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Article

On the distribution and economic use of natural and anthropogenically transformed peatlands in the mountain-forest zone of the Republic of Bashkortostan and in the Bashkir Trans-Urals

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Abstract. An inventory and a GIS-map of natural and anthropogenically transformed peatlands of the mountain-forest zone of the Republic of Bashkortostan and the Bashkir Trans-Urals, represented by forest-steppe and steppe regions, are created in this study on the basis of expeditionary research data and Earth remote sensing methods. A total of 360 peatlands, encompassing more than 45.6 thousand ha, are detected. It is found that more than one third of the peatlands under study were subject to drainage and peat extraction, and the degree of their disturbance in the Bashkir Trans-Urals (about 60% of the area) is much higher than in the mountain-forest zone of the Republic of Bashkortostan (25%). Among the peatlands preserved in their natural state, more than 70% of the areas are not used for agriculture. Drained but undeveloped peatlands are the most in demand among anthropogenically transformed peat mires. Peatlands from which peat was extracted are of lower economic value, with more than 40% of their area not used for agriculture.

Keywords: mires, the Southern Urals region, GIS-map, drained peatlands

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Научная статья

О распространении и хозяйственном использовании естественных и антропогенно трансформированных торфяников в горно-лесной зоне Республики Башкортостан и Башкирском Зауралье

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Аннотация. На основе данных экспедиционных исследований и методов ДЗЗ созданы перечень и ГИС-карта естественных и антропогенно измененных торфяников горно-лесной зоны Республики Башкортостан и Башкирского Зауралья, представленного лесостепными и степными районами. Выявлено 360 торфяников общей площадью более 45.6 тыс. га. Установлено, что осушению и добыче торфа было подвержено более трети площадей обследованных торфяников, причем степень их нарушенности в Башкирском Зауралье (около 60% площади) значительно выше, чем в горно-лесной зоне РБ (25%). Среди торфяников, сохранившихся в естественном состоянии, не используются для сельского хозяйства более 70% площадей. Среди антропогенно трансформированных торфяников наиболее востребованы земли осушенных, но не разработанных торфяников. Меньшую хозяйственную ценность представляют торфяники, на которых производилась добыча торфа, более 40% их площадей не востребованы в сельском хозяйстве.

Ключевые слова: болота, Южно-Уральский регион, ГИС-карта, осушенные торфяники

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Introduction

Mires are important elements of the vegetation cover that contribute significantly to the regulation of the water regime of specific territories, peat formation, carbon storage, maintenance of the atmosphere gas composition, formation of the global climate and conservation of biodiversity. In the 21st century, significant areas of mires worldwide have been drained for agricultural, forestry, and peat extraction purposes (Joosten et al., 2016; Minaeva and Sirin, 2012; Sirin, 2022).

Given the differences in the use of the terms "mire" and "peatland" in the scientific literature, it is necessary to clarify which definitions are used in this paper. According to GOST 19179-73[1], a mire is "a natural formation occupying a part of the earth's surface and representing peat deposits saturated with water and covered with specific vegetation". We categorize all ecosystems with peat deposits as "peatlands". Undisturbed or slightly disturbed peatlands covered with vegetation typical of mires are referred to as "mire", "peat mire", or "natural peatlands". Peatlands whose hydrological regime and vegetation cover was significantly altered as a result of drainage and/or development (peat extraction) or other factors are referred to as “anthropogenically altered (or transformed) peatlands”, “drained peatlands”, and “developed peatlands”.

Research on the ecological consequences of peatland drainage and development is currently a high priority, but such studies are still scarce in Russia and focus on a small number of regions. On drained peatlands, changes in the hydrological regime and landscape mesorelief, increased wind and water erosion of soils, degradation of soil cover, release of greenhouse gases into the atmosphere, transformation of peatland vegetation, increased fire hazard, etc. are observed (Ilyasov et al., 2017; Minaeva and Sirin, 2012; Sirin, 2022; Sirin et al., 2020; Suvorov et al., 2015).

The Republic of Bashkortostan (RB) is not among the regions with a high degree of paludification. However, in the northwestern part of the Republic (in the interfluve of the Kama and Belaya rivers), as well as in the mountains and eastern foothills of the Southern Urals, peatlands are quite common (Atlas Respubliki Bashkortostan, 2005; Gareev and Maksyutov, 1986). A significant number of peat mires in the RB were disturbed, and until the mid-20th century they were used for peat extraction, especially in the forest-steppe zone, and later drained to increase the area of cultivated land (Gulenok et al., 1989).

[1] GOST 19179-73. Terrestrial hydrology. Terms and definitions.

The state of drained peatlands and their impact on the surrounding areas in the RB is not adequately studied, although such studies are necessary for planning rational nature management and optimizing the protection of vegetation cover in the Republic.

In a previous study, the authors conducted research aimed to create a peatland map and inventory of the Bashkir Cis-Urals region (Baisheva et al., 2022a, b). The objective of this study is to analyze the distribution, state, and current economic use of peatlands in the mountain-forest zone of the RB and in the Bashkir Trans-Urals.

Material and methods

The study was carried out in the Bashkir (Southern) Trans-Urals and regions of the Southern Urals, located in the territory of the Republic of Bashkortostan and hereinafter referred to as the mountain-forest zone of the RB, in accordance with the system of natural and agro-soil zoning of the Republic (Fiziko-geograficheskoe..., 1964).

