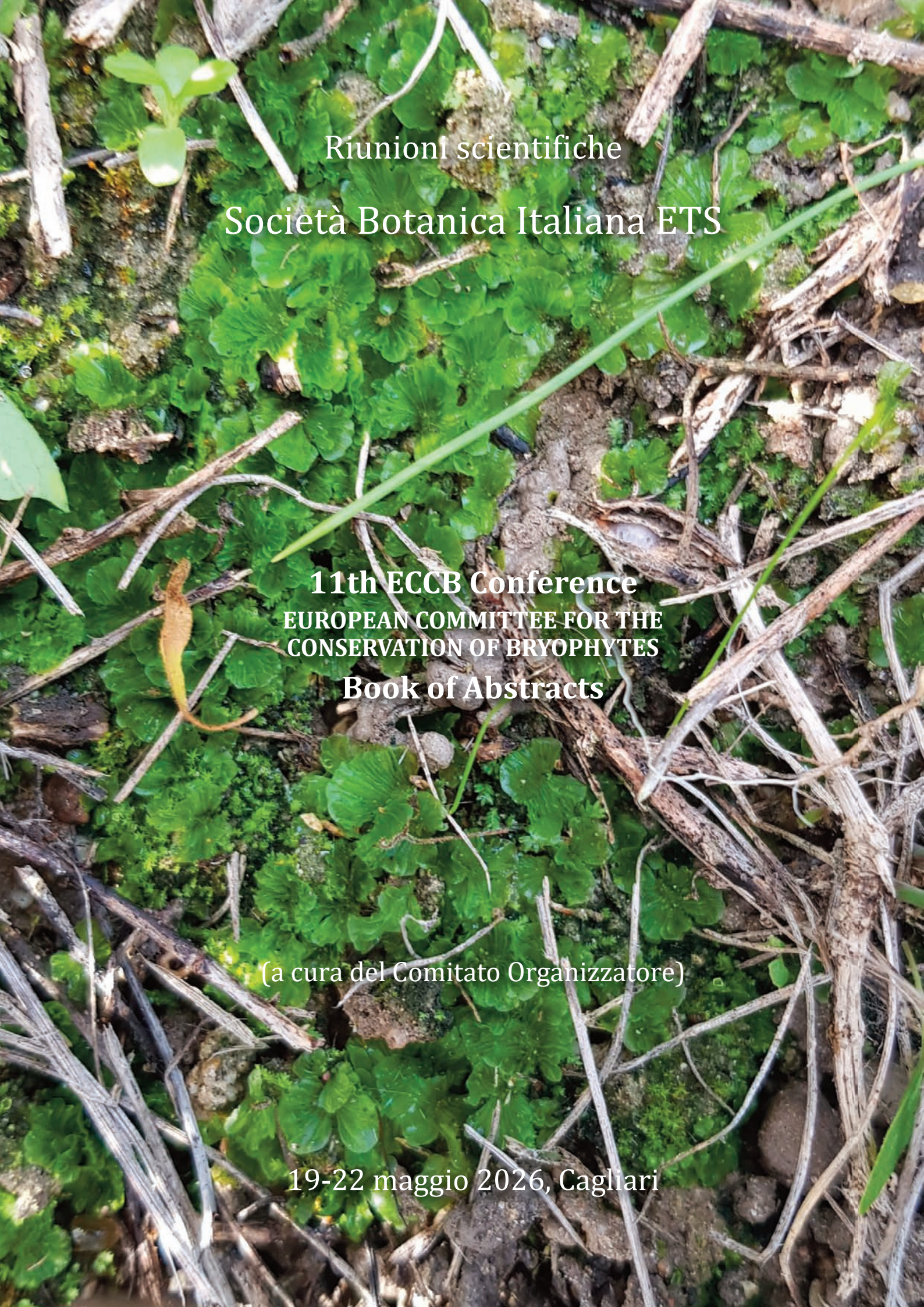


Riunioni scientifiche

Società Botanica Italiana ETS

11th ECCB Conference

EUROPEAN COMMITTEE FOR THE CONSERVATION OF BRYOPHYTES

Book of Abstracts

(a cura del Comitato Organizzatore)

19-22 maggio 2026, Cagliari

In copertina: *Petalophyllum ralfsii* (Wilson) Nees & Gottsche ex Lehm.
Parco Naturale Regionale Molentargius-Saline, Cagliari
foto di Annalena Cogoni

Introduzione

Dal 19 al 22 maggio si è svolta a Cagliari la 11ª Conferenza dell'European Committee for the Conservation of Bryophytes (ECCB), che ha riunito briologi, ricercatori e professionisti della conservazione provenienti da numerosi Paesi europei. L'evento ha rappresentato un'importante occasione di confronto scientifico sui più recenti sviluppi della ricerca briologica e sulle principali sfide legate alla conservazione delle briofite. Attraverso relazioni plenarie, comunicazioni orali, sessioni poster e momenti di discussione, i partecipanti hanno condiviso risultati di ricerca, esperienze e prospettive riguardanti la tassonomia, l'ecologia, il monitoraggio, la valutazione dello stato di conservazione, la gestione degli habitat e le strategie di tutela, sottolineando il ruolo fondamentale delle briofite per la conservazione della biodiversità europea. A conclusione della conferenza sono state organizzate due giornate di escursione in siti di alto valore naturalistico come Giara di Gesturi, il Parco di Laconi e la Foresta del Marganai.

Introduction

From 19 to 22 May, the 11th Conference of the European Committee for the Conservation of Bryophytes (ECCB) was held in Cagliari, bringing together bryologists, researchers, and conservation professionals from numerous European countries. The conference provided an important forum for scientific exchange on the latest advances in bryological research and the major challenges related to bryophyte conservation. Through plenary lectures, oral presentations, poster sessions, and discussion forums, participants shared research findings, experiences, and perspectives on taxonomy, ecology, monitoring, conservation status assessment, habitat management, and conservation strategies, highlighting the fundamental role of bryophytes in preserving Europe's biodiversity. At the conclusion of the conference, two field excursions were organized to sites of outstanding natural value, including the Giara di Gesturi, Laconi Park, and the Marganai Forest.

Scientific and Organising Committee

Annalena Cogoni, Department of Life and Environmental Sciences, University of Cagliari, Italy
Thomas Kiebacher, Stuttgart State Museum of Natural History, Germany
Beáta Papp, Botanical Department of the Hungarian Natural History Museum, Hungary
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Roberta Lai
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Damiana Manca
Eva Meloni Lopez
Anna Di Luca

PROGRAM

Tuesday 19 May

Venue: Aula Magna Baffi (Edificio A – Palazzo Baffi), Via Sant'Ignazio da Laconi, 74

08:30-09:30 Registration

09:30-09:45 Opening ceremony and institutional greetings:

Prof. Enzo Tramontano, Chair of the Department of Life and Environmental Sciences,

Prof. Valentina Onnis, Vice Rector for Student Affairs at our University,

Prof. Michela Marignani, Coordinator of the Bachelor's Program in Natural Sciences

Intro: Annalena Cogoni and Silvia Poponessi – Gruppo di Lavoro per la Briologia of SBI

09:45-10:15 Thomas Kiebacher: ECCB matters and Irene Bisang: IUCN in brief

Session 1: Effects of environmental, including climate, changes on bryophyte diversity

10:15-10:45 KEYNOTE: Adèle Hotermans – European bryophytes under climate change: predicted decline of a lilliputian world

10:45-11:15 Coffee Break Botanic Garden

11:15- 11:35 Giulia Bacilliere – The influence of climate change on the distribution dynamics of Petalophyllum ralfsii in Europe

11:35-11:55 Ariel Bergamini – Current and future distribution of Tayloria rudolphiana in the Alps: implications for conservation

11:55-12:15 Hannah Little – Which bryophytes are most at risk from ammonia? Evidence from UK-scale distribution models

12:15-12:35 Silvia Poponessi – Monitoring environmental quality with epiphytic mosses along an urban-rural gradient in south Tyrol

12:35-12:55 Vedran Šegota – Diversity and vulnerability of bryoflora on four mountain mires (Mt Velebit, Croatia, SE Europe) in the context of climate change

13:00-14:00 Lunch Break Botanic Garden

Session 2-1: Bryophyte conservation: from redlisting to conservation actions

14:00-14:30 KEYNOTE: Irene Bisang & Ariel Bergamini. Bryophyte conservation beyond Redlisting: Which redlisted bryophytes warrant highest conservation priority in Europe and where are they found?

14:30-14:50 Sorin Stefanut – The peatlands restoration in Romania

14:50-15:10 Erzsébet Szurdoki – The impact of nature conservation management on bryophyte layer in Kismohos bog, Kelemér, North Hungary

15:10-15:30 Lars Hedenäs - Behind the scenes – Swedish red-listing practices

15:30-15:50 Miruna-Maria Stefanut: The conservation status of the Sphagnum species in Romania

15:50-16:20 Coffee Break Botanic Garden

Session 2-2: Bryophyte conservation: from redlisting to conservation actions

16:20-16:40 Pere Miquel Mir-Rosselló – Can we correctly assess the conservation status of balearic bryophytes with the available chorological data? A critical revision

16:40-17:00 Nele Ingerpuu – Bryophyte conservation priorities in Estonia

17:00- 17:20 Līga Strazdiņa – Assessment of threat status and habitat pressures on Latvian bryophytes using IUCN criteria

17:20-17:40 Beáta Papp – Is Physcomitrium arenicola Laz. still globally endangered?

