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GEOGRAPHICAL RESPONSE TO THE NEW WORLD ORDER CHALLENGES

ECOSYSTEM SERVICES AND CULTURAL VALUES OF THE GREAT KEMERI MIRE

LIELĀ ĶEMERU TĪREĻA EKOSISTĒMU PAKALPOJUMI UN KULTŪRĀLĀS VĒRTĪBAS

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Abstract. Several studies have focused their attention on Great Kemeri Mire, one of the largest peatland areas in Latvia. These included its formation, hydrological regime and value within the historical development of Kemeri National Park. While previous studies have detailed various ecological and cultural aspects of the Great Ķemeri Mire, no comprehensive research has evaluated the overall value of the mire to nearby areas in a holistic way. To address this, we used open-source forestry, geological and population density data, along with pollen analysis, to provide a comprehensive look on Great Kemeri Mire and describe ecosystem services it provides to nearby communities. We conclude that The Great Kemeri Mire has historically served as a vital area for local communities while also playing a crucial role in combating climate change by acting as a carbon sink. Additionally, it supports biodiversity through diverse forest habitats, contributing to ecosystem services and facilitating biodiversity conservation.
Keywords: *peatland degradation; quaternary deposits; pollen analysis; population density*

Introduction

Peatlands are essential ecosystems for climate regulation and biodiversity but are increasingly threatened by human activities and climate change (Swindles et al. 2019, Antala et al. 2022). History of anthropogenic impact and use of wetlands is vast and dates back to oldest known civilizations across the globe (Williams 1990, Denevan 2001). Peatlands have seen a significant decrease in their area during the last century mainly due to human activities (Fluet-Chouinard et al. 2023). This has resulted in substantial changes not only in greenhouse gas emissions, but also a decline in provided ecosystem services value, which wetlands are known for (Mitsch et al. 2015).

Great Kemeri Mire is one of the largest mires in Latvia, covering an area of more than 6000 km^2. Like the majority of Latvian mires, Great Kemeri Mire experienced degradation during the Soviet occupation. While there have been numerous studies on the formation, development and hydrological properties (Daņiļēvičs 2010, Prols 2010, Kleinhofa 2022, Skomorohovs 2024), no analysis has been performed on the ecosystem services provided by the mire. Ecosystem values require the functioning of the entire wetlands ecosystem, not just a few species of plants, animals, or microbes, to mitigate regional climate hazards, improve water quality and even sustain human cultures (Mitsch et al. 2015). Ecosystem services provided by peatlands are beneficial to human communities, and they can be grouped into three categories: regulating and supporting services, provisioning services, and cultural services (Varin et al. 2019).

The aim of this study is to assess the ecosystem services and cultural values provided by the Great Kemeri Mire. By doing so, we observe relevant factors in a holistic approach including both published and unpublished information from pre-history to the present day.

Data and methods

In the current study, Great Kemeri Mire (located in the central of Latvia) and its nearby territories were selected as a research area (see Figure 1). Boundaries of the research area are based on natural and human made objects and their role in limiting the expansion of flora and fauna. Study area comprises 25 342 ha spanning over most of the Kemeri National Park and ending along Lielupe river on the east, with Slampe village on the west as well roads and rivers in the north and south.

The pre-Quaternary sedimentary rocks consist of Middle and Upper Devonian formations, including dolomite, sandstone, clay, and gypsum-bearing layers. These rocks are overlain by various Quaternary deposits, dominated by peat, glaciolacustrine silts and clays, and locally by glacial and aeolian sands. Raised type bogs, such as Great Kemeri Mire, contain thick peat layers. The landscape is largely flat, with minor undulations in areas shaped by aeolian sand dunes (Ķemeru nacionālā parka fonds, S.a).