The climate of the RB is continental, moderately cold and humid in the northern and central regions, and semi-arid in the south. The Ural Mountains play a significant role in shaping the climatic conditions; in the Trans-Urals, the degree of climate continentality increases. The annual amplitude of air temperature in the Republic ranges from 33.5 to 36.5 °C. In summer the maximum air temperatures can reach +36.5...+42 °C, in winter the absolute minimum air temperatures of −41... −53 °C are recorded. The hydrothermal coefficient is 0.69–1.65 (Atlas..., 2005). The main climatic indicators of the study area are presented in Table 1.

The relief of the mountain-forest zone of the RB is characterized by a system of low and medium-high ridges, wide intermountain depressions, and marginal plateaus, dissected by rivers flowing through deep valleys. The absolute altitudes range from 200 to 1640 m a.s.l. The western and central ridges are formed mainly by quartzites, conglomerates, basalts, hyperbasites, sandstones, limestones, shales and dolomites, while the eastern ridges (Krykty, Kraka, etc.) – by igneous rocks: porphyrites, dunites, peridotites, serpentinites, tuffs (Atlas..., 2005).

According to their position in the landscape, peat mires of the mountain-forest zone of the RB are most often represented by two types: hanging mires on mountain slopes and intermountain spring-fed mires. Floodplain mires are rare because the narrow and deeply incised valleys of mountain rivers are unfavorable for mire formation. Slope mires are fed by weakly mineralized, mainly atmospheric waters flowing downhill. The peat deposit of slope mires is shallow, with a maximum depth of 1.5 to 2 meters, but often less than one meter. These mires are characterized by a large difference between the peat deposit boundary and the industrial peat deposit. In these mires, small areas with more or less deep deposits are surrounded by large marginal areas with a thin peat layer. In terms of feeding type, slope mires are usually mesotrophic, rarely changing to oligotrophic due to the low thickness of peat deposits. The vegetation cover is usually represented by a sedge-sphagnum carpet with birch krummholz forest. The peat deposit is composed of sphagnum-sedge peat of low degree of decomposition and low ash content (Bradis, 1951).

Table 1. Main climatic indicators of the study area.

Climate indicator	The mountain-forest zone of the RB	The Bashkir Trans-Urals
Average annual temperature, °C	+0.5...+2.0	+1.5...+2.0
Average January temperature, °C	–15.5...–17	–15.5...–16
Average July temperature, °C	+16.5...+17.5	+18.0...+19.5
The frost-free season length, days	50–80	65–120
Average annual precipitation, mm	600–700	350–400
Average snow depth, cm	60–75	30–45

Intermountain spring peat mires are located at the mountain foothills, in intermountain valleys and depressions, and have more diverse water sources: they are fed not only by surface runoff from slopes but also by spring waters. Typically, these mires have very deep peat deposits (Zhuravlinoe mire, for instance, had the thickness of peat deposits of 10 m before the beginning of peat extraction), mainly of the eutrophic type. In areas with thick deposits, upper peat layers may become oligotrophic, but smaller deposits remain eutrophic throughout the profile. The vegetation cover is usually formed by oligotrophic shrubby-sphagnum spruce and pine forests, eutrophic moss-grass birch forests and other types of forest mires (Bradis, 1951).

The Bashkir Trans-Urals is represented by foothills and low mountains in the eastern slope of the Southern Urals and high Sakmara-Tanalyk and Kizil-Urtazym Planes. The relief is strongly dissected, high foothills of the Ural Mountains and gently-rugged ridges with numerous rock outcrops alternate with valleys, often bordered by strips of small hills. There are numerous endorheic lake depressions and gullies. Absolute altitudes vary from 300 to 600 m a.s.l. Most of the area is composed of volcanic and slightly metamorphosed rocks (granites, gneisses, porphyrites), which underwent horizontal and vertical movements by sedimentary rocks (siliceous-clay shales, limestones, etc.) in the Late Paleozoic. Jurassic and Cretaceous deposits of the Mesozoic era as well as Tertiary sediments (clays, marls, etc.) are widespread in the southern Trans-Urals (Atlas..., 2005).

Despite the low amount of precipitation, peat mires are quite numerous here; they are primarily located on the slopes of mountains and hills and at their foothills, in drainless depressions, and in the floodplains of rivers. These mires often cover large areas, reaching several hundred hectares. In terms of nutrients supply, the mires are eutrophic. Their vegetation cover includes both forest (reed and sedge-brown moss birch forests and black alder forests) and open rush-reed, reed-sedge, sedge-brown mosses, and other communities. Peat deposits have an average thickness of 1.6 m and are composed of grass-sedge, tree-sedge, reed-sedge, and hypnum-sedge peats (Bradis, 1951).

According to the system of zoning, published in the book "Swamps of the Earth" (Katz, 1971), the mountain-forest zone of the RB belongs to the province of mountain mires, and the Bashkir Trans-Urals – to the province of southern steppes and deserts of Kazakhstan with reed and salt mires.

