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Objectives and conditions for protection of unique peatlands in the south of Western Siberia in connection with issues of conservation and use of unique reed mire in suburbs of Tomsk

N M Semenova

Tomsk State University, 36, Lenin Avenue, Tomsk, 634050, Russia

Email: nmsemnv@mail.tomsknet.ru

Abstract. The article covers the issues of protection of the wetlands located in different natural and economic conditions of Western Siberia. The main focus is on preservation and wise use of the peatlands in the southern part of the West Siberian Plain, which was greatly altered and transformed during the long-term economic development. The field research was conducted in the southern suburbs of Tomsk. A unique peatland, which is an object of a special protection effort, is described in this work. The peatland develops in the conditions of a rich groundwater feed. The peatland deposits are a mixture of peat and travertine. The extension area and the maximum thickness of organo-mineral deposits were determined. The composition of the peat deposits waters and feeding springs was studied. The specific properties of the surface waters formed under the influence of the wedging-out underground waters of the Paleozoic horizons were considered. The flora and vegetation of the study area were analyzed. A list of rare and endangered plant species was compiled. The ecological and social value of the investigated territory was substantiated. As a result we defined pertinent measures needed to protect the natural landscape and to use wisely its resources.

1. Introduction

The Western Siberia is widely known for its giant watershed peatlands that attained international fame as gigantic filters-absorbers of atmospheric pollutants, water and carbon storage of global significance. Here we talk about the peatlands of the northern half of the region, where they utterly dominate in the structure of surrounding landscape directing and transforming the order of nature development [1, 2]. However, the peatlands of the southern part of the Western Siberia, despite their less massive extension and relatively small individual sizes, present some unique features of equal significance [3]. Initially representing the economic interest, mainly as a source of valuable organic or carbonate raw materials, they gradually began to be perceived as the resources of a special environmental purpose.

The tasks of protecting the unique peatlands in the south of the Western Siberia usually correlate with the tasks of the biota conservation, including the rare and endangered species of animals and plants, which are permanently, temporarily or forcedly associated with these habitats [4]. The structure and features of the peatland sediments present a particular nature protection interest. The third component of the protection motivations is formed in a specific natural and economic environment in connection with certain forms of use of peatland landscapes and their immediate surroundings [5]. The same circumstances determine the possibility and conditions for protection of individual most important peatlands.

Thus, the purpose of this article is to analyze the existing prerequisites and conditions for the establishing of special protection of a small reed mire on the outskirts of Tomsk.



The following 3 tasks were set to achieve the objective:

1. Study the vegetation of the research area and define rare and endangered plant species and specifics of their localization related to a type of habitat.
2. Define the specifics of the studied reed mire in connection with the geologic and geomorphologic and hydrogeologic conditions of its development.
3. Establish a possibility of special protection of the mire in connection with the common practice of use of the natural resources and landscape in this area.

2. Study Area

The territory under study is administratively located within the boundaries of the Tomsk oblast in the suburban area of the city of Tomsk. Geomorphologically, it is an area on the right bank of the river Tom, which includes the lower reaches fragment of the Basandayka river valley.

Basandayka is a small right-bank tributary of the river Tom, which limits from the south the main residential development around the city of Tomsk. The distance from the residential areas of Tomsk along the highway is about 7 km (figure 1), from the river Tom in a straight line is about 4 km.

