

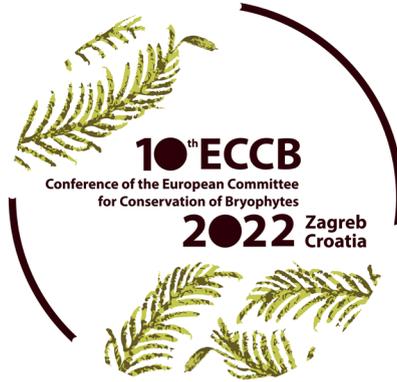
European Committee for Conservation of Bryophytes
Croatian Botanical Society
Botanical Garden, Department of Biology, Faculty of Science, University of Zagreb

10th ECCB

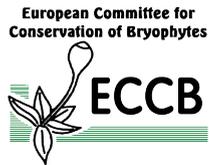
Conference of the European Committee
for Conservation of Bryophytes

24 - 27th May **2022** Zagreb
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BOOK OF ABSTRACTS



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TIME SCHEDULE

1st day, Tuesday, May 24

- 8.00-10.00 Registration and poster mounting
- 10.00-11.00 Opening ceremony
- 11.05-13.00 Oral presentations
- 13.00-15.00 Lunch break
- 15.05-16.40 Oral presentations
- 16:40-17:00 Coffee break
- 17:00-18:00 Poster session
- 18:00-19:00 ECCB Board meeting

2nd day, Wednesday, May 25

- 9.05-11.00 Oral presentations
- 11.00-12.00 Poster session and coffee break
- 12.00-14.00 Oral presentations
- 14.00-16.00 Lunch break
- 16.00-17.20 Oral presentations
- 17.20-17.30 Excursions service information
- 17.30-18.30 Poster session

3rd day, Thursday, May 26

- 8.00-19.00 Excursion 1: Gorski Kotar, Mt Risnjak National Park

4th day, Friday, May 27

- 8.00-19.00 Excursion 2: Plitvice Lakes National Park

PROGRAM

Tuesday, May 24

8.00-10.00 Registration and poster mounting (The posters remain on display throughout the whole conference)

10.00-11.00 Opening ceremony

Oral presentations

1st Session: From genetic to habitat diversity and how to assess and restore bryophyte diversity

Keynote lecture:

1. 11.05-11.40 Lars HEDENÄS: Genetic variation and bryophyte diversity conservation

Lectures:

2. 11.40-12.00 Jessica NELSON, Imran SADOVIĆ: Bryophyte diversity in urban and mining areas: a case study in Maastricht

3. 12.00-12.20 Evita OLEHNOVIČA, Anna PASTARE-SKUTELE, Ligita LIEPIŅA, Anna MEŽAKA: Bryophyte species diversity along black alder swamp forest chronosequence

4. 12.20-12.40 Tiina SAMSON, Anna-Grete REBANE, Edgar KAROFELD, Nele INGERPUU, Kai VELLAK: Does peatland restoration help to control the growth of *Campylopus introflexus*, an invasive species from Southern Hemisphere?

5. 12.40-13.00 Anja RIMAC, Antun ALEGRO, Vedran ŠEGOTA, Nina VUKOVIĆ, Nikola KOLETIĆ: Aquatic bryophytes of Croatia – distribution, ecology and threats

13:00-15:00 Lunch break

2nd Session: Bryophyte diversity and conservation beyond the national approach

Keynote lecture:

6. 15.05-15.40 Nick G. HODGETTS: Beyond the Red List: Important Bryophyte Areas of Europe

Lectures:

7. 15.40-16.00 Kristel VAN ZUIJLEN, Irene BISANG, Michael NOBIS, Ariel BERGAMINI: How do traits and environmental conditions affect extinction risk in European bryophytes?

8. 16.00-16.20 Norbert SCHNYDER, Christian SCHRÖCK, Irene BISANG, Ariel BERGAMINI, Neil LOCKHART, Nick HODGETTS: Conservation Priorities for European Bryophytes

9. 16.20-16.40 Marc-Frédéric INDORF, Tana ROUTE, Yves BERGERON, Nicole J. FENTON: Vegetation community assembly patterns in boreal peatlands: using a spatial hierarchical approach

16:40-17:00 Coffee break

17:00-18:00 **Poster session**

18:00-19:00 **ECCB Board meeting**

Wednesday, May 25

Oral presentations

3rd Session: Insights into national bryophyte conservation

Keynote lecture:

10. 9.05-9.40 Irene BISANG, Luc LIENHARD, Ariel BERGAMINI: The fate of arable bryophytes in the Swiss Plateau: Agricultural intensification, promotion of agrobiodiversity and three decades of monitoring hornworts

Lectures:

11. 9.40-10.00 Snežana DRAGIĆEVIĆ, Antun ALEGRO, Vedran ŠEGOTA, Snežana VUKSANOVIĆ, Ilinka ĆETKOVIĆ, Jaanus PALL: An overview of *Sphagnum* peatlands in Montenegro

12. 10.00-10.20 Thomas KIEBACHER, Markus MEIER, Julie STEFFEN, Norbert SCHNYDER, Ariel BERGAMINI & Heike HOFMANN: A new Red List of bryophytes for Switzerland

13. 10.20-10.40 Anna MEŽAKA, Ligita LIEPIŅA, Anete POŠIVA-BUNKOVSKA, Evita OĻEHNOVIČA, Māris NITCIS, BAIBA BAMBE, Linda GERRA-INOHOSA, Ansis OPMANIS, Uvis SUŠKO: Rare EU Habitat directive bryophyte distribution and conservation perspectives in Latvia

14. 10.40-11.00 Silvia POPONESSI, Antonio DE AGOSTINI, Annalena COGONI: Preliminary investigations of the effects of climatic events in the bryophytic communities of riparian habitats, Southern Sardinia (Italy)

11.00-12.00 Poster session and coffee break

4th Session: Monitoring bryophyte diversity

Keynote lecture:

15. 12.00-12.40 Beáta PAPP, Péter ÓDOR, Erzsébet SZURDOKI: Twenty years of the Bryophyte Biodiversity Monitoring System in Hungary

Lectures:

16. 12.40-13.00 Irene BISANG, Jacques VAN ROOY, Ariel BERGAMINI: The Bryophyte Specialist Group – who we are and what we do

17. 13.00-13.20 Rory HODD, Nick HODGETTS, Neil LOCKHART: Results of a survey to monitor the EU protected habitat Calaminarian grassland and its unique bryophyte assemblage

18. 13.20-13.40 Eliška VICHEROVÁ: Bryophyte conservation and monitoring in the Czech Republic

19. 13.40-14.00 Oleg MASLOVSKY: Methodology and program of threatened bryophytes monitoring of in Europe

14.00-16.00 Lunch break

5th Session: Species diversity and floristics

20. 16.00-16.20 Snežana DRAGIĆEVIĆ, Snežana VUKSANOVIĆ, Gordana TOMOVIĆ, Marjan NIKETIĆ, Uroš BUZUROVIĆ, Ksenija JAKOVLJEVIĆ, Ilinka ĆETKOVIĆ, Peter GLASNOVIĆ: The first data about moss *Campylopus introflexus* (Hedw.) Brid. (Dicranaceae) in bryophyte flora of Serbia

21. 16.20-16.40 Simona STRGULC KRAJŠEK, Žan LOBNIK CIMERMAN: The rediscoveries of *Riccia* species in Slovenia

22. 16.40-17.00 Oleh PUNDIAK: Another epiphyllous bryophyte found in Arboretum Stradch (Ukraine)

23. 17.00-17.20 Nadezhda KONSTANTINOVA, Anna VILNET: Schuster's species in Europe: distribution, taxonomic and threatened status

17.20-17.30 **Excursions service information**

17.30-18.30 **Poster session**

ORAL PRESENTATIONS

1. Genetic variation and bryophyte diversity conservation

Lars HEDENÄS

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Biodiversity, including bryophyte diversity, can be subdivided into genetic, species, and ecosystem diversity. Species and ecosystem diversity are relatively well addressed in European conservation, but the genetic level is mostly overlooked, especially in small organisms like bryophytes. This is crucial when gradual genetic diversity erosion in species that are relatively frequent probably constitutes a greater overall biodiversity loss than the extinction of rare species. Large-scale habitat loss or modification, in general or regionally, may therefore cause crucial loss of biodiversity through genetic loss even if little is first seen at the species level. I will illustrate these points using bryophyte examples and discuss intraspecific variation and cryptic speciation in relation to earlier and ongoing habitat changes at the European level. It is known from other organisms that areas of high species diversity are not necessarily the same as those with the highest intraspecific genetic diversity, and I will provide bryophyte examples of this lack of correlation. Finally, I will discuss genetic variation beyond the species limits, including hybridization and horizontal gene transfer, and focus on the relationship between these and artificially disturbed habitats. Seriously considering the genetic component of bryophyte diversity can aid in developing better conservation management plans in Europe.

