A miniature world in decline

European Red List of Mosses, Liverworts and Hornworts

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Foreword

Europe has a rich natural heritage, with habitats ranging from dry Mediterranean maquis in the south to the Arctic tundra in the far north. Much of Europe's landscape has been shaped by centuries of diverse farming and forestry traditions. As a result, a large number of agricultural and semi-natural landscapes have emerged and significantly influenced the continent's biodiversity.

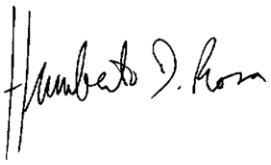
Biodiversity loss as a result of human impacts is one of the major challenges that the world currently faces, and this has considerably affected valuable ecosystem services. In order to halt the loss of biodiversity, the EU Biodiversity Strategy aims to protect, value and restore biodiversity and the services it provides – Europe's natural capital. This is important not only to protect nature for its own sake, but also for its essential contribution to human well-being and economic prosperity, and to avert catastrophic changes caused by biodiversity loss. After all, everyone will understand that we cannot act sustainably if we keep destroying nature.

In recent years, awareness has risen surrounding the crucial role of plants in providing ecosystem services and on their decline – they are one of the essential foundations of healthy ecosystems that we depend on. However, significant gaps in knowledge still remain. In this context, *A miniature world in decline: European Red List of Mosses, Liverworts and Hornworts* provides the first-ever comprehensive assessment of the extinction risk of all native bryophyte species to Europe. With 1,817 species assessed, this assessment highlights that 22.5% of bryophyte species are threatened with extinction in Europe. Main threats to these species include land modifications such as those caused by the construction of dams and through increased frequency of fires, the impacts of climate change as well as agricultural and forestry practices, such as the conversion of natural forest to plantation woodland. While 88.2% of species are recorded in at least one protected area (whether it is a national park, Natura 2000 site or nature reserve), eight species are already lost from Europe, and so it is clear that we continue to have a responsibility to conserve these unique species to prevent further extinctions in our region.

By comparison to European bryophytes, 2% of medicinal plants, 8% of aquatic plants, 16% of crop-wild relatives, 20% of ferns and lycopods, 42% of trees and 57% of "policy plants" (listed under European or international policy instruments) are threatened, ranking bryophytes third as the most threatened group of plant species assessed so far.

Immediate action must be taken in order to improve the status of European bryophytes. A multidisciplinary approach needs to be established; while species and protected area management are key, the proper implementation of the existing European legislation will be crucial in providing protection to the species, including the EU Birds and Habitats Directive.

I hope that this new IUCN European Red List will help place plants higher on the conservation agenda as well as inform the wider debate and contribute to the discussion on priorities within the conservation community. A network of bryophyte experts is already in place, therefore more investment in scientific research, and increasing awareness and communications will help towards the delivery of real results and positive impacts for these species.



Humberto Delgado Rosa
Director for Natural Capital
DG Environment, European Commission

Preface

This publication has been prepared by IUCN (International Union for Conservation of Nature) as a deliverable of the LIFE European Red Lists project (LIFE14 PRE BE 001). *A miniature world in decline: The European Red List of Mosses, Liverworts and Hornworts* is, therefore, a part of a series of publications released since 2015, when the project began, that also include:

- *European Red List of Lycopods and Ferns*, 2017
- *European Red List of Saproxylic Beetles*, 2018
- *European Red list of Terrestrial Molluscs: slugs, snails, and semi-slugs*, 2019
- *European Red list of Trees*, 2019
- *European Red list of Selected Endemic Shrubs*, 2019

Based on other European Red List assessments, 59% of freshwater molluscs, 40% of freshwater fishes, 28% of grasshoppers, crickets and bush-crickets, 23% of amphibians, 20% of reptiles, 20% of ferns and lycopods, 17% of mammals, 16% of dragonflies, 13% of birds, 9% of butterflies and bees, 8% of aquatic plants and 2% of medicinal plants are threatened at the European level (Allen et al., 2014; IUCN, 2015; Hochkirch et al., 2016; García Criado et al., 2017). Additional European Red Lists assessing a selection of species showed that 22% of terrestrial molluscs, 16% of crop wild relatives and 18% of saproxylic beetles are also threatened (Cuttelod et al., 2011; Bilz et al., 2011; Cálix et al., 2018). The findings of this work suggest that 23% of bryophytes are threatened species in Europe, representing the fifth most threatened group of plants assessed so far.