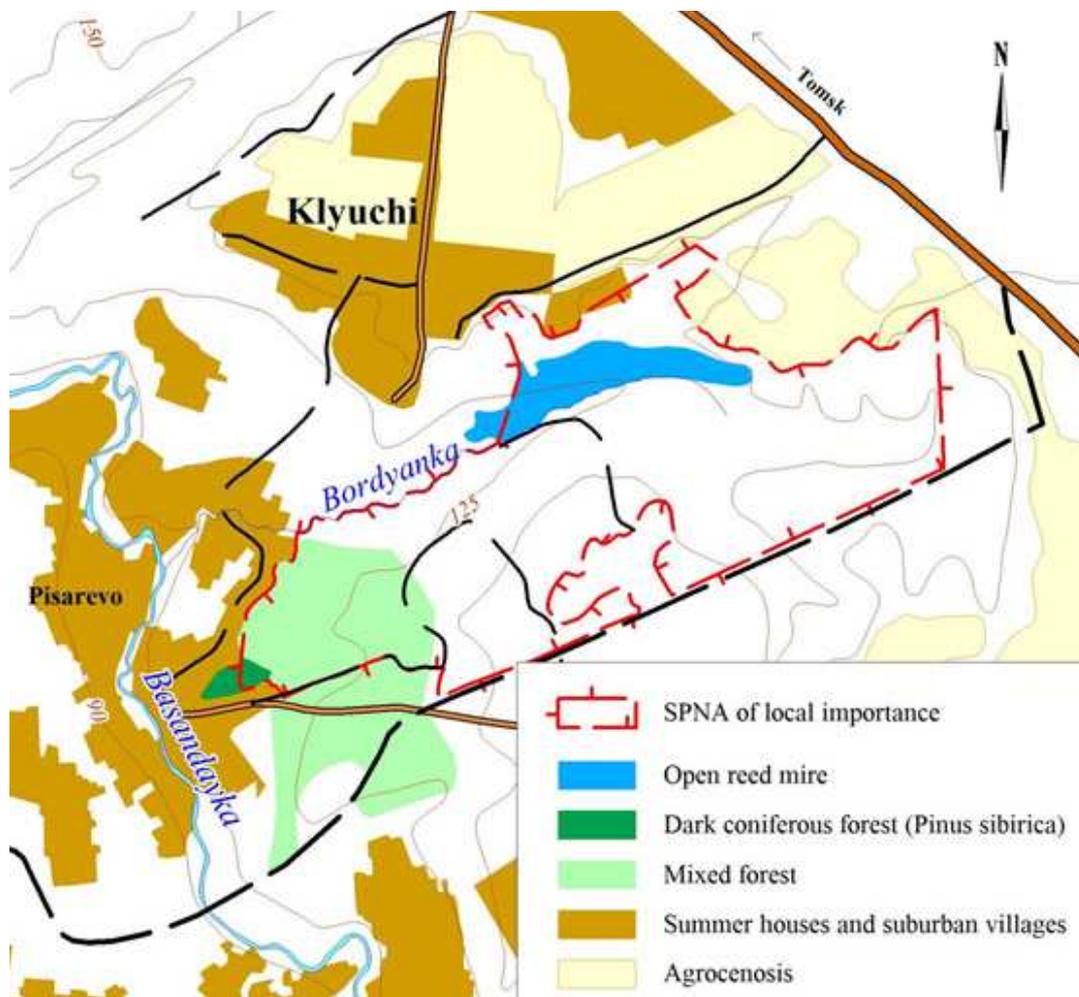


Figure 1. Study area [5].

The terrain is strongly dissected and very contrasting. The elevations vary from 90 m to 190 m. The landscapes are very picturesque. A distinguishing characteristic of the territory is the abundance of springs. The area has long been popular in a recreational sense. The health rehabilitation centre

‘Klyuchi’ located there is the oldest health resort in Tomsk and at the same time a modern well-known medical and health organization in Siberia.

The natural vegetation was transformed by human activities, except for the ravines and valleys of small tributaries of the river Basandayka, the bottoms of which are generally swamped. An extended valley bottom of one of the tributaries of Basandayka – the river Bordyanka is occupied by a reed fen of a rich groundwater feed (figure 1).

The great portion of the fen is a part of a specially protected natural area of local significance, which was established there in 2010 at the request of the local residents objecting to the uninterrupted development of recreationally valuable land. The protected area is about 100 hectares in size and is not effective for solving pressing research and applied tasks of the environmental and landscape protection in this area.

3. Materials and methods

The data describing the conditions and specifics of the studied area were obtained by analysing the archived materials and through field research. Among the archives we studied as well the geological archives of the Tomsk oblast. The field studies were conducted from 2009 to 2016 and included landscape and geobotanical research, landscape mapping, defining rare and endangered plant species, soil probing and natural water sampling for an analysis in the accredited laboratories of Tomsk.