This study is based on the data collected during the field studies of the Laboratory of Geobotany and Plant Resources of the Ufa Institute of Biology (UIB), Ufa Federal Research Center, Russian Academy of Sciences; scientific literature on the flora and vegetation of mires in the Southern Urals and the Bashkir Trans-Urals; reports of geological survey parties on detailed exploration of peat deposits in the Bashkir ASSR and other sources.

The work was carried out using geobotanical and floristic survey methods, Earth Remote Sensing (ERS), and GIS technologies. The data were collected and summarized, and a list of anthropogenically altered peatlands was compiled. We found the locations and mapped the peat deposit boundaries for each peatland, created a GIS-map and database. The information obtained was also statistically processed and analyzed.

A geoinformation system was developed in QGIS 3.4 program. The system includes map layers and attribute (text) data with the survey results on the current state of vegetation cover and economic use of these areas (grazing, haying, arable land, etc.). For peatlands where a floristic and geobotanical survey was conducted, the main formations of mire vegetation are indicated according to the traditional ecological and physiognomical (dominant) approach. These formations include dominant tree, shrub, and grass layers, as well as rare plant species. Data from GoogleEarth maps and topographic maps of the second half of the 20th century were used for georeferencing of the objects.

Results and discussion

Analysis of peatland distribution in geobotanical regions

In the course of this project, it was decided to abandon the use of the peatland zoning system of the RB territory (Bradis, 1951), which was employed in similar studies in the Bashkir Cis-Urals (Baisheva et al., 2022a, b). This decision was made because at the time of development of the peatland zoning system of the Republic in the middle of the 20th century, the vegetation cover of the Southern Urals and the Bashkir Trans-Urals was rather poorly studied. As a result, this vast territory was divided into only two very large and heterogeneous areas in terms of natural and climatic conditions: the mountain peatlands and the Trans-Urals eutrophic peatlands (Bradis, 1951). For this reason, the units of the geobotanical zoning system of RB (Zhudova, 1966) were used in this study.

A total of 360 peatlands with a total area of 45.6 thousand ha are found in the mountain-forest zone of the RB and in the Bashkir Trans-Urals. According to the geobotanical zoning of RB (Zhudova, 1966), peatlands of the study area are located in the zones of broad-leaved forests, steppe, forest-steppe and in the Southern Urals mountain province (Fig. 1). The distribution patterns of mires on the territory of the units of this system are summarized below.

In the western foothills and low mountain ranges of the Southern Urals, peatlans are found in the zone of broad-leaved forests (B) and in the valley of the Belaya River and adjacent watersheds (E). To the south, in the steppe zone (G), which is represented here by two regions of the golden feather grass steppe subzone of the Cis-Urals (G1), peatlands are absent (Fig. 1).

In the study area, the broad-leaved forests zone (B) is represented by only one Ulu-Telyaksky-Arkhangelsky region of mixed broadleaf, oak and linden forests (B6). The area is characterized by broadly undulating gently-rugged relief and numerous rivers with well-developed wide valleys, ancient alluvial terraces and gentle slopes of watersheds (Zhudova, 1966). In this area, 23 peat mires with a total area of 4490 ha are detected (Fig. 1). The majority of peatlands are floodplain mires located in valleys of the rivers Inzer, Sim, Zilim and their tributaries. The peatlands located in the watershed and karst depressions are scarcely represented. The vegetation cover of mires is characterized by the predominance of woody and shrubby vegetation, dominated by black alder and downy birch, as well as various species of sedges (*Carex riparia* Curtis, *C. atherodes* Spreng., *C. acutiformis* Ehrh., etc.).

To the south is the territory, designated in the zoning system developed by P.P. Zhudova (1966) as an extra-zonal district of the Belaya River valley and adjacent watershed areas (E). This district crosses different zones, but the formation of its vegetation is mainly affected by alluvial floodplain factors. In the study area, this district is represented by only one Ishimbay-Yumaguzinsky district of mixed broad-leaved forests, Volga fescue and common feather grass steppes, floodplain meadows and forests (E44). The area of this region is characterized by a hilly and broadly undulating relief, pronounced gully-low ridge floodplain of the Belaya River with differentiated genetic zones and a width of up to 5 km. In this region, 18 peat mires with a total area of 2478 ha are found. Most of them are located in the floodplains of the rivers Belaya, Zilim, Inzer and their tributaries in the western parts of the Arkhangelsky and Gafuriysky districts of the RB. Peatlands occasionally occur along the lakeshores and in drainless depressions of the relief. Vegetation is represented by woody and shrubby mire communities and wet meadows.

In the Southern Urals mountain province (D), peatlands occur in most of the districts and regions. The Aryshparovsky-Arshinsky central upland district of dark coniferous and mixed broadleaf-dark coniferous forests, high grass meadows, birch and coniferous sparse forests (D1) includes the highest region of the Southern Urals: the Belyagush, Nary, Mashak, Bakty, Avalyak, Zilmerdak and other ridges. The relief is mountainous, and the vegetation cover shows clear zonality: at an altitude of 1300 m a.s.l. and above there are mountain tundras, at an altitude of 900–1300 m a.s.l. – mountain high grass meadows, park birch and coniferous sparse forests, below – mountain taiga, secondary birch and aspen forests and other types of vegetation (Zhudova 1966). In this district, 30 mountain peatlands with a total area of 7967 are found, but the area is rather poorly studied, so some small mires may be overlooked. The vegetation of peatlands is represented by sphagnum and sedge-sphagnum forest communities dominated by downy birch, Siberian spruce, and common pine. The majority of the peatlands in this district were not drained and exploited, except for the Zhuravlinoe mire, which was developed from 1907 to 1946, the Petrovskoye mire, which still has a drainage network constructed in the 1930s, and several other mires in the Beloretsky region of the RB. The peat mires of the district are of high water conservation value and serve as the sources of many rivers in the Southern Urals (Ai, Yuryuzan, Tyulyuk, Bolshoy Inzer, Belaya, etc.).