Lindenberg's featherwort *Adelanthus lindenbergianus* (Endangered liverwort) © Rory Hodd

Acknowledgements

All of IUCN's Red Listing processes rely on the willingness of scientists to contribute and pool their collective knowledge to make the most reliable estimates of the status of a species. Without their enthusiastic commitment to species conservation, this kind of regional overview would not be possible. Bryophytes are no exception, and the knowledge mobilized through the Europe-wide network of members of the European Committee for the Conservation of Bryophytes (ECCB) has been pivotal to the completion of this Red List. We are therefore indebted for their support and contributions.

Thanks go to the Red List Unit, in particular Caroline Pollock, David Allen, Jemma Window, Kate Harding and Anna Puttick for their support in the coordination of the European Red List of Mosses, Liverworts, and Hornworts. Anna Rosenberg and Corinna Karlsen provided substantial assistance with financial management of the project.

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Executive summary

Aim

This Red List is a summary of the conservation status of the European species of mosses, liverworts and hornworts, collectively known as bryophytes, evaluated according to IUCN's Guidelines for Application of IUCN Red List Criteria at Regional Level. It provides the first comprehensive, region-wide assessment of bryophytes and it identifies those species that are threatened with extinction at a European level, so that appropriate policy measures and conservation actions, based on the best available evidence, can be taken to improve their status.

Scope

All bryophytes native to or naturalised in Europe (a total of 1,817 species), have been included in this Red List. In Europe, 1,796 species were assessed, with the remaining 21 species considered Not Applicable (NA). For the EU 28, 1,728 species were assessed, with a remaining 20 species considered NA and 69 species considered Not Evaluated (NE). The geographical scope is continent-wide, extending from Iceland in the west to the Urals in the east, and from Franz Josef Land in the north to the Canary Islands in the south. The Caucasus region is not included. Red List assessments were made at two regional levels: for geographical Europe and for the 28 Member States of the European Union.

Results

Overall, 22.5% of European bryophyte species assessed in this study are considered threatened in Europe, with two species classified as Extinct and six assessed as Regionally Extinct (RE). A further 9.6% (173 species) are considered Near Threatened and 63.5% (1,140 species) are assessed as Least Concern. For 93 species (5.3%), there was insufficient information available to be able to evaluate their risk of extinction and thus they were classified as Data Deficient (DD). The main threats identified were natural system modifications (i.e., dam construction, increases in fire frequency/intensity, and water management/use), climate change (mainly increasing frequency of droughts and temperature extremes), agriculture (including pollution from agricultural effluents) and aquaculture.

Exormotheca welwitschii (Endangered liverwort) © Michael Lüth

Recommendations

Policy measures

- Use the European Red List as the scientific basis to inform regional/national lists of rare and threatened species and to identify priorities for conservation action in addition to the requirements of the Habitats Directive, thereby highlighting the conservation status of bryophytes at the regional/local level.

- Use the European Red List to support the integration of conservation policy with the Common Agricultural Policy (CAP) and other national and international policies. For example, CAP Strategic Plans should include biodiversity recovery commitments that could anticipate, among others, the creation of Important Bryophyte Areas. An increased involvement of national environmental agencies in the preparation of these strategic plans, and more broadly in ongoing discussions on the Future CAP Green Architecture, would likely also ensure the design of conservation measures better tailored to conserve bryophytes in agricultural landscapes.

- Update the European Red List every decade to ensure that the data remains current and relevant.

