, Trofimov, & Trofimova, 2018; Ryabinina, 2014). The dynamics of changes of the cultivated area in Russia is shown in Figure 1.

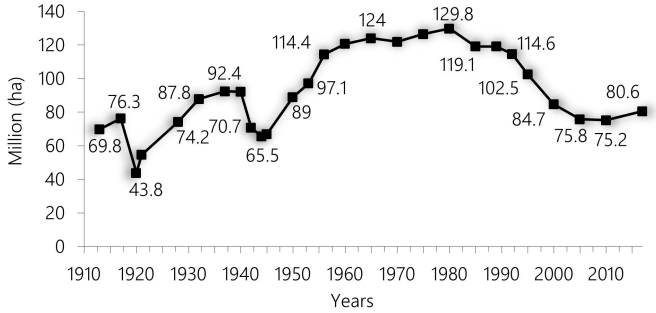

Figure 1. The dynamics of changes in cultivated area in Russia (1913–2017). Data for the period 1913–1921 are from "Selskoe hozyaystvo Rossii v XX veke: Sbornik statistiko-ehkonomicheskih svedeniy za 1901–1922 gg." [Agriculture in Russia: Collection of statistical and economic information for 1901–1922] by N. D. Kondratev, 1923, Moscow, Russia: Novaya derevnya; Data for the period 1928–1940, 1950–1989 are from "Statisticheskie ezhegodniki "Narodnoe hozyaystvo RSFSR" [Statistical yearbooks "National economy of the RSFSR" [by years]]" by CSU RSFSR, Goskomstat RSFSR, 1957–1991 (http://istmat.info/node/21356); Data for the period 1942–1945 are from Narodroe hozyastvo SSSR v Velikoi Otechestvennoi voine 1941–1945. Statistichesky sbornik [National economy of the USSR in the Great Patriotic War 1941–1945. Statistical book] by Goskomstat USSR, 1990, Moscow, Russia: Goskomstat USSR; Data for the period 1992–2017 are from Rossiya v cifrah. [Russia in figures] by Rosstat, 2002–2018b (http://old.gks.ru/wps/wcm/connect/rosstat_main/rosstat/ru/statistics/publications/catalog/doc_1135075100641).

The ability of steppe landscapes to renew is weakened (Smelansky & Tishkov, 2012), which is manifested by reduced biological diversity (Dajić-Stevanović, Lazarević, Petrović, Aćić, & Tomović, 2010), by reduced carbon deposit (Kurganova, de Gerenyu, & Kuzyakov, 2015) and by the necessity to take special measures concerning the protection of the steppe biome (Hölzel, Haub, Ingelfinger, Otte, & Pilipenko, 2002). Recently, numerous steppe-related geoecological problems (Werger & van Staalduinen, 2012) have included climate changes (Ćirić et al., 2017). For the first time, problems of steppe nature use of Russia were indicated by V. V. Dokuchaev in 1892 in the work "Our steppes before and now" (Dokuchaev, 1953). It was the answer of the scientist on drought and crop failure in 1891. Having had extensive data on natural-historical conditions of Chernozem zone, Dokuchaev developed a unique project of transformation of the nature of the steppes according to the changes that were caused by the influence of human activities. This project contained a detailed analysis of geological, geomorphological and hydrological features of the steppe zone, a comprehensive description of the soil cover, flora and fauna. The same author considered that the main reasons of drought in steppes were excessive plowing, inept cultivation of chernozem soils, and, as a result, the change of the water regime of landscapes. Dokuchaev's associate A. A. Izmailsky came to the same conclusions. In his work "How our steppe dried", published after Dokuchaev in 1893, he considered that the main reasons of drought in steppes were human agricultural activities, including steppe fires and excessive grazing, as well as the changes in the water regime of the steppes (Izmailsky, 1937). The famous Russian climatologist A. I. Voeykov joined the views of V. V. Dokuchaev and A. A. Izmailsky on

the features of the human impact on the steppes. He noted that the soils of the south steppe of Russia are more affected by dust storms, similar in character to the Central Asian ones, where this event is typical (Voeykov, 1963). The process of desertification of the steppes under the influence of cattle grazing is described in the works of Vysotsky (1915), Lavrenko (1940), Komarov (1951), Ivanov (1958), and others. Most researchers agree that grazing of sheep and goats has an especially important role in the desertification of the steppes. This process was studied in detail by G. N. Vysotsky, who identified 4 stages of grazing degradation of vegetation. Researches of 1950–1960s clearly showed that the main conclusions of Dokuchaev and Izmailsky on drying steppes are true. A. S. Gorshkova and A. M. Semenova-Tyan-Shanskaya established that, under the influence of grazing, plants of south steppe and semi-desert continue to move north. Their researches also showed that soil moisture reserves depend on the degree of pasture vegetation oppression and the preservation of sod cereals (Chibilev, 1990).