The geobotanical research was conducted using the route method. The herbarium samples were identified in the Krylov Herbarium of the Tomsk State University. The stratigraphy specifics and total reserves of the peat and travertine deposit of the studied mire were described using preliminary data from geological scouting activities. The data on extension of travertines were revised during the field studies. The map of the geological structure of this area was compiled using the software MapInfo and a 1:25 000 scale topographic map.

The content of the chemical elements in the water samples analyzed in this article in connection with the peculiarities of local geochemical conditions was determined in the laboratory of the ‘Analytical Centre of Geochemistry of Natural Systems’ of the Tomsk State University using the ICP-MS (Agilent 7500 cx, research associates Rabtsevich E., Nikitina E.) in accordance with HCAM-XM No. 480-X [6].

The development trends and prospects of nature management in the studied area were assessed using (1) the available data on the reserves and quality of the most valued resources, (2) the evaluation of current or possible ways of using them, (3) the study of the outcomes from the previous research of natural waters conducted by the Tomsk Research Institute of health resorts and physiotherapy

4. Results and discussion

The results of this work correspond to the main tasks of peatland protection in the south of the Western Siberia. They confirm the natural value of the reed fen in the valley of the river Bordyanka near the Klyuchi village in the southern suburbs of Tomsk and the need for its special protection along with the neighbouring territories. The study shows the peculiarities of the nature management in the area and the forms and methods of use of natural resources that emphasize the unique traits of the local landscape.

4.1. Biological and landscape diversity

The valley of the river Bordyanka is a unique natural habitat in a picturesque summer-house nearby suburbs of Tomsk with a symbolic name ‘Klyuchi’. The local landscape is dominated by the slope surfaces with numerous springs and diverse vegetation: meadow-steppe, forest-meadow, taiga, swampy. About 250 species of higher vascular plants, 23 of which are rare and endangered species, are registered there along a relatively small the specially protected area ‘The Bordyanka river valley’ (table 1). In terms of habitat diversity, floristic richness and repletion with rare species the site is considered unique in botanico-geographical respect not only for Tomsk, but for the oblast on the whole [5]. Almost in the city boundaries one can encounter there, yet in high abundance, *Cypripedium*

macranthon Sw. and *Cyrtopodium guttatum* Sw. Actually, the reed mire communities are the most rare in the nature conservation cluster of the Tomsk oblast [7].

The reed (*Phragmites australis* (Gav.) Tril) on the mire of the river Bordyanka valley forms dense thickets and a heavy bed from its dead stems and is the dominant species and displaces other plants. Under the canopy of less closed reed communities there can be found horsetails, marsh willowherb (*Epilobium palustre* L.) and yellow loosestrife (*Lysimachia vulgaris* L.). In waterlogged micro-depressions dominant are sedge (*Carex acuta* L.) and moisture-loving species: marsh marigold (*Caltha palustris* L.), tufted loosestrife *Naumburgia thyrsoflora* (L.) Reichenb.), marsh bedstraw, veronica, stitchwort, etc. Some areas are dominated by water horsetail (*Equisetum fluviatile* L.).

At spring, across the debris cones tussocks (*Carex cespitosa* L.) exits to the surface among the sedge, hogweed (*Heracleum dissectum* Ledeb.), meadowsweet (*Filipendula ulmaria* (L.) Maxim.), great willowherb (*Epilobium hirsutum* L.) lavishly grow. Almost always one can find melancholy thistle (*Cirsium heterophyllum* (L.) Hill.), nettle (*Urtica dioica* L.), white nettle (*Lamium album* L.).

In the headwaters of Bordyanka the mire surface is open to boast of sporadic willows (*Salix cinerea* L.), birches (*Betula pubescens* Ehrh.) and pines (*Pinus sylvestris* L.). In the lower course of the river along its channel basket willow (*Salix viminalis* L.) appears and the entire surface of the mire is covered with a dense stand of birch trees.

On the slopes of the valley Bordyanka, which descends to the swamp, one can be find some plant communities typical for different landscape-geographical provinces of Western Siberia. The southern slopes are characterized by forest-steppe kind of vegetation. The slopes of the northern exposition may be associated with the taiga communities existing at different stages of the natural and anthropogenic successions.