- Develop Key Biodiversity Areas for bryophytes in Europe with a view to ensuring adequate site-based protection for bryophytes.

Research and monitoring

- Use the European Red List as a basis for future targeted fieldwork on possibly extinct and understudied species.

- Establish a monitoring programme for targeted species (for example, threatened species and/or arable bryophytes).

- Use the European Red List to obtain funding for research into the biology and ecology of key targeted species.

Action on the ground

- Use the European Red List as evidence to support multi-scale conservation initiatives, including designation of protected areas, reform of agricultural practices and land management, habitat restoration and rewilding, and pollution reduction measures.

- Use the European Red List as a tool to target species that would benefit the most from the widespread implementation of the solutions offered by the 1991 Nitrates Directive (Council Directive 91/676/EEC), including the application of correct amounts of nutrients for each crop, only in periods of crop growth under suitable climatic conditions and never during periods of heavy rainfall or on frozen ground, and the creation of buffer zones to protect waters from run-off from the application of fertilizers.

Ex situ conservation

- Undertake ex situ conservation of species of conservation concern in botanic gardens and spore and gene banks, with a view to reintroduction where appropriate.

1. Background

1.1 The European context

Europe is the world's second smallest continent in terms of area after Australia, covering approximately 10.4 million km², or 2% of the Earth's surface. In terms of human population, Europe is the third largest continent (after Asia and Africa) with a population of around 546 million (UN DESA, 2018) – about 13% of the world's population. Therefore, Europe is one of the smallest and one of the most densely populated continents in the world.

The European Union (EU), consisting of 28 Member States (EU 28), is Europe's largest political and economic entity. The ecological footprint of the EU 28 has been estimated to exceed the region's biological capacity (the total area of cropland, pasture, forest, and fishing grounds available to produce food, fibre and timber, and absorb waste) by 2.6 times (EEA, 2015).

Europe has a great diversity of landscapes and habitats and a wealth of flora and fauna. For example, the Mediterranean Basin, which is especially rich in plant and animal species, many of them endemic to that region, has been recognised as a global biodiversity hotspot (Mittermeier et al., 2004; Cuttelod et al., 2008).

The European continent has a highly fragmented landscape, and up to 80% of land in Europe is currently used for settlement, industry, production systems (including agriculture and forestry) and infrastructure (EEA, 2006; Pedroli & Meiner, 2017). Consequently, European species are to a large extent dependent upon habitats created and maintained by human activity, and many are affected by overexploitation, pollution and the impacts of invasive alien species. Additionally, climate change is becoming an increasingly serious threat. Europe is a diverse region and the relative importance of different threats varies widely across its biogeographic regions and countries.

Although considerable efforts have been made to protect and conserve European habitats and species (see Sections 4.1 and 4.2), and the Natura 2000 network of protected areas covers more than 18% of the EU terrestrial territory, biodiversity decline and the associated loss of vital ecosystem services (such as water purification, pollination, flood protection and carbon sequestration) continues to be a major concern in the region.

1.2 European mosses, liverworts and hornworts

Bryophytes are a large, diverse group of plants. According to Villareal et al. (2010), there are between 18,000 and 23,000 described species worldwide, comprising about 11,000-13,000 mosses, 7,000-9,000 liverworts and 200-250 hornworts, making them second only to flowering plants in terms of species richness. This could, however, be an underestimate, with molecular studies revealing 'new' species all the time. Each of the three groups of bryophytes has been traditionally considered to be a separate phylum (or division): Bryophyta (mosses), Marchantiophyta (liverworts) and Anthocerotophyta (hornworts) (Frey & Stech, 2009), although the latest evidence, with increasing support, suggests that mosses and liverworts form a clade, termed "Setaphyta" (Puttick et al., 2018). Nevertheless a number of biological and ecological characters are common to the three groups: They are small (rarely larger than a few centimeters), unable to produce lignin (they cannot become woody), have their life cycle dominated by the gametophyte (rather than the sporophyte) generation – see Box 1 - and are able to dry out completely in dry periods, quickly resuming their metabolism when rewetted. They fulfill a range of important ecological functions, particularly in water retention, soil-building and in their relationships with other organisms. For example, bog-moss (*Sphagnum* spp.) is one of the most important plants, and certainly the most important peat producer in the world, locking away an enormous amount of carbon and holding vast quantities of water: bogs are essentially huge sponges. Bryophytes, particularly epiphytes, are also great indicators of air pollution. Bryophytes show a vast range of specific sensitivity and visible symptoms to pollutants greatly exceeding that of higher plants (Govindapyari et al., 2010).