The Beloretsk-Subkhangulovsky district of light coniferous and small-leaved forests and high-grass meadows (D2) is located southeast of the central elevated part of the Southern Urals and includes the Yurmatau, Bashty, Ardakty, Utyamysh, Belyatur, Bashtau, Ural-Tau, Kraka and other ridges. The relief is mountainous, the vegetation cover is dominated by grassy pine, birch, and aspen forests, with occasional larch forests. Tallgrass meadows are common at an altitude of 800–900 m a.s.l. (Zhudova, 1966). A total of 79 peatlands with an area of 7680 ha are found in the Beloretsk-Subkhangulovsky district. The majority of these peatlands are located in its northeastern part (D2–33) (Fig. 1). Most of the peatlands are located in the floodplains of rivers (Belaya, Ural, Bolshoy and Maly Avnyar, Yumaza,

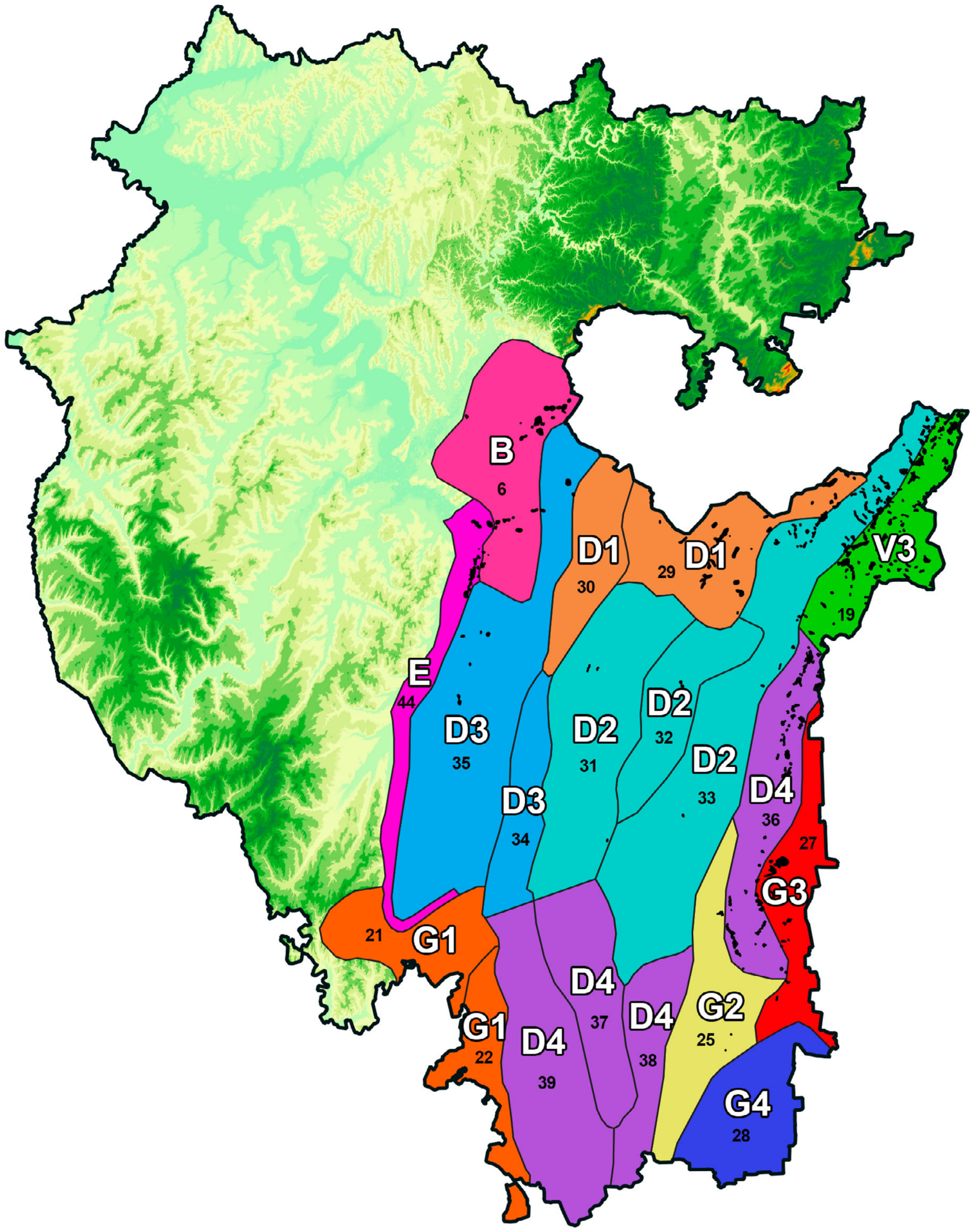

Fig. 1. Distribution of peatlands in the mountain-forest zone of the RB and in the Bashkir Trans-Urals within the territory of units of the RB geobotanical zoning system (Zhudova, 1966).
Western foothills and low mountains of the Southern Urals: B – broad-leaved forests zone (6 – Ulu-Telyaksky-Arkhangelsky region); E – extra-zonal district of the Belaya River valley and adjacent watershed areas (44 – Ishimbay-Yumaguzinsky region); D – steppe zone, G1 – subzone of golden feather grass steppes of the Cis-Urals (21 – Meleuzovsky-Mrakovsky region, 22 – Mrakovsky-Abzanovsky region).
The Southern Urals mountain province (D): D1 – Aryshparovsky-Arshinsky district (29 – Assyussky-Arshinsky region, 30 – Aryshparovsky region); D2 – Beloretsky-Subkhangulovsky district (31 – Zigazinsky-Subkhangulovsky region, 32 – Avzyansky-Beloretsky region, 33 – Beloretsky-Subkhangulovsky region); D3 – Mikhailovsky-Voskresensky district (34 – Kulguninsky region, 35 – Mikhailovsky-Voskresensky region); D4 – Abzelilovsky district (36 – Abzelilovsky region, 37 – Poboishche-Baidavletovsky region, 38 – Kananikolsky-Zilairsky region, 39 – Yuldybaevsky region).
The Bashkir Trans-Urals: V – forest-steppe zone, V3 – subzone of southern pine-birch forest-steppe (19 – Uchalinsky district); G – steppe zone, G2 – subzone of common and *Stipa zalesskii* feather grass steppe of the Trans-Urals (25 – Baymaksky region), G3 – subzone of *Stipa zalesskii* feather grass steppe (27 – Sibaevsky region), G4 – subzone of Lessing feather grass steppes (28 – Akyarsky region).
The zoning units that do not belong to the mountain-forest zone of the RB and in the Bashkir Trans-Urals are not marked in the figure.

Uy, Semibratskaya, etc.) and along the shores of lakes (Kurmankul, Nuralinskoe, Beloe, etc.). The peatlands are dominated by woody and shrubby mire vegetation, mainly grassy black alder forests and birch forests, occasionally sphagnum pine and spruce forests.

Located on the western macro-slope of the Southern Urals, the Mikhailovsk-Voskresensky mid-mountain district of broadleaf forests (D3) is characterized by hilly, gently-rugged and mid-height mountainous relief consisting of low ridges (Alatau, Kalu, Utyamysh, etc.) with an average altitude of 500–900 m a.s.l. Moisture conditions and water-permeable parent rocks (sandstones, limestones, marls, etc.) are unfavorable for mire formation processes (Zhudova, 1966). Only 9 floodplain peatlands with a total area of 1186 ha are detected in this area, covered with woody and shrubby vegetation dominated by black alder, downy birch and various species of willows.