2. Bryophyte diversity in urban and mining areas: a case study in Maastricht

Jessica NELSON & Imran SADOVIĆ

Maastricht Science Programme, Maastricht University, The Netherlands

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Many bryophytes thrive in habitats disturbed by human activities, from agricultural fields to industrial sites and city centres. Since hard substrates like city walls or exposed rock in quarries can host plant communities that have very little natural habitat available, understanding the bryophyte communities on such man-made structures can inform nature management and conservation efforts. This presentation details two surveys of bryophyte diversity conducted by students in the Maastricht Science Programme in and near the city of Maastricht in the Netherlands. The first is a preliminary assessment of

the bryophyte flora within the city and the second compares bryophyte communities between areas under different restoration management regimes in a nearby quarry. The results are used to make recommendations about involving undergraduates in bryophyte research and about management of restoration sites for bryophyte diversity.

3. Bryophyte species diversity along black alder swamp forest chronosequence

Evita OLEHNOVIČA, Anna PASTARE-SKUTELE, Ligita LIEPIŅA & Anna MEŽAKA

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Black alder swamp forests offer various microniche availability for diverse bryophyte community development. There is still a lack of knowledge in bryophyte successional patterns in black alder swamp forests. The aim of the present study was to investigate bryophyte succession along black alder swamp forest chronosequence. We studied bryophytes in 30 black alder swamp forest stands from three age classes (young, middle, old) in Latvia. In each forest stand, we identified bryophytes on different substrates (dead wood, soil, living tree stem) within 2 m to right and left direction from 28 m long transect. Our results show that many bryophyte species can be found in all three forest age classes, but several other bryophyte species are associated with specific forest age class. Our results show that bryophyte diversity does not differ much among black alder swamp forest age classes, but old-growth forests ensure particularly rare bryophyte species distribution.

4. Does peatland restoration help to control the growth of *Campylopus introflexus*, an invasive species from Southern Hemisphere?

Tiina SAMSON, Anna-Grete REBANE, Edgar KAROFELD, Nele INGERPUU & Kai VELLAK

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The restoration of peatlands is a long-lasting process and recovery of the prior-disturbance vegetation depends among other conditions from the diaspore bank too, which can include also propagules of invasive species. Invasive species are more effective in disturbed communities and they may supersede community-specific local species, due to their better ability to spread and/or persist in propagule bank. Thus, restoring conditions for natural communities is a way to suppress the expansion of invasive species. We seek answers to the questions: 1) is the germination of invasive

species more successful than native species, and 2) does re-vegetation of abandoned peatlands inhibit germination of invasive species. *Campylopus introflexus*, an invasive species growing mainly in mined bogs, and *Polytrichum strictum*, a native species in northern natural bogs, also a nursing plant in abandoned peat-fields, were selected for growth chamber experiment. Peat was collected from the area where both species were found and germinated in Petri dishes in controlled conditions for one month. Half of the dishes were covered by living *Sphagnum*-shoots imitating restoration, other half was left uncovered. At the end of the experiment, the number of shoots, as well as their cover, was estimated. Our experiment revealed that *Campylopus introflexus* germinated better than *Polytrichum strictum* in both treatments. However, cover with *Sphagnum*-layer significantly suppressed the germination success, lowering cover and shoot number. We can conclude that the expansion of *Campylopus introflexus* could be controlled by the restoration with active re-vegetation of abandoned peat-fields.

5. Aquatic bryophytes of Croatia – distribution, ecology and threats

Anja RIMAC, Antun ALEGRO, Vedran ŠEGOTA, Nina VUKOVIĆ & Nikola KOLETIĆ

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Division of Botany, Department of Biology, Faculty of Science, University of Zagreb, Croatia

An extensive macrophyte field survey of running and standing waters was conducted from 2016 to 2021 at 786 sampling sites across Croatia. This survey is the first to present a comprehensive floristic catalogue of the freshwater bryoflora, along with an analysis of the distribution and diversity patterns on a national level. In all, 83 bryophyte species (68 mosses and 15 liverworts) were recorded in 228 sites, with average species richness of 4.17 species per site. The most frequent species were *Fontinalis antipyretica*, *Rhynchostegium riparioides*, *Leptodictyum riparium* and *Cratoneuron filicinum*. The majority of the species encountered were rarely found with over 70% of species recorded on less than 10 sampling sites and the majority of the species not being truly aquatic, rather being classified as facultative aquatics. Bryophytes were the dominant component of the macrophyte vegetation in 76 sites. Classification and ordination analyses of these sites revealed five community types segregated across the gradients of several climatic, physiographic and water chemistry parameters. The *Didymodon tophaceus*–*Apopellia endiviifolia* and the *Berula erecta*–*Cratoneuron filicinum* communities were associated with basic and alkaline, clean water with low nutrient content. They were mostly recorded to karstic rivers of the Dinaric Ecoregion under the influence of the Mediterranean climate. *Didymodon tophaceus*–*Apopellia endiviifolia* community was a tufa-forming community associated with seasonally dry watercourses of a small catchment area and cascades along the karstic rivers, while *Berula erecta*–*Cratoneuron filicinum* community was associated with Mediterranean rivers with a larger

catchment area and permanent flow. On the other hand, the *Oxyrrhynchium hians-Chiloscyphus pallescens* and *Fissidens pusillus-Veronica beccabunga* communities were mainly restricted to small rivers of the Pannonian Ecoregion under the influence of the temperate climate, associated with water of low alkalinity and higher nutrient content. Finally, the *Cinclidotus* community was the most represented and widespread in Croatia with a wide ecological range, however, with the majority of the sites situated on karstic rivers of the Dinaric Ecoregion. Both, floristic and vegetation analysis have revealed that this region provides more aquatic habitats and microhabitats suitable for the freshwater bryophytes, while in the Pannonian Ecoregion freshwater bryophytes are restricted to the periodically submerged riparian zones and are more threatened by unsuitable water management.

6. Beyond the Red List: Important Bryophyte Areas of Europe

Nick G. HODGETTS

Nick Hodgetts Botanical Services, Portree, Isle of Skye, UK

Presenting author: nick1901@hotmail.co.uk

The publication of the European bryophyte Red List in 2019 marked a watershed in bryophyte conservation in Europe, with a published document and an important presence on the IUCN website. The next step was to see how the data behind the Red List could be used. One such use is to determine Important Bryophyte Areas (IBrAs), to highlight the places of most importance for bryophytes in Europe. This is useful because it will facilitate better protection for these areas, and we will be able to see how IBrAs relate to protected areas such as SACs, National Parks and nature reserves. While it is difficult to generate public enthusiasm for bryophytes *per se*, people relate to places much better, and if bryophyte data can support other data in protecting areas of high biodiversity, that will be a great gain. This is a three-year project to collate information on Red Listed, endemic and near-endemic species (much of which has already been gathered for the Red List project). Outputs will include improved distribution maps, analysis to show areas of high diversity and endemism, and liaison with IUCN so that IBrAs can eventually be included in their Key Biodiversity Areas (KBA) programme.