17:40-18:10 ECCB General Assembly (election result, future activities, next conference)

Wednesday 20 May

Venue: Aula Magna Bafi (Edificio A – Palazzo Baffi), Via Sant'Ignazio da Laconi, 74

Session 3-1: Bryophyte systematics, diversity and floristics

09:00-09:30 KEYNOTE: Louis Rigaud & Thomas Kiebacher: Exploring intraspecific diversity and differentiation in a conservation framework – insights from Schistidium atrofuscum and S. spinosum

09:30-09:50 Simona Strgulc Krajšek – Students' contributions to the research of bryophyte flora in Slovenia

09:50-10:10 Anna Kartasheva – Integrating environmental DNA (eDNA) approaches for bryophyte monitoring

10:10-10:30 Kristian Hassel – The mountain bryophytes of the Scandinavian peninsula

10:30-10:50 **Speed poster presentation** (3 minutes / poster) Pavel Širka: New findings in the bryophyte flora of Slovakia. Rebecca Vetrani: Contribution to the submerged bryophytic flora and vegetation of the watercourses in the Abruzzo, Lazeio and Molise National Park. Marija Bučar: Hellish landscape – heavenly bryophytes: the bryoflora of Vražji skok (Central Croatia). Ilze Barone: Bryophyte assessment within Latvia's national forest inventory. Alberto Aleffi: The bryophyte diversity in Mediterranean temporary ponds (Habitat 3170* MTP): a critical resource for Salento (Apulia, Italy). Maria Shorohova: Epiphyllous liverworts case studies from old-growth forests in Phia Oac – Phia Den and Kon Tu Rang in Vietnam. Silvia Poponessi: Long-term bryophyte surveys under the Biodiversity Monitoring South Tyrol project (BMS).

10:50-11:20 Coffee Break Botanic Garden

Session 3-2: Bryophyte systematics, diversity and floristics

11:20-11:40 Antun Alegro – Diversity and conservation significance of forest bryophytes in Plitvice lakes national park (Croatia, SE Europe)

11:40-12:00 Kristýna Ratajová – Deadwood microhabitats as refugia for red list bryophytes in old-growth forests

12:00-12:20 Henk Siebel – How to deal with forgotten bryophyte diversity in conservation?

Workshop

12:20-13:00 Beata Papp and Irene Bisang - Conservation actions and monitoring in Europe: Exchange of best-practrice and potential coordination

13:00-14:00 Lunch Break Botanic Garden

Session 3-3: Bryophyte systematics, diversity and floristics

14:00-14:20 Martina Pöltl – Riccia and beyond: updated bryophyte records from northern Sardinia

14:20-14:40 Alix Milis – Towards the automatized identification of moss species from their spore morphology

14:40-15:00 Christian Berg – New identification keys in the book project 'Moosflora von Österreich' (bryophyte flora of Austria)

15:00-15:20 **Speed poster presentation** (3 minutes / poster) Rayna Natcheva: 20 Years later: Towards a new bryophyte Red List of Bulgaria – Preliminary reevaluation of liverworts and hornworts. Mingai Li: Arsenic tolerance in the snake liverwort, Conocephalum salebrosum. Anja Rimac: Bryophyte

diversity of Mediterranean semi-natural habitats: New national records and ecological patterns from Rt Kamenjak (Croatia). Iti Jürjendal: Challenges of growing of bryophytes in artificial environment: lessons from greenhouse experiment. Beata Cykowska-Marzencka: Rediscovery of historic sites of Oreoweisia torquescensand Oreas martiana, two endangered mosses in Switzerland through the establishment of local action plans.

15:30-16:00 Coffee Break Botanic Garden

Session 4: Bryophyte experimental biology

16:00-16:20 Belén Albertos – From spores to survival: evaluating bryophyte spore longevity for effective conservation

16:20-16:40 Claudio Varotto – Development of sex-specific DNA-markers and their application to conservation of liverworts

16:40-17:00 Christina Campbell – In vitro investigation of the copper requirements of the endangered liverworts *Cephaloziella nicholsonii* Douin and *C. massalongoi* (Spruce) Müll.Frib.

17:00-17:20 Beata Zimowska – Fungal endophytes supporting bryophyte resilience and biodiversity conservation: insights from Marchantia polymorpha

17:20-17:40 Julie Steffen – Roof greening and bryophyte promotion in Geneva city, Switzerland

17:40-18:00 Introduction to the excursion

20:30 Congress Social Dinner

Thursday, May 21

Excursion to Giara Park (3170* Mediterranean temporary ponds) and Laconi Park [7220* Petrifying springs with tufa formation (Cratoneurion)]

Friday, May 22

Excursion to Marganai Forest

ORAL PRESENTATIONS

From spores to survival: evaluating bryophyte spore longevity for effective conservation

B. Albertos, A. Ruzic, R. Garilleti, F. Lara, D. Ballesteros

Bryophytes are among the most threatened plant groups in Europe, yet key life-history traits influencing their conservation, such as spore longevity, remain insufficiently quantified. Spore persistence underpins dispersal potential, soil spore bank dynamics, and the feasibility of *ex situ* conservation through spore banking. OBJECTIVES: This study tested the hypothesis that bryophyte spores are relatively long-lived and assessed whether longevity varies among species and according to spore maturity, with implications for conservation management. A standardized accelerated ageing protocol commonly applied to seeds was used for the first time on spores of four moss species with contrasting ecological strategies. Spores were exposed to 45 degrees Celsius and 60 percent relative humidity, and viability decline was modelled using probit analysis to estimate the time required for viability to fall to 50 percent. In addition, spores of one species were stored under dry conditions at 15 percent relative humidity and 20 degrees Celsius to evaluate natural longevity and the effect of maturity stage. All species exhibited short longevity under accelerated ageing, with time to 50 percent viability ranging from 0.4 to 5.7 days. Under dry storage, longevity increased but remained limited, ranging from 58 to 150 days, with fully mature spores surviving significantly longer than immature ones. Compared with seeds and fern spores tested under similar conditions, bryophyte spores showed markedly lower persistence. The limited longevity observed suggests that many bryophytes may have restricted capacity to form persistent spore banks, particularly epiphytic species occupying unstable substrates. For conservation, rapid viability decline under standard storage conditions indicates that spore banks require frequent monitoring and that cryogenic storage may be preferable for long-term ex situ preservation. Understanding intrinsic variation in spore longevity is therefore essential for improving both *in situ* and *ex situ* conservation strategies for bryophytes.

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Diversity and Conservation Significance of Forest Bryophytes in Plitvice Lakes National Park (Croatia, SE Europe)

A. Alegro, A. Rimac, V. Šegota

This research presents the results of a comprehensive survey and monitoring of forest bryophytes in Plitvice Lakes National Park conducted between 2021 and 2023. The study aimed to assess bryophyte diversity across different forest communities and to monitor two Natura 2000 species: *Buxbaumia viridis* and *Dicranum viride*. Field investigations covered a range of forest types within the Park, including spruce forests, mixed beech-fir forests, pure beech stands, thermophilous forests with hop-hornbeam, Scots pine forests, alder forests, and willow scrub communities. These diverse forest ecosystems provide a variety of microhabitats, such as forest soil, rocks, living tree bark, and particularly deadwood, which significantly contribute to bryophyte diversity. A total of 132 bryophyte taxa were recorded (22 liverworts and 110 mosses), confirming the high diversity of forest bryophytes in the Park. Special attention was given to bryophytes growing on decaying wood, which represent an ecologically important group associated with nutrient cycling, water retention, and forest regeneration processes. Species characteristic of dead - wood habitats were frequently recorded, highlighting the importance of well-preserved forest structure and sufficient quantities of decomposing logs and stumps. *Buxbaumia viridis* was recorded in most surveyed grid cells in beech-fir and spruce forest, primarily on well-decayed spruce and fir logs in humid, shaded forest stands. Its occurrence is strongly linked to advanced stages of wood decomposition and stable microclimatic conditions. *Dicranum viride*, a rare epiphytic moss at the southern margin of its European distribution, was confirmed at very limited localities, mainly on old beech trees in structurally preserved forest stands. The presence and population trends of these species indicate a high degree of forest naturalness, continuity, and ecological stability within Plitvice Lakes National Park.

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The influence of climate change on the distribution dynamics of *Petalophyllum ralfsii* in Europe

G. Bacilliere, M. Puglisi, D.P. Božović, M. Sabovljević

The impacts of global change are increasingly evident across ecosystems; nevertheless, yet small and often overlooked components of biodiversity remain underrepresented in climate-impact assessments. Among these, *Petalophyllum ralfsii* (Wilson) Nees & Gottsche, a liverwort of high conservation value, deserves particular attention. The species, listed in Annex II of the 92/43/EEC Habitats Directive, is linked to lowland coastal habitats, mostly calcareous sand dunes, vulnerable to climatic and anthropogenic pressures. Rising temperatures, combined with intensifying human disturbance, are expected to profoundly alter the ecological conditions underpinning the persistence of this species and potentially threatening its long-term survival. In this study, Species Distribution Modelling (SDM) was employed to evaluate future changes in habitat suitability for *P. ralfsii* across Europe under projected climate change. Model projections were developed for two Shared Socioeconomic Pathways (SSP2-4.5 and SSP5-8.5) and two future time windows (2040-2060 and 2080-2100). Under the intermediate emission scenario (SSP2-4.5), results indicate a moderate contraction of suitable areas, with estimated habitat loss ranging between 6% and 13%. Conversely, simulations based on the high-emission scenario (SSP5-8.5) reveal a dramatic decline in habitat availability, with reductions approaching 50% by the end of the century. Overall, the projected trends suggest a pronounced shrinkage and spatial fragmentation of suitable environments for *P. ralfsii*, increasing the risk of regional extinction. By highlighting the sensitivity of a specialized bryophyte to future climatic conditions, this study underscores the necessity of incorporating predictive distribution modelling into conservation planning, particularly for ecologically significant taxa threatened by accelerating environmental change.