During the second half of the 20th century, the development of the steppes was carried out exclusively from consumer positions. As a result of the geoecological crisis in the steppe zone, since the end of the 20th century in Russia there have been new researches and promising projects on the problems and the optimization of the nature use of steppe. In this regard, it is especially necessary to note the researches of A. A. Chibilev and scientists of the Institute of steppe of the Ural branch of the RAS, which is currently the leading scientific center for the study of the steppes of Russia.

According to the statistics, there is a tendency of increasing agricultural production in Russia in the recent years. It poses a threat to the preservation of steppe landscapes and thus leads to quantitative and qualitative transformation of flora and fauna and to the degradation of the soil cover. The cultivated area in 2017 compared to 2005 increased by 4.8 million ha and amounted to 80.6 million ha. During the same period, the number of sheep and goats that cause the greatest damage to steppe landscapes in pastures increased by 5.9 million heads and amounted to 24.5 million heads. In addition, a tendency of growth of irrigated land area began to be noticeable (approximately 9% from 2010 to 2016) (The Federal State Statistics Service of Russian Federation [Rosstat], 2002–2018a). That is why the preservation of steppe landscapes is one of the most important modern issues. The common problems with steppe preservation can be studied by the example of the Volgograd Region in Russia.

Study area and methodology

The Volgograd region occupies the middle part of the south-east of the Eastern European (Russian) Plain with a well-marked latitudinal geographical zoning (Figure 2). The total area of the region is 112,900 km^2. On its territory there are 1,509 settlements that are part of 38 municipalities: 6 city districts (Volgograd, Volzhsky, Kamyshin, Mikhailovka, Uryupinsk, Frolovo) and 32 municipal districts. The population of the region in 2017 was 2.521 million people, comprising urban population (77%) and rural population (23%), with the population density of 22.3 inhabitants per km^2 (Rosstat, 2018b). The population of the region increased until 1995 – from 1.444 million people in 1951, followed by 2.343 million people in 1971, 2.632 million in 1991, to 2.702 million people in 1995. Since 1995 the population started to decrease: 2.6582 million people in 2000, and 2.6075 million people in 2010. The percentage of the rural population in the period from 1951 steadily decreased and amounted to 56.5% in 1951, 33.7% in 1971, and 24% in 1991. In the 1990s the percentage of rural population increased to 26%. However, since 2000, this value has been gradually reduced. This trend is connected with the migration of the population from rural to urban areas (Goskomstat USSR, 1988, The Federal State Statistics Service of Russian Federation [Rosstat], 2002–2018b, Statistical committee CIS, 1991).

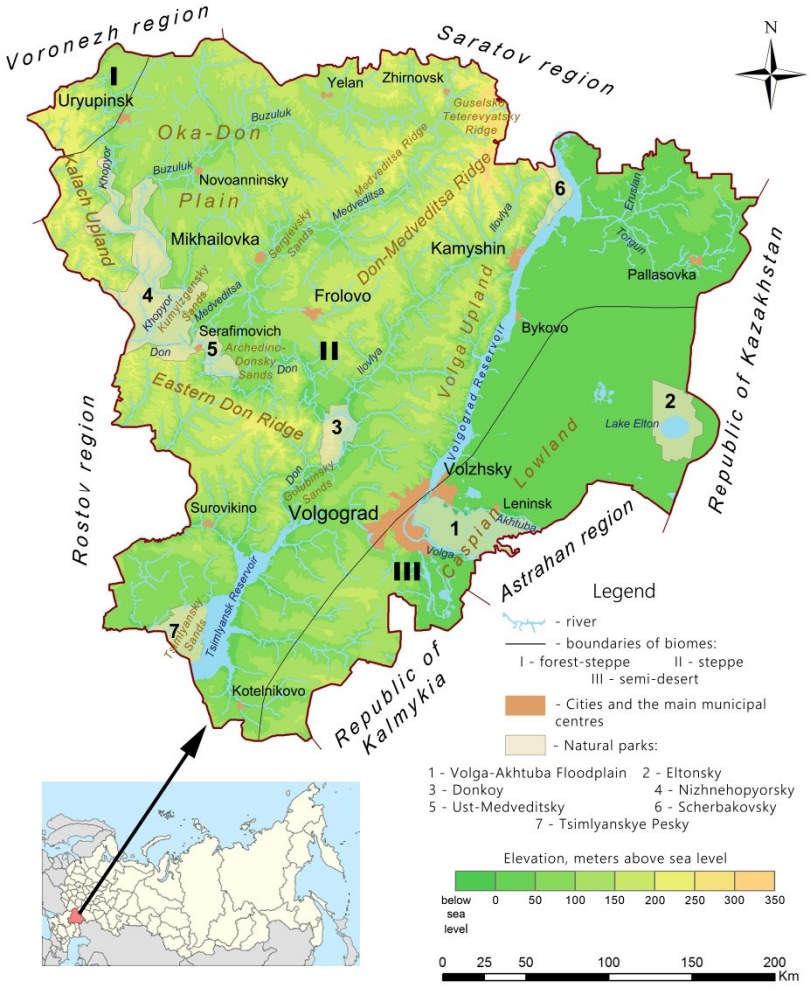

Figure 2. Physical map of the Volgograd region.

