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Multidisciplinary Study of a Wetland in a Lakeside Lowland Area East of Lake Onega

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Abstract. Wetlands along the eastern and southern shores of Lake Onega are of interest because of their biodiversity, ecological function, and vulnerability to human impact and climate change. This study made a reference transect in the lake-river stretch on the northern bank of the River Andoma, which exhibits a change in natural conditions and an interaction between different ecosystem levels in the lakeside lowland area. Based on the results of the fieldwork, a profile of ground-penetrating radar observations with a total length of 4800 m was completed, supplemented with boreholes and soil sections. The combination of ground-penetrating radar data with field descriptions and the borehole survey produced a section that characterizes the variability of the mire system. The analysis of the section revealed zones differing in biological and ecological conditions caused by the action of several natural factors and contributing to biological diversity. Such reference transects provide a basis for the initial identification of vulnerabilities and for long-term monitoring of the ecological transformation of the region.

Keywords: wetland, transect, ground-penetrating radar, ecosystems, Lake Onega

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1. Introduction

The postglacial history of Lake Onega coast in combination with modern natural and anthropogenic impacts create conditions for the formation of complex lakeside ecosystems [1], which, in turn, are highly vulnerable due to climate change and alteration of the Lake Onega drainage basin [2]. Such systems include wetlands along the eastern and southern shores of Lake Onega. This hard-to-reach territory at the Andoma River mouth is of great scientific interest, as it combines the influence of channel processes of a large river, the dynamics of Lake Onega coast, and the growth of wetlands. It should be noted that scientists have proposed to consider this territory as a critical element of the "ecological framework" of the Vologda Region [3]. A task for the multidisciplinary study was to create a reference transect in the lake-river stretch on the northern bank of

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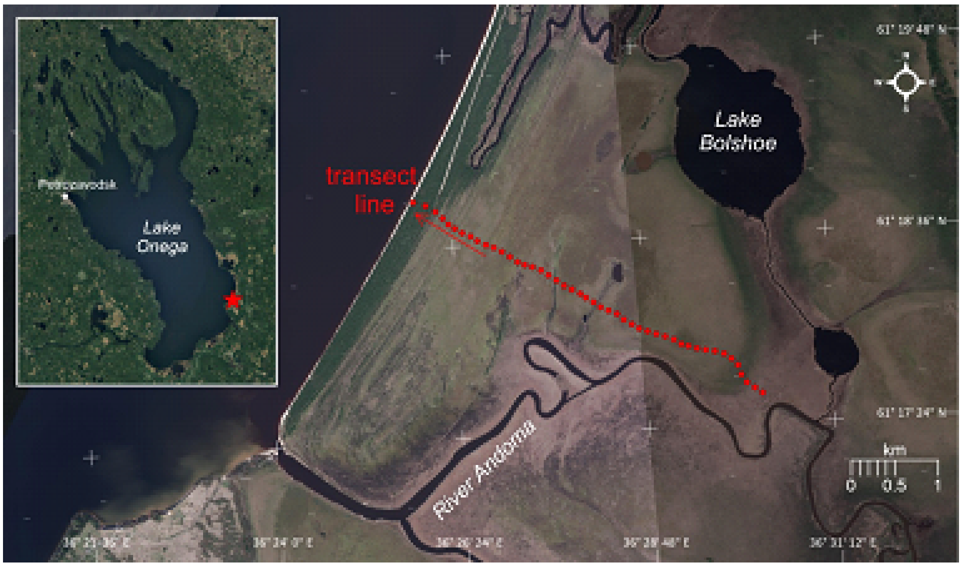

Figure 1: The study site and position of the transect

the River Andoma, which exhibits the change in natural conditions and the interaction of different ecosystem levels in the lakeside lowland. Specific tasks included performing a continuous profile of observations and identifying natural zoning along the transect, with the following analysis of their possible transformations and vulnerabilities.