AUTHORS

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New identification keys in the book project 'Moosflora von Österreich' (Bryophyte Flora of Austria)

C. Berg, M. Pöltl, T. Kiebacher

Due to new research findings in bryophyte systematics, old identification characteristics that grouped families and genera together are often no longer applicable. The identification keys in our book project "Moosflora von Osterreich" have therefore not only been redesigned in many cases but are also purely feature-oriented and thus artificial. This applies most clearly to the basic key. Although this reduces the taxonomic learning effect of identification keys, it may generally increase their accuracy. There is at least one learning effect in that the current names are used and the new systematics are reflected in the structure of the entire book. Occasionally, however, newly split genera have also been grouped together in the traditional sense because there are no good common characteristics of the modern genera. The lecture will focus separately on several genera whose keys differ from those found in traditional identification guides. Examples include the genera *Scapania*, *Gymnomitrium* / *Marsupella*, *Riccia*, *Encalypta*, *Dicranum*, *Oncophorus* / *Brideliella* / *Symblepharis*, *Gymnostomum* / *Hymenostylium*, *Molendoa*, *Tortella*, *Schistidium*, *Lewinskya* and *Rhynchostegiella*. Another factor contributing to the success of identification is that we have photographed important characteristics at each stage of the identification process. Since approximately 58% of all European mosses occur in Austria, these keys contribute to improving knowledge of the European bryophyte flora beyond Austria's borders.

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Current and future distribution of *Tayloria rudolphiana* in the Alps: Implications for conservation

A. Bergamini, M. Peintinger, P. Brun, T. Moser, T. Kiebacher

Climate change is predicted to have considerable impacts on biodiversity. In the Alps, impacts may be even larger than in many other regions, as temperatures there have risen twice as fast as the global average. Here, we focus on the moss *Tayloria rudolphiana*, a rare, threatened, near-endemic species of high conservation concern in Europe. It is the only European species of Splachnaceae growing epiphytically, mostly on old sycamore maples (*Acer pseudoplatanus*) in wooded pastures. Its distribution is limited to the northern Alps (mostly 1000–1600 m) in areas with high precipitation and low temperatures.
To better characterise its distribution, we compiled all available presence-absence data across the European Alps and used these to model the current range and, given its narrow elevational band, its future potential distribution under different climate change scenarios. Models based on present-day conditions performed very well (AUC 0.93–0.977). Spatial predictions identified large parts of both the northern and southern Alps as suitable, although in the southern Alps the species has so far never been found. In some of the suitable regions in the northern Alps where *T. rudolphiana* has not been known from, there have already been intensive searches for the species, but without success. The mismatch between modelled habitat suitability and known absences strongly suggests dispersal limitation, consistent with earlier hypotheses. Future projections depend strongly on emission scenario and general circulation model. The most optimistic predictions show little change, while the most pessimistic suggest no suitable habitat will remain in the Alps by 2070. Intermediate scenarios indicate that parts of the current range will persist as refugia while higher-elevation sites become newly suitable. For the long-term conservation of *T. rudolphiana*, priority should be given to both these refugial and emerging areas, where targeted measures such as sycamore planting can ensure habitat continuity and facilitate future range expansion.

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Bryophyte conservation - beyond Redlisting: Which redlisted bryophytes warrant highest conservation priority in Europe and where are they found?

I. Bisang, A. Bergamini

The latest IUCN Red List of European bryophytes assessed 22% of the species as threatened (CR, EN, VU) and 10% as Near-Threatened (NT). Limited economic and human resources require prioritisation to efficiently safeguard bryophyte diversity. We used two independent criteria to define conservation priorities: i) Red List status in Europe; ii) European population relative to global population size, or global rarity, respectively. We assigned a quantitative score for each criterion separately to each of the 553 threatened and NT species and calculated their sum as the "Priority Score for conservation". Applying distinct thresholds to the Priority Scores yielded 135 (24%) species of high, 126 (23%) of medium, and 292 (53%) of low conservation priority. Areas with oceanic climates and mountainous regions harbour many high-priority species and endemics. More than 90 species occur in only one European country, implying high responsibility for the countries concerned. Occurrences of all scored threatened and NT, and additional 115 endemic species, together with their Priority Scores, are freely available per individual European country or territory. ECCB recommends to use the priority ranking for national conservation strategies. We further developed a tool to identify "Important Bryophyte Areas", using c. 100,000 geo-referenced records for 500 threatened, NT or endemic species. Each record was assigned species-based attributes of Red List status, relative population size and Priority Score. We generated spatial density surfaces exploring different weightings of attributes by applying a Gaussian kernel density function. We finally present Important Bryophyte Areas using three selected weighing schemes based on the attributes. Important Bryophyte Areas and Priority Scores will assist national agencies and conservationists to direct resources to conservation actions for bryophytes species and relevant areas whose persistence in Europe is critical from a global perspective. By using reproducible and transparent approaches, our tools are open to updates.

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In vitro investigation of the copper requirements of the Endangered liverworts *Cephaloziella nicholsonii* Douin and *C. massalongi* (Spruce) Müll.Frib.

C. Campbell, D.L. Kelly, N. Smyth, N. Lockhart, D.T. Holyoak, D. Long

In addition to acting as a repository for rare and threatened species and their genetic diversity, *ex situ* conservation collections and techniques, such as in vitro cultivation (tissue culture), can be used to investigate life history traits and nutrient requirements. Many rare specialised bryophyte species have adapted to metal-rich soil habitats, such as those found at former copper, lead and zinc mine sites, which are toxic to most other plant species. Some of the bryophyte species found in this habitat are facultative metallophytes and others are regarded as strict metallophytes, the so-called 'copper mosses'. It is a general assumption in the literature that the liverworts *Cephaloziella nicholsonii* and *C. massalongi*, both categorised as Endangered on the IUCN Red List for Europe, are also strict metallophytes and obligate copper bryophytes. This in vitro cultivation experiment investigated the growth and gemma production of these two species from different sites in Ireland and Britain on treatment plates of 0 ppm, 3 ppm, 6 ppm, 12 ppm, 24 ppm, 48 ppm and 96 ppm copper. Results show that elevated copper is not an obligate requirement for optimum growth. Differences in response to the copper treatment levels among populations from sites with varying soil copper levels, evident within both species, could possibly be due to ecotypic variation. The results have implications for the species' conservation and highlight the need for a taxonomic revision of the *Cephaloziella* genus.

AUTHORS

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The mountain bryophytes of the Scandinavian Peninsula

K. Hassel

The Scandinavian Peninsula is characterized by the Scandes mountain range running northsouth. During the last glacial maximum, 29-19 000 years ago, the region was nearly completely covered with ice. Most species must therefore have recolonized the area when the ice retreated. Today the Scandinavian bryophyte flora consists of about 1 280 species, and about 20% have their main distribution in the mountains above the tree line. Based on the current distribution patterns for the mountain bryophytes of Scandinavia we explore the importance of different routes of recolonization. What is the contribution of species recolonizing from the south, east, southwest and the Arctic after the retreat of the ice after the last glaciation? What are the signs of long-distance dispersal? Most of the Scandinavian mountain bryophytes have a wide distribution, we find 79%, 77%, 68%, 53% in common with eastern, Arctic, central European and southwestern areas, respectively. Five species are not found in any of the regions and have probably arrived by long distance dispersal. One species is currently considered as a Scandinavian endemic.

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Behind the scenes - Swedish red-listing practices

L. Hedenäs

In Sweden, red lists are revised every five years. The red-listing work is performed by organism-specific expert committees and is coordinated by the SLU Swedish Species
Information Centre in Uppsala. The red lists are based on the IUCN criteria - for bryophytes with organism-specific adaptations. Background information on Swedish habitats and their changes is centrally gathered by the Swedish Species Information Centre based on statistical data, inventories, and scientific publications. All expert committees use the same methodology and share the same background information. I will here discuss how the Swedish expert committee for bryophytes, currently with eight members, evaluated important parameters in the process leading to the latest red list. To define species' generation lengths and to define (mature) individuals was relatively easy, following bryophyte-specific recommendations. How to handle criteria like severe fragmentation and extreme fluctuations was more demanding, considering our limited knowledge of important aspects of bryophyte biology. Finally, we often had to estimate the 'true' population sizes of species and to predict future population trends based on indirect evidence. The evaluation work itself was finished during 2025, and the newest Swedish red list will be published in April 2026.

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European bryophytes under climate change: predicted decline of a Lilliputian world

A.F. Hotermans, B. Albertos, I. Bisang, T.L. Blockeel, J.A. Calleja, P. Campisi, J. Celle, A. Cogoni, I. Draper, N. Garcia, R. Garilleti, L. Hedenäs, N. Hodgetts, V. Hugonnot, D.N. Karger, T. Kiebacher, J. Kučera, F. Lara, J. Lembrechts, J. Lenoir, A. Mežaka, R. Natcheva, B. Papp, L. Sparrius, H. Zechmeister, A. Vanderpoorten, F. Collart

Bryophytes, the second most diversified lineage of land plants, have long been identified as the canaries in the coal mine of climate change, but a comprehensive assessment of future climate change impacts on their distribution and diversity is still missing. We compiled a database of >2,900,000 occurrences for 1664 (93%) species across Europe to calibrate species distribution models at 100 m resolution and project them onto 2071-2100 climate layers under several scenarios of global warming. We demonstrate that the moderate impact of climate change in terms of net suitability outcome across species and biogeographical regions masks significant variations among regions, and most importantly, contrasting trends among species within these regions. The Arctico-Alpine and Boreal biogeographical regions are predicted to undergo the highest loss of mean suitability driven by an average loss of 12 to 67% of climatic suitability for cold-adapted species and a suitability increase of no less than 13 to 533% for warm-adapted southern species, of which 37 and 74%, respectively, are not currently present within the Arctico-Alpine and Boreal regions. Our results thus do not necessarily point to a huge impact of climate change on habitat suitability, but to a risk of increased competition for already vulnerable northern species with allochthonous southern species. The present results open the door to the identification of areas important for conservation under present and future conditions to provide conservation guidelines in European bryophytes, wherein one third of species is threatened or near threatened by extinction.