Table 1. Rare and endangered species of plants in the study area.

No.	Species name	No.	Species name
1	<i>Erythronium sibiricum</i> (Fisch.et May.) Kryl. ^{a, b}	13	<i>Anemone caerulea</i> DC. ^c
2	<i>Hemerocallis minor</i> L. ^c	14	<i>Pulsatilla patens</i> (L.) Mill. ^c
3	<i>Lilium pilosiusculum</i> (Freyn) Misch. ^c	15	<i>Actaea erythrocarpa</i> Fisch. ^c
4	<i>Cyrtopodium guttatum</i> Sw. ^c	16	<i>Corydalis bracteata</i> (Steph.) Pers.
5	<i>Cyrtopodium guttatum</i> Sw. ^c	17	<i>Viola mirabilis</i> L. ^c
6	<i>Dactylorhiza fuchsii</i> (Druce) Soó ^c	18	<i>Daphne mezereum</i> L. ^c
7	<i>Lychnis chalconica</i> L. ^c	19	<i>Circea alpina</i> L. ^c
8	<i>Dianthus versicolor</i> Fischer ex Link. ^c	20	<i>Primula macrocalyx</i> Bunge
9	<i>Paeonia anomala</i> L. ^c	21	<i>Polemonium caeruleum</i> L. ^c
10	<i>Aconitum anthoroideum</i> DC. ^b	22	<i>Brunnera sibirica</i> Stev. ^b
11	<i>Adonis sibirica</i> Patrín ex Ledeb. ^c	23	<i>Myosotis krylovii</i> Serg. ^c
12	<i>Anemone altaica</i> Fisch. ^c		

^aSpecies in the Red Book of the Russian Federation [8].

^bSpecies in the Red Book of the Tomsk oblast [9].

^cSpecies requiring local protection [10].

For instance, a southward right-bank slope of the river Bordyanka valley is mostly open, covered with meadow vegetation and some scarce caragana shrubs (*Caragana frutex* (L.) C. Koch). A dense cover of wild grass on the upper slope features such meadow-steppe species as leopard plant (*Ligularia glauca* (L.) Hoffm.), daylily (*Hemerocallis minor* L.), pasqueflower (*Pulsatilla patens* L.), dropwort (*Filipendula vulgaris* Moench.), salsify (*Tragopogon orientalis* L.). Around the slope there is a large abundance of martagon lily (*Lilium pilosiusculum* (Freyn) Misch.). The main aspect in the flowering period is produced by Jacob's ladder (*Polemonium caeruleum* L.), northern wolfsbane (*Aconitum septentrionale* Koelle), various species of peavines. The species composition of herbaceous plants includes more than 60 species.

A thin birch forest (*Betula pendula* Roth) with a small trace of pine grows in the gutter strip and small ravines that dissect the slope. Occasionally, one can see Siberian peashrub (*Caragana arborescens* Lam.). On the aligned areas along the slope the grass stand is comprised of sedge (*Carex macroura* Meinsh.), bushgrass (*Calamagrostis epigeios* (L.) Roth) and pine purple grass (*C. Langsdorfii* (Link) Trin).

The left-bank slope of the valley is occupied by a mixed forest. The dominant species is birch there. There are also Siberian pine (*Pinus sibirica* Tourn.), spruce (*Picea obovata* Ledeb.) and fir (*Abies sibirica* Ledeb), which are typical representatives of the communities of the dark coniferous taiga, once widespread in the suburbs of Tomsk. Under the cover of dark coniferous species one can see a bed of short grass: wood sorrel (*Oxalis acetosella* L.), muskroot (*Adoxa moschatellina* L.), *Circea alpina* L., and others. There are many fallen trees and stumps covered with green mosses and ferns.

A quite rare, owing to limited suitable habitats in the suburbs of Tomsk, common spotted orchid (*Dactylorhiza fuchsii* (Druce) Soó) is associated with those communities. There are as well Siberian trout lily (*Erythronium sibiricum* (Kryl.) Fisch.), which is still abundant on the forested slopes of that area, and *Brunnera sibirica* Stev. – a tertiary relic on the Red Books of the Tomsk oblast [9]. However, the most replete with rare and decorative species are the communities found on the open southern slopes of the valley in contact with the open reed fen.