Mosses

The most species-rich of the three main groups of bryophytes, mosses, encompasses a wide range of forms. 'Typical' mosses (class Bryopsida) are mostly small,

Box 1 - The life history of bryophytes

What distinguishes bryophytes collectively from all other land plants is that their life cycle is dominated by the gametophyte generation; that is, by the haploid or sexual phase, as opposed to the diploid, spore-producing phase. In contrast, all flowering plants, conifers and ferns are dominated by the sporophyte generation, with the gametophyte much reduced, often to just a few cells. In other words, the main plant that one sees, the leafy green part, that is mainly photosynthetic, is the gametophyte in bryophytes, whereas it is the sporophyte in all other plants. The bryophyte sporophyte is usually reduced to a spore-producing, stalked capsule that remains attached to the gametophyte, and is entirely dependent on it for sustenance.

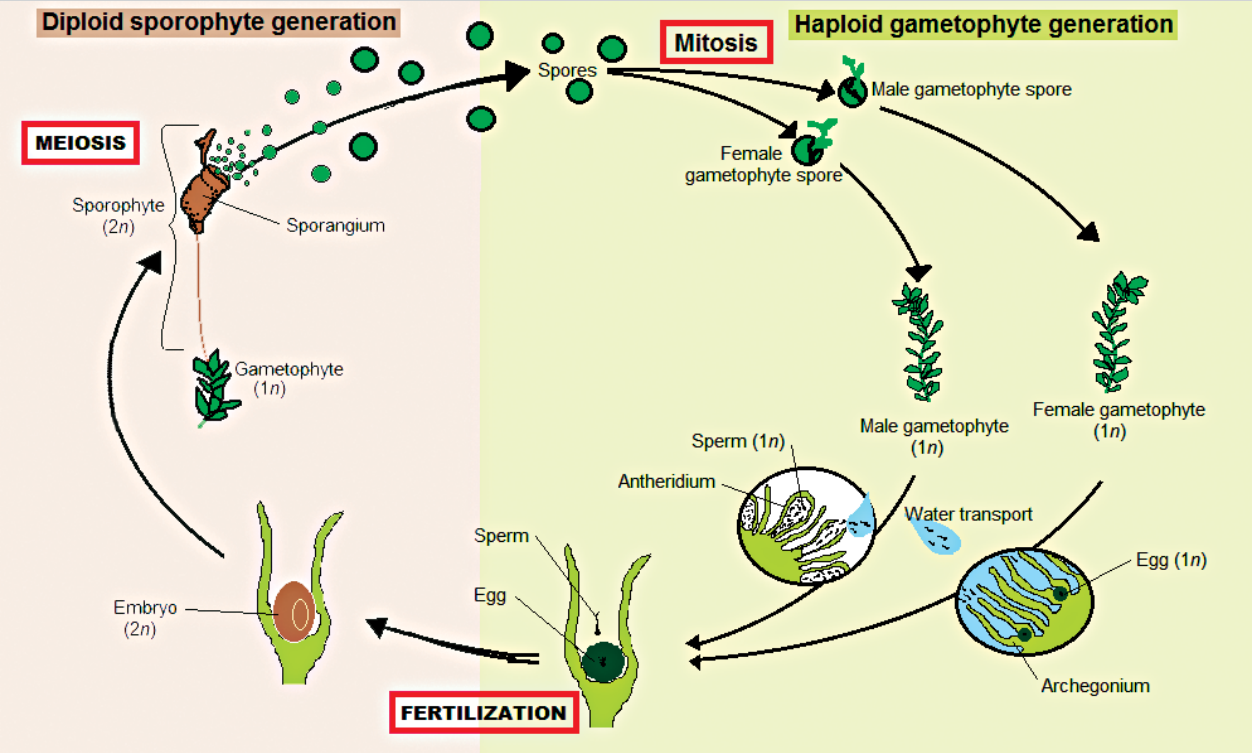

Figure 1. The life cycle of a bryophyte © MADBRYO initiative

The spore is the first stage in the haploid gametophyte generation, with a single set of unpaired chromosomes. Spores germinate into a green protonema, from which the mature gametophyte grows, either producing a structure with a stem and leaves (as in mosses and leafy liverworts) or a structure with no differentiation, usually a flat plate of tissue called a thallus (as in thallose liverworts and hornworts). The gametophyte produces (either on the same plant [bisexual, Figure1] or on separate plants [unisexual, Fig. 1]) male and female sex organs (antheridia and archegonia, respectively). The antheridia produce sperm, which swim in a film of water to the archegonia. In each archegonium only a single egg cell is found which may be fertilized by a sperm cell. If fertilization has been successful, i.e. if male and female elements of the gametophyte have fused, a new sporophyte starts to develop. The sporophyte relies largely on the gametophyte for its nutrition. At maturity it eventually produces spores by the process of meiosis, the kind of cell division that halves the number of chromosomes. In other words, the brief reign of the sporophyte is over, and a new gametophyte generation is ready to develop.

While there is a lot of variation in the detail of how bryophytes conduct their life cycle, they all conform to this basic pattern. In addition, many of them produce specialised asexual reproductive organs, such as gemmae, which circumvent the sporophyte generation entirely, simply replicating the gametophyte parent. In addition, all bryophytes are to some extent totipotent: they can regenerate from fragments, or even single cells, making them great survivors.