AUTHORS

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Bryophyte conservation priorities in Estonia

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The list of Estonian bryophytes contains 621 species; 158 species of them are evaluated as threatened and 65 species as near threatened. Altogether 45 bryophyte species are under state protection in Estonia. There are three protection categories, but only the strictest category ensures the species conservation on the whole territory. Three bryophyte species belong to this category in 2026.
To give a perspective of the bryophyte conservation in Estonia we analysed the distribution, state of protection and future protection possibilities of those species that have European conservational priority according to Bisang et al. 2025.
Altogether 60 species of European conservation priority are recorded in Estonia; eleven of these belong to the medium and high priority categories. At present only nine species of all and two of higher priority categories are under state protection.
Most protected species are monitored in Estonia. The evaluation basis is the count of individuals. The monitoring results show that the number of individuals of some species stay on the same level, but some are declining. For example, *Bryum marratii* and *Fissidens arnoldii,* that are of high and medium conservation priority in Europe, have stable populations in Estonia, while populations of the low priority species *Enclaypta mutica* and *Hamatocaulis vernicosus* are declining.
Since a number of medium and high priority species are not under protection locally, we consider it necessary that the list of species in Habitats Directive should be updated with the highly prioritized species to justify their inclusion into conservation acts at country level.

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Integrating Environmental DNA (eDNA) Approaches for Bryophyte Monitoring

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Assessing bryophyte diversity is often constrained by survey effort and imperfect detectability, particularly in habitats such as the canopy. Environmental DNA (eDNA) is genetic material released by organisms and recovered from environmental samples, which offers opportunities to partly overcome these limitations, yet applications to bryophytes remain scarce. Within a multitaxon framework, we explore the effectiveness of airborne eDNA sampling strategies for monitoring bryophytes by comparing these novel methods to traditional field surveys. We will analyse two sampling substrates deployed at the same sites in Germany: readily available preservative ethanol from Malaise traps collected in an ongoing insect monitoring programme, and passive airborne spore traps. For the traditional approach we will conduct bryophyte surveys in a nested design around each trap. This is a part of a larger scale project aiming to assess vascular plants, fungi, lichens and insects alongside bryophytes. As an initial result we developed extraction protocols and custom bryophyte-specific primers to optimise detectability in both sample types, and evaluated the current gap in internal transcribed spacer 2 (ITS2) reference coverage for the regional bryophyte species pool. As this is a key bottleneck of eDNA studies, we intend to fill this knowledge gap for common local species. We will then proceed with metabarcoding and taxonomic assignment against quality-checked reference datasets. Our goals are to quantify the overlap of the eDNA approach with the local and regional species pools detected using traditional surveys and evaluate how detection bias correlates with species traits and functional groups, as well as testing the suitability for monitoring species of conservation concern and neobiota.

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Which Bryophytes Are Most at Risk from Ammonia? Insights from Distribution Models Across Great Britain

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Atmospheric ammonia (NH_3) is an important but often overlooked component of nitrogen pollution, contributing to eutrophication and alkalisation of sensitive habitats. Bryophytes are particularly vulnerable to elevated NH_3 concentrations because, as non vascular plants, they lack a protective cuticle and absorb nutrients directly from atmospheric inputs. Many bryophyte species, especially rare and specialist taxa, are associated with nutrient poor environments and may therefore be disproportionately affected by increasing ammonia exposure. Bryophyte distributions are also affected by other factors such as temperature, precipitation, land cover and land use. Therefore, separating the effects of atmospheric NH_3 from other environmental drivers is essential for understanding patterns in bryophyte distribution. This study assessed the factors driving the distributions of 767 species of bryophytes across Great Britain and sought to separate the effects of atmospheric NH3 concentrations on these species' distributions. Records of bryophyte occurrences from the British Bryological Society (for years 2010–2020) were combined with spatial data on environmental conditions, including estimated NH_3 concentrations from the EMEP4UK atmospheric chemistry transport model (a UK scale model of air pollution and deposition), along with climate and land cover data. To place species responses in an ecological context, results were examined in relation to Hill environmental indicator scores, including fertility (N) and alkalinity (R). Nitrogen sensitive species showed stronger negative associations with increasing NH_3 concentrations, while more nitrogen tolerant species were generally less affected. Selected examples of rare and common species illustrate contrasting responses to ammonia gradients. This work highlights atmospheric NH_3 as a significant pressure on nitrogen sensitive bryophytes and helps to identify which species may benefit most from ammonia reductions.

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Towards the automatized identification of moss species from their spore morphology

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Background: Automatized species identification tools have massively facilitated plant identification. In mosses, spore ultrastructure appears to be a promising taxonomic character, but has been largely underexploited. Here, we test artificial intelligence-based approaches to identify species from their spore morphology. In particular, we determine whether the number of spores, their polarity, and variation among populations and capsules affect model accuracy. Methods: Scanning electron microscopy spore images were generated for five capsules of five populations in ten species. Convolutional neural networks with a highly modularized architecture (ResNeXt) were trained to identify the species, population and capsule of origin of a spore. The training set was progressively sub-sampled to test the impact of sample size on model ac~ curacy. To assess whether variation in spore morphology among populations affected model accuracy, one population was successively removed to test a model trained on the four remaining populations. Key Results: Species were correctly identified at average rates of 92 %, regardless of polarity. Model accuracy decreased progressively with decreasing sample size, dropping to about 80 % with 15 % of the initial dataset. The population and capsule of origin of a spore was retrieved at rates >75 %, indicating the presence of diagnostic population and capsule markers on the sporoderm. Strong population structure in some species caused a substantial drop of model accuracy when model training and testing was performed on different populations Conclusions: Spore morphology appears to be an extremely promising tool for moss species identification and may usefully complement the suite of morphological characters used so far in moss taxonomy. The presence of spore diagnostic features at the population and capsule level raises substantial questions on the origin of this structure, which are discussed. Substantial infraspecific variation makes it necessary, however, to train an automatized identification tool from a range of populations and capsules.

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Can we correctly assess the conservation status of Balearic bryophytes with the available chorological data? A critical revision

P.M. Mir-Rosselló, L. Sáez

The Balearic bryophytic flora is considered highly known and studied. However, most chorological works have been elaborated after occasional visits by researchers from outside the archipelago. This supposes a limitation for correctly assessing the regional conservation status of many bryophyte species, especially when only old records are available. Here, we present a preliminary analysis considering the 60 threatened bryophyte species present in the Balearic Islands. We compiled the available recollection date of all the published records of these species and noted if any of the records were posteriorly confirmed. We also compared our data with different traits to check if there was a temporal bias of the records. More than 75 % of the threatened species are perennial, and around 60 % of the total can be identified with only vegetative structures. Moreover, more than half of the published records were collected between January and June, which is the optimal period for bryophyte development and sexual reproduction in the Balearic archipelago. This confers a high degree of reliability to these records. However, most records are at least 10 years older than the regional Red List and have not been confirmed recently. This shows a lack of field work over the last decades. Although (considering the previously indicated traits) most threatened species should be easily detected and monitoring programs could be initiated. However, this may be different for rare and nearly threatened species, where more ephemerals are included. In the future, we plan to revise all the herbarium specimens available for Balearic species to deepen in this issue, after which we expect to better understand a potential temporal bias for rare ephemeral species. This would allow a better assessment of management and conservation plans, more focused on highly threatened species.

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Is *Physcomitrium arenicola* Laz. still globally endangered?

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Physcomitrium arenicola Laz. was described by Andrey S. Lazarenko from saline areas of the Ukrainian steppes in 1928. It is considered endemic to Eastern Europe and was evaluated as endangered on the IUCN Red List in 2019, both globally and in Europe. It is morphologically very similar to *Entosthodon hungaricus* (Boros) Loeske described by Ádám Boros from Hungary in 1924 and shares the same habitat. The main distinctive morphological differences are found on the sporophytes: the size and wall thickness of the exothecial cells of the capsule, and the size and shape of the spores. In the last years, field survey carried out in saline grasslands in Slovakia revealed specimens of Ph. arenicola. This unexpected finding stimulated a revision of herbarium specimens deposited at the Hungarian Natural History Museum (BP) previously identified as *E. hungaricus*. After examining 244 specimens of *E. hungaricus* deposited in the Bryophyte Collection of HNHM (BP), 53 specimens were found to be *P. arenicola* and 31 specimens partially contained this species. All in all it was present in 34.4% of the *E. hungaricus* specimens, suggesting it is not that rare in the Pannonian region. The earliest proven specimens were collected in Hungary in 1926 and in Austria in 1927, and there are also several recent collections from the last 25 years. In addition, in the Bryophyte Collection of HNHM, specimens were found from Greece, Moldova, Romania, and Serbia. This species is not only red-listed globally, but also highly prioritized in species conservation in Europe. The new records significantly extend its distribution westwards and overall known distribution range. Based on new data and knowledge on its habitats and ecology, the risk of extinction is expected to be significantly reduced in a new assessment. However, prior to that, additional data on its distribution, biology and ecology are needed.