7. How do traits and environmental conditions affect extinction risk in European bryophytes?

Kristel [VAN ZUIJLEN](#)¹, Irene BISANG², Michael NOBIS¹ & Ariel BERGAMINI¹

¹*Swiss Federal Research Institute WSL, Birmensdorf, Switzerland*

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Extinction risk is not randomly distributed among species but depends on the one hand on biological and ecological traits and on the other on the relationship between environmental factors (e.g. climatic conditions, habitat types) and threats (e.g. land use change, nitrification, climate change). While knowledge of which factors influence extinction, risk is increasingly available for some taxonomic groups, this is still largely lacking for bryophytes. The Red List of European Bryophytes, published in 2019, provides a unique opportunity to assess how these factors affect the threat status of bryophytes on a continental scale. In this project, we study the relationships and interactions between species traits, environmental conditions and extinction risk in European bryophytes. To do this, we compiled data on the 1796 bryophyte species assessed for the European Red List and several readily available trait databases, including biological (e.g. size, life strategy, mating type, spore size) and ecological traits (e.g. indicator values, substrate classes), as well as bioclimatic variables calculated from the species' distributions in Europe. In addition, we complemented data gaps with trait values from relevant literature. To quantify the relationships between the species' threat status and factors like species traits and environmental conditions, we use machine learning techniques such as classification trees and random forests. In this presentation, we will show the first results of our analyses. We will present which factors are important drivers of extinction risk and which traits make a species more likely to be threatened with extinction.

8. Conservation priorities for European bryophytes

Norbert SCHNYDER¹, Christian SCHRÖCK², Irene BISANG³, Ariel BERGAMINI⁴, Neil LOCKHART⁵ & Nick HODGETTS⁶

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The European Red List for bryophytes (ERL), published in 2019, revealed that 22% of the more than 1800 species that occur in Europe are threatened with extinction. A further 10% are considered near-threatened. Given that economic and human resources are limited, we need to prioritise how to most efficiently and sensibly use these resources to safeguard bryophyte diversity. Red List status itself is not an adequate means to identify the species of highest conservation priority in a certain region. A strongly threatened species in Europe may be common and highly viable in other regions of the world. In this project, we combine Red List status and a quantitative assessment of 'European responsibility' to set priorities for the conservation of European bryophyte species. We assessed 'European responsibility' by estimating the proportion of a species' worldwide

population size, in terms of distribution area or known occurrences, found in Europe. So far, we have scored 414 bryophytes classified as threatened and near-threatened in the ERL, of which almost 150 species are endemic to Europe. Further, for each species with a high score based on threat status and 'European responsibility', we evaluate the current need for conservation action, and whether conservation measures are known. This evaluation process using these four criteria will result in a priority list of bryophyte species of European conservation concern to be considered in national conservation action plans. We will present the methodology and first results and discuss the next steps necessary to improve European bryophyte conservation.

9. Vegetation community assembly patterns in boreal peatlands: using a spatial hierarchical approach

Marc-Frédéric INDORF, Tana ROUTE, Yves BERGERON, Nicole J. FENTON

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In the remote area of Eeyou Istchee James-Bay in north-western Québec, Canada, there is an important need to better understand vegetation communities and how they may interact with climate change and increasing human activities (mainly mining and hydroelectricity production). Since peatlands occupy 14–50% of the territory, we chose undisturbed peatlands to study vegetation community assembly patterns across a 1000 km gradient. For this, we developed an innovative spatial-hierarchical approach combining classical ordination methods, indicator species analysis, and randomisation techniques to test assembly hypotheses at various spatial scales and across different taxonomical groups. Surprisingly, environmental factors did not prove to be important for assembling communities at the regional scale. Results suggested instead either stochastic processes or an interaction between opposing factors (competition and environmental filtering on one side and facilitation and dispersal on the other). Coarser grain factors (e.g., climate and physiography) at the territorial scale did prove important for distinguishing regional species pools of tracheophytes, sphagna, and lichens, but not bryophytes and liverworts. At the finest scale, converging factors (e.g., facilitation) also proved significant. While contributing to baseline knowledge of peatland communities in the territory, our results show that different taxonomical groups respond differently to scale and that environmental factors have little effect or their effects may be integrated with other scales and factors. This understanding of how different communities and taxonomical groups respond to various assembly factors is necessary for better understanding resistance-resilience capacities of these communities over the near future.

10. The fate of arable bryophytes in the Swiss Plateau: Agricultural intensification, promotion of agro-biodiversity and three decades of monitoring hornworts

Irene BISANG¹, Luc LIENHARD² & Ariel BERGAMINI^{3,1}

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Land-use changes are the major drivers for the dramatic loss of biodiversity in Europe. To halt the decline of farmland biodiversity, Switzerland has in 1998 adopted agri-environment schemes (AES) that require explicit sustainable farming practices against financial compensation. To investigate the effects of arable management, AES directives, and weather conditions, we monitored *Anthoceros agrestis* and *Phaeoceros carolinianus* in selected arable fields in the intensively cultivated Swiss Plateau during almost three decades. These two hornworts are characteristic species of the specialized short-lived arable bryophyte flora of Central Europe that depends on bare substrate in regularly ploughed fields. We also studied the effects of Biodiversity Promoting Areas (BPA), a key element of Swiss AES, on arable bryophyte diversity. Hornwort occurrences significantly declined between 1991 and 2018. It was largely explained by a strong decrease in unmanaged stubble-fields, the preferred habitat of many arable bryophyte specialists. This is a consequence of a reduced cereal cultivation area, and, mainly, increasing practice of immediate post-harvest management. The latter was accentuated by AES directives amended in 2005 to reduce nitrate leaching. Hornwort occurrences were favoured by high air humidity during summer, but weather effects were subordinate to management effects. While BPA harboured bryophytes, specialist richness was relatively low and was lower in older BPA. Diaspore banks contained arable bryophyte specialists not occurring above-ground and may serve as a reservoir during unsuitable cultivation. We recommend tailored modifications of the current AES regulations that maintain suitable habitats for arable specialists, and promote BPAs of short duration.

11. An overview of *Sphagnum* peatlands in Montenegro

Snežana DRAGIĆEVIĆ¹, Antun ALEGRO², Vedran ŠEGOTA², Snežana VUKSANOVIĆ¹, Ilinka CETKOVIĆ¹ & Jaanus PALL³

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Sphagnum peatlands are rare habitats in Montenegro, present in the northern part of the country within the Alpine bio-geographical region. These specific ecosystems,

which contain layers of compact organic material formed mainly by *Sphagnum* mosses, were inventoried in 2017–2019. They are located in mountains of Bjelasica, Durmitor, Sinjajevina, Bogičevica, Visitor and Hajla. Moreover, several new habitats not recognized by previous scientists in bryological literature as peatlands with *Sphagnum* mosses were discovered: in Semolj (Sinjajevina Mt.), around Lake Pešiča, in Pešiča Rupe and below Zekova Glava and Bogičevica (Prokletije Mt.), Nadgora (Durmitor Mt.). According to the EU Habitats Directive, open habitats with *Sphagnum* mosses represent the EU Habitats directive type 7140 Transition mires and quaking bogs, and have all-European importance; therefore, they are all included in the Montenegrin Natura 2000 network. Moreover, two forest habitat types with *Sphagnum* mosses also represent the Natura 2000 habitats: (i) 9410 Acidophilous *Picea* forests of the montane to alpine level (*Vaccinio-Piceetea*), recorded in Bandžov, Grope (Hajla Mt.), along the road to Lake Hridsko (Bogičevica Mt.) and in Nadgora (Durmitor Mt.) and, (ii) 95A0 High oro-Mediterranean pine forests, on Bogičevica (Macedonian pine forest in the surrounding of Lake Hridsko). Coniferous forests with *Sphagnum* mosses are not well-known habitats in Montenegro and require additional research and eventual distinction in the Montenegrin forest typology. The recent paper provides information on distribution, floristic diversity, state and endangerment of *Sphagnum* peatlands in Montenegro.