The Abzelilovsky mid-mountain pine and birch forest district (D4) covers the southern and southeastern edge of the Southern Urals, including the Irendyk and Krykty ridges and the Zilair plateau. The relief is mountainous, divided into a number of gently rugged ridges and small ranges, separated by wide valleys of the Bolshoy and Maly Kizil rivers and their numerous tributaries (Zhudova, 1966). In the Abzelilovsky region of this district, 62 peat mires with a total area of 7368 ha are found. Most of them are located in floodplains, less frequently – in endorheic and flowing basins. No peatlands are detected on the Zilair plateau and adjacent areas in the Poboishche-Baidavletovsky (D4–37), Kananikolsk-Zilairsky (D4–38) and Yuldybaevsky (D4–39) regions (Fig. 1).

The forest-steppe zone (V) in the study area includes only one Uchalinsky forest-steppe district of birch and pine forests, common feather grass, and Volga fescue steppes (V3), represented by the Uchalinsky geobotanical district (V3–19) (Fig. 1). The district is located on the western edge of the Zauralsky peneplain in the interfluves and headwaters of the Miass, Uy, Kidysh and Ural rivers. The relief of the area is a broadly hilly plain with scattered lake basins, separated from the ridges by a strip of foothills (gently rugged ridges, hills and sopkas). This area is characterized by a complex geological structure, with ancient Paleozoic and pre-Paleozoic metamorphosed rocks alternating with granites, peridodites, serpentinites and other igneous and tuffogenic rocks. In the watersheds, the main soil-forming rock is clay deluvium, on which chernozems are formed (Zhudova, 1966). A total of 118 peatlands, encompassing an area of 11518 ha, are found in the district. They are located in endorheic and flowing intermountain depressions and basins, along overgrown lakeshores, in the floodplains of the Miass, Uy, Kandy-Bulak, Ural and other rivers.

In the steppe zone (G) of Bashkir Trans-Urals, the degree of waterlogging is low. In the subzone of *Stipa zalesskii* feather grass steppes (G3), the relief is represented by a broadly undulating gently rugged plain with numerous lake depressions and river floodplains with weakly incised flat banks (Zhudova, 1966). A total of 17 peatlands with an area of 2826 ha are found in this subzone. Most of these peatlands are located in the floodplains of small rivers (Bolshoi Kizil, Karasaz, Samaika, etc.) and are covered with complexes of woody and shrubby vegetation, rarely – sedge and reed vegetation. Three peatlands with a total area of 124.5 ha are detected in the subzone of common and *Stipa zalesskii* feather grass steppes of the Trans-Urals (G2), and one peatland (Tanatar) is found in the subzone of Lessing feather grass steppes (G4). The peatlands of these subzones are located in floodplains, are small in area, and covered with sedge, reed and willow mire communities.

