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PRELIMINARY BIODIVERSITY SURVEY IN A NEWLY PROPOSED SITE OF COMMUNITY IMPORTANCE: THE AVRIG PEAT BOG

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Abstract

Peatland habitats are well-known for their function in sequestering carbon, characterized by peat-forming species such as Sphagnum mosses. The Avrig peat bog, located at the foothills of the Făgăraș Mountains in the Olt River basin, is a small site (less than 4 hectares) proposed for designation as a Natura 2000 site. A eutrophic palustrine zone encircles the peat bog`s center oligotrophic zone, dominated by Sphagnum mosses. This area is characterized by the presence of the European-protected priority habitat Active raised bogs (habitat code 7110). We employed a combination of field surveys and aerial investigations to assess the site`s biodiversity and evaluate potential threats. The collected Sphagnum samples were morphologically examined in the laboratory, revealing several species, like Sphagnum medium Limpr., Sphagnum capillifolium (Ehrh.) Hedw. and Sphagnum girgensohnii Russow. The bog also supports rare plant and amphibian species of conservation interest. Targeted management strategies are necessary to mitigate pressures including agricultural runoff, drainage, invasive species, and peat extraction.

Key words*: Sphagnum, peatland restoration, amphibians, rare plant species, Natura 2000, raised bogs.*

INTRODUCTION

Peat bogs are among the most ecologically significant habitats due to their dual role as refugia for endangered species, including glacial relicts, and as natural carbon sinks that accumulate atmospheric CO_2 over millennia. These habitats, particularly in continental regions such as the Făgăraș Mountains' Olt Basin (Sibiu County), are under increasing conservation scrutiny.

In the continental region of Romania, several peat bogs are found in the Făgăraș Mountains' Olt Basin, within the administrative area of Avrig, Sibiu County. Historically, the vascular flora of the Avrig peat bogs has been documented extensively by researchers such as Pop (1937; 1945; 1955; 1960), Șerbănescu (1961; 1964), and Drăgulescu (2003; 2010). Peat stratigraphy and formation processes have been analyzed since the 19th century (Herbich, 1884; Staub, 1884; 1891; Pax, 1908), confirming the Avrig peat bogs as some of the oldest in Romania, with an estimated age of 13,880 ± 90 years (Tanțău et al., 2006; 2009). Notably, the term "Avrig" has been attributed to a specific paleoclimatic cooling phase, dated at 12,360 ± 70 years BP.

Evidence of early anthropogenic influence, dating back 6,000-6,500 years BP, is supported by pollen analyses indicating the presence of cereal crops (Tanțău et al., 2011).

This paper presents the results of the biodiversity and conservation status assessment conducted within the framework of two major restoration projects PeatRO and PeatRO2 - focusing on peat bogs restauration and Natura 2000 site proposals in Romania.

MATERIALS AND METHODS

Among the four peat bogs in Avrig, Sibiu County, previously described by Pop (1960), one was rediscovered in 2016 as part of the PeatRO project. Although the habitat was found in a degraded state, it showed high restoration potential due to the presence of *Sphagnum* species and peatland indicator vascular plants such as *Drosera rotundifolia* L. and *Menyanthes trifoliata* L.

Within the PeatRO2 project - *Degraded Mires and Peatlands Restoration in North-East Romania* (2021-2024), funded by an EEA grant - restoration efforts were carried out, including assessments of vegetation (vascular and bryophyte), faunal composition, and conservation status. We employed a combined qualitative approach, integrating field surveys and drone-based assessments, to evaluate the site's biodiversity, existing pressures, and potential threats. Bryophyte samples were collected and morphologically identified in the laboratory using light microscopy. *Sphagnum* species were classified based on the keys by Plămadă (1998) and Laine et al. (2018), while vascular plants were identified following Ciocârlan (2009). Bryophyte nomenclature adheres to Hodgetts et al. (2020), and vascular plant taxonomy follows *Flora Europaea* with updates from the Euro+Med PlantBase. Plant associations were described in accordance with Sanda et al. (2008a; 2008b).