12. A new Red List of bryophytes for Switzerland

Thomas KIEBACHER¹, Markus MEIER¹, Julie STEFFEN¹, Norbert SCHNYDER¹, Ariel BERGAMINI² & Heike HOFMANN¹

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In Switzerland, Red Lists of species are official documents that form the basis for nature conservation measures. Within a four-year project, we compiled a Red List of bryophytes which will be published soon and will replace the current list from 2004. The project included fieldwork and revisions of herbarium specimens to improve the data basis for selected taxa. Methodologically the new Red List follows the IUCN Guidelines and the adaptations to bryophytes applied in the recently published European Red List. One problem that had to be solved was the treatment of conservation dependent species. The IUCN criteria offer limited options to list species as threatened whose populations stabilized due to conservation measures. However, not listing these species may result in cessation of conservation measures because in Switzerland Red Lists are used to prioritise conservation measures. Preliminary results show that about one-third of the ca. 1150 taxa in Switzerland are threatened and about 14 % are near threatened. Climate change, which had hitherto not been considered in Swiss Red Lists assessments, was identified as one of the major threats to the bryophyte flora of Switzerland.

13. Rare EU Habitat Directive bryophyte distribution and conservation perspectives in Latvia

Anna MEŽAKA¹, Ligita LIEPIŅA¹, Anete POŠIVA-BUNKOVSKA¹, Evita OĻEHNOVIČA¹, Māris NITCIS¹, Baiba BAMBE², Linda GERRA-INOHOSA², Ansis OPMANIS³, Uvis SUŠKO⁴

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Latvia is relatively small country, but due to the geography, deglaciation history and historical landscape management, high habitat diversity has been found there which ensures the presence of rare bryophytes. In total seven EU Habitats Directive bryophyte species and the genus *Sphagnum* are present in Latvia, but monitored since 2003 are five bryophyte species: *Buxbaumia viridis*, *Dicranum viride*, *Hamatocaulis vernicosus*, *Hamatocaulis lapponicus* and *Leucobryum glaucum*, which are rare and are indicators of high-value habitats in Latvia. Apart from species records, there is a lack of knowledge of EU Habitat Directive bryophyte species ecological requirements. The objectives of our study were to increase the knowledge of the EU Habitats Directive rare bryophyte species distribution among habitats and substrates and evaluate the conservation perspectives of these species in Latvia. We compiled data about five rare bryophyte species occurrences from Natural Data Management System OZOLS database. We analyzed the bryophyte occurrences in relation to EU habitats and substrates. The most common EU Habitats Directive species was *Leucobryum glaucum* growing on forest floor with significantly higher occurrence in Western taiga. The second most common species was *Hamatocaulis vernicosus* with significantly higher occurrence in Transition mires and quaking bogs. The significantly higher number of occurrences for most of the studied species, except *Buxbaumia viridis*, was found in specially protected territories. However, as the level of conservation among different types of specially protected territories differ and the habitat quality can decrease with time, the prospects of EU Habitats Directive bryophyte species' long-term conservation in Latvia are not clear.

14. Preliminary investigations of the effects of climatic events in the bryophytic communities of riparian habitats, Southern Sardinia (Italy)

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The purpose of this study is to understand the effects of climate change by using bryophytic communities. The Mediterranean basin is considered a hotspot sensitive to global warming and the related temporal and seasonal rainfall variability and annual decrease. Effects of climate change on the environment are often disproportionate to the duration of the climate-change-induced phenomena. For this reason, the assessment of the effects of climate change on species, ecosystems and communities represents a major challenge for basic research. This is the case of the study area, where in recent decades anomalous climatic phenomena took place, altering previous ecosystem balances. Bryophytes generally thrive at relatively low temperatures, with a low potential (in a hydrated state) for short-term thermal acclimation to higher temperatures. Higher temperatures exert a significant physiological pressure on the survival of poikilohydric bryophytes by reducing the individuals' metabolically-active time-span and increasing the intensity of individuals' drying. Moreover, islands are ideal microcosmos to study the local effects of global climate change since they host several endemic species.

15. Twenty years of the bryophyte biodiversity monitoring system in Hungary

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Monitoring of bryophyte species and bryophyte vegetation is an ongoing activity started in 2000 in the frame of the National Biodiversity Monitoring System. In the course of species monitoring, the sizes of extant populations of species listed in EU Habitat Directive (*Buxbaumia viridis*, *Dicranum viride*, *Mannia triandra*, *Pyramidula tetragona*) have been traced. In bryophyte vegetation monitoring, 50 sampling plots in habitats rich in bryophytes have been surveyed. The sampling is done every 4th year in forests, 3rd year in wetlands, 2nd year in dry grasslands, yearly in saline-alkaline grasslands. The size of the permanent quadrates is 10 × 10 m in wetlands, dry grasslands and alkaline areas, while in forests quadrates of 16 × 16 m are used. In forests sampling of epiphytic bryophyte vegetation has also been carried out in three levels: at 10 cm, 70 cm and 140 cm upwards from the base of the tree. Changes in species composition (species pool, frequency, distribution), distribution of functional groups (distribution of ecological indicator values, life strategies), characteristic variables of assemblages (e.g. diversity) have been analyzed. In this presentation, we give a methodological overview used successfully for 20 years and the results obtained.

16. The Bryophyte Specialist Group – who we are and what we do

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The Bryophyte Specialist Group (BSG) is one of more than 130 specialist groups that are constituted of volunteer experts and are unified in the IUCN Species Survival Commission. We work for the exploration of bryological diversity and its long-term conservation across all geographic scales. Currently, the BSG includes 33 members representing 23 countries. One of the primary tasks of the BSG and other specialist groups is to assess species for risk of extinction on the global scale, using the red-listing methodology established by IUCN. The current global bryophyte Red List urgently needs to be updated and complemented. Today, it includes 282 species of which 77% are species endemic to Europe that were evaluated in the recent European bryophyte Red List project. We present several ongoing approaches, such as the Top 10 Initiative, and possible ways forward, to increase the number and geographic coverage of globally red listed bryophytes. We also support regional and national red listing and other conservation projects. We will end the presentation with a discussion on how the BSG can support your bryophyte conservation actions and how you can contribute to the goals of BSG.

17. Results of a survey to monitor the EU protected habitat Calaminarian grassland and its unique bryophyte assemblages

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Calaminarian grassland is a habitat that occurs on heavy metal-rich substrates, on which few species of plant can grow, and is listed on Annex I of the EU Habitats Directive. In Ireland, this habitat exclusively occurs where mining of lead and copper has taken place in the past and is primarily defined by the presence of rare metalliferous bryophytes, which are restricted to this habitat and are threatened in Europe. Under Article 17 of the EU Habitats Directive, member states are required to monitor the condition of habitats listed on Annex I of the Directive. Twenty-nine sites containing Calaminarian grassland were monitored across the Republic of Ireland and the conservation status of

Calaminarian grassland was assessed at both a site and national level. These sites were previously surveyed in 2008 and the current survey endeavoured to refind populations of rare bryophytes recorded during that survey. The survey shows that the habitat is of inadequate conservation status in Ireland, and its condition is declining. In particular, two rare metallophytes, *Ditrichum plumbicola* and *Cephaloziella integerrima*, show a decline since the previous monitoring period and may be at risk of extinction in Ireland in the near future. *Ditrichum cornubicum*, which is restricted worldwide to a handful of sites in Southwest England and Southwest Ireland, is also of concern, as it was found in very small quantity at its only Irish site. It is likely that Calaminarian grassland is undergoing a continuing decline in Ireland and ensuring its long-term survival will be highly difficult.