rather delicate, often translucent plants that absorb water and nutrients externally, over their entire surface. The sporophyte consists of a capsule in which the spores are produced supported by a stalk (seta). When mature, the capsule releases its spores through an opening at the top, which is usually surrounded by a ring of tooth-like structures (the peristome).

Not all mosses conform to this general template. There are a few groups of mosses that are so distinctive they are put in their own classes within the Bryophyta. Most obviously, and certainly most importantly, are the bog-mosses, the genus *Sphagnum* (class Sphagnopsida) with 61 species in Europe. They differ from typical mosses in almost every respect, except for the dominance of the gametophyte generation. Its unique cell structure allows *Sphagnum* to take up water quickly by capillary action, and release it only very slowly, like a sponge. Other features of its physiology and morphology make it possible for *Sphagnum* to dominate entire landscapes, as in the extensive boglands of northern Europe, which store tremendous amounts of peat built by thousands of years of *Sphagnum* growth.

A further oddity among the mosses is *Andreaea* (rock-moss, class Andreaeopsida), tiny black or very dark red-brown tufts on acid rocks in the mountains, with a capsule that splits into four lobes joined at the top, a bit like a miniature Japanese lantern. Then there are the haircap mosses, the genus *Polytrichum* and its allies (class Polytrichopsida). As well as having a distinctive spore capsule, these plants have an internal conduction system somewhat analogous to the xylem and phloem of vascular plants, enabling them to grow much bigger than 'ordinary' mosses, and shoots of *Polytrichum* are capable of attaining heights of half a metre or even more.

A) Five-ranked Bog-moss *Sphagnum quinquefarium* (Least Concern moss) © Christian Schröck, B) snow rock-moss *Andreaea nivalis* (Near Threatened moss) © Michael Lüth, C) *Polytrichum commune* (Least Concern moss) © Fred Rumsey, D) *Oedipodium griffithianum* (Near Threatened moss) © Vladimiar Fedosov

Another couple of small classes, the Oedipodiopsida and the Tetraphidopsida, differ fundamentally from the Bryopsida in features of the sporophyte, but have few species.