Geospatial analysis (ESRI ArcGIS Desktop 10.8.2. and QGIS 3.40) and Forest Soil Inventory were used for analyzing recent and current environments. The population density map used in this study is based on 2021 Census data using 1 km^2 grid cells (Oficiālās statistikas portāls 2021). The study area includes the municipalities of Tukums, Jelgava and Mārupe, as well as the city of Jūrmala.

As historic information on vegetation cannot be observed from maps but is crucial in understanding for current overall land cover situation, pollen analysis was carried out to prolong the insights into historic forest composition in the region. Due to its size, Great Kemeri Mire pollen results represent regional vegetation patterns (Hellman et al. 2007), thus, ideal, to reconstruct overall dominant tree species within the region.

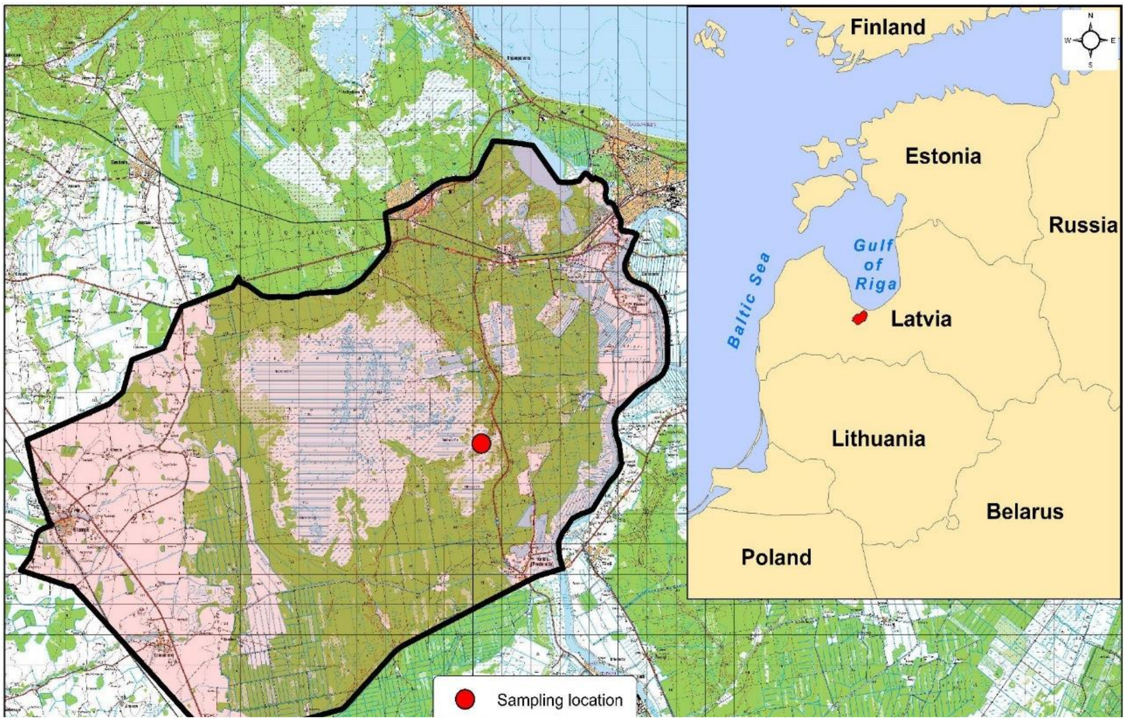

Figure 1. **Research area and pollen sampling location. Sample collection located at 56°52'21"N, 23°31'44"E.** (authors' figure)

Great Kemeri Mire was sampled in September 2024 using a peat corer with a diameter of 5 cm. Peat samples for pollen analysis were collected from a core site located at 56°52'21"N, 23°31'44"E (see Figure 1). The sampling site was chosen to minimize edge effects and ensure representation of regional vegetation patterns. The sediment thickness reached 300 cm. Lithologically, sediment sequence consisted of peat (20 cm fen type peat at the base and 280 cm raised mire peat on top of it) which formed above the Quaternary sand sediment. Peat subsampling was done in the field following known information on peat age of similar peat thickness and characteristics nearby locations analysed by Skomorohovs (2024). Altogether ten subsamples were taken for pollen analysis (depths, cm: 0-5, 18-20, 30-31, 35-36, 40-41, 44-45, 48-49, 54-55, 69-70 and 109-110).