The Volga River divides the region into two parts, different in relief: the western elevated part and the eastern lowland—the Zavolzhye. The western part of the region is geomorphologically heterogeneous, dissected by river valleys and gullies. It is characterized by large orographic elements with heights of 240 m or more (Kalach, Volga uplands, Medveditsa, Eastern Don, and Don-Medveditsa ridges) and flat spaces with surface marks from 0 to 170 m. Most of the territory of the Zavolzhye is flat, slightly sloping Caspian Lowland with surface heights from 10 to 35 m, a characteristic feature of which is the development of the processes of salt dome tectonics, which is associated with the formation of elevated relief elements—salt domes and depression with salt lakes (for example, lake Elton).

The climate continentality of the Volgograd region increases from north-west to south-east: the average annual air temperature rises from 5.2 to 8 °C, the amount of precipitation decreases from 400–500 to 270–300 mm per year. The region is characterized by moderately cold winters with small amount of snow, and hot dry summers. During July (the warmest month), the average monthly air temperature ranges from 21.5 °C (Uryupinsk) to 24.5 °C (Elton). The average air temperature in January (the coldest month) varies from –8.5 °C (Kotelnikovo) to –12 °C (Pallasovka). The absolute maximum of air temperature is usually observed in July–August and can reach +45 °C (Elton), the absolute minimum—in January–February can fall to –40 °C (Rudnya). The climate also affects agriculture. As we move from the north-west to the south-east, the share of grain and industrial crops decreases, and the crop area of vegetable and melon increases. The share of pasture livestock grows (Brylev, 2011).

The Volgograd region is characterized by a variety of water bodies belonging to two river basins—the Volga River Basin and the Don River Basin, and to two endorheic basins—the Peri-Caspian Basin and the Sarpa Basin. In the region, there are 200 rivers with a total length of more than 8,000 km, including 9 rivers stretching >200 km each, more than 130 lakes, most of which are confined to floodplains. The salt lake Elton is the most famous and the largest lake in the Volgograd region (Brylev, 2011).

Within the European part of Russia one cannot find another large region where there is a unique combination of natural conditions and remarkable variety of landscapes belonging to three natural zones – forest-steppe, steppe and semi-desert ones (Table 1). The formation and change of soil and vegetation cover in the Volgograd region are closely connected with climate and geomorphological peculiarities and they take place endwise – from north-west to south-east due to the increasing aridity of climate: ranging from southern forest-steppe to southern semi-desert (Rulev, 2011; Ryabinina, 2015).

Table 1
Spatial distribution of soil and vegetation types in the Volgograd region

Geographical zone	Type of vegetation	Type of soil
Forest-steppe	Temperate deciduous forest	Alfisols; Leached chernozems
	Meadow grass-forbs steppes	Leached chernozems; Typical chernozems
Steppe	Rich-forbs-fescue-feathergrass steppes	Typical chernozems
	Forbs-fescue-feathergrass steppes	Southern chernozems
	Fescue-feathergrass poor-forbs steppes	Dark kastanozems; Kastanozems
Semi-desert	Sagebrush-fescue-feathergrass steppes	Light kastanozems with solonetzs
	Sagebrush-fescue and fescue-feathergrass-sagebrush halophytic steppes	Solonetzs and solonchaks with light kastanozems

Note. Adapted from *"Priroda i landshafty Volgogradskoj oblasti"* [Nature and landscapes of Volgograd region] (p. 206) by N. O. Ryabinina, 2015, Volgograd, Russia: Volgograd State University.

The research of the current state and protection of steppe landscapes of the Volgograd region is based on the analysis of science literature on the subject of research, statistical data and official reports of government for certain periods of time, and the authors' own research.

Results

The landscapes of the Volgograd region are transformed as the result of economic activity by 70–75%. Many steppe landscapes remain in their original condition mainly in the areas unsuitable or

unprofitable for development (for example, the areas with rugged terrain, rocky, sandy, saline soils or the areas remote from settlements with virtually undeveloped transport infrastructure) (Ryabinina, 2015). Steppe landscapes are also transformed and degraded by agricultural activity. For example, in 2017 the portion of agricultural lands on the region territory accounted for 77%, from which 66.82% falls on arable lands, 30.28% on pastures, 2.36% on hayfields, 0.49% on permanent crops, and 0.05% on set–aside lands (The Federal Service for State registration, cadastre and cartography of Russian Federation [Rosreestr], 2018).