RESULTS AND DISCUSSIONS

The Avrig peat bog is situated in Sibiu County at 405 m a.s.l. (45.716282°N, 24.400133°E). Ecosystem evaluation during restoration confirmed the presence of species and habitats protected under Council Directive 92/43/EEC (1992). Based on field surveys and drone-based assessments, the area encompassing species and habitats of European interest was delineated. Consequently, the 3.6 h area (Figure 1) was proposed as a new Natura 2000 site, "Mlaștina Avrig" (Avrig Peat bog), aligning with the 2020 Eu State Nature Report emphasis on conservation and biodiversity assessment.

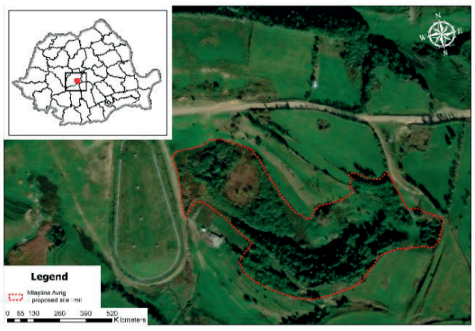

Figure 1. The area of Avrig Peat bog - new NATURA 2000 site proposal

The proposal received official endorsement from Avrig City Hall and the Sibiu Environmental Protection Agency, and has been submitted to the Ministry of Environment, Waters and Forests for final approval. The most ecologically significant area is located at the center of the site - an oligotrophic habitat characterized by acidophilic plant communities and dominated by typical *Sphagnum* species (Figure 2).

This zone corresponds to the EU priority habitat "Active Raised Bogs" (habitat code 7110), covering approximately 1 hectare. The dominant taxa within this habitat belong to the *Sphagnum magellanicum* complex (Figure 3).

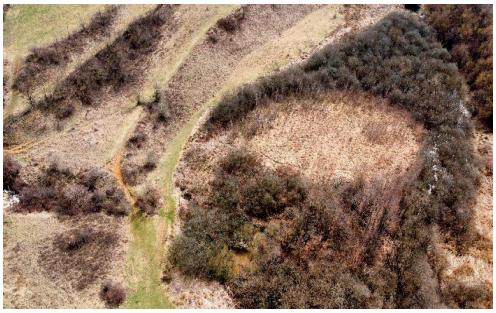

Figure 2. Avrig Peat bog - drone image.
The *Sphagnum* area is an open area surrounded by forest trees (13.03.2025)

Recent taxonomic revisions have limited the distribution of *Sphagnum magellanicum* Brid. to South America, with all previous European occurrences now attributed to either *Sphagnum medium* Limpr. or *S. divinum* Flatberg & K. Hassel (Hassel et al., 2018). Within the Avrig Peat bog, *S. medium* (Figure 4) was recently documented and formally reported as a new record for the Romanian flora (Tomović et al., 2024), highlighting the site's significance for bryological diversity and biogeographical research.

The plant association characterizing this habitat is *Sphagnetum magellanici* (Malcuit, 1929) Kästner et Flösner, 1933. Dominant bryophyte species include *Sphagnum medium* Limpr., *S. divinum* Flatberg & K. Hassel, and *S. palustre* L. (Figure 5). These are accompanied by a diverse assemblage of other *Sphagnum* species, notably *S. angustifolium* (Russow) C.E.O. Jensen (Figures 3 and 6), *S. girgensohnii* Russow, *S. capillifolium* (Ehrh.) Hedw., *S. fallax*

(H. Klinggr.) H. Klinggr. var. *fallax* (Figure 6), and *S. russowii* Warnst. Additional bryophytes recorded include *Polytrichum strictum* Menzies ex Brid. and *Aulacomnium palustre* (Hedw.) Schwägr., further enriching the site's moss flora and underscoring its ecological complexity.