18. Bryophyte conservation and monitoring in the Czech Republic

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Monitoring and conservation of Czech bryophytes have been aimed primarily at critically endangered species (according to the Red List of bryophytes of the Czech Republic) and on long-term monitoring of species listed in Annex II of Habitats Directive (Natura 2000 species), i.e. *Orthotrichum rogeri*, *Dicranum viride*, *Mannia triandra*, *Notothylas orbicularis*, *Buxbaumia viridis* and *Hamatocaulis vernicosus*. In addition, detailed bryophyte inventories were made in selected protected areas over the past decades. Recently, Operational program Environment allowed for detailed bryophyte inventories of protected areas and monitoring of rare species in Czech National parks and Protected Landscape Areas. Long-term monitoring of Natura 2000 species led to the discoveries of many new localities of each species (except for *Mannia triandra*) and resulted in our better understanding of their ecology. Unfortunately, efforts to include some of the rare bryophyte species (including *H. vernicosus*, *M. triandra*, *N. orbicularis*) into the list of species protected by Czech law had failed in 2016–2017 and 2020–2021. Consequently, the only protection the rare and Natura 2000 species have is by growing in protected areas or being listed as species protected in Natura 2000 sites. This might be sufficient for some species (e.g. *Hamatocaulis vernicosus*, *Mannia triandra*), yet many other are not protected or are protected insufficiently. One of the examples is critically endangered *Notothylas orbicularis*, for which two new Natura 2000 sites are now being prepared.

19. Methodology and program of threatened bryophytes monitoring in Europe

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Monitoring of threatened bryophytes in Europe is the system of field measurement, modelling and analysis of the state and dynamics of populations and may base on 3 levels: Pan-European (regional), metapopulation and local. Its program includes several stages: 1) preparatory, including the collection of information about the distribution and inventory of existing populations, the study of the ecological and coenotic characteristics of each species, growth conditions, biology features; 2) field-measurement of the required parameters on model populations; 3) cameral, including the analysis of the collected information and the preparation of a development forecast. Some aspects are very important at the field and cameral stages: determination of the metapopulation structure based on the analysis of distances between local populations; calculation of the optimality coefficients; making a prognosis of the development of a metapopulation based on the obtained optimality coefficients and some indicators. For monitoring system development are needed: 1) unification of methods and development of a common monitoring protocol; 2) creation of a data collection and processing centre and special website; 3) initialization of the Pan-European project; 4) conducting a series of regional methodological seminars and involving bryologists from different countries; 5) preparation of regular analytical reviews under the auspices of the ECCB on the state and dynamics of rare and endangered species of bryophytes in Europe.

20. The first data about moss *Campylopus introflexus* (Hedw.) Brid. (Dicranaceae) in bryophyte flora of Serbia

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Campylopus introflexus (Hedw.) Brid. is a native bryophyte in the Southern Hemisphere, but in Europe it is considered an invasive species. After it was first recorded in Great Britain, in 1941 this species spread rapidly in European countries which disrupted the natural structure of communities, especially in coastal sand habitats, in Western Europe. In the part of South-Eastern Europe, this alien bryophyte species has so far been registered only in Croatia. During a brief visit to Pešter Plateau (Raška region) in Serbia in 2019, *Campylopus introflexus* (Hedw.) Brid. was found only in one locality at the peat

land. The registered population is very small so it cannot be considered as realistic indicator of its distribution in the area, particularly taking into account peat exploitation. The paper provides information about the locality, investigated area and information on the possible presence and occurrence of this species in the wider area (environmental modelling) for the purpose of preventing further spreading of the species.

21. The rediscoveries of *Riccia* species in Slovenia

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Until recently, little was known about the genus *Riccia* in Slovenia. In the national Red List of bryophytes from 2016, *R. bifurca* is listed as endangered and *R. fluitans* as near threatened species. Additionally, 4 species *R. canaliculata*, *R. ciliata*, *R. sorocarpa* and *R. glauca*, are in the category data deficient–vanished, all of them only with more than 100 years old data. Recently, we have become more focused on bryophytes growing in the fields, and we discovered that riccias are much more frequent, as it was presumed. We have confirmed that *R. glauca*, *R. bifurca* and *R. sorocarpa* are common in the extensive fields in the central and eastern part of Slovenia. But some rarer *Riccia* species were also found in the same habitats. *Riccia cavernosa* was already confirmed in a humid field near Maribor. Most probably, *R. warnstorffii*, *R. gothica* and *R. rhenana* were collected, but we still need to confirm the identifications. *Riccia canaliculata*, with one historical data, was discovered in humid grassland in central Slovenia. The habitats of all mentioned *Riccia* species are connected to human activities and consequently dependent on proper use. The main threats are the intensification of agricultural land and the draining of grasslands and ditches. So despite numerous new data, we suggest all *Riccia* species remain on the national Red List. *Riccia fluitans* should stay in the category NT, *R. glauca*, *R. bifurca*, and *R. sorocarpa* should be included in the category VU, and *R. cavernosa* in the category EN.

22. Another epiphyllous bryophyte found in Arboretum Stradch (Ukraine)

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Epiphyllous (growing on leaves) bryophytes occur mostly in tropical regions or rarer in highly humid sub-tropical and temperate localities. The epiphylls living in more dry temperate regions were found recently in arboreta Mlyňany (Slovakia) and Stradch

(Ukraine). The epiphylls in both arboreta grew exclusively near the trees or rocks densely covered by mosses of the same species. In 2020 in the Arboretum Stradch, mosses *Brachythecium salebrosum* and *Hypnum cupressiforme* were found as epiphylls growing on needles of young individuals of *Abies alba* and leaves of *Corylus avellana*, *Ulmus glabra* and *Rubus caesius*, while in more arid Arboretum Mlyňany five epiphyllous taxa occur growing on eleven phorophyte taxa. The aim of this work was to investigate more deeply epiphyllous bryoflora of the Arboretum Stradch looking for the other epiphylls. The occurrence of epiphyllous bryophytes was surveyed on leaves of undergrowth plants (0–2.5 m above the ground level). A bryophyte was considered as epiphyllous only if it was firmly attached to the leaf. This time, the moss *Pylaisia polyantha* was found as well, growing on needles of *Taxus baccata* 'Aureo-variegata'. The total surface area of its mats was about 10 cm². One of its mats had abundant spore boxes. It was revealed also that woody *Sambucus nigra*, *Tilia cordata*, and herbaceous *Glechoma hederacea* can serve as phorophytes for *Brachythecium salebrosum* and *Hypnum cupressiforme*. This investigation shows that epiphyllous bryophytes in not highly humid temperate localities may be considerably widespread.

23. Schuster's species in Europe: distribution, taxonomic and threatened status

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Ca. 300 species and infraspecies taxa described by R.M.Schuster are accepted in recent world checklist of liverworts. Of these 34 taxa including 13 infraspecies are recorded in Europe. All of these taxa but two (*Frullania stylifera* R.M.Schust. and *Diplophyllum obtusatum* R.M.Schust.) were described from the Arctic of the Western hemisphere and were recently found in northern regions of Europe. Due to occurrence in hard-to-reach areas and relatively recent description, the distribution, taxonomy and variability of these hepatics are poorly known. Some of these species are rather common in some areas e.g. *Lophozia polaris* (R.M.Schust.) Konstant. & Vilnet, *Saccobasis polymorpha* (R.M.Schust.) Schljakov. The study of these species using an integrative approach has shown that the first of them is correctly interpreted at the species level, while the species status of the second has not been confirmed. Several species, e.g. *Cryptocolea imbricata* R.M.Schust. are extremely rare but the largest number of taxa described by Schuster are known in Europe from a few locations. Both variability and morphological peculiarities of these taxa are poorly known. Most of the recent records are based on determining samples only from the description of the species in the monographs of Schuster and Damsholt, and it is obvious that their verification is necessary based on comparison with type specimens. Since samples collected by Schuster are still suitable for molecular phylogenetic studies, it is necessary to undertake them in the near future. This is especially important for species classified as Data Deficient in Europe.