4.2. Particular characteristics of mineral and peat deposits

In the valley of the river Bordyanka there formed a unique carbonate-rich deposits consisting of peat, travertine and peat-travertine mixture. In the headwaters of the valley, under the cover of abundant reed thickets and reed waste lies the wet black peat of a high degree of decomposition. When exposed to hydrochloric acid, the peat effervesces from the surface. At the depth of 30-40 cm there are spots inside the peat deposits that were cemented with new formations of travertine. The level of peat waters varies from 15-20 cm at the foot of the valley slopes to 0 cm in water holes and closer to the river bed.

The carbonate deposits of the river valley were geologically studied as a deposit of travertines and peat-travertine mixtures (figure 2). It was established that the average thickness of the deposits is about 3 m [11], while the peat beds and peat-travertine mixtures in the main deposit of carbonate rocks are of a subordinate significance, though their bedding conditions are quite diverse. Occasionally the peat forms the very surface of the mire, accumulating in cavities of the travertine foundation. Sometimes, the peat deposits are uncovered in the base of the carbonate formation lying on the surface of the underlying Paleogene clays of the mineral bed of the mire. Sometimes, peat beds lie between layers of travertine. In some spots of the valley the total thickness of peat and travertine deposits is quite massive. In particular, the thickness of the carbonate-rich peat that formed in a travertine depression within the reed fen in the headwaters of Bordyanka is over 6 m. The total thickness of the carbonate deposits in this area is up to 8 m.

The general waterlogging of the river Bordyanka valley and the accumulation of lime material brings to the leakage of the fissure-veins waters of the Paleozoic aquifer and the overlying aquifer of the Neogene age. The process of travertine formation is observed almost everywhere, encompassing the vast slopes of the river valley. Given the total area of the open reed fen, which occupies the extended bottom of the valley of only about 8 hectares, the traces of carbonate deposits can be seen across the area of over 30 hectares.

The mineralization of water in the studied samples varies from 370 mg/l to 580 mg/l, pH is 7,1-8,2. The content of calcium and magnesium in the river and mire waters is 10-20% lower than in the spring water (table 2). According to a number of determined indicators, the maximum concentrations were observed on the contrary in the river or peat waters. However, some additional studies are required in order to establish any regularities in the distribution of chemical elements in the local landscape-geochemical system.