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Riccia and Beyond: Updated Bryophyte Records from Northern Sardinia

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Sardinia is known as a hotspot for *Riccia* species in the Mediterranean region of Central Europe. Nearly every European species of the genus has been found on this island. In the late 1970's Susanne Jovet-Ast and Helene Bischler already undertook field trips to Sardinia to study the liverwort flora. In their footsteps, we revisited some of their study sites in the north of the island in 2025 and made additional field trips to further bryological interesting localities between Sassari and Olbia. For each of the 27 localities investigated by us we conducted a separate species list. In total, we observed 227 taxa, including eleven *Riccia* species. The mosses *Entosthodon mouretii, Isothecium holtii*, and *Lewinskya fastigiata* are not included in the updated Italian checklist from 2023, but could be found during our trip. New for Sardinia we could name *Campylopus subulatus, Leptobarbula berica, Trichostomopsis umbros*a and *Vinealobryum nicholsonii*. 12 bryophyte species could be approved after more than 50 years according to the checklist. The collected *Riccia* plants helped to get a better understanding in the group of *Riccia bicarinata-beyrichiana-michelii* and are incorporated in our ongoing phylogenetic studies on the genus. A publication of the findings of this survey is in progress.

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Monitoring environmental quality with epiphytic mosses along an urban-rural gradient in South Tyrol.

S. Poponessi, R. Dellavedova, A. Aleffi, U. Tappeiner, A. Hilpold

Within the Biodiversity Monitoring South Tyrol (BMS) program, two research lines have been initiated for the first time that employ epiphytic bryophytes to calculate the Index of Atmospheric Purity (IAP). Data are collected along transects crossing 32 urbanized settings and 32 forested areas, enabling comparisons along an urban-rural gradient. Field sampling follows a standardised protocol within each BMS site. Three suitable trees are selected for each site to minimise the confounding effects of the microenvironment. The resulting presence/absence, abundance and richness data are used to calculate numerical values that classify sites into seven categories of increasing environmental naturalness when compared with a reference scale. The main European law on air quality is Directive 2008/50/EC, implemented in Italy through Legislative Decree 155/2010 and later updates. It sets rules for assessing and managing air quality, including monitoring, reporting, and action plans for critical situations. The directive also recognizes the value of complementary tools such as bioindicators. In this context, bryophytes are especially useful because they absorb and accumulate pollutants, particularly trace metals. This makes it possible to obtain a time-integrated view of air pollution and to identify spatial differences and potential hotspots with good resolution. The methodology was employed to obtain a time-integrated perspective on air pollution in South Tyrol.

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Deadwood microhabitats as refugia for Red List bryophytes in old-growth forests

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Old-growth forests are biodiversity hotspots for many groups of organisms, including bryophytes. Epixylic bryophytes in particular benefit from the continuous presence of large amounts of dead wood and, in contrast to intensively managed forest stands, can reach high species richness and form well developed communities. In Central Europe, increasing land-use intensity and ongoing forest fragmentation have led to the decline and near disappearance of old-growth forests, contributing to population declines and elevated threat status in many bryophyte species; the remaining old-growth stands therefore represent critical refugia for a substantial proportion of Red List taxa. Coniferous logs are particularly notable for their high species richness of epixylic specialists and threatened species. To better understand the dynamic, fine-scale variation in epixylic bryophyte communities, we studied microhabitats on decaying spruce and fir logs in three old-growth forests in the Bohemian Massif. The survey was conducted using a set of plots placed directly on the 66 logs to sample bryophyte vegetation on a range of microsites across different log's positions and orientations. Microsite heterogeneity was a significant positive predictor of both total species richness and threatened species richness. At the within-log scale, the number of Red List species increased with lower bark cover and lower canopy cover. It peaked at intermediate decay stages and was higher on the sides of the logs. Our findings advance the understanding of the dynamic nature of epixylic bryophyte communities within individual logs and highlight the importance of microsite diversity for threatened species. This knowledge will enable us to establish more targeted and accurate conditions for the survival of these species.

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Exploring intraspecific diversity and differentiation in a conservation framework - insights from *Schistidium atrofuscum* and *S. spinosum*

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Preserving biodiversity encompasses its protection at all levels of organisation from ecosystems down to genes. While much effort has been directed towards habitats and species, substantial knowledge gaps remain regarding the consideration of intraspecific and cryptic diversity in conservation. Understanding phenotypic, genetic, and ecological differentiation within species is crucial for assessing both the value and vulnerability of populations. Here, we present preliminary results from two monoicous species in the moss genus *Schistidium*, an ecologically important genus known for colonising bare rock surfaces, including artificial substrates, worldwide. Using whole genome sequencing, morphometrics, and ecological data, we examine patterns of intraspecific variation in *Schistidium atrofuscum* and *S. spinosum*. *Schistidium atrofuscum* occurs across mountainous regions in central and southern Europe, as well as in disjunct populations in northern Europe. Among these northern populations it is especially frequent in the Alvar region in southern Sweden, a European conservation priority area due to its unique environmental conditions and biodiversity. We investigate the phylogeographic history and differentiation of Nordic populations compared to more southern and southwest Asian populations, and examine how genomic clusters correspond to morphological variation and ecological conditions. In contrast, *S. spinosum* is restricted to a few mountain ranges in Central Europe and the Pyrenees. Its populations occupy small, spatially limited habitat islands, and the species is globally assessed as critically endangered. Our study aims to clarify the ecological niche of *S. spinosum* and to assess the genetic isolation and diversity of its populations, with the goal of providing recommendations for future conservation measures. Overall, we detected divergent genomic clusters that correlate with morphological variation, but not with macroenvironmental conditions. Furthermore, our results indicate reduced genetic diversity in disjunct populations, due to founder effects and reproduction by intragametophytic selfing.

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Diversity and vulnerability of bryoflora on four mountain mires (Mt Velebit, Croatia, SE Europe) in the context of climate change

V. Šegota, M. Bučar, A. Rimac, A. Alegro

Mires are globally endangered wetland habitats that host unique biodiversity and provide many valuable ecosystem services, e.g. carbon accumulation, greenhouse gases storage and water retention. Bryophytes play a special role in mires' vegetation being abundant and engaged in peat formation. Croatia lies at the southern border of the boreal mire distribution; therefore, these habitats are found only sparsely in the northwestern part of the country, are small in area, and are critically endangered. The bryoflora of four remaining mires on Mt Velebit (three alkaline fens and one acidic bog) was investigated during 2023 in terms of species diversity, abundance, chorology and ecological affinities. In total, 44 bryophyte species were recorded, with the highest diversity on acidic bog, where ecotonal influence of the surrounding spruce forest is present. The predominance of the perennial life-strategies, weft life-form and species indicating permanent moisture (using Ellenberg-like indicator value system) clearly elucidates the established submerged bryophyte communities, while prevailing boreal and boreo-temperate chorotypes indicate favorable humid and cold montane climate. Analyses of the climatological data from the two adjacent meteorological stations for the last two climate standard periods (1961-1990 and 1991-2020) clearly show an increase in thermal parameters (annual mean and maximum air temperatures, as well as a number of the warm (Tmax ≥ 25 °C) and hot (Tmax ≥ 30 °C) days) and decrease in pluviometric parameters (annual mean precipitation, number of days with precipitation (≥ 0.1 mm), number of days with snow (≥ 1 cm) and maximum snow height), highlighting the fragility and vulnerability of investigated mire habitats and plant communities. With evident warmer climate and changes in precipitation patterns, a shift in species composition and vegetation phenology is foreseen, generating changes in carbon storage and greenhouse gases release.

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How to deal with forgotten bryophyte diversity in conservation?

H. Siebel

In the Dutch DNA-barcode project all the morphological bryophyte variation present in the Netherlands was sampled. This large project made it possible to estimate how much bryophyte species were unrecognized in this well investigated country. Previously 600 species were known. Integrative taxonomy made clear that 118 additional species and subspecies could be recognized (+19,7%). 91 were present for a longer period, but not recognized before in The Netherlands. 38 of them are not presently recognized on the European checklist and a further 31 only recognized this century. Surprisingly, only one species *Bryum touwii* was described as new. All the other were already described in the past, often more than a century ago, and regularly more than once. It is important to be aware of this substantial bryological amnesia in Europe when protecting bryophytes. These forgotten species were mainly species of places that are inundated in winter (like winter pools) and of dry calcareous environments. Herbarium revisions may deliver information of past occurrences of the species, but an integrative ecological study about the main threats and habitats is necessary to determine their threat status. The forgotten species of places inundated in winter may have become rare in Europe and will possibly need protection. In the Netherlands they are mainly present in nature restoration areas in which drainage is stopped and they partly even escape being red listed. The forgotten species of dry calcareous environments do not seem to be very rare in Europe. However, in The Netherlands chalk areas are very rare and the forgotten species also, making them candidates for the red list and extra protection.

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The Conservation status of the *Sphagnum* species in Romania

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The *Sphagnum* species are the most significant bryophytes from peatlands which store more amounts of carbon every year and are involved in the peat formation process. Recent data confirms 35 *Sphagnum* species in Romania which represents 59.32% of the *Sphagnum* species from Europe. Three new species have been published to Romania in the last years and five species have been rejected. The conservation status assessment of *Sphagnum* species in Romania led to the conclusion that seven species are threatened at national level (*Sphagnum affine*, *S. balticum*, *S. jensenii*, *S. obtusum*, *S. papillosum*, *S. subfulvum* and *S. wulfianum*). Our results provide a refined understanding of the *Sphagnum* species identification and distributional patterns in Romania.