Pollen analysis was done in the Quaternary Environment laboratory, Department of Geology at the University of Latvia. Pollen samples of known volume (1 cm^3) were treated with 10% HCl, boiled in 10% KOH and then acetolysed for 5 min using standard acetolysis procedures (Berglung and Ralska-Jasiewiczowa 1986). At least 50 terrestrial pollen per sample were counted and identified to the lowest possible taxonomic level using published pollen keys. The percentage of dry-land taxa was calculated using arboreal and non-arboreal pollen sums (excluding sporomorphs). Counts of spores were calculated as percentages of the total sum of terrestrial pollen. Pollen results were visualized using the RStudio environment (v. 2024.04.0+735, R Core Team 2024) using the riojaPlot package (Juggins 2024).

Assuming simultaneous vertical growth of the whole bog surface (Ilomets et al. 1984) and lateral peat surface expansion fixed at zero for the entire studier period, we employed an age-depth modelling to associate chronology for analysed peat samples. Using ^{14}C data from Skomorohovs (2024), we applied the latest IntCal20 calibration data set, producing an age-depth model in the R environment using the Clam package (Blaauw 2010).

Results

Our analysis shows that approximately 3.5% of the total research area has been subject to mineral extraction over various time periods (see Figure 2). However, based on data from the Subsurface Information System of the Latvian Center for Environment, Geology, and Meteorology, as well as analysis of cartographic materials such as topographic maps and satellite imagery, it can be concluded that nearly all mining activities in the area have ceased or been discontinued for other reasons. The only active site is the medicinal mud extraction site “Sloka” (see Figure 2).

With the retreat of the glacier from the territory of Latvia about 15 000 years ago, the Great Kemeri Mire could begin to form. Thanks to glacioisostasy, the area began to rise, ensuring that it was initially covered by the waters of the Baltic Sea’s development stages (the Zemgale Ice-Dam Lake and the Baltic Ice Lake, Pēcleduslaikmeta shēma 1981). With the end of the Baltic Ice Lake, the water level in the Baltic Sea dropped by 25 meters, resulting in the Great Kemeri Mire area becoming dry. This led to the formation of dune relief (still recognized under and within the Great Kemeri Mire itself) due to wind action. Radiocarbon dating (Skomorohovs 2024) indicates that organic matter in the Great Kemeri Mire began to accumulate around 9885 cal BP. Initially, it developed as a fen-type mire and remained so until 2300 cal BP, when it transitioned into its next development phase – a raised mire.