Figure 3. *Sphagnum* species (*S. divinum* - red plants and *S. angustifolium* - geen and yellow plants) from Avrig Peat bog (Photo: Ștefănuț M.-M., 18.11.2022)

Figure 4. *Sphagnum medium* from Avrig Peat bog (Photo: Ștefănuț M.-M., 18.11.2022)

Figure 5. *Sphagnum palustre* from Avrig Peat bog (Photo: Ștefănuț M.-M., 18.11.2022)

Figure 6. *Sphagnum angustifolium* and *Sphagnum palustre* in the bottom right corner (Photo: Ștefănuț M.-M., 18.11.2022)

Among the characteristic vascular plants of peatland ecosystems identified at the site were *Drosera rotundifolia* (Figure 7), *Eriophorum vaginatum* L., and *E. gracile* W.D.J. Koch ex Roth. These species are indicative of acidic, oligotrophic conditions and are commonly associated with well-preserved raised bog habitats.

The site is also ecologically significant due to the presence of the priority habitat *Depressions on peat substrates of the Rhynchosporion* (habitat code 7150). This habitat includes plant assemblages characteristic of the *Sphagno cuspidati–Rhynchosporion albae* Osvald 1923 em. Koch 1926 association. Notable species within this community include *Sphagnum angustifolium*, *S. fallax* var. *fallax*, *Aulacomnium palustre*, *Epipactis palustris* (L.) Crantz, *Eriophorum angustifolium* Honck., *Menyanthes trifoliata* (Figure 8), *Comarum palustre* L. (Figure 9), and *Lysimachia thyrsiflora* L.

The peat bog is encircled by a broad, marshy, eutrophic zone dominated by woody species such as *Salix caprea* L., *Betula pendula* Roth, *Alnus glutinosa* (L.) Gaertn., and *Rhamnus frangula* L. The herbaceous and bryophyte layer comprises a diverse mix, including *Phragmites australis* (Cav.) Trin. ex Steud., *Typha angustifolia* L., *Carex acutiformis* Ehrh., *C. rostrata* Stokes, *Equisetum fluviatile* L., *Thelypteris palustris* Schott, *Alisma plantago-aquatica* L., *Menyanthes trifoliata*, *Caltha palustris* L., *Sphagnum fallax* var. *fallax*, *S. angustifolium*, *S. centrale* C.E.O. Jensen, *Aneura pinguis* (L.) Dumort., *Atrichum*

undulatum (Hedw.) P. Beauv., and *Brachythecium rutabulum* (Hedw.) Schimp.
This zone corresponds to the plant association *Salici cinereae–Sphagnetum recurvi* (Zólyomi 1931) Soó 1954. It is important to note that *Sphagnum recurvum* sensu stricto has recently been confirmed only in the Azores (Dias et al., 2009); in most European contexts, this name refers to a complex comprising *Sphagnum flexuosum* Dozy & Molk., *S. fallax*, and *S. angustifolium* (Hodgetts et al., 2020).

Figure 7. *Drosera rotundifolia* from Avrig Peat bog (Photo: Ștefănuț S., 27.07.2016).

Figure 8. *Menyanthes trifoliata* from Avrig Peat bog (Photo: Ștefănuț S., 27.07.2016)

Figure 9. *Comarum palustre* from Avrig Peat bog

In stagnant water zones within the peatland, an additional carnivorous plant, *Utricularia* sp., was observed, alongside notable herpetofauna of conservation concern. These include the European tree frog (*Hyla arborea*, Linnaeus, 1758) and the European fire-bellied toad (*Bombina variegata*, Linnaeus, 1758), both listed under the annexes of the EU Habitats Directive (Council Directive 92/43/EEC, 1992).
Under the PeatRO2 project, restoration efforts at the Avrig Peat bog targeted the removal of invasive wood vegetation and the mitigation of hydrological degradation.
The overarching goal was to reestablish a favourable water regime, thereby promoting the proliferation of characteristic peatland species while inhibiting the spread of invasive vascular plants.
Restoration activities involved several key interventions:
a) *Hydrological Restoration:* the ecological function of the peatland was enhanced by blocking existing drainage channels to restore natural water retention. During the 2016 assessment (PeatRO project), a drainage channel was identified as a significant source of water loss. In 2023, this channel was blocked by constructing a dam, resulting in a water level increase of approximately 25 cm. This intervention successfully maintained soil moisture even during the severe drought conditions of the 2024 summer and autumn seasons (Figures 10 and 11).
b) *Vegetation Management and Peatland Reconstruction:* the ecological reconstruction of the peatland included the manual removal of invasive woody plant species from its central zone. During the 2016 PeatRO project assessment, this core area was found to be heavily colonized by species such as *Betula pendula*, *Alnus glutinosa*, and *Rhamnus frangula*, whose presence was contributing significantly to water loss through elevated evapotranspiration rates (Figure 12).
As part of the PeatRO2 project, in 2022, the central area of the peatland was cleared of woody plant species (Figure 13). The activity was carried out manually by the project team

members, through careful selection of the cut plants.