Liverworts

A less species-rich group than mosses, yet showing a greater range of forms, liverworts can be subdivided into leafy (class Jungermanniopsida) and thallose (class Marchantiopsida), plus a group of rather anomalous plants that show features of both leafy and thallose liverworts (class Haplomitriopsida, with only a single species in Europe).

Leafy liverworts are especially diverse in the form of the leaves, which range from entire and rounded, through simply bilobed or trilobed, to deeply divided into filaments or asymmetrically divided so that one lobe is larger than the other, or even modified into a tiny pocket or helmet-shaped structure. Furthermore, while leafy liverworts typically have two rows of main (lateral) leaves running down opposite sides of the stem, many species have an additional row of leaves on the under-surface of the stem (underleaves, or amphigastria): these are usually smaller than the lateral leaves, and often quite different in shape.

The form of the sporophyte is relatively uniform among the liverworts, although there is great variation in the various gametophytic structures that support and protect it. Unlike mosses, where the spore capsule and seta mature slowly together, and then spores are released gradually, the liverwort capsule matures inside a protective sheath (usually a structure derived from modified leaves called a perianth), and is raised up on a seta only when ready to release its spores. The seta therefore grows at a tremendously fast rate, by sudden elongation of its cells, and forms a delicate, ephemeral structure which lasts just long enough for the mature capsule to release all its spores at once.

Hornworts

The least species-rich group of bryophytes, the hornworts, superficially resemble thallose liverworts, but are not closely related. They probably emerged as a group at about the same time as the other bryophytes, in the Ordovician period about 470 million years ago, or even earlier (Morris et al., 2018), but whether they were even then part of the same taxonomic group as other bryophytes is still a matter for research. They have an unusual combination of features, some shared with other bryophytes, some having more in common with vascular plants or algae. For example, the thallus cells contain just one large chloroplast, while the sporophyte, which is a long narrow structure with no differentiation into seta and capsule, has stomata. Hornworts reach their greatest diversity in the tropics, with only a small handful of species occurring in Europe. Nonetheless, certain species can be locally abundant given the right conditions.

Distribution, habitats and ecology

Bryophytes occur on all continents and in many different habitats except in the sea. They are almost ubiquitous, growing even in very dry semi-deserts, but require some moisture, at least at some stages of their life cycle. Unlike vascular plants, most species are poorly equipped to regulate their water content internally, instead drying out and rewetting rapidly according to external conditions

A) *Mannia triandra* (Vulnerable liverwort) © Christian Schröck, B) *Phaeoceros carolinianus* (Near Threatened hornwort) © Michael Lüth

Grimmia mollis (Vulnerable moss) © Michael Lüth

(poikilohydric). This means that they are often luxuriant in moist forest and in high rainfall areas. Bryophytes absorb water, along with the minimal amounts of nutrients they require, over their entire surface from the surrounding environment, rather than taking it up through roots and a vascular system. However, many bryophytes, and most of the European bryophytes, have a physiology that allows them to dry out completely in the absence of moisture, suspend physiological activity, and then 'come back to life' when wetted again. Different species do this to different degrees, but herbarium specimens of the great hairy screw-moss (*Syntrichia ruralis*) were recently found to have retained their vitality after over 20 years dried in a packet (Stark et al., 2016), and there are unsubstantiated anecdotes about much longer periods of survival in the herbarium. Many species which grow directly on rock in exposed conditions (*Grimmia*, *Didymodon*, etc.) dry out and rehydrate virtually on a daily basis, particularly in warmer climates; this is their strategy for enduring drought. This contrasts with most vascular plants, which could not survive this level of dehydration.