POSTER PRESENTATIONS

1. Recommendations for the use of critical terms when applying IUCN red-listing criteria to bryophytes

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The IUCN Red List of threatened species (<http://www.iucnredlist.org/>) is widely recognised as an objective system to assess the extinction risk of animals, plants and fungi and as an authoritative tool to catalyse conservation actions. The IUCN criteria developed for estimating the extinction risk of species are most readily applied to large organisms with clearly identifiable sexually reproducing individuals, while they may be difficult to employ to bryophytes and other clonal and colonial organisms. Here, we present refined, pragmatic definitions for three key terms that are critical when using the IUCN red-listing methodology, notably 'mature individuals', 'generation length' and 'severe fragmentation'. These definitions facilitate the application of the IUCN Red List criteria for bryophytes. They have been successfully applied in the recent Red List assessment of all 1816 bryophyte species of Europe (Hodgetts et al., 2019.) and in the updated bryophyte Red List of Switzerland (Kiebacher et al., in press) The definitions provide an effective way of using the IUCN Red List criteria for bryophytes and may have a wider application to other clonal organisms.

2. Monitoring of changes in mire vegetation using data of SENTINEL 2

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Mires are habitats of high conservation significance throughout the world. As a habitat to

Sphagnum species, these areas are of special importance for maintaining a favourable status of peat moss populations. The data from Sentinel 2 opens the possibility for objective detailed spatial information about the landscape mosaic of the peat land. The aim of this pilot study in Vitosha Mt. in Bulgaria was to obtain objective detailed spatial information about the landscape mosaic of the peat land, which is necessary both for its management and for its use as an indicator of changes in the environment. Multispectral images from Sentinel-2 were used to characterize in the GIS environment a landscape mosaic; eight spectral indices; orthophoto drone mosaic; data from 304 test areas; classification with the nearest neighbour method in 24-dimensional space. In yearly bitmaps, for each pixel, distances in 24-dimensional space are calculated. The final result raster was obtained by raster mask extraction, which included sets with RasterValue > 0 corresponding to pixels related to only the 4 peat classes, and those of class 5 removed. An algorithm has been successfully developed to characterize a landscape mosaic of peatland. Raster landscaping mosaics were obtained. Its matrix includes four classes: 1) peat bryophytes and hydrophilous grasses, 2) mesophilous grasses with the presence of peat bryophytes, 3) *Juniperus* shrubs with the presence of mesophilous grasses and peat bryophytes, 4) willow shrubs (*Salix lapponum*, *S. waldsteiniana*). Among them are scattered spots of the fifth assembly class (forests, screes, etc.).

3. Rare and threatened European bryophytes in Murmansk Region, Russia

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Of the 178 liverworts assessed in the European Red List of bryophytes with one of the threatened categories, 40 species occur in Murmansk Region (MR). Five species are classified in Europe as Critically Endangered (*Scapania sphaerifera* and *Calycularia laxa*) or Endangered (*Cephaloziella integerrima*, *Schizophyllopsis sphenoloboides* and *Cephaloziella polystratosa*). These liverworts are extremely rare in MR. Fourteen species found in MR are classified in the European Red List of bryophytes as Vulnerable. The majority of these are rare and considered threatened in MR, e.g. *Isopaches decolorans*, *Lophoziopsis pellucida*, *Mannia triandra*, etc. Additionally, some of the species are assessed as vulnerable in Europe due to the wide distribution of suitable habitats that are located in hard-to-reach areas. Specifically, Arctic alpine species restricted to late snow areas (*Lophozia savicziae*, *Marsupella condensata*, *Moerckia blyttii*) are not considered threatened in the region. Arctic alpine calcephite *Mesoptychia gillmanii* is not rare in MR too. Of the species assessed as Near Threatened in Europe and found in MR, the majority are rather widespread and not threatened in MR (*Geocalyx graveolens*, *Odontoschisma francisci*, etc.), whereas some are very rare in the region, e.g. *Aneura mirabilis*. Of the species classified in Europe as Data Deficient, eight occur in MR. This group includes recently described (*Frullania subarctica*), poorly known (*Lophoziopsis rubrigemma*, *Lophozia silvicoloides*), as well as taxonomically unclear (*Lophozia*

murmanica) or potentially overlooked (*Barbilophozia rubescens*, *Isopaches alboviridis*, *Scapania obscura*) species. The majority of Red Listed European liverworts are known in protected areas of MR.

4. Results of a monitoring survey (2015–2018) of the Annex II listed bryophytes *Hamatocaulis vernicosus* (Mitt.) Hedenäs and *Petalophyllum ralfsii* (Wils.) Nees & Gottsche in the Republic of Ireland

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The Republic of Ireland has two bryophytes on Annex II of the EU Habitats Directive (92/43/EEC), the pleurocarpous moss *Hamatocaulis vernicosus* (Shining Green feather-moss), of mesotrophic fen and flushes, and the thallose liverwort *Petalophyllum ralfsii* (Petalwort), a calcicolous pioneer species of dune slacks and machair. Under Article 17 of the Directive, reporting on the species' conservation status must be completed every six years, most recently in 2019. As part of a monitoring survey 2015–2018, assessments of three parameters, Population, Habitat for the Species and Future Prospects, were undertaken at all 11 known sites for *H. vernicosus* and 22 of the 30 known sites for *P. ralfsii* following an established monitoring protocol. Damaging drainage activities were recorded at two *H. vernicosus* sites causing the Population parameter to fail for both, but the prospect of recovery was deemed to be good if no further drainage activities took place. Ten of the sites (c. 90%) containing over 99% of the habitat area recorded achieved a Favourable result for Habitat for the Species. *Petalophyllum ralfsii*, an ephemeral species, was not recorded at three sites; results indicate these sites are not grazed appropriately for the species. However, 19 of the 22 monitored sites (86%), containing over 99% of the habitat area recorded, achieved a Favourable result for Habitat for the Species. Combining the results obtained for all parameters, the national conservation status for both species was assessed as Favourable. Recommendations for improving the conservation condition of the less favourably scored sites were put forward.

5. Macrofungi from sphagnum bogs, new to Montenegro

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Sphagnum bogs are wetland habitats characterised by acidic soil reaction, low nutrient content, peat accumulation and the dominance of sphagnum mosses. Those habitats are among the most endangered ecosystems in Montenegro, occupying small and isolated areas. Fungi are a regular component of sphagnum bogs and some species are exclusive to such habitats. The first research on macrofungal biodiversity of sphagnum bogs in Montenegro was conducted between the end of May and the end of October in 2017 and 2018. Three mountain sphagnum bogs were explored, two on Sinjajevina mountain (on Semolj saddle) and one on Durmitor mountain (Lake Barno), with thirteen field visits in total. Several fungal species new to Montenegro have been discovered so far, two of which are presented here: *Galerina hybrida* and *G. tibiicystis*, which always live on dense carpets of sphagnum mosses. In this presentation, both species are illustrated, shortly described and compared with similar taxa.