Thus, about half of the peatlands in the study area are located in the Southern Urals mountain province (50% of the number and 53% of the area of all surveyed peatlands in the mountain-forest zone of the RB and in the Bashkir Trans-Urals), followed by the Uchalinsky forest-steppe district (33% of the number and 25% of the area). The smallest number of mires is located in the steppe zone (Table 2).

There are practically no mires in the southern parts of the western macroslope and central ridges of the Southern Urals, as well as on the Zilair plateau and in the south of the steppe zone, which is associated with unfavorable conditions for mire formation: the prevalence of fractured and water-permeable rocks, low precipitation, narrow river valleys, etc.

Specifics of the economic use of natural and anthropogenically altered peatlands

The degree of disturbance to peatlands in the mountain-forest zone of the RB and in the Bashkir Trans-Urals varies greatly depending on natural conditions and the level of economic development of the region. Overall, about 23% of the number and 35% of the total area of mire ecosystems in the study area were subject to drainage, development, and other types of land-reclamation activities. Drainage

Table 2. Territorial distribution of the surveyed peatlands in units of the geobotanical zoning system of the Republic (Zhudova, 1966). MFZ – mountain-forest zone of the RB, BTU – the Bashkir Trans-Urals.

Unit of the geobotanical zoning system	The number of peatlands	% of the peatland number in MFZ and BTU	% of the total peatland area in MFZ and BTU
The broad-leaved forests zone	23	6.4	9.8
The extra-zonal district of the Belaya River valley and adjacent watershed areas	18	5.0	5.4
The Southern Urals mountain province	180	50.0	53.0
The forest-steppe zone (the subzone of southern pine-birch forest-steppe of BTU)	118	32.8	25.2
The steppe zone of BTU	21	5.8	6.5

(including partial drainage) was carried out on 16% of the total peatland area, and 11% of the area was fully or partially developed. Less than 4% of the peatland area was completely or partially flooded by ponds (Table 3).

Analysis of the history of the wetland use in the districts and regions of the geobotanical zoning system shows that the largest proportion of mires preserved in their natural state occurs in the zone of broad-leaved forests (82% of the peatland area within the region) and in the Southern Urals mountain province (74%), while the smallest percentage is found in the forest-steppe zone (42%) and in the steppe zone (about 35%) (Fig. 1). The degree of peatland disturbance in the Bashkir Trans-Urals (about 60% of the total peatland area) is much higher than in the mountain-forest zone of the RB (about 25%). This is because in the last century the demand for peat as a fuel source was quite high in the forest-steppe and steppe regions; in addition, wetlands were intensively drained in order to increase the area of arable land.

Compared to the Bashkir Cis-Urals, where anthropogenically transformed peatlands occupy more than 47 thousand ha (Baisheva et al., 2022a, b), the area of disturbed peat mires in the mountain-forest zone of the RB and in the Bashkir Trans-Urals is much smaller (about 16 thousand ha). The percentage of anthropogenically disturbed peatlands in the Bashkir Cis-Urals (27.6% of the area of all identified peatlands) is higher than in the mountain-forest zone of RB (25%) and lower than in the Bashkir Trans-Urals (about 65% in the steppe zone and 58% in the forest-steppe zone).

According to the State report on the state and use of lands in the Republic of Bashkortostan in 2021[2], more than 10 thousand ha of the study area in Abzelilovsky, Arkhangelsky, Baimaksky, Beloretsky, Gafuriysky, Iglinsky and Uchalinsky regions of the RB, are registered in the State Drained Land Cadastre. In this study we revealed more than 12 thousand ha of drained land. The discrepancies can be attributed to reclassification of some land; some drained areas, while remaining in the category of arable land, were transferred to the category of undrained, most often on the basis of certified current non-operational status of the drainage systems in these areas.

It turns out that the economic use of undisturbed and anthropogenically altered peatlands differs significantly. Among the peat mires preserved in their natural state, there is a significant proportion of peatlands which are not in use for agriculture (about 70% of the total area), 20% are used for haymaking and less than 10% for grazing.

[2] State (national) report on the state and use of lands in the Republic of Bashkortostan in 2020, 2021. Federal Service for State Registration, Cadastre and Cartography in the Republic of Bashkortostan, Ufa, Russia, 230 p.

Table 3. Distribution of peatlands with different history of economic development in the study area. MFZ – mountain forest zone of the RB, BTU – the Bashkir Trans-Urals. Unit designations correspond to Fig. 1.