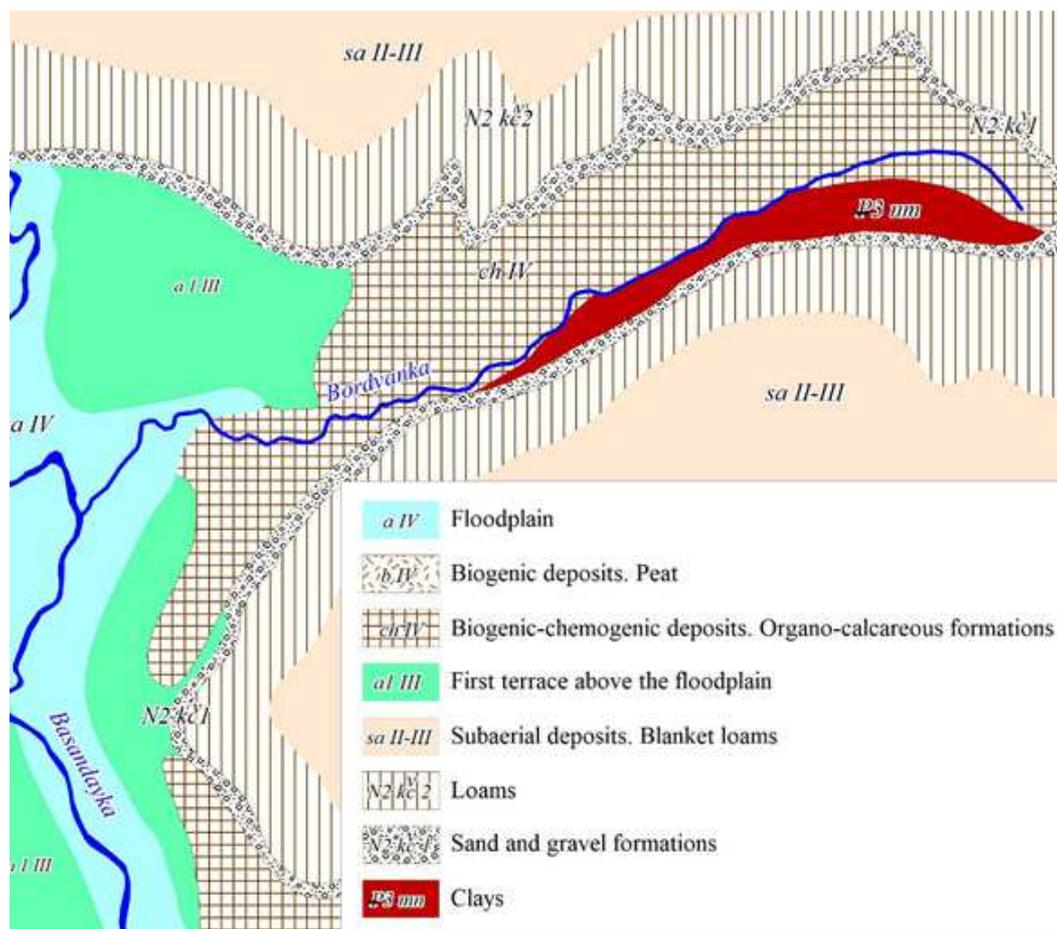


Figure 2. Features of the geological structure of the study area.

4.3. Prerequisites and forms of nature management

The environmental conditions of the territory under study determine the presence of two types of natural resources, which have a traditional economic significance and are used in one way or another by the local population. Firstly, it is the underground waters that discharge to the surface on the slopes of the river Bordyanka valley by means of numerous springs. Secondly, it is the specific organo-mineral deposits lying at the floor of the valley, which belong to valuable agricultural raw materials that can be applied to increase fertility of acidic soils in the farmland zones of the Tomsk oblast.

The wedging out subsurface waters in the river Bordyanka valley have long been known as healing and widely used by the population. Not only the local people but also city residents come there from Tomsk to take the water from those springs for their own use. The water users are usually confident about the useful properties and quality of the spring water, though the sanitary conditions of the springs is not always satisfactory. Out of 33 of all known springs in the river valley only 2 are landscaped and arranged.

The balneological properties of the Paleozoic horizon water from the springs and wells of this area have been studied at the present time by the Tomsk Research Institute of Health resorts and Physiotherapy. According to the results, the water was qualified as natural mineral drinking water. It was found to contain sufficient quantities of silicic acid acting as a biologically active component of potable mineral waters. Its content varies from 23.4 to 36 mg/dm³, while the balneological norm in the Russian Federation is 50,0 mg/dm³. However, the water is suitable for treatment and prevention of gastrointestinal diseases. The active role of low concentrations of silicic acid for the biological effect of low-salt waters was experimentally substantiated and is taken into account when justifying the

quality of health-related resources in a number of health resorts in the south of Western Siberia. The clinical studies of the local water have shown its unique properties: it reduces blood cholesterol and glucose and has a protective effect on gastric mucosa [12].

Table 2. Content of some chemical elements in water samples.

Feature	Units	Wells at the headwaters in the river Bordyanka valley	Springs at the headwaters in the river Bordyanka valley	Open reed mire in the river Bordyanka valley	Bordyanka river downstream of the reed fen
K		0,60	0,64	0,94	0,53
Na		5,62	5,82	5,64	6,73
Mg	mg/l	17,33	18,29	16,71	16,61
Ca		111,04	122,79	109,34	102,42
Fe		5,6	14,2	181	141,7
Mn		0,27	1,86	14,68	63,26
Cu		0,21	0,18	0,39	1,47
Zn		5,54	5,46	8,28	8,17
Pb		0,074	0,067	0,171	0,066
Ni		3,97	3,9	4,07	3,7
Co		0,779	0,601	0,628	0,489
V	mkg/l	0,862	0,618	1,17	0,322
Mo		0,401	0,369	0,387	0,377
Cd		0,002	0,002	0,003	0,001
Cr		2,12	3,211	0,779	0,007
Ag		0,024	0,058	0,046	0,067
Be		0,010	0,017	0,035	0,022
Sb		0,066	0,062	0,059	0,061