The modern structure of regional anthropogenic landscapes formed in the 1950–1960s, after putting into economic rotation about 1.6 million ha of virgin lands, chiefly carbonate, solonetzic, brackish, non-fully profiled, sandy-loam, stony and others soils. Also this period witnessed the confiscation of agricultural areas for constructing industrial and hydrotechnical buildings and for the expansion of settlements. Agriculture can be marked as the main contributing factor of degrading zonal steppe landscapes (Brylev, 2011).

The proportion of cultivated area in Volgograd region reached its maximum by the middle of the 1970s and comprised about 50% of territory. It is significantly above optimal value if we consider the high degree of terrain ruggedness in the south of the Volga Upland and Middle Russian Upland. Then the cultivated area began to decline (Figure 3).

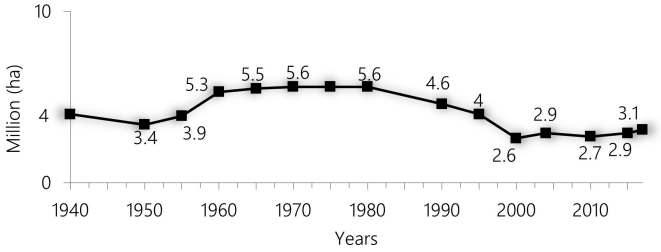

Figure 3. The dynamic of changes in cultivated area in the Volgograd region (1940–2017). No data for the period 1940–1950; Data for the period 1940, 1950–1990 are from "Statisticheskie ezhegodniki "Narodnoe hozyaystvo RSFSR" [Statistical yearbooks "National economy of the RSFSR" [by years]]" by CSU RSFSR, Goskomstat RSFSR, 1957–1991 (http://istmat.info/node/21356); Data for the period 1995–2017 are from "Regiony Rossii. Socialno-ekonomicheskie pokazateli [Regions of the Russia. Socio-economic indicators]" by Rosstat, 2002–2018a (http://old.gks.ru/wps/wcm/connect/rosstat_main/rosstat/ru/statistics/publications/catalog/doc_1138623506156).

The maximum of cultivated area was specific for the Oka-Don Plain where the value reached 80–85% of the territory. Oka-Don Plain is characterized by flat terrain and the most fertile types of soil: typical chernozems and southern chernozems. Landscapes of the Guselsko-Teterevyatsky Ridge and the Eastern Don Ridge suffered least from the economic activity, where, due to ruggedness of the terrain, dense erosion network, complicated composition of soil-forming rocks and generally worse land quality, the crop area accounted for less than 40%. Not only plakors (flat planation surfaces), but gently upland slopes were also almost totally converted into arable land in 1960–1980s. For crops growing, river terraces and floodplains in the valleys of Don and its tributaries were also used. Edge parts of lands of Archedino-Donsky, Kumylzgensky and Sergievsky on-river terrace sandy tracts were tilled. The areas of abandoned fields on these sandy lands were subjected to wind erosion. Nowadays highly eroded and low productive lands are being excluded from crop rotation (Ryabinina, 2015).

Pastures are allocated primarily to the south-east of the region within the Caspian Lowland, where the main areas of cattle breeding are concentrated. In spite of the significant decrease of grazing load due to dramatic reduction of the number of sheep and cattle in the 1990s (Figure 4), zonal steppe and semi-desert landscapes are recovering very slowly. The pathways of cattle-driving on the territory of the Caspian Lowland can be clearly followed on satellite snapshots even now. In the western part of Volgograd region, pastures occupy small areas on steep and slanting streamside slopes, in river valleys and gullies. All the pastures of the Volgograd region have undergone massive changes due to overgrazing. The natural plant cover has thinned out and lacks zonal differences, valuable fodder grass and legumes disappear and they are replaced by sagebrush (*Artemisia)*, weeds and annual plants ignored by cattle. Pasture rotation and haymaking rotation are neglected. The tendency of increasing the number of sheep and goats in the region begin to threaten the condition of the steppe landscapes again. Hayfields are mainly allocated to floodplains and seldom to river terraces, gullies and uplands. The settlements hayfields close to settlements are also often used as pastures, which leads to quick degradation of landscapes.