The history of economic development	Area, ha	The number of peatlands	% of the peatland number	% of the total peatland area
The broad-leaved forests zone (B)				
Peatlands were not drained or developed	3688.8	20	87	82.2
Peatlands were drained, including partially	268.9	2	8.7	6
Peatlands were drained and developed, including partially	532.4	1	4.4	11.9
Peatlands were developed without drainage	–	–	–	–
Peatlands completely or partially flooded by ponds	–	–	–	–
Total	**4490.1**	**23**	**100**	**100**
The extra-zonal district of the Belaya River valley and adjacent watershed areas (E)				
Peatlands were not drained or developed	1698.3	14	77.8	68.5
Peatlands were drained, including partially	504.1	2	11.1	2.1
Peatlands were drained and developed, including partially	275.3	2	11.1	0.1
Peatlands were developed without drainage	–	–	–	–
Peatlands completely or partially flooded by ponds	–	–	–	–
Total	**2477.7**	**18**	**100.0**	**100**
The Southern Urals mountain province (D)				
Peatlands were not drained or developed	18153.1	150	82.8	74.4
Peatlands were drained, including partially	2867	12	7.1	12.6
Peatlands were drained and developed, including partially	2185.3	10	6.1	9.2
Peatlands were developed without drainage	1005.1	8	4	3.8
Peatlands completely or partially flooded by ponds	–	–	–	–
Total	**24210.5**	**180**	**100**	**100**

The history of economic development	Area, ha	The number of peatlands	% of the peatland number	% of the total peatland area
The forest-steppe zone (V)				
Peatlands were not drained or developed	4875.8	79	67	42.3
Peatlands were drained, including partially	2135.2	15	12.7	18.5
Peatlands were drained and developed, including partially	1693.1	13	11	14.7
Peatlands were developed without drainage	1357.7	6	5.1	11.8
Peatlands completely or partially flooded by ponds	1456.2	5	4.2	12.6
Total	**11518**	**118**	**100**	**100**
The steppe zone (G)				
Peatlands were not drained or developed	1036.7	14	66.7	35
Peatlands were drained, including partially	1514.9	2	9.5	51.1
Peatlands were drained and developed, including partially	226.2	4	19.1	7.6
Peatlands were developed without drainage	–	–	–	–
Peatlands completely or partially flooded by ponds	187.2	1	4.8	6.3
Total	**2965.1**	**21**	**100**	**100**
Total in MFZ and BTU				
Peatlands were not drained or developed	29452.7	277	76.9	64.5
Peatlands were drained, including partially	7290.1	33	9.2	16
Peatlands were drained and developed, including partially	4912.3	31	8.6	10.8
Peatlands were developed without drainage	2362.8	14	3.9	5.2
Peatlands completely or partially flooded by ponds	1643.4	5	1.4	3.6
Total	**45661.1**	**360**	**100**	**100**

The most in demand are drained but undeveloped peatlands, where peat was not extracted: among them, the percentage of lands not used in the economic turnover is less than 1%. Developed peatlands are of much less economic value; about 40% of their areas are not used.

Agricultural use of drained peatlands is accompanied by the depletion (decrease in thickness) of peat soil, loss of organic matter and carbon. These processes are especially intense during plowing; the cultivation of perennial grass vegetation is more environmentally friendly. The use of drained peatlands as hayfields and pastures can reduce carbon losses by 3-4 times and nitrogen losses by 2 times, compared to arable land and fallow in similar areas (Molchanov et al. 2020; Truskavetskii, 2014).

In the study area, about 28% of the total area of drained and about 4% of developed peatlands are used for cultivating row crops. The most common activities on anthropogenically altered peatlands are haymaking (44% of drained peatlands and 32% of developed peatlands) and grazing (25% and 16% of areas, respectively). The percentage of land used for other purposes (berry picking, horticulture, construction) both among natural and anthropogenically disturbed peatlands is small – less than 2%. Less than 4% of the total area of peatlands are completely or partially flooded.

Ecological consequences of anthropogenic transformation of peatlands in the study area

According to the literature, peatland drainage changes the hydrological regime, micro- and mesorelief of landscapes, reduces the groundwater level and eutrophies surface waters due to the inflow of nutrients and minerals from drained peatlands into receiving rivers. Wind and water erosion of soils, which are rapidly losing fertility, is increasing, and drained peatlands are no longer able to perform their functions of carbon storage, water regulation, and water purification. Mire vegetation is being transformed and replaced by meadow, segetal, woody and shrubby vegetation (Minaeva and Sirin, 2012; Sirin, 2022).

At present, the impacts and ecological consequences of drainage reclamation on landscapes and ecosystem biodiversity in the RB are poorly studied. Floristic studies of the vegetation cover in anthropogenically altered peatlands show a reduction in the number and disappearance of populations of stenotopic rare and endangered plant species sensitive to changes in the ecological regime of their habitats. As a result of peat mining, the populations of *Rhynchospora alba* (L.) Vahl in the Zhuravlinoe mire in the Beloretsk region and *Schoenus ferrugineus* L. in the Mullakaevskoe mire in the Arkhangelsky region of the RB disappeared. In the Bashkir Trans-Urals, populations of rare species, such as *Gentianopsis barbata* (Froel.) Ma, *Artemisia laciniata* Willd., *Orchis militaris* L., and others, declined due to intensive and increasing grazing on mires during dry years.