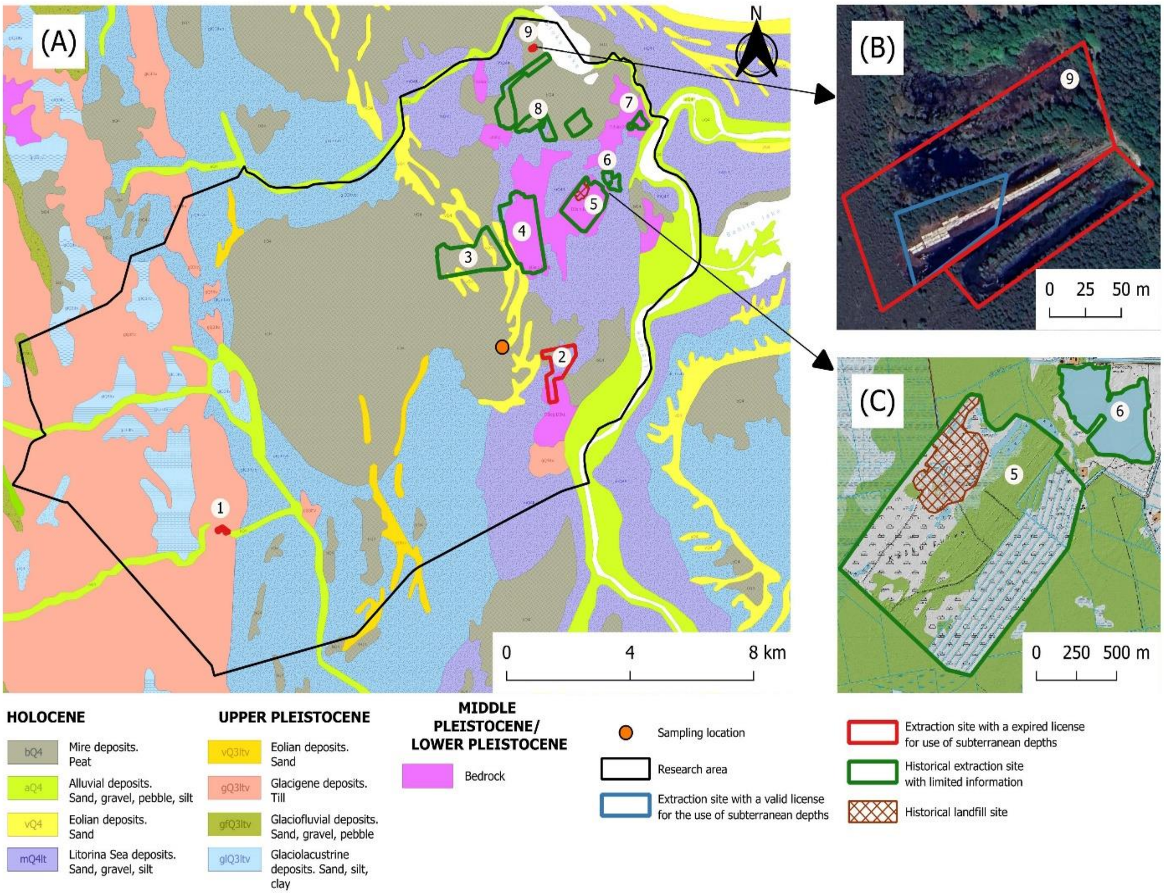

Figure 2. **(A) Overview of extraction sites across Quaternary sediments (**basemap: LEGMC 2001**): 1. Dolomite extraction site "Lancenieki"; 2. Dolomite extraction site "Kalnciems II"; 3. Peat extraction site "Lielais Ķemeru tīrelis"; 4. Peat extraction site "Labais purvs"; 5. Peat extraction site "Kašķu purvs"; 6. Dolomite extraction site "Sloka 2.laukums"; 7. Dolomite extraction site "Sloka"; 8. Peat extraction site "Slokas (vecais) purvs"; 9. Medicinal mud extraction site "Sloka". (B) Detailed view of the healing mud extraction site "Sloka", showing areas with expired and valid licenses for material extraction** (basemap: Google 2024**). (C) Peat extraction site "Kašķu purvs" featuring landfill and adjacent dolomite extraction site "Sloka 2.laukums"** (authors' figure using LGIA basemap**)**

According to the population density map, the area has low or no population (Figure 3). The highest population density is observed in the northern part of the territory - in the area of Jūrmala City and Marupe Municipality, where the maximum population reaches 978 people per grid cell. A relatively high population density is also observed in Slampe which is located in Tukums municipality. In general, the most densely populated areas are concentrated around cities and villages. Most of the grid cells with high population density cover the border of the study area