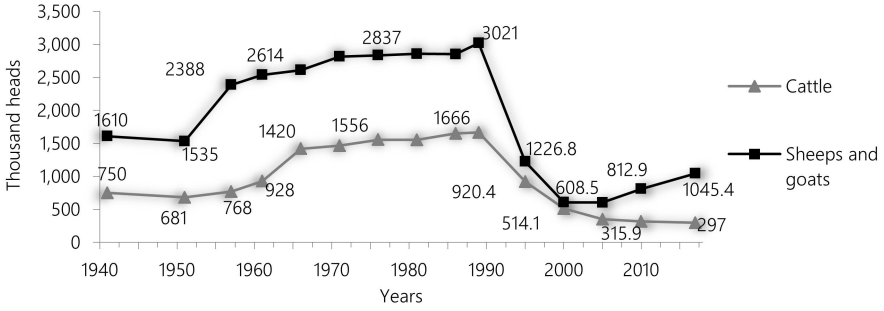

Figure 4. The dynamic of changes of number of livestock (cattle, sheep and goats) in the Volgograd region (1941-2017). No data for the period 1942–1950; Data for the period 1941, 1951–1989 are from "Statisticheskie ezhegodniki "Narodnoe hozyaystvo RSFSR" [Statistical yearbooks "National economy of the RSFSR" [by years]] by CSU RSFSR, Goskomstat RSFSR, 1957–1991 (http://istmat.info/node/21356); Data for the period 1995–2017 are from "Regiony Rossii. Socialno-ekonomicheskie pokazateli [Regions of the Russia. Socio-economic indicators]" by Rosstat, 2002–2018a, (http://old.gks.ru/wps/wcm/connect/rosstat_main/rosstat/ru/statistics/publications/catalog/doc_1138623506156).

Irreparable damage on zonal steppe and semi-desert landscapes became a result of large-scale construction and operation of irrigation systems in the 1970–1980s. as a base for the development of irrigation farming. In 1917 the area of regular irrigation in the Volgograd region was only 8,700 ha, in 1960 it was 26,300 ha, and in 1980 the irrigated lands occupied 169,800 ha. The peak irrigation development was reached in 1989, when 345,200 ha of arable lands were irrigated (4.6% of the total agricultural land). In the 1990s, due to the economic situation in Russia, the irrigated land area in the region fell. The area of this lands was 259,400 ha in 2001 (3.2% of the agricultural land area), and in 2016 it was 178,800 ha, or 2% of the agricultural land area. The irrigated lands are located mainly in the dry steppe zone of dark kastanozems and kastanozems soils and in the semi-desert zone of light kastanozems soils within the Caspian Lowland. The landscapes of the Caspian Lowland are most affected, where natural drainage is negligible, and the naturally saline soils (which represent 90% of the irrigation area) were involved in irrigation. Closing the surface bedding of mineralized ground waters and excessive moistening during watering resulted in the formation of secondary saline lands

on irrigated fields and the neighboring areas. Currently, 13% of the regional territory (1,436,400 ha) is subjected to soil salinization, while the land improvement and the restoration of the damaged landscapes are not carried out (Pankova & Novikova 2004; Rosreestr, 2016).

The landscapes of Volgograd region are also subjected to water and wind erosion. About 20% of the territory (2,220,500 ha) is under the influence of water erosion. Linear erosion is more characteristic of more rugged western part of Volgograd region. Due to irrational land use, low farming culture and the deforestation of ravines and floodplains, water erosion processes intensify, soil washout increases several times as much. Water erosion is prominently developing on the elevated right banks of the Volga River, the Don River, the Khoper River, the Medveditsa River and other rivers. For the last 25–30 years, the level of ruggedness of the territory on the Volga Upland by gully network rose from 4.4 to 7.8 km^2, the presence of gullies rose from 7 to 12.4 ha per km^2, and gully density from 34 to 60 pieces per km^2, resulting that the total value of the all parameters increased 1.8 times (Rosreestr, 2016).

The landscapes of Volgograd region are less subjected to deflation in comparison with water erosion. About 0.8% of the territory (87,330 ha) is under the influence of deflation. "The ploughed soil of the steppe zone used in agriculture annually loses tens of tons of fine earth from each hectare. This reduces the natural fertility of lands and quickens the general degradation of steppe landscapes" (Kulik, Rulev, & Sazhin, 2018, p. 607). During the active periods of dust storms, from April till June, the total number of winds which are higher than the critical value (from 8–9 m/s and stronger) ranges from 30–40 cases in northern and central regions to 100–107 cases on open elevated plateaus of the Privolzhskaya Uplands and Zavolzh'ye. In Zavolzh'ye, the area of Lake Elton has 18 days in a year with dust storms, whereas the south Kotelnikovsky area has 16 such days. The distinctive local conditions (light soil textures, overgrazed pastures, on-terrace lands of Archedino-Donsky, Tsymlyansky, Golubinsky and other sand lands, primary and secondary saline lands of Caspian Lowland) contribute to the formation of focal spots of increased dust storm intensity. In this area there are about 10–16 days in a year with dust storms, while the adjacent areas have fewer such days (Rosreestr, 2016).