The useful properties of the groundwater from the springs and wells can be used to conduct health-related and recreational activities of the ‘Klyuchi’ Rehabilitation Centre located in the area, which will certainly increase its attractiveness as a health-improvement institution. The use of the spring waters with due account of interests of the local population is connected with solving the issues of providing public amenities and general landscape improvement in the places of their localization.

Whereas the use of groundwater from the springs can be made harmless provided the site is maintained and landscape is improved, the potential use of peat-travertine deposits in the river Bordyanka valley will result in a fundamental disturbance of the natural landscape. According to the data from the geological surveys, the deposits of agricultural raw materials in the river valley is 1 000 000 tons. It is the largest known deposit of this type in the Tomsk oblast. Given the CaCO_3 content of 75%, the reserves of calcareous material are 750 000 tons [11].

The high useful yield of carbonate material and its quality have long determined the interest in the development of this deposit. The sphere of application of carbonate raw material was considered in quite a broad manner that is from its use in agriculture to application in construction works. In particular, as early as in the 1940s of the last century it was believed that the deposits of calcareous tuff in the river Bordyanka valley is a material that allows, if properly burned, to obtain a high-quality lime. The conditions of occurrence and a small amount of surface stripping required allow the open-pit development of the deposit. Drainage appears to be easily achievable by excavation of the downstream carbonate sections [11].

However, it should be taken into account that the development of peat deposits of different quality and condition is generally connected with major disruptions of the environment. The development of peatlands and other types of wetlands in recent years has been conducted amid a backdrop of an increasing interest in their preservation in a natural state and a variety of conflict situations between the local economic needs and environmental initiatives [13]. The issue of rehabilitation of disturbed peatlands in spite of at least one hundred years of experience remains a topical environmental issue

worldwide [14], especially when it comes to restoring the specific flora of peatlands and preservation of their bio-diversity [15]. In this regard, the lack of any positive experience in the peatlands reclamation in the Tomsk oblast raises concerns that the potential consequences of developing peat-travertine deposits in the river Bordyanka valley may become irreparable. Particular concerns are raised about undesirable consequences of a radical landscape transformation, in case of development of the deposit, and its close proximity to a large health improvement institution of Tomsk as well as the traditional use of the surrounding territories for recreation activities and construction of summer houses and suburban villages.

So the above may be used to support the effort for preservation of the natural landscape and traditional forms of the environmental management in the vicinity of the village Klyuchi in the southern suburbs of Tomsk, the restrictions on construction and further transformation of the territory, the implementation of its scientific and informational and educational potential, and support and development of its recreational functions through special improvement and organizational measures. These tasks may be solved through planning and organization of a specially protected multi-use area such as a landscape park.

5. Conclusions

The reed mire studied under this article is a part of a unique natural landscape of a small river valley in the southern suburbs of Tomsk. The mire stands in the way of housing and nature development thus aiding to preserve the biological and landscape diversity concentrated in this area.

The mire is a singular example of an intensive accumulation of carbonate-rich peat and travertine in the Tomsk oblast. The process of formation of peat-calcareous deposits in this area is of a high scientific and educational interest. Their economic development will result in some irreparable consequences.

The objectives of protection of the unique reed mire are consistent with the interests of preserving the traditional social and economic functions of the surrounding landscape and wise use of its recreation resources. The area of interest has long been used for recreation purposes. The exploitation of organic and mineral deposits of the mire as well as housing development in the adjacent areas will result in a decline or a total loss of aesthetic and recreational values of the area.

For the purpose of preservation of the reed mire and other natural and cultural monuments of the said area in the suburbs of Tomsk it is essential to establish a specially protected area under the patronage of regional authorities

Acknowledgments

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