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The peatlands restoration in Romania

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The Institute of Biology Bucharest developed the National Strategy for the Restoration of Peatlands in Romania, between 2015 and 2017. Within the framework of the strategy, 80 peatlands were selected for which urgent interventions are required. From this list, 45 peatlands were selected and restored between 2022 and 2024 within a program financed by the Ministry of Environment, Waters and Forests of Romania through five EEA Grants. In this presentation, we show how the 22 peatlands were restored by the Institute of Biology Bucharest.

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Roof greening and bryophyte promotion in Geneva city (Switzerland)

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Man-made stony infrastructure, such as most city roofs, provides refuge for specialized flora and fauna threatened by growing urbanization, which leads to the loss of natural habitats. These structures constitute extreme environments, characterized by high temperatures and limited water availability. They provide substitute habitats for adapted ruderal and xerophilous vegetation, including many bryophytes. In Switzerland, 35% of bryophyte species are endangered or extinct and 73% of them are associated with dry environments. Although green roofs provide optimal developmental conditions for many species, bryophytes are still not widely accepted in urban ecosystems. The objectives of this study are: 1) to develop a methodology for greening roofs with native mosses; 2) to identify and to test the most suitable substrates and to assess the mosses influence on these substrates; and 3) to create an educational moss garden within a public park to raise public awareness of mosses. The experiments were carried out on experimental roof prototypes at the HEPIA campus and on a public-school roof in Geneva (Switzerland). A selection of different lightweight substrates with high water retention capacity was made. In addition, various designs for moss gardens were discussed and communication materials were developed. First results show the selection of three organic materials (miscanthus, cellulose and compost), mixed with one mineral material (moraine). Each combination will be tested according to three organic/mineral ratios: 90/10%, 75/25% et 50/50%. The selected moss garden design consists of two mounds flanking an existing path, sheltered and enhanced by three Caucasian walnut trees, allowing visitors to pass through while minimizing the impact on existing vegetation and tree roots. The interdisciplinary approach of this project, involving biologists, agronomists and landscape architects, as well as several departments of the City of Geneva, ensures a good integration of bryophytes into the urban environment.

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Assessment of threat status and habitat pressures on Latvian bryophytes using IUCN criteria

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Between 2021 and 2023, the project LIFE for Species assessed the conservation status of 1,624 taxa (species, subspecies), including bird populations, for the new Latvian Red Data Book, published in six volumes in 2025, including volume on bryophytes. Although this represents less than 7% of species recorded in Latvia, the assessment focused on species that are nationally protected, potentially threatened, listed as rare in neighbouring countries, or protected at the European level. The evaluation followed the IUCN methodology, ensuring internationally comparable extinction risk assessments. Of the 648 bryophyte taxa known in Latvia, 190 species were evaluated. Their distribution and occurrence were analysed based on records from the last 50 years (1973-2023), using herbarium and database data. The results classified species as follows: 30 RE, 12 CR, 29 EN, 40 VU, 44 NT, 20 LC, 15 DD. Most assessments used Criterion B (extent of occurrence and area of occupancy). Some species were evaluated using combinations with Criterion A (population decline) or Criterion D (very small or restricted populations), while several relied solely on Criteria C or D. Many bryophyte species assessed as threatened in Latvia (CR, EN, VU) are not considered threatened in Europe (LC). These are mainly species related to calcareous fens, spring fens, limestone quarries - habitats that are scarce in Latvia. Conversely, some peatland and wet forest species are not threatened in Latvia (LC) but are nearly threatened in Europe (NT) due to declining habitats. Most evaluated bryophytes occur in forests and mires, while grassland species were least represented. Species with lower risk categories (NT, DD, LC) are primarily affected by intensive forestry, whereas those with higher risk categories are mainly threatened by drainage, habitat degradation, and microclimatic changes. Additional pressures include peat extraction, recreational damage to rock exposures, water pollution, and abandonment of managed open habitats.

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Students' contributions to the research of bryophyte flora in Slovenia

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Slovenia has a remarkably rich moss flora. Despite its small size, around 870 bryophyte species have been recorded to date. A large proportion of species with Data Deficient (DD) status, many of which have records older than 100 years, highlights the shortage of researchers focusing on bryophytes in Slovenia in recent decades. Until about ten years ago, only one specialist, Prof. Dr Andrej Martinčič, was an active bryologist in the country. In the 2021/22 academic year, the Department of Biology introduced the elective course Bryology, which annually enrols 15-20 students. The course includes lectures, laboratory and field classes, and an individual project. Students are also invited to join domestic and international excursions and are involved in project-based work. In 2024 and 2025, they participated in mapping the bryophytes of the Tivoli, Rožnik, and Šišenski hrib Landscape Park, located in the heart of Ljubljana. This survey recorded 181 moss species, including six species new to Slovenia. In an ongoing project, students analyse bryophytes from bird nests, an initiative conceived by the students themselves. Students may also prepare a bryophyte herbarium as part of the compulsory course Fieldwork in Botany and Zoology, which previously focused exclusively on ferns and seed plants. These herbaria occasionally yield noteworthy discoveries, such as unexpected *Ulota calvescens*, a species new to the region. Several master's theses have already been completed in the field of bryology, mainly focusing on the biology or ecology of bryophytes. Students' work has resulted in numerous publications in domestic and international journals, as well as contributions to the website 'Mahovi Slovenije', written in Slovene, which helps popularise the field. Through these activities, we aim to strengthen the community of bryologists in Slovenia and advance our understanding of the nation's bryophyte flora.

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The impact of nature conservation management on bryophyte layer in Kismohos bog, Kelemér, North Hungary

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The peatmoss-dominated mires are rare and protected in Hungary. Maintaining the current state is an important task for nature conservation. Succession processes, such as the growth of woody vegetation, also require active intervention. A part of the Kismohos bog has increasingly become covered by trees in recent decades, threatening the extension of the peatmoss carpet. In 2020, the Aggtelek National Park Directorate reduced the canopy cover to 30-40%. Trees in a 15-20 meter-wide zone were felled. The aim of our study was to follow up on the impact of the treatment on the moss layer. The changes were monitored annually along three 35 to 41 m long permanent transects, in contiguous 0.5 × 0.5 m quadrats. The vascular plant and moss cover were recorded, and the presence absence data of moss species in each quadrat were documented. The cover of vascular plants increased across all three transects as a result of the treatment. However, a downward trend has been observed over the last two years, although the cover along transect 3 remains much higher than before cutting. This trend is most evident in the central part of the transects affected by the cutting. The average moss cover shows an upward trend in transects 1 and 2 and a downward trend in transect 3. The most common peat moss was *Sphagnum recurvum* agg., which forms several contiguous carpets. *Sphagnum divinum* is also present in large quantities and shows an upward trend. *Polytrichum commune* is also significant forming large carpets, mainly in transects 1 and 2. The frequency of this species is also increasing. Mire bryophyte species dominated the study area throughout the monitoring. We observed an increase in the frequency of some species associated with decaying matter in the years following cutting, but their frequency is no longer increasing.

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Development of sex-specific DNA markers and their application to conservation of liverworts

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Sexual reproduction and sexual organ formation in natural bryophyte populations is poorly understood especially in the context of global changes. As in liverwort species individual sex cannot usually be determined before the plants develop sex organs, research in population biology, evolution, ecology, and conservation of liverworts would greatly benefit from rapid sexing methods. The recent elucidation of the sex-determining FEMINIZER (BPCU) gene and its gametolog BPCV in liverworts has opened new opportunities for the development of molecular sex-determining markers capable of distinguishing the sexes in the pre-reproductive phase. The goal of this study was to develop a set of sex-determining molecular markers based on polymerase chain reaction that are diagnostic in a wide range of liverworts species to develop a much-needed protocol for rapid sexing of individuals. Multiple sequence alignments were carried out with publicly available sequences of the BPCU and BPCV genes. Primer pairs were designed in the most conserved regions and tested by PCR on a panel of 10 liverwort species. Sequencing of the amplification products was used to confirm primer specificity. Additionally, the characterization of the sex of *Conocephalum conicum* and *C. salebrosum* individuals that had been sexed based on reproductive organs was further used for validation. The developed primers showed preferential amplification from Marchantiales species due to a possible bias in the sequences used for primer design. The amplification from individual gametophytes of natural populations of both *Conocephalum* species resulted to be strongly affected by DNA quality. While the sex-determining molecular markers developed show promising results, they require further optimization to achieve more robust amplification. Additionally, new primer pairs are being developed to avoid the observed bias towards Marchantiales species of liverworts.

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Fungal Endophytes Supporting Bryophyte Resilience and Biodiversity Conservation: Insights from Marchantia polymorpha

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Endophytic fungi associated with bryophytes represent an underexplored reservoir of metabolic diversity with significant implications for conservation biology. This study investigates fungal endophytes isolated from *Marchantia polymorpha* collected in the Campania region of southern Italy. Our results provide evidence of a groundbreaking discovery: these microorganisms are capable of synthesizing biologically active compounds previously attributed exclusively to the metabolism of their hosts. This finding reshapes current understanding of secondary metabolite biosynthesis and highlights the evolutionary and ecological importance of bryophyte-fungus interactions. Endophytes were isolated from healthy thalli and identified by rDNA -ITS sequencing. BLAST analysis revealed high similarity values (98-100%) to representatives of several genera, including *Alternaria*, *Didymella*, *Phoma*, *Nemania*, *Phlebia*, *Colletotrichum*, *Biscogniauxia*, *Dichotomopilus*, and *Paraboeremia*, indicating substantial taxonomic diversity within the liverwort-associated mycobiota in this Mediterranean region. To maximize metabolite recovery, an optimized extraction protocol was established using chloroform ($CHCl_3$) as the organic phase in a liquid-liquid extraction system. Extracts were dried over anhydrous magnesium sulfate, filtered, and evaporated under reduced pressure. The resulting residues were dissolved in methanol and analyzed using GC/MS and HPLC/ESI-QTOF-MS. Fifteen fractions were screened for bis-bibenzyl compounds, which have not previously been reported from fungal endophytes of common liverwort. GC/MS analysis also enabled detection of trace terpenoid compounds characteristic of *M. polymorpha*. Beyond their biosynthetic capabilities, endophytes influence bryophyte resistance to environmental stress, enhancing host adaptability and ecosystem stability. Recognizing these fungi as alternative producers of valuable metabolites introduces the concept of endophytes as "natural laboratories." Exploiting their metabolic potential may reduce harvesting pressure on rare bryophyte populations, directly supporting strategies for conserving genetic resources and maintaining biodiversity in vulnerable habitats worldwide.