The Volgograd region has the maximum share of transformed (37–39%) and destroyed (39–41%) native landscapes due to human activity in Russia, which affects the biodiversity of the region. The flora and other organisms of the Volgograd region include more than 2,970 species of vascular plants, at least 438 species of fungi, about 170 species of myxomycetes, 150 species of mosses, about 250 species of lichens, and about 300 species of algae. The list of rare and endangered species of flora and other organisms of Volgograd region recorded in the Red data book of Russia includes 53 species of plants, comprising 46 species of angiosperms, 2 species of ferns, 2 species of lichens, and 2 species of fungi. The Red data book of the Volgograd region includes 193 species of flora and other organisms, i.e. 20 species of bryophytes, 3 species of sphenopsida, 6 species of pteridophytes, 138 species of angiosperms, 23 species of lichens, 2 species of fungi, and 1 species of myxomycetes (Baranova & Sagalaev, 2017).

Intensive agricultural activity in the region caused not only the transformations of native steppe landscapes with typical types of vegetation into the agricultural landscapes, but also led to the disappearance and displacement of many species of the steppe fauna. The fauna of the Volgograd region includes at least 18,000 invertebrates and 480 vertebrates species: about 2,000 species of worms, about 100 species of molluscs, about 18,000 species of arthropods (more than half of them are insects), 73 species of fish and agnathans (lampreys), about 25 species of amphibians and reptiles, at least 300 species of birds, and about 80 species of mammals. The species adapted to agricultural landscapes are dominant in the fauna of steppes. The number of species that prefer to live in the native steppes has decreased dramatically. The list of rare and endangered species of the

animals of the Volgograd region, listed in the Red data book of Russia, include 2 species of mammals, 42 species of birds, 1 species of reptiles, and 14 species of invertebrates. The Red data book of the Volgograd region includes 132 species of animals – 55 species of invertebrates and 77 species of vertebrates (7 reptile species, 55 bird species, 5 mammal species) (Belik, 2017).

Discussion

Currently, extensive agriculture is still prevailing in the Volgograd region. The degradation of steppe landscapes is aggravated by the fact that in the Russian federal and regional legislation, steppes are not determined as a distinctive category of land management. Within the legal framework, steppes belong to agricultural land, their protection and use are regulated by the Land Code of the Russian Federation and regulatory acts of land laws, such as "On land management", "On turnover of agricultural lands" and others. Regrettably, these acts are of generalized character and do not take into consideration the peculiarities of steppe landscapes, and thus, such acts cannot provide adequate legal support to rational use and protection of steppes. Steppes are not officially recognized as a conservation priority. Steppe conservation on the one hand and steppe use and management on the other, are strongly separated from each other in Russia—both are regulated by different sectoral legislation and managed by different governmental institutions (Reinecke et al., 2018).

To solve the geoecological problems of the steppe zone, it is necessary to improve the legislation, which should be based on the provisions on the importance of steppe landscapes not only as the basis of agricultural production, but also as a component of the environment.

The practical solution of the problems of steppe grassland use can be based on the directions of landscape-ecological optimization. Landscape-ecological optimization is the set of measures which are directed to maintaining ecological balance in the separate regions through the achievement of rational ratio between transformed area and natural area. For the Volgograd region, the following directions of landscape-ecological optimization can be used:

- Optimization of structure of regional agricultural landscapes to prevent their further degradation. It includes the formation and maintenance of the ratio of different types of land and their size, which provides the necessary diversity and stability of the landscape. For example, there is a need to reduce the share of unproductive arable area and increase the area of pastures and hayfields in the structure of agricultural landscapes.
- Optimization of farming based on the use of soil and moisture-saving technologies, effective use of climatic factors, water and fertilizers, aimed at regulating the balance of organic substances through crop rotation, soil mulching, etc.
- Rationalization of grazing load and the prevention of pasture degradation through pasture rotation, compliance of periods and norms for grazing, restoration of pasture vegetation.
- Restoration and preservation of biodiversity of steppes.
- Reforestation and ecological optimization of man-made protective afforestation. This group of activities includes the restoration of natural forests, the creation of a unified system of protective forested buffer strips on plough lands, corresponding to zonal types of landscapes and formed only from local species of trees and shrubs, afforestation of areas with sandy soil (Chibilev, 1992; Chibilev et al., 2012).
- Restoration and maintenance of natural water balance in the regions, the solutions for geoecological problems with small and middle-long rivers within the steppe zone, optimization of water use. This group of measures involves the use of technologies that reduce surface

runoff, a prohibition of plowing slopes with a steepness of more than 5°, afforestation of the banks of small rivers, compliance with the optimal parameters of streamflow regulation, the elimination of temporary earthen dams, rational water withdrawal from small rivers, which does not allow the process of silting and shallowing of riverbeds.

- Preservation of landscape variety and nature heritage, construction of an integrated ecological network of the territory based on the protected areas to provide the maintenance of ecological balance in the Volgograd region (Chibilev, 1992; Ryabinina, 2014).