From the physical and geographical point of view, fieldwork was carried out in a composite mire system in the lower reaches of the River Andoma – Sukhoyaletskoe mire (Fig. 1). This mire belongs to the South Prionezhsky wetland territory, where 12.8% of the area is paludified [5]. This area is dominated by mires of lacustrine genesis: transitional dwarf shrub-cotton grass mires with pine and birch; horsetail-sedge fens; sedge-brown moss with willow [4]. Meso-oliotrophic and oligotrophic bog sites dominate overall, while eutrophic and mesotrophic mires are found in the riverine part [6]. The peat deposit comprises all types of peat, but transitional types dominate; the ash content of peat is within 3.1–6.5% (average 4.9%). The average depth of the deposit is 2.2 m (maximum 5.1 m). The flora of the bog system contains about 85 species of vascular plants and more than 40 species of mosses. The swamp is subject to protection as a typical upland forested bog and a valuable natural object.

2. Methods and Equipment

Ground-penetrating radar (GPR) has been used to study peatlands for a long time. GPR can determine the depth of the mineral floor under the peat deposit; also, in some cases, intermediate layers are distinguished due to peat inhomogeneities [7, 8].

Besides, assessing the gas component of peat in natural deposits [9] and studying the structure and evolution of the peatland ecosystem [10] are relevant for GPR-based research. GPR proved to be effective in the study of wetlands in Eastern Fennoscandia, primarily because of the low TDS content in soil water [11].

We used a GPR device OKO-2 (Logis-Geotech, Russia) with a 100M antenna unit with 100 MHz central frequency. The step along the profile was 0.1 m; the distance traveled was determined by a displacement sensor. The signal was recorded in a time interval of 400 ns with a 12-fold signal accumulation. A GPS receiver recorded the positions of observations along the transect line. Further, in the GeoScan32 software, the GPR cross-section was processed using altitude correction, bandpass filter, mean subtraction, and amplitudes gain. The GPR cross-section was then analyzed, and individual GPR facies were marked. The average velocity of the GPR pulse in the peat was 4.7 cm/ns, which ensured an adequate depth section image down to 7 m. The position of the structural elements of the bog system, their spatial distribution and thickness were determined from GPR facies. The irregularities of the peat deposit structure detected in the GPR cross-sections were verified by manual drilling with mapping the stratigraphy of the peat column and subsequent detailed description. Boreholes were drilled down to the mineral floor.

3. Results

Based on the results of the fieldwork, a profile of GPR observations with a total length of 4800 m was completed, supplemented with boreholes and soil sections. A total of 6 boreholes 2.0 to 5.8 m in depth were drilled. Analysis of the initial recording showed a clear reflector formed at the interface of the peat deposit and the mineral basement. In this case, signal attenuation can be used to differentiate the sandy composition of the basement from the clay. Further interpretation of GPR data was carried out based on facies analysis – identifying fragments of the wavefield characteristic of a particular type of sediments. Overall, the main GPR patterns map general changes in the peat deposit structure. The results of the combined processing and interpretation of the GPR cross-section, borehole data, and landscape descriptions are shown in Figure 2. It is interesting to see the plateau-like uplift of the mineral basement at points 2300-2600, which is framed by fault zones with accompanying streams. The study of GPR facies of the plateau shows the presence of oblique reflectors that adjoin at an angle of 10-15° to a kind of core at mark 2640. We interpret it as an anticlinal fold formed due to glacial dislocations or neotectonic impacts. In addition to the main structural elements, local