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POSTER PRESENTATIONS

The bryophyte diversity in Mediterranean Temporary Ponds (Habitat 3170* MTP): a critical resource for Salento (Apulia, Italy)

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Mediterranean temporary ponds (MTP) are small, shallow water bodies, isolated from permanent water bodies, which undergo a periodic cycle of flooding and drought. They host rare and endemic flora and fauna well adapted to this water oscillation and therefore they are classified as a priority natural habitat under the Habitats Directive 92/43/EEC. Despite bryophytes play a key ecological role, they are neglected or undervalued in most projects adressing the management of temporary ponds. The data here presented were collected during the winter and the spring of 2020-2025 in 19 sites, located in the central part of Salento, an area called "Paduli". The soil is sandy and clayey, the surrounding landscape is made up of agricultural areas and olive groves. The stations are distinguished in: cupular pools, waterlogged soils and dolines. For each pond, at least two inventories has been accomplished both in the flood phase and the dry one. A total of 45 species were discovered, 10 of which are new to Apulia. Among these, two rare species typical of these ephemeral habitats are of peculiar interest: *Riccia crozalsii* Levier and *Ephemerum serratum* (Lindb.) Grout. The outcomes obtained from this study, compared with those of previous studies on temporary ponds in Umbria and Sardinia, strongly suggest that bryophytes need a tailored monitoring approach and special care in addressing management and conservation decisions in these habitats.

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Bryophyte assessment within Latvia's national forest inventory

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Understanding current species status and temporal changes is essential for effective bryophyte conservation. In Latvia, bryophyte monitoring has been integrated into the National Forest Inventory (NFI) since 2019, providing a systematic, country-wide framework for long-term assessment. NFI plots are evenly distributed across Latvia using a systematic sampling design. During the initial monitoring phase (2019-2023), bryophytes were surveyed on 1,797 living trees and 251 logs across 441 plots, with a different subset of plots assessed each year. In 2025, plots surveyed in 2020 were revisited to evaluate changes over five years. Epiphytic bryophytes were recorded on up to four living trees per plot, representing different tree species and favoring larger-diameter trees to maximize species detection. Epixylic bryophytes were surveyed on logs with a minimum diameter of 20 cm. In total, 47 bryophyte taxa were recorded on living trees, with the most frequent species being *Hypnum cupressiforme* (39% of plots), *Dicranum montanum* (36%), and *Radula complanata* (30%). Six recorded epiphytic species were classified as indicator species for European Union Protected Habitats. On logs, 73 bryophyte taxa were found, including seven indicator species for European Union Protected Habitats. Comparison of bryophyte species richness and cover between 2020 and 2025 showed no significant differences in most plots where all surveyed trees remained alive. These results suggest that bryophyte communities on living trees and logs are relatively stable over five years under unchanged forest conditions, highlighting the value of NFI-based monitoring for detecting long-term trends relevant to bryophyte conservation.

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Hellish landscape - heavenly bryophytes: the bryoflora of Vražji skok (Central Croatia)

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Vražji skok (Eng. *Devil's Jump*) is a 600 meters long ravine which follows a creek of the same name in the southern part of Central Croatia. The whole region is poorly explored floristically compared to other regions in Croatia. The toponym most probably refers to a small number of cascades and a waterfall which is 3,5 meters high. The landscape is shaded mostly by common hornbeam and beech trees. Geologically, this area is made of carbonate flysch and clastic sedimentary rocks. This area was studied for its bryoflora in January 2026. Bryophytes were sampled from the soil, exposed rocks, inundated rocks, tree bark and deadwood. In total, 38 bryophyte and 12 livewort species were identified, among them some rare and underrecorded species in Croatia. *Leucobryum albidum* is confirmed for the first time for Croatia, however, being data deficient, it is likely the species is distributed elsewhere as well. *Heterocladium heteropterum*, *Didymodon sinuosus* and *Rhabdoweisia fugax* are all known from very few localities in Croatia. Most of the recorded species (53%) occur in conditions of weak to absent hemeroby, and no species tolerate strong hemeroby. Regarding the environmental conditions, the species checklist indicates somewhat colder environment than expected for the broader area, but also a variety of light conditions and substrates regarding the moisture and pH reaction, leading to a relatively rich bryoflora. Due to the unwelcoming steep terrain, this landscape seems to be safe from forest exploitation and deadwood extraction, while the historic hiking trail is nearly lost and only occasionally used by the local hiking club. This study highlights the importance of small-scale landscapes with a high level of naturalness in contributing to biodiversity and their value for conservation.

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Rediscovery of historic sites of *Oreoweisia torquescens* and *Oreas martiana*, two endangered mosses in Switzerland through the establishment of local action plans

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Oreoweisia torquescens (Hornsch. ex Brid.) Wijk & Margad. and *Oreas martiana* (Hoppe & Hornsch.) Brid. are rare alpine rock mosses with a strictly Palearctic distribution. Both species are classified as Vulnerable (VU) according to the European Red List for Bryophytes and Endangered (EN) according to the Swiss Red List. The majority of European populations of these species are located in the Alps, spanning countries such as Austria, France, Italy, Germany, and Switzerland. There are also individual *O. torquescens* sites in Norway and Slovakia, and *O. martiana* sites in Svalbard and Slovakia. They face similar threats, particularly from the impact of climate change on alpine landscapes. In 2024, during field research conducted as part of a project to prepare a conservation plan for both species in the canton of Graubtinden (east Switzerland), the historical locations were carefully revisited. Each species was known from fewer than ten locations in Switzerland, most of which had not been confirmed for around a hundred years. Both species were rediscovered in three locations and, wherever they were found, occupying areas ranging from a few to several dozen square centimeters and producing numerous sporophytes. All sites were difficult to access, being located far from human settlements and tourist trails. In one case, the failure to rediscover an historic *O. torquescens* site could be directly inferred to the establishment of a hydrological dam. Some *O. martiana* sites were located in highly dynamic landscapes, with the species apparently tracking retreating glaciers. We showcase the ways these findings can flow into concrete actions for the conservation of the species in Switzerland through the establishment of a cantonal action plan.

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Challenges of growing of bryophytes in artificial environment: lessons from greenhouse experiment

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Species propagation is a primary limiting factor for the restoration of habitats and species' populations. An additional constraint for bryophytes is their specialization to substrates with specific physico-chemical properties. The aim of the study is to understand and describe, how to propagate and grow bryophytes in artificial, anthropologically disturbed or newly created environments. The study focuses on poorly vegetated and shady artificial areas, where ground-layer forest bryophytes could be grown. Although their substrate preferences are well documented in natural habitats, the observed patterns may be constrained by interspecific competition. Physiologically, the species should be able to grow on wider range of substrates, in other words, the range of their fundamental niche is unknown. We used 20 common forest bryophyte species by setting up a greenhouse experiment under controlled temperature, moisture and light conditions. Species selected for the study represent both acro- and pleurocarpic bryophytes with different growth forms. We used six growing substrates all common in horticulture. To consider species-specific growth peculiarities, we employed two propagation methods: patch fragments and plant cuttings. The growth and survival of bryophytes were regularly monitored by photographing each test pot. Here I present preliminary results of the experiment after running it for a full year. According to our initial results almost all bryophytes used in experiment can grow on different type of substrates. This means that they have much broader fundamental niche than observed in nature, though the propagation mode may be the limiting factor. A next logical step would be testing the same approach with some strictly specialized, threatened and rare bryophyte species.

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Arsenic tolerance in the snake liverwort, *Conocephalum salebrosum*

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The tolerance towards arsenic (As), a metalloid toxic for most plant species, has been thoroughly characterized in vascular plants, but much less is currently known in the other major group of land plants, the bryophytes. In this study we characterized the tolerance to arsenic of *Conocephalum salebrosum* Szweykowski, Buczkowska & Odrzykoski, a large thallous liverwort a pan-boreal distribution and occurring in Europe. We determined toxicity response curves to different amounts of arsenite, As(lll), or to selected As(lll) concentrations for different amounts of time using different techniques ranging from fresh weight measurements to noninvasive hyperspectral measurements of indexes related to thallus growth, relative chlorophyll and nitrogen content, senescence, as well as destructive measurements of membrane leakage, lipid peroxidation and total As content. Chronic exposure to increasingly high As concentrations reduced plant growth and accelerated senescence with concomitant reduction of chlorophyll content in *C. salebrosum*. On the other hand, acute exposure to high As concentrations induced significant lipid peroxidation and decreased functional integrity of cellular membranes due to intracellular accumulation of elevated amounts of As. Of the two genes coding for the arsenite efflux pump ACR3 in *C. salebrosum*, only CsACR3-1 seem to be active and transcriptionally responsive to As-induced stress, while CSACR3-2 is likely a subfunctionalized or pseudogenized paralogue. These results provide the first quantitative characterization of the capacity of *C. salebrosum* to withstand both chronic and acute As toxicity, suggesting that this species can be a valid bioindicator of As in addition to heavy metal contamination in the environment.