The mentioned optimization ideas for utilizing steppe landscapes can only be put into practice when the country government, business entities (in particular farmers) and population are comprehensively aware of the existing geoecological problems and intend to solve them. But the imperfect legislation, the low environmental responsibility of the state, businesses and people and their low interest in solving the problem of steppe use and conservation, impede the solutions.

In conditions of high anthropogenic transformation of steppe landscapes, it is advisable to take measures aimed at both preserving the natural and restoring the damaged steppe landscapes within the protected areas (PAs). However, at present, steppe areas in PAs are so small in the Russia that they account for only several thousand hectares, have an "island-like" feature and fragmentarily represent natural diversity. Moreover, these areas experience a strong boundary effect, which is expressed in a significant impact on them of the surrounding disturbed (transformed) areas. It is necessary to note that in Russia, a small number of PAs are specialized in protecting only steppe landscapes. Most of the existing PAs which encompass plots of steppes are aimed at preserving other types of landscapes (forests, wetlands and so on). Depending on the level of the management, PAs in Russia are divided into federal, regional and local. The most comprehensive protection of landscapes in most cases can be provided only on the protected areas of federal importance due to their relatively sufficient funding, best management infrastructure, features of their legal status. The steppe area under strict protection does not exceed 2% of the biome area of Russia (Reinecke et al., 2018).

In the Volgograd region, protection of steppe landscapes is chiefly provided by the natural parks (IUCN category V) which are in essence a unique form of PAs of regional level of management. On their territories, economic and nature conservation activities can be combined. Nowadays there are 7 natural parks in Volgograd region with an area from 34,500 (Scherbakovsky) to 231,200 ha (Nizhnehopersky). The total area of natural parks is 6% of the region. Among them, in 5 natural parks (Donskoy, Eltonsky, Nizhnehopersky, Scherbakovsky and Tsimlyanskie peski) steppe landscapes occupy more than 25% of the territory, and in natural parks Ust-Medveditsky and Volga-Akhtuba floodplain the share is less than 10% (Committee of natural resources, forestry and ecology of the Volgograd region, 2018; Smelansky & Tishkov, 2012).

There are numerous features in the functioning of natural parks. Nature conservation, recreational, agroeconomic and other functional zones can be distinguished, including the zones of protected historic-cultural complexes and objects. Within natural parks, different types of economic activity might be forbidden or limited (such as mining, building, agriculture, logging and others) as such activities result in reducing ecological, esthetic, cultural and recreational value of a territory. The important aspect of the functioning of natural parks is to maintain the balance between social-economic interests of the local residents and recreational and nature-conservation activity provided by parks' administration (Kirillov & Kholodenko, 2011).

Natural parks in the Volgograd region are affected by anthropogenic impacts from both inside and outside their boundaries. The reason for the external influence is the absence of buffer zones

between natural parks and the adjacent territories where authentic natural complexes are replaced by anthropogenically transformed ones or sometimes by degraded ones. The reason for internal impact is their functioning within the status which allows certain parts of parks to be included into active economic use. These features are typical for all natural parks in Russia (Ob osobo ohranyaemyh prirodnyh territoriyah, 1995).

Among the major problems related to the economic activity on the territories of natural parks of the Volgograd region, the following should be mentioned:

- Steppe fires caused by anthropogenic factors, and prescribed fires. Fire impact to steppe is assessed ambiguously (Dusaeva, Kalmykova, & Dusaeva, 2019). According to research in "Donskoi" and "Eltonsky" natural parks of the Volgograd region after fires, biological productivity of landscapes is significantly reduced (1.5–3 times for dry steppes, 3–4 times for semi-desert areas), the height of the grass stand and projective cover are reduced, the structure simplifies, and the homogeneity of the vegetation cover increases. The upper layer (2–4 cm) of the humus horizon burns out, and, as a result, the amount of humus in upper layer of soil is reduced by 20–25% (Ryabinina, Kanischev, & Shinkarenko, 2018).
- Spontaneous livestock farming, absence of pasture rotation and haymaking rotation, uncontrolled (un-shepherded) grazing by cattle, horses and sheep, which, in total, exceed the carrying capacity of landscapes.
- Re-cultivating abandoned croplands after 10–30 years of grassland restoration, ploughing up of saline, stony and underdeveloped soils.
- Littering up of park territories with household waste and building refuse and turning them into junkyards which results in the degradation of phytocenosis and pollution of soil cover and ground waters (Kirillov & Kholodenko, 2011; Ryabinina et al., 2018).

Apart from other economic activities on the territories of natural parks, recreational activities have negative impact on steppe landscapes. Recreational activities in natural parks are presented in organized and non-organized forms, while the latter prevails.