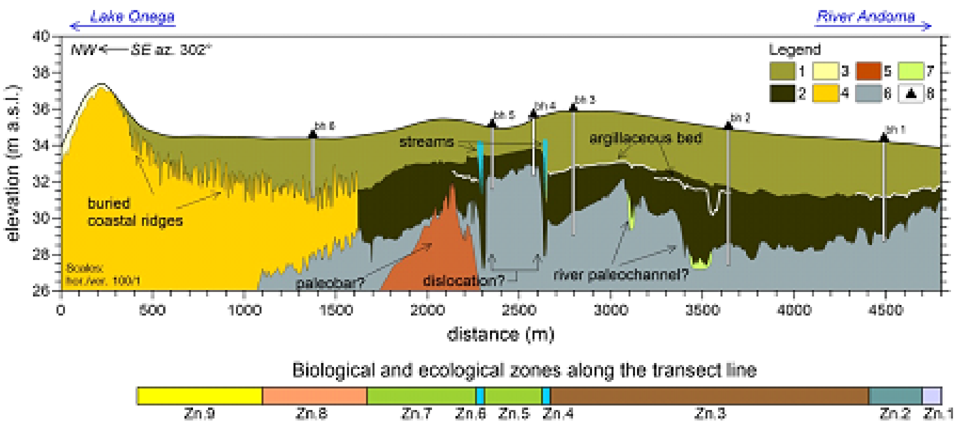

Figure 2: Cross-section of the bog system along the observation transect based on GPR data with biological and ecological zoning: 1 – transitional-mire type of peat with an intermediate degree of decomposition, 2 – highly decomposed fen peat, 3 – aeolian sand, 4 – levee sand, 5 – buried paleobar, 6 – silt, and clays of lacustrine sediments, 7 – sand of the prospective river paleochannel, 8 – boreholes.

erosion cuts were found at the top of the clayed lacustrine sediment at points 3100-3200 and 3400-3700, accompanied by sandy deposits, which may be interpreted as buried paleochannels of the River Andoma. Also, separate argillaceous horizons were identified in the body of the peat deposit. The formation of such sediments may be associated with flooding by the River Andoma.

The next stage of the study was biological and ecological typological classification with zonation by the internal structure of the peat deposit, the composition of the mineral basement, the conditions of water-mineral nutrition, and the composition of the plant cover:

Zone 1. A section of the bog adjacent to the River Andoma, characterized by variable moisture conditions, covered with mesoeutrophic sedge-herb communities with willows and a poor moss cover. The thickness of the peat deposits is about 2 meters.

Zone 2. The site is about 2 km long and 250-300 m wide, stretching south to north, covered with a pine-dwarf shrub-Sphagnum community. The sparse tree layer is represented by *Pinus sylvestris* with some *Betula pubescens*, with a canopy closure of 0.1-0.2 and a height of 2-6 m. There is a well-developed herb-shrub layer dominated by *Chamaedaphne calyculata*, *Ledum palustre*, and *Eriophorum vaginatum*. The moss cover is continuous and formed by *Sphagnum angustifolium* and *S. fuscum*. The thickness of the peat deposit is 4.7 m; thin clay interlayers are found at depths from 2 to 3.3 m.

Zone 3. The site occupies the central part of the bog. The wavy microrelief is covered with ombrotrophic shrub-cotton grass-Sphagnum plant communities. The arboreal layer is represented by single pines up to 0.5-2.0 m high. The field layer is formed by *Chamaedaphne calyculata*, *Eriophorum vaginatum*, *Andromeda polifolia*, with the participation of *Ledum palustre* and *Vaccinium uliginosum*. The continuous moss cover is dominated by *Sphagnum fuscum*, with *S. angustifolium* and *S. magellanicum*.

Zones 4 and 6. These are flowage mires with mesoeutrophic sedge-horsetail-herb communities. The field and shrub layer is formed by *Betula nana*, *Carex rostrata*, *Equisetum fluviatile*, *Comarum palustre*, and *Menyanthes trifoliata*. There is a thin moss cover of *Sphagnum squarrosum*, *S. riparium*, *Warnstorfia fluitans*, and *Calliergonella cuspidata*. The peat deposit is 2.5 m thick, the lower layers of peat are mixed with clay particles. According to the GPR data, these areas are confined to edges of a dislocation, which ensures the flowage of mire water and favors the growth of flora species more demanding towards water and mineral nutrition.