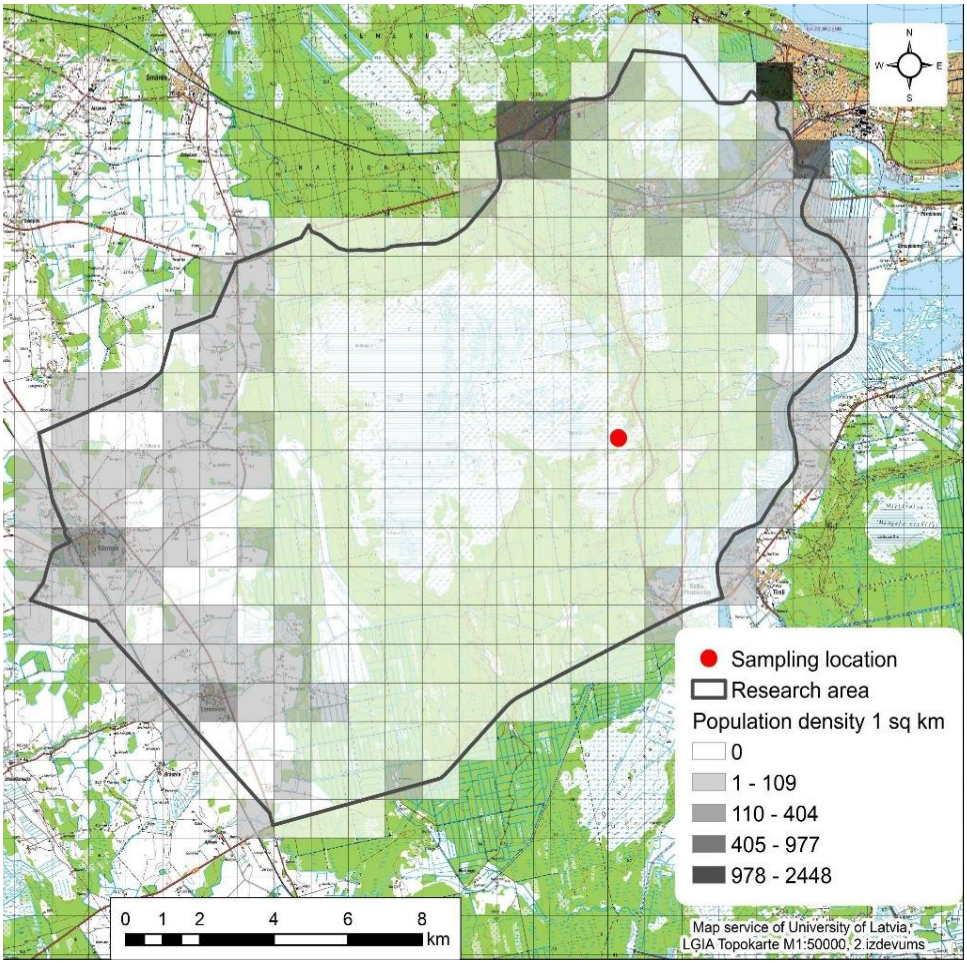

Figure 3. **Current population density within the study area**

Pollen analysis of the sampled peat profile reveals pine dominance throughout the entire profile (30-70%, see Figure 4). Notably, a significant increase during the last 200 years was observed, likely due to the proximity of the sampling location to the bog's edge and the expansion of pines there. Birch (15-40%) and alder (3-10%) also had notable occurrences but their presence has been less stable over time. This may suggest that around 1500-1700 CE, nearby forests experienced changes in flora as evidenced by a sudden increase in Pteridium spores and graminoid pollen during this period, which could be attributed to agricultural activities or early logging. Spruce values were generally low, averaging approximately 4%.

Sphagnum spores show a relatively high continuous presence throughout the time. The low moss values observed in some of the oldest dated samples might indicate hydrological changes from transitional to raised bog conditions.