6. Contribution to the knowledge of *Mannia triandra* (Aytoniaceae, Marchantiophyta) in Montenegro

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Mannia triandra (Scop.) Grolle is a protected species in the European Union (listed in Annex II of the European Union Habitats Directive) as well as in Montenegrin legislation. The Red List status in Europe is vulnerable (VU). Previously known data on the distribution of this liverwort in Montenegro go about five decades back (one report was based only on a review of herbarium material). New data on this species was published in 2019 and refers to the area of Prokletije Mountains, wherefrom the species was unknown until then. Bryological research conducted during 2019 and 2020 resulted in more than 10 new localities of *Mannia triandra*. Registered populations grow at altitudes between 40 and 1,716 m above sea level, which is expected for this montane element, which is also found at lower altitudes in Central and Southern Europe. The recorded populations of *Mannia triandra* are in good condition, but cover only small areas and are not rich in individuals. We summarize the occurrences of this species in Montenegro and present ecological conditions and potential factors of its endangerment in this country.

7. Old parks and gardens as refuges for bryophytes in cultural landscape (Slovakia)

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Old parks and gardens are highly valued in cultural landscapes primarily for their historical and cultural heritage but they also serve as a refugium for bryophytes and other various organisms. Eleven historical castle parks, two historical public parks and

one historic botanical garden in urban and rural areas of Slovakia were surveyed. The purpose of the research was to find out possible correlations between species richness and habitat characteristics and to evaluate their bryophyte diversity in selected parks and gardens. In total, 104 bryophyte species were identified, among them 12 liverworts and 92 mosses. Generally, small urban parks hosted fewer bryophyte species compared to parks in rural areas. As the most frequent species, in terms of substrate preference, epigeic species were predominant, followed by epilithic, epiphytic and epixylic species. The indirect estimation of ecological conditions showed a dominance of semi-heliophobic, semi-heliophilous, acidophilous to basiphilous bryophyte taxa. Present at all studied sites were species such as *Amblystegium serpens*, *Brachythecium rutabulum*, *Bryum argenteum* and *Tortula muralis*, but parks and gardens hosted also common forest and meadow species. Diversity of old parks and gardens should be given increased attention and further investigation of these habitats should be done.

8. Alkaline fens—a host for threatened bryophytes from Romania

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Alkaline fens are well known as a specific habitat not only for vascular plants but also for bryophytes that are the main functional component of these ecosystems, with a distinctive floristic composition. Our study was a part of a vegetation survey of Romanian mountain fens. Our aims were (1) to confirm or update the distribution of some red-listed species; (2) to identify new localities of some species of European or national interest (3) to evaluate the recent status of the species of European interest at the national scale. The data were collected during the previous field surveys conducted over five summers (from 2014 to 2018). The studied fens are legally protected in small national reserves or large Nature 2000 protected areas, mostly in mountains. According to the national red list (Ștefănuț & Goia, 2012), we found six species that are critically endangered (*Aneura maxima*, *Calliergon trifarium*, *Cephaloziella spinigera*, *Ditrichum gracile*, *Drepanocladus cossonii* and *Harpanthus flotovianus*), four are endangered (*Paludella squarrosa*, *Pohlia sphagnicola*, *Riccardia incurvate* and *Sphagnum obtusum*), and 10 are vulnerable (*Barbilophozia kunzeana*, *Drepanocladus polygamus*, *Hamatocaulis vernicosus*, *Helodium blandowii*, *Oncophorus virens*, *Plagiomnium ellipticum*, *Sarmentypnum sarmentosum*, *Scapania paludosa*, *Sphagnum majus*, *Tayloria lingulata*). *Hamatocaulis vernicosus* and *Meesia lonigiseta* are species of European interest, but the latter was not recently found. These records bring new data for the proper assessment of the national bryophytes red list. There are still some literature records that need to be confirmed.

9. Current knowledge on the species composition of subgen. *Ricciella* (gen. *Riccia*) in Bulgaria

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Subgenus *Ricciella* is a controversial group of complex thalloid liverworts. They are classified into two sections (*Spongodes* and *Ricciella*). Some of the species are aquatic with terrestrial forms, while others are found only at the edges of dams, lakes, or temporary wet places. In Europe, eight species are present. Of them, six have been found in Bulgaria. The aim of this study was to reveal the species diversity of the *Ricciella* genus in Bulgaria. The morphological examination was made for primary differentiation between *fluitans/rhenana* and *duplex/canaliculata* species pairs and for identification of *R. cavernosa* and *R. frostii*. Chromosome counting was used to identify the ploidy level since *Riccia rhenana* is proposed to be a diploid of *R. fluitans* and *R. duplex* to be a diploid of *R. canaliculata*. Four new species were found and published: *R. rhenana* (n=16), *R. canaliculata* (n=8), *R. cavernosa* and *R. frostii*. In the future, more species are expected to be found, since the territory of Bulgaria is still not well studied, especially with respect to *Riccia* species. The complex morphology and ecology of the *R. fluitans* complex require much more additional work, being poorly known in Europe. This work is supported by Bulgarian National Science Fund, project “Cryptic species in Bulgarian flora—molecular species delimitation in the *Aneura pinguis* complex” (KП-06-H21 from 19.12.2018).

10. Historical data in the context of distribution of rare species: “Zapiski bryologiczne” by K. Szafnagel and his herbarium

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“Zapiski bryologiczne” written by amateur botanist Kazimierz Szafnagel (1908) was the first book of botanical studies issued in Vilnius after the closure of Vilnius University in 1832. It presented the data of original research on bryophyte diversity from seven regions currently located in Belarus, Lithuania, Poland and Ukraine. About 240 bryophyte species were recorded for the studied territories; it was nearly twice as much as previously reported in the Floras by the botanists of Vilnius University. Kazimierz Szafnagel's data are still relevant for assessing species diversity. They are the basis

for determining distribution of some bryophyte species in Belarus. In the context of anthropogenic activity and landscape changes, they are significant for the assessment of distribution pattern of rare species, e.g. *Dicranum viride*, *Catoscopium nigratum*, *Meesia uliginosa*, *Meesia triquetra*, *Palustriella decipiens*, *Pelekium minutulum*, *Timmia megapolitana*. Unfortunately, the herbarium, by which the data provided by K. Szafnagel can be approved, was unknown for a long time. In 2017, in the storage of the Herbarium of Vilnius University, about 800 specimens without indications of the collector were found. The localities and the year of collection indicated on the labels made it possible to determine that this was K. Szafnagel's collection described in his book. The studies of the herbarium were started in 2019 (project is funded by the Research Council of Lithuania (LMTLT), agreement No S-LIP-19-62).

11. A comparative analysis of the effects of heavy metals on the liverworts *Lunularia cruciata* and *Marchantia polymorpha*

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Bryophytes are known as effective heavy metal accumulators in the environment and can play an important role in restoring soil fertility. They have been already used as monitoring species in heavy metal pollution studies and have been shown to have a wide range of adaptability and strong reproductive capacity even in heavily metal-polluted areas. Through promoting biological soil crusts, water conservation, and improvement of ecological environment, bryophytes biomonitoring can become an important and economically viable model system for bioremediation. *Marchantia polymorpha* and *Lunularia cruciata* have been selected to assess heavy metal bioaccumulation in plant tissues and plant photosynthetic capacity. After exposure to zinc, lead, copper, and cadmium, and mixtures of pairs of metals, heavy metal content in the sample will be determined and chlorophyll levels will be observed, in comparison to field species, alongside a constant growth measurement of the green area of each sample, to determine pollution progress throughout the weeks.

12. Genetic structure of endangered fen bryophytes along the large-scale gradient of habitat connectivity

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Mires represent island-like refugia of endangered bryophytes in the Central European landscape. Although these species act as one of the main objects for nature protection, very few studies aimed at their genetic diversity along a geographical gradient from the
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boreal to the temperate zone. We explored the population structure and connectivity of rich fen specialists within and among areas that differ in the density of mire islands in the landscape matrix, landscape relief and intensity of human impact. We used Restriction site-associated DNA sequencing to understand better processes that have formed the current genetic structure of the target species. The genetic structure of moss populations obtained from RADseq data appears to reflect the genome-forming processes in postglacial Europe slightly compared to the usually distinct genetic structure in vascular plants. The divergence of moss populations on a large scale gradient is not very pronounced, while cushions on individual peatlands are often clonal.