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20 years later: towards a new bryophyte Red List of Bulgaria – preliminary reevaluation of liverworts and hornworts

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The most recent bryophyte Red List of Bulgaria was published in 2006. During the last 20 years, a large body of information has been accumulated both on the occurrence of known species and of newly reported species in the country. We have therefore began a critical re-evaluation of the conservation status of all bryophyte species in Bulgaria. Here we present preliminary data on the liverworts and hornworts. The 2006 Red List included 64 species (36,6% of the total number of hepatic species) of which 61 received a threat category (CR, EN, or VU). The data analysis indicates that of the CR, 33% of the species will retain their category, and 67% will be downgraded, of the EN 65% retain, and 35% will be downgraded, and of VU 94% retain, and 6% will be downgraded. The only upgrading in threat category is seen within the DD category, where 44% will be upgraded and 11% will be downgraded. Further 11 species that were discovered in Bulgaria between 2006 and 2015 will undergo evaluation as well. Thus, the current list includes 74 (35,6%) candidate species. Of the LC category none has changed its status. Our the preliminary data shows that with the acquisition if new data the Red list is considerably refined and evaluations that are more objective are obtained, however the percentage of the total number of species remains similar, albeit slightly lower.

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Long-Term Bryophyte Surveys under the Biodiversity Monitoring South Tyrol Project (BMS)

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Mountain regions constitute globally significant biodiversity hotspots and are increasingly investigated through integrative, multidisciplinary frameworks. Biodiversity Monitoring South Tyrol (BMS) is a long-term programme surveying 320 terrestrial sites across South Tyrol, spanning a broad gradient of habitat types and resampled at five-year intervals. Since 2019, 64 sites have been monitored annually using standardized protocols to quantify biotic responses to climate and land-use change. The focus of the report will be on the methodology used, with a particular emphasis on bryophytes and the data that has been collected up to now. Sites were selected via stratified random sampling approach to represent habitats from near-natural to strongly anthropogenically modified systems. Bryophytes were sampled in four smaller random subplots within a 100 m2 area where vegetation surveys were conducted according to the Eurasian Dry Grassland Group (EDGG) methodology. A total of 230 species of bryophytes, accounting for 25% of South Tyrol's bryoflora, were identified in the first two years of surveys (2019-2020). Identification of the samples collected in the remaining seasons (2021-2024) is still ongoing. Monitoring integrates biodiversity data with measurements of abiotic conditions, landscape structure, and management regimes. The programme further supports knowledge transfer between specialists and local authorities to address biodiversity impacts of agricultural and forestry practices and to document emerging pressures, including extreme events and biological invasions. Outcomes will inform the evaluation and refinement of species- and habitat-level conservation measures within and beyond protected areas.

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Bryophyte diversity of Mediterranean semi-natural habitats: new national records and ecological patterns from Rt Kamenjak (Croatia)

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Rt Kamenjak, the southernmost part of the Istrian Peninsula (Northern Adriatic, Croatia), is a protected Mediterranean significant landscape of high vascular plant diversity, yet its bryophyte flora has remained largely understudied. To reduce the knowledge gap for coastal Croatia and evaluate the conservation value of local habitats, field surveys were conducted between 2019 and 2021 across 32 sites representing olive groves, maquis, garrigues, Mediterranean grasslands, forest edges and stonewalls. A total of 75 taxa were recorded (14 liverworts and 61 mosses) from 22 families, with Pottiaceae predominating (37.3%), reflecting adaptation to xerothermic conditions. Four taxa (*Bryum gemmilucens*, *Tortula pallida*, *Petalophyllum ralfsii*, *Microbryum davallianum* var. *conicum* and *Microbryum muticum*) represented new national records for Croatia. Additionally, several rare and insufficiently documented species were confirmed or newly recorded for the Mediterranean region of the country, including *Acaulon muticum*, *Ephemerum serratum*, *Gymnostomum viridulum*, *Cheilothela chloropus*, *Sphaerocarpos michelii*, and *Zygodon conoideus*. Chorological analysis revealed a predominance of Mediterranean-Atlantic (32%), temperate (22.7%) and southern-temperate (21.3%) elements. The life-form and life-strategy spectra were dominated by turfs (56%) and colonists (40%), with a substantial proportion of annual shuttles (29.3%), indicating strong adaptation to open, seasonally dry habitats. Most species were associated with open soil in olive groves and along paths within maquis and garrigues, i.e. habitats shaped by long-term traditional land use. In the Mediterranean region, abandonment of such practices often leads to shrub encroachment, habitat homogenization and biodiversity loss. The results demonstrate that continued management of semi-natural habitats within the protected Significant Landscape “Lower Kamenjak and Medulin Archipelago” is essential for maintaining bryophyte diversity.

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Epiphyllous liverworts: case studies from old-growth forests in Phia Oac - Phia Den and Kon Tu Rang in Vietnam

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Epiphyllous liverworts are specialized bryophytes growing on leaves of plants in humid tropical forests. These species represent one of the characteristic elements of tropical rainforests, and may indicate climate change and forest disturbances. Within the Indochinese floristic region, data on their diversity and distribution along latitudinal gradients in Vietnam remain scarce. We examine epiphyllous liverworts in two Vietnamese old-growth forests: Phia Oac - Phia Den National Park in the north (Cao Bang province) and Kon Chu Rang Nature Reserve in the central highlands (Gia Lai province). Sampling was conducted along three transects, where 3x3 m sample plots were placed with the spacing of 30 m. The epiphyllous liverworts were collected from all leaves at the height below two meters. We sampled the leaves of trees, Calamus palms, and ferns. The percent of plots with epiphyllous liverworts was 10, 80, and 65% in the forests including conifers (Kon Chu Rang), and without conifers in Kon Chu Rang and Phia Oac - Phia Den, respectively. The number of leaves with epiphyllous liverworts ranged from 1 to 15 per plot. Preliminary, over 30 species were found with the highest number of species from Lejeuneaceae - the largest epiphyllous liverwort family in tropical Asia. The data analysis will focus on species richness, frequency, Jaccard similarity, and NMDS ordination to assess compositional differences between sites. We hypothesize that latitudinal climate and forest type differences will yield distinct epiphyllous communities, contributing to biogeographic understanding in Indochina. This research is supported by the Joint Russian-Vietnamese Tropical Research and Technology Centre (a branch of A.N. Severtsov Institute of Ecology and Evolution, Russian Academy of Sciences).

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New findings in the bryophyte flora of Slovakia

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National bryophyte checklists and redlists are dynamic tools that require continuous revision as new data accumulate and taxonomic concepts evolve. Since the publication of the most recent Slovak check- and redlists (2020, 2021), the bryophyte flora of Slovakia has undergone substantial updates. To date, we register 40 taxa newly recorded for the country (or previously omitted in the checklists), together with five species rediscovered after having been classified as Regionally Extinct/Vanished (RE/VA). Overall, the bryophyte flora of Slovakia now consists of 972 taxa. These additions reflect intensified field research across underexplored regions and habitats (e.g. Cerová vrchovina Protected Landscape Area, saline grasslands, loess cliffs), as well as targeted surveys focusing on rare and overlooked species or neglected genera such as *Schistidium*. Several records result from recent taxonomic revisions within critical species complexes, including *Lewinskya affinis*, *Oxyrrhynchium hians*, *Tortella tortuosa*, and *Ulota crispa*, which have clarified species delimitations and revealed previously unrecognized diversity. Additional changes stem from the recognition of infraspecific taxa (subspecies and varieties) adopted in the most recent European checklist but not previously reflected in the national lists (e.g. *Fissidens dubius* var. *mucronatus*, *Microbryum davallianum* var. *conicum*, *Pohlia wahlenbergii* var. *glacialis*, *Schistidium brunnescens* subsp. *griseum*, *Streblotrichum convolutum* var. *commutatum* and *Tortula acaulon* var. *pilifera*). Together, these findings highlight both the dynamic nature of bryophyte diversity assessments and the importance of sustained taxonomic and floristic research for accurate biodiversity evaluation and conservation planning. Further discoveries can be expected as ongoing fieldwork, taxonomic revision, and critical re-evaluation of herbarium material continue to refine our understanding of the country's bryophyte diversity.

AUTHORS

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Contribution to the submerged bryophytic flora and vegetation of the watercourses in the Abruzzo, Lazio and Molise National Park

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Cryptogamic flora, and specifically the bryophyte component, represents a fundamental structural and functional element of lotic ecosystems, contributing to the regulation of trophic balance and the stabilisation of riverbed substrates. Despite this ecological relevance, Italian scientific literature regarding the bryophytes of central Apennine fluvial environments is fragmentary and primarily focused on major watercourses (e.g., Tiber and Aniene), leaving significant knowledge gaps concerning minor mountain systems. An ongoing research project aims to analyse the diversity and floristic composition of cryptogams in relation to environmental parameters within the Abruzzo, Lazio and Molise National Park. The investigation covered several reaches of the Sangro, Giovenco, and Melfa rivers, alongside the Scerto and Fondillo streams. In August 2025, 48 floristic-vegetation relevés were carried out on 1 m^2 sample plots within the riverbeds, sampling the entire macrophyte community (vascular plants, bryophytes, and principal macroalgae) according to the shoot-presence criterion. To date, the survey has identified 21 bryophyte species, providing an update to the cryptogamic flora of the Park's river and stream systems, which was previously partially investigated in 2000 - across a smaller number of watercourses - by C. Allegrini. The results highlight the relationships between floristic composition and key environmental parameters, such as the distribution between calcareous and clay substrates. This study underscores the importance of considering bryophyte biodiversity when assessing the floral consistency of protected areas and its management implications, particularly for the conservation of mountain fluvial environments.

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