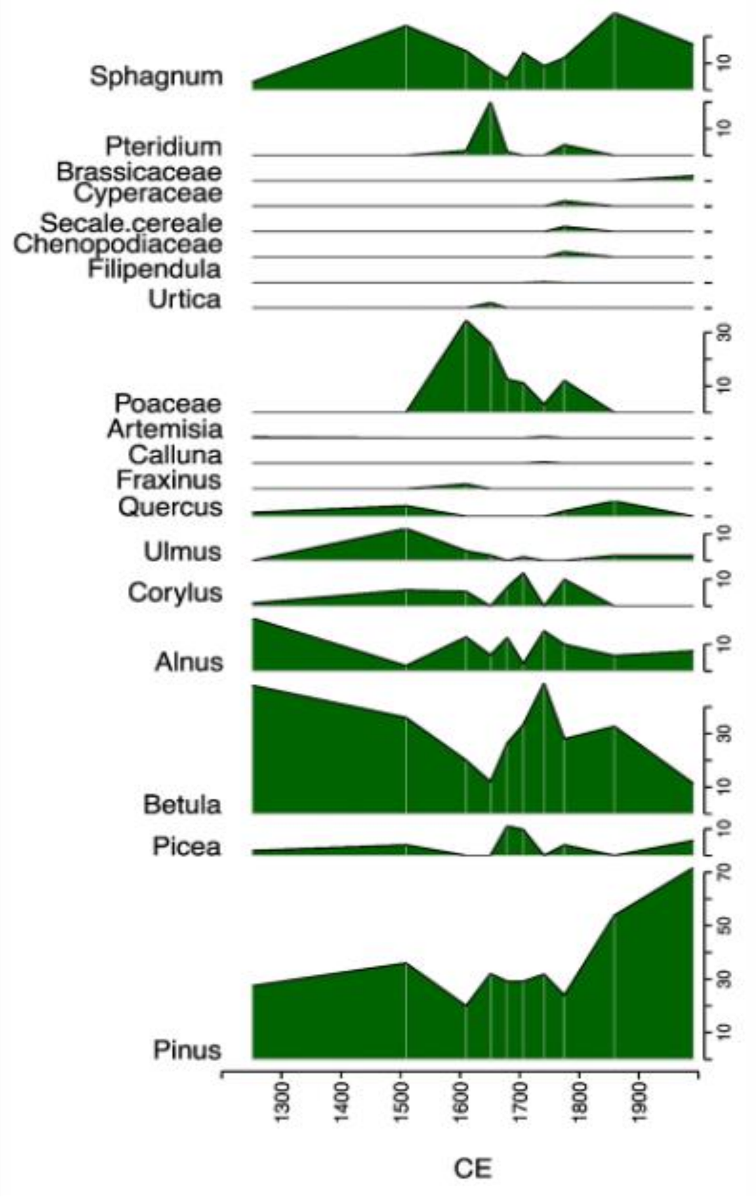

Figure 4. **Pollen and spore analysis results from Great Kemeri Mire. Chronology (calendar years, CE) on y axis and pollen taxa with subsequent percentage (%) share on x axes.** (authors' figure)

Figure 5. **Aerial view of eastern peatland extraction sites in November 2024 (56°54'39"N, 23°32'07"E).** (photo by M.A. Zuperka)

The oldest available cartographic records of wetland existence near Kemeri date back over 200 years, with the Atlas von Liefland maps from the (Dodies.lv, S.a., Vāvers 2021). Since then, the wetlands have accumulated a considerable amount of peat. Large quantities of peat were extracted from the northeastern part of the mire during Soviet times. Although some areas have largely recovered their natural vegetation following these extraction activities (see Figure 5), certain sites continue to remain flooded and are unlikely to recover without intervention for several years. Fortunately, the affected area is relatively small compared to the overall size of the Great Kemeri Mire, which remains predominantly natural. This natural state is crucial for providing essential habitats for wetland-specific fauna and flora, mitigating flood risks, and ensuring water resources accessibility for local residents. Aerial imagery and field observations also indicate that the eastern part of the mire is susceptible to woodland expansion, which was also noted in pollen analysis.