13. Is quality of bryophyte surveys related to observer experience?

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The long-term monitoring program “Monitoring the effectiveness of habitat conservation in Switzerland (WBS)” is designed to observe developments and changes in about 7000 sites of national importance, including bogs and fens. Within a sample of 250 fen and bog sites, floristic surveys are conducted on approximately 2000 plots. Each plot has an area of 10 m² and a full list of vascular plants and bryophytes is compiled for each plot. The floristic surveys are carried out by field botanists. All species not known in the field are collected and identified later in the lab by experienced bryologists. Field botanists can be divided into three experience levels (beginner, advanced, expert) in terms of their knowledge of bryophytes. To increase survey quality, botanists with less bryophyte knowledge are repeatedly invited to bryophyte excursions and courses to improve their knowledge on bryophytes. Therefore, the bryophyte survey quality of the less experienced botanists is expected to increase with the duration of the program. Here we will present the first analyses on observer group effects on the quality of the bryophyte survey and on interactions between these effects and project duration (i.e. learning effects).

14. Conservation pattern of deadwood dwelling bryophytes in European beech dominated old-growth forests

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A group of European bryologists has been regularly surveying bryophyte communities on dead wood in beech dominated forest reserves. The studied forests represent the best reference for beech stands of the regions. Hitherto, 73 sites were inventoried in 16 European countries. In each site, 20–40 large dead beech logs were sampled representing all decay stages. In the overall survey of 2242 logs in 17 European countries, we have found a total of 235 bryophyte species. The regional species pool of bryophytes is geographically determined, and many species show a distinct preference or are restricted, to a specific region of Europe. The diversity hotspots of epixylic bryophytes are the primeval forests of the montane beech-fir zone in the Alps, Carpathians and Dinaric mountains. These old-growth relicts are characterized by high species richness and the presence of specialist epixylic species (many liverworts), which are regionally rare in Europe. Peculiar stands are Rotwald in Austria, Boubin in the Czech Republic, Dobroc in Slovakia and Rajhenav in Slovenia. The presence of coniferous species (fir and Norway spruce) increases the bryophyte diversity occurring on beech logs compared to pure beech dominated stands. Forest site, landscape and climate also influence bryophyte diversity. The preservation of stands with long dead wood continuity is crucial for the conservation of strict epixylics and epiphytics. These reserves maintain the core populations of many endangered species that may colonize also the managed forests. Epixylic populations are sensitive to substrate availability (presence of large logs) as well as microclimatic conditions (humidity).

15. Reintroduction of *Hamatocaulis vernicosus* to Hungary

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Hamatocaulis vernicosus is a moss species listed in the EU Habitats Directive, and vulnerable (VU) in Europe according to the latest European red-list of bryophytes. It is a key species of mineral-rich, mesotrophic mires and fens and is still quite common in the north, but it became rare in Central and Southern Europe. The last record from Hungary comes from 1968. Despite intensive and detailed search after 2000, when the monitoring of EU Habitats Directive species started in Hungary, it has not been re-found in any historically known sites. Thus, it was considered to be regionally, i.e. nationally

extinct in Hungary. An attempt at the reintroduction of this species to Hungary has been made. A less than one-year-old herbarium *H. vernicosus* specimen from a neighbouring country was used to establish *in vitro* culture of the species and propagate it. Then, the lab originated material was used to grow colonies under controlled conditions in a native medium originating from the targeted reintroduction site. Finally, the moss plants were reintroduced and a population was established in 2015. Monitoring of the reintroduced population is ongoing. Water parameters (pH, conductivity, temperature) and accompanying bryophytes were also sampled two-three times a year. Water parameters are as follows; average pH is 6 and average conductivity is 107 μ S. It seems the reintroduced population is already stable and continuously increasing.

16. Restoration of rare rich-fen bryophytes: effect of sod-moss removal

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Peatlands have been managed by a range of land uses for decades, which affected ecosystem services such as biodiversity. Rich fens are known as biodiversity hot-spot among peatlands encompassing many endangered species. Characteristic sedge-moss fen vegetation, hosting many red-listed bryophytes, has been currently outcompeted by few expansive *Sphagnum* species and/or competitively strong vascular plants at many sites as a result of eutrophication and water table decline. The absence of disturbances, such as scything, raking, or occasional grazing, was one of the main causes. Removal of expansive *Sphagnum* species together with tussock of graminoids was carried out on 31 sites to set back the undesired succession by restoring microhabitats available for non-sphagnaceous fen bryophytes and small sedges. After two years, the disturbed patches showed a positive increase in the cover of fen-specialized target bryophytes and a decline of expansive, fast-growing *Sphagnum* species. Removal of expansive *Sphagnum* species is a promising tool for restoring rich fen vegetation that developed to poor fens because of modern anthropogenic interventions to the agricultural landscapes.

17. Contribution of citizen science in the knowledge of rare Latvian bryophytes

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During the last decades, public virtual databases available to bryophyte experts and amateurs have become efficient way to study species distribution. Aim of study was to analyse whether interest about bryophytes might benefit as a contribution to understand rare bryophyte species distribution in Latvia, using online nature database: Dabasdati (www.dabasdati.lv). The first records of bryophyte species in Dabasdati are registered already from year 2000, since then, 384 bryophyte species have been recorded by 148 persons for more than 5700 times, reaching 61 % from all bryophyte species ever found in Latvia (i.e. 630 species). For the study, we were focusing on rarities registered in Dabasdati, specifically to 78 especially protected species in Latvia, 41 Red-listed species in Latvia and nine new for the country or with the second or third known locality ever documented in the country. Since 2016, additional motivation to find certain bryophyte species is a campaign organized by the Latvian Botanical Society which chooses one species as a Bryophyte of the Year, some of them under protection in Latvia or in European region. Due to this campaign, interest among portal users about bryophytes has increased. Each bryophyte record in Dabasdati accompanies species photography and this is checked by bryophyte experts regularly. Some of the species are hard to recognize in photographs and if sample is not collected, they remain unidentified. However, the number of unidentified species is relatively small, only 3 % from all observations or 173 times, confirming the plausibility of data stored in the portal.

18. Zoos as hotspots of bryophyte diversity – case study from Košice (Eastern Slovakia)

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Urban environments have good preconditions for a rich flora, especially of cryptogams, since they offer various ecological situations and microhabitats. However, zoological gardens are rarely botanically studied. In addition to providing leisure and recreation, zoos are also important scientific and educational centres. Here, we examine bryophyte functional and ecological diversity (based on species traits) of the Košice zoo, the third largest zoo in Europe, and discuss its potential role in biodiversity conservation. Within the zoo, 124 bryophyte taxa (114 mosses and 10 liverworts) from 42 different families were recorded, including some species of conservation concern (*Physcomitrium*

eurystomum, listed as vulnerable both in Slovakia and on a whole-European level). The recorded taxa represent as many as 18 different life forms and display seven life strategies. The species found indicate more basic, infertile, drier, lighter, but at the same time colder conditions and most taxa occur predominantly on soil and rocks (natural and man-made) but a significant portion are also epiphytic and epixylic. Most species are found in both forests and open land, but one quarter is restricted to the closed forest, and almost half shows a stronger affinity towards natural ecosystems with weak human impact. Although the primary role of zoos is to display and protect animal species, they also have tremendous potential in promoting education and awareness about plant and habitat diversity as part of the animal environment. By active engagement, zoos can develop the capacity to become fully integrated conservation organizations.

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