The organized form of recreational activity on a park territory takes the shape of ecological tourism oriented at introducing visitors to peculiar landscapes and unique places of tourist interest based on the developed routes and paths. The route system based on the network of predominately dirt roads and paths that had long existed and are used by local residents. Eco-tourist routes include coach, car and bike tours, horse rides and walking tours, lasting from several hours to several days and offering stops at observation points or green stops near unique natural and cultural objects. The number of visitors in tourist groups is limited and set individually for each route (Committee of natural resources, forestry and ecology of the Volgograd region, 2018). Though, it should be noted that green stops, parking places and observation points are mostly poorly equipped, and obviously not sufficient to preserve the landscapes around these objects.

The non-organized form of recreation is spontaneous and does the most considerable harm to steppe landscapes. Besides, unauthorized usage of the park infrastructure by visitors inflicts economic damage on natural parks. The main reason of the non-organized recreation is connected with the free-visiting of the park territories. Visitors often violate the rules of visit and movement around the territory of the natural parks.

Among major consequences of recreation which lead to degradation of natural steppe landscapes, the following can be named:

- Soil compaction, disturbed structure of plant communities and the decrease of biological diversity along roads and paths;

- Reduction of species diversity due to the uncontrolled removal of flowering wild growing herbs and the uneasiness of wild animals (Kirillov, et al. 2014).

In addition, it is necessary to note the following consequences:

- Trampling down and degradation of plant cover outside roads and paths and at poorly equipped green stops and observation points;
- Steppe fires which are caused by casual handling of fire;
- Littering up of territories along roads and paths, at parking places, formation of bonfire sites.

The efficient management of natural parks is closely connected with the quality of protection of the surviving natural steppe landscapes, with detecting and precluding the violation of the set preservation regime and with precluding the violation of land use of the territory. At present, insufficient financial support provided for natural parks in the Volgograd region (which is typical for other natural parks of Russia as well), improper ecological conduct of visitors and local residents are key factors for causing and aggravating negative consequences of anthropogenic activity for steppe landscapes. The number of detected violations of the natural parks preservation regime in 2014 amounted to 720 cases, followed by 934 in 2015, 570 in 2016, and 560 in 2017 (Committee of natural resources, forestry and ecology of the Volgograd region, 2015, 2016, 2017, 2018). The decrease in the amount of registered violations clearly does not show an increase in the environmental responsibility of the population and economic entities and this may be associated with the changes in the sphere of state environmental supervision which have occurred in recent years.

The increase in funding will allow extending the array of actions aimed at detecting and precluding violations, at raising efficiency of protective measures for unique natural objects and landscapes, at updating the park structure to promote eco-tourism, at resuming full-fledged landscape-ecological monitoring and at providing ecological education for local residents. Programs about ecological education for local population organized by park management will help prevent and reduce the number of violations of the preservation regime and the territory usage within PAs. Putting the above-mentioned measures into practice presents a demanding task conditioned by a specific mindset of local people, their social-economic welfare and interests.

Conclusion

Steppe landscapes as the solid basis for agricultural production play an important role for economic activities. This fact conditions the appearance and further increase of geoecological problems. Steppe is one of the first landscape types in Russia which is endangered to face the total loss of its initial character. The replacement of natural steppe landscapes by agricultural landscapes is particularly specific for the Russian Plain.

The imperfect Russian legislation and misunderstandings of issues related to steppe preservation and rationalization of steppe management from the state, businesses and population prevent making arrangements aimed at the protection and restoration of these landscapes. The efficiency of steppe protection within PAs remains low due to small areas of protected landscapes, due to their "island-like" character of location, and due to boundary effects they experience. Taking the existing steppe landscapes under full control is difficult. Steppes are not the main type of protected landscapes in most of the PAs.

The Volgograd region, which is situated in the south-eastern part of the Russian Plain and includes a vast range of steppe landscapes on its territory, is one of the regions where agricultural activity has had a destructive influence on the condition of steppe landscapes. In spite of the reduction of agricultural production during the 1990s, the condition of steppe landscapes is worsening, and the restoration of

disturbed landscapes is practically not carried out. Ongoing processes of reducing soil fertility, decreasing biological diversity and erosion are preconditioned by the irrational agricultural activity.

The protection and restoration of steppe landscapes in the Volgograd region are possible mainly on the territories of natural parks. But the functioning regime of this type of PAs does not imply complete protection of these landscapes and prohibits economic activities on such territories. Thereby, there are certain problems related to constant search for the balance between economic interests of population that live on the park's territory and recreational and nature conservation activities provided by park administration.

According to the authors, only on the condition that the state, business entities and population fully understand the necessity of the preservation and rational use of steppe landscapes, the change of legislation and principles of the work of state structures, the condition of these landscapes can be improved and they can normally function in the future. This statement is the subject for future research.

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