Historical maps also reveal that major drainage systems were constructed around the mire during the last century. These actions explain the high percentage of wet and dry drained forests around the study area (see Figure 6). Drainage negatively impacted the carbon sequestration potential of these forests by both promoting peat layer oxidation due to reduced groundwater levels, as well as restricting new peat formation. Nevertheless, a high forest taxonomic diversity is observed around the Great Kemeri Mire, which positively impacts the ecosystem services provided. Dry forests are known for recreational activities like hiking and mushroom or wildberry picking among local population. Naturally moist forests are mostly located on fertile soils, promoting biodiversity.

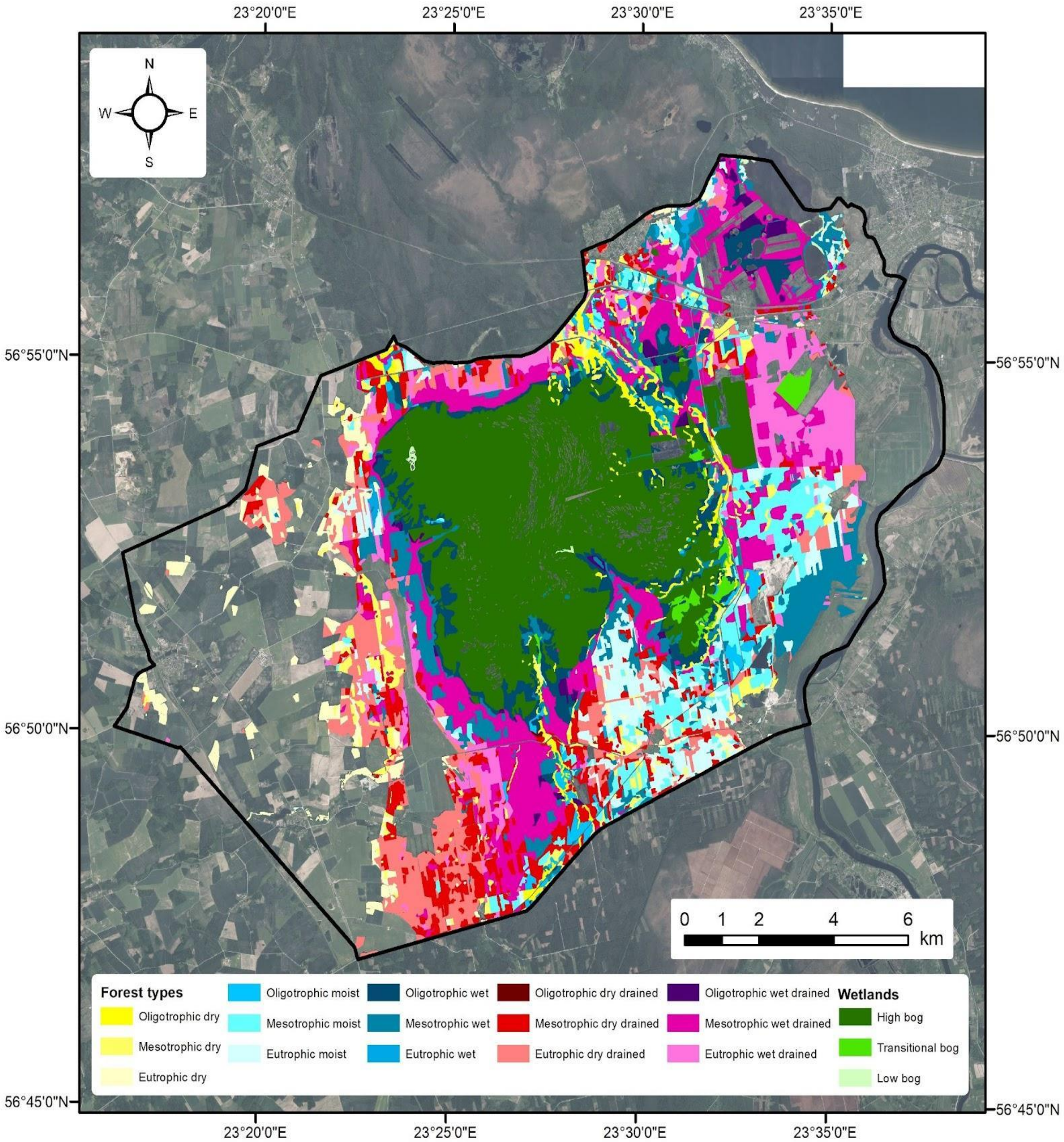

Figure 6. **Forest and wetland types in the research area. Data courtesy of National Forest Registry** (Valsts meža dienests 2025).

While Great Kemeri Mire has not been a central area for urban development, provided ecosystem services have been used extensively. Due to wet nature, mire as such is not the primary area for living. Indeed, both historic and current information on population density and distribution (e.g., Fig. 3) indicate higher population densities along marginal positions of Great Kemeri Mire. Nevertheless, Great Kemeri Mire provides several critique services underlined also by the United Nations (see Figure 7). Area is used for recreation activities and provides various berries. Mire itself serves as huge sponge holding high amount of freshwater and ensuring lower flood-risk for surrounding area. While there is sufficient water level within the mire, a healthy natural ecosystem can persist and ensure life within the mire. Due to photosynthesis, new carbon dioxide is captured from the air and stored in the peat in a form of carbon for centuries and millennia. Hence, Great Kemeri Mire is crucial for climate change mitigation. These values are somewhat forgot or unappreciated but forms a backbone of defining cultural values of this region.

Figure 7. **The role of Great Kemeri Mire in scope of the United Nations goals.** (authors' figure)