Figure 10. Blockage of the drain channel (13.03.2025)

Figure 11. Drone image with the drainage channel and the dam (13.03.2025)

Figure 12. The *Sphagnum* area, invaded by woody plants, before restoration
(Photo Bîrsan C.-C., 18.11.2022)

Several ongoing pressures have been identified at the site, including the illegal dumping of household waste and manure, elevated nitrogen input from potential runoff originating at a nearby sheepfold, recurring wildfires, and the encroachment of invasive plant species.
To address these concerns and ensure long-term ecological stability, the area has been integrated into a monitoring program under the sustainability phase of the PeatRO2 project, which extends from 2024 to 2029. Continued efforts will be essential to maintain the peatland in a favourable hydrological state, safeguarding its ecological functions and biodiversity value.

Figure 13. Drone image with the *Sphagnum* area, after restoration (Photo Ștefănuț S., 13.03.2025)

The restoration activities were promoted on the website of the Institute of Biology Bucharest (IBB) and locally, through discussions with locals, local entrepreneurs and the local administration, and by installing an information board at the entrance to the site (Figure 14). The information board provides two links to the dedicated website (RO and EN) via QR codes.

Figure 14. Information panel installed at the site entrance (Photo: Ștefănuț S., 05.07.2024)

In Romania, peat bog restoration is guided by the National Peat Bog Restoration Strategy, developed in 2017 under the PeatRO project. As part of this initiative, 218 peat bogs were assessed for their biodiversity and conservation status, and 80 were selected for restoration. Among these, the 45 most threatened peat bogs were included in the RO-MEDIU Programme - Environment, Climate Change Adaptation, and Ecosystems - funded through the European Economic Area (EEA) Financial Mechanism. These sites were restored between 16 December 2021 and 30 April 2024.

Under the PeatRO2 project, 12 additional peat bogs in Romania were restored, including the Avrig Peat Bog. The structure of this bog, particularly its central area overgrown with woody vegetation, closely resembles that of Mlaca Tătarilor, the pilot restoration site from the original PeatRO project where the feasibility of peat bog restoration in Romania was first tested. Given that Mlaca Tătarilor, restored over eight years ago, shows promising signs of ecological recovery as of March 2025 (Figure 15), it is likely that the restoration of the Avrig Peat Bog will also result in a better-preserved bog habitat. This aspect supports the conservation of the peatland vegetation, in line with a synthesis of evidence for the effects of such restoring interventions (Taylor et al., 2019) and with the monitoring frameworks and best practices outlined in the European Environment Agency`s 2025 Guidebook for Monitoring and Evaluating Ecosystem-based Adaptation Interventions.

Figure 15. Drone image of the restored Mlaca Tătarilor peat bog, originally rehabilitated in 2016 (Photo: Ștefănuț S., 12 March 2025)

CONCLUSIONS

Peat bogs represent a priority conservation target at the European level, and the restoration actions undertaken by the Institute of Biology Bucharest (IBB) align closely with the objectives outlined in the EU Biodiversity Strategy for 2030. These include expanding the protected area network, enforcing strict protection for high-biodiversity-value sites (covering at least 10% of EU land), and ensuring legal protection of a minimum of 30% of EU territory.

The activities implemented at the Avrig Peat bog not only contribute to achieving these strategic goals but also offer a replicable model for future peatland restoration initiatives. As such, this case study holds significant value for informing Romania's forthcoming national restoration plan, to be finalized by 1 September 2026, under the provisions of EU Regulation 2024/1991. The Avrig Peat bog exemplifies how small-scale restorations can contribute meaningfully to continental biodiversity goals.

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