Studies on the state of drained lands in the RB were conducted mainly in the 1970s–1980s (Garifullin, 1982; Khaziev and Mukatanov, 1985), and there have been only few similar studies in the last two decades (Komissarov et al., 2011). In some regions of the Bashkir Trans-Urals, peatland soils are subject to salinization (primarily sulfate, though there may be accumulation of hydrocarbonates, particularly in the valleys of the Sakmara and Tanalyk rivers and their tributaries), and these processes intensify after drainage. In order to maintain the soil cover in a satisfactory condition, it is necessary to regulate the water regime of these lands, increasing water drainage in wet years and retaining moisture during dry periods (Khaziev and Mukatanov, 1985). Currently, these recommendations are not implemented, due to the unsatisfactory technical condition of the drainage systems, as well as a poor monitoring system of drained peatland ecosystems and the activities of users and leaseholders of these lands. According to the State report on the status and use of lands in the Republic of Bashkortostan in 2013[3], some areas of drained lands in the Bashkir Trans-Urals, specifically in Abzelilovsky (295 ha) and Uchalinsky (1248 ha) regions of the RB, have signs of salinization.

The fire hazard of peatlands altered by human activity increases significantly with the increasing frequency of dry periods associated with climate change, particularly in the Bashkir Trans-Urals. For instance, in 2020 and 2021 alone, peat fires were extinguished on the drained peatland near the village of Bakhtigareevo in the Baimaksky regions of the RB.

At present, the effects of floodplain peatland drainage on water runoff and channel formation are poorly studied in Russia. This is primarily due to the relatively short history of drainage system operation

[3] State (national) report on the state and use of lands in the Republic of Bashkortostan in 2013, 2014. Federal Service for State Registration, Cadastre and Cartography in the Republic of Bashkortostan, Ufa, Russia, 262 p.

and the insufficient funding allocated for their maintenance and rehabilitation following the deterioration in social and economic conditions during the 1990s. This makes it difficult to study the cause-and-effect relationships between mire drainage and the development of channel processes (Nazarov, 2014).

Drained peatlands can cause changes in the nature of river feeding (shifts in the timing of flood peaks, the magnitude and duration of rain floods, increased river discharge during the summer-autumn low water period, etc.). In the first years following the drainage of any peatland, there is typically an increase in river flow due to the influx of mire water into rivers and a decrease in water evaporation from the peatland surface. In general, runoff from drained peatlands is more balanced throughout the year due to a decrease in spring flood runoff and an increase in summer runoff, which ensures a consistent water supply to rivers (Babikov, 2018).

There is conflicting data on the long-term effects of drainage and reclamation on groundwater levels and the flow of receiving rivers, both positive and negative, depending on local conditions. On the example of drained oligotrophic and mesotrophic mires in Valdai, it is shown that waterlogging of lakes and riverheads decreases the supply of water into rivers, while hydromelioration of peatlands by a network of shallow canals, on the contrary, improves it (Babikov, 2018).

In other regions, for example, the Middle Amur Lowland, the network of drainage canals in peatlands causes general degradation of watercourses within the floodplains and catchment surfaces, and the discharge of drainage water from drained peatlands affects the chemical composition of the water and river sediments. As a result, shoals can develop in the beds of receiving rivers, contributing to siltation and overgrowth of upstream sections of these rivers and erosion of their channels downstream of the mire water inflow. The combination of these processes leads to the shallowing of riverbed (Anoshkin and Zubarev, 2012). For the steppe and forest-steppe zones of Bashkortostan, it is also shown that the drainage of floodplain peatlands leads to significant nutrient removal, especially nitrates, with drainage waters (Garifullin, 1982).

Studies conducted in the Ukrainian Poliesie show that the impact of peatland drainage on receiving rivers becomes substantial if the area of drained lands exceeds 20% of the catchment area, which is especially critical for small and medium-sized rivers (Chemeris, 1993; Nazarov, 2014). The effects of drainage on the groundwater level decline is especially significant for lowland mires, and over time the drainage network's impact zone extends to more and more remote areas (Kozulin and Tanovitskaya, 2010).

In its upper course, the Ural River flows through the Bashkir Trans-Urals. The zone of the most intensive runoff from the catchment area is located in the upper forest-steppe part of the river basin. In recent decades, there has been a downward trend in the proportion of spring runoff in the Ural basin, which is explained by a combination of climatic changes and intensive anthropogenic pressure (Sivokhip et al., 2017). This is likely also due to large areas of drained and partially developed peatlands (Rysaevo, Kalkanovskoye, Yuldashevskoye, Urazovskoye, Ak-Tubya-Saz, etc.) in the Ural River floodplain of the RB. Additional research is needed to assess the impact of the floodplain peatland drainage on the rivers of the Republic.

Conclusion

A total of 360 peatlands are found in the study area. Half of them are located in the mountainous regions of the Southern Urals. About a quarter of the total peatland area in this region are subject to drainage and exploitation; the degree of disturbance of peatlands in the forest-steppe and steppe zones of the Bashkir Trans-Urals is much higher – about 60% of the total area.

Among peatlands altered by human activity, the areas of drained but undeveloped peatlands are most in demand; peatlands from which peat was extracted are of low economic value.

In order to develop scientifically sound recommendations on the rational use of natural resources and the reduction of carbon dioxide emissions from anthropogenically transformed peatlands in the RB, a comprehensive study of these areas is necessary with the participation of specialists from various fields (hydrology, wetland science, soil science, botany, zoology, ecology, etc.). At present, we can only discuss the prospects of these studies, as there is very little actual data on the current state of natural complexes of drained peatlands.

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