Zones 5 and 7. They have a relatively flat microtopography and are covered with oligotrophic cotton grass-Sphagnum communities of *Eriophorum vaginatum* with *Andromeda polifolia*, *Oxycoccus palustris*, *Scheuchzeria palustris*, and *Drosera rotundifolia*. The moss layer is dominated by *Sphagnum balticum* with some *S. magellanicum*. The peat deposit is 3.8 m thick, significant admixtures of clay particles are observed at 2.4-2.9 m depths.

Zone 8. Represented by a ridge-hummock-hollow complex. Low hummocks (20-50 cm), sometimes merging into ridges, are covered with shrub-Sphagnum communities. Scheuchzeria-Rhynchosporic-Sphagnum communities occupy the hollows. Levee sands underlie a 2.5 m thick peat deposit.

Zone 9. Situated on buried sandy ridges with a cover of pine-dwarf shrub-Sphagnum communities. Moreover, the older the coastal ridge and the thicker the peat deposit, the more depressed the vegetation, which is especially obvious for pine. Scheuchzeria-Rhynchosporic-Sphagnum and sedge-Sphagnum communities occupy the spaces between the ridges.

4. Conclusions

The research shows that the bog complex at the mouth of the River Andoma is a valuable natural object, interesting for a comprehensive study. The presence of a meandering river, a series of coastal sand ridges, and some local heterogeneities make this territory a curious object for the study of the structural interactions of natural landscape elements and their influence on the formation of ecosystems. The reference section made along the transect line revealed zones differing in biological and ecological conditions caused by several natural factors, which ultimately contribute to biological diversity. In addition, the results provide a scientific basis for the initial identification of ecosystem vulnerabilities and for long-term monitoring of the ecological transformation of the region.

5. Funding

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References

[1] Kaufman ZS. Ecosystem of Lake Onega and tendencies of its change. Leningrad: Nauka; 1990.

[2] Filatov N, Baklagin V, Efremova T et al. Climate change impacts on the watersheds of Lakes Onego and Ladoga from remote sensing and in situ data. Inland Waters. 2019;9(2):130–141.

[3] Ivanishcheva EA. Ecological network of Vytegra district in Vologda region. Izvestia of Samara Scientific Center of the Russian Academy of Sciences. 2010;12(5):1383–1386.

[4] Abramova TG. Bogs of the Vologda region, their zoning and agricultural use. Severo-Zapad Evropejskoj Chasti SSSR. 1965;4:65–93.

[5] Filonenko IV, Filippov DA. Assessment of the area of bogs in the Vologda region. Trudy Instorfa. 2013;7:3–11.

[6] Filippov DA. Structure and dynamics of ecosystems of floodplain bogs in the Onega Lake basin (Vologda region) [PhD dissertation]. Vologda State Pedagogical University; 2008. Syktyvkar.

[7] Hänninen P. Application of ground penetrating radar and radio wave moisture probe techniques to peatland investigations. Geological Survey of Finland Bulletin. 1992; 361:71 pp.

[8] Slater LD, Reeve A. Investigating peatland stratigraphy and hydrogeology using integrated electrical geophysics. Geophysics. 2002;67:365–378.

[9] Comas X, Slater L, Reeve A. Seasonal geophysical monitoring of biogenic gases in a northern peatland: Implications for temporal and spatial variability in free phase gas production rates. Journal of Geophysical Research: Biogeosciences. 2008;113:1–12.

[10] Loisel J, Yu Z, Parsekian A, Nolan J, Slater L. Quantifying landscape morphology influence on peatland lateral expansion using ground-penetrating radar (GPR) and peat core analysis. Journal of Geophysical Research: Biogeosciences. 2013;118:373–384.

[11] Ryazantsev PA, Ignashov PA. Ground penetrating radar measurements of bog deposits (a case study of the Zaonezhskii peninsula, Karelia). Geography and Natural Resources. 2019;4(158):125–134.