Conclusion

This study investigated multiple dimensions of the Great Kemeri Mire, providing an integrated assessment of its ecological and cultural significance. Pollen and spatial analyses indicate that parts of the area were historically influenced by agricultural activity, whereas current trends suggest progressive encroachment of woody vegetation from the mire margins. Numerous inactive peat extraction sites and associated remnants reflect the historical importance of the area for surrounding communities, despite the presently low population density. The mire encompasses a diversity of forest ecosystems that provide habitat for a wide range of species and support recreational use, while its extensive wetland complexes play a substantial role in carbon sequestration and climate regulation. Overall, the results emphasize the multifunctional role of the Great Kemeri Mire in biodiversity conservation, ecosystem service provision, and sustainable land-use planning, while also contextualizing its present state within its historical development.

Kopsavilkums

Lielais Ķemeru tīrelis laika gaitā ir piesaistījis daudzu pētnieku uzmanību. Tas rezultējies vairākos pētījumos par tīreļa hidroloģisko režīmu, veidošanos un kultūrvēsturisko vērtību, tomēr trūkst holistisku pētījumu par Lielā Ķemeru tīreļa nozīmi gan ekosistēmu pakalpojumu skatījumā, gan vietējiem iedzīvotājiem, tādēļ rakstā tika apskatīti dažādi Lielā Ķemeru tīreļa ģeogrāfijas aspekti, piemēram purva hronoloģiskās attīstības un zemes izmantošanas veidu pagātnē rekonstrukcijas pēc putekšņu analīzēm un esošo mežu daudzveidības raksturojums. Rezultāti parāda ka Lielais Ķemeru tīrelis ir bijis aktīvi izmantots un nozīmīgs resursu avots vietējiem iedzīvotājiem vairākus gadsimtus, uz ko norāda gan putekšņu analīžu rezultāti, gan mūsdienu ekoloģiskie procesi tīreļa apkārtnē. Tīrelis aizvien ir svarīgs gan vietējiem iedzīvotājiem, nodrošinot plašu klāstu ekosistēmu pakalpojumu, gan klimata pārmaiņu seku mazināšanā, veicinot oglekļa piesaisti un bioloģisko daudzveidību.

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