Bryophytes have several ecological attributes that are very distinctive:

- They are poikilohydric, i.e., they dry out and rewet rapidly according to external conditions.
- They grow in 'microhabitats': whether they grow in woodland, heathland or grassland is less important than the immediate micro-environment, such as a rock crevice or a moist patch of soil.
- A large proportion of species are colonists, and therefore form pioneer communities and assemblages. There are, for example, many short-lived ruderal (weedy) species that colonise bare ground, disappearing as vegetational succession proceeds.
- Many species are very efficient at dispersal, with spores and vegetative propagules potentially capable of travelling worldwide in the air or via vectors such as migratory birds.
- Due to the latter, levels of endemism are low (in Europe, *ca.* 10% compared to *ca.* 28% vascular plants; Patino & Vanderpoorten, 2018), but levels of disjunction are high (for example, a species may occur in western Europe, the Himalayas and British Columbia).
- Those species that are less efficient at dispersal often have large spores that can remain viable in the soil for a long time.
- They are often excellent ecological indicators (for example, of nutrient status or pH).

Ecosystem services and commercial use

The ecosystem services that bryophyte species provide might not be conspicuous, but investigation soon shows us that these small plants, useless as food or building materials, are actually of vital importance. In particular, there are three main features of bryophytes that make them important in the ecosystem:

- Their ability to retain water. All bryophytes act to some extent as sponges, taking up water rapidly, holding it, and releasing it only slowly. This is most obvious in bog-moss *Sphagnum*, which dominates vast areas of mire in northern Europe. On hillsides and hilltops, *Sphagnum* is an important stabilising influence in areas with heavy rainfall. A similar effect is seen in forest ecosystems. A substantial part of the water-holding capacity of forests is bound up in the bryophytes, and when it is clear-felled, the resultant erosion, flooding and destabilisation is at least partly because the bryophytes have been removed from the landscape along with the trees.
- They are efficient colonisers and stabilisers of bare substrates. When natural erosion occurs, bryophytes are usually the first plants to appear on the newly exposed surfaces. After volcanic eruptions, bryophytes are the first to colonise the cooling lava flows. In post-industrial landscapes, and in urban habitats more generally, bryophytes often build up thick carpets over crumbling concrete and tarmac, trapping detritus, building new soils, providing rooting substrates for larger plants and ultimately the basis for entire new ecosystems.
- They serve as hosts for blue-green algae (cyanobacteria), which have an important role in nitrogen (N) fixation, and provide a major source of N for boreal ecosystems (for example, Ackerman, 2013). It is likely that epiphytic cyanobacteria are a key factor in determining the abundance of feather mosses across the boreal biome (Zacckrissson et al., 2019).

Additionally, they provide habitats for other organisms; seed-beds for vascular plants, shelter and food for invertebrates, nesting material for birds and small mammals. Bogs in particular form entire ecosystems fundamentally dependent on bryophytes.

Sphagnum mosses are used commercially - peat is (or has been, historically) burned for fuel. However, this has rarely been done in a sustainable way, and several countries have established peat-burning power stations, which have had a devastating effect on peatlands. It has also been used as a mildly antiseptic dressing for wounds (it was harvested for this purpose during the First World War), and as an absorbent material in babies' nappies. Bryophytes are harvested commercially (sustainably or otherwise) for horticultural purposes such as packing material for bulbs or a water-retentive substrate for hanging baskets. *Sphagnum* harvested for horticultural purposes is also not usually sustainable. A more modern use is that of mosses, particularly the Habitats Directive

The procession of 'moss men' in Béjar, Spain, commemorating the use of moss as camouflage in battles during the 12th century by local Christians © Eloy Díaz-Redondo

Annex V *Leucobryum*, for 'moss walls' and other 'green' architectural purposes. Other commercial uses are largely historical or minor: *Polytrichum commune* for brooms, mosses as insulation for homes, decorative garlands and even clothing for the famous 'moss men' of Béjar in Spain.

1.3 Assessment of species extinction risk

The conservation status of plants, animals and fungi is one of the most widely used indicators for assessing the condition of ecosystems and their biodiversity. At the global scale, the primary source of information on the extinction risk of plants and animals is *The IUCN Red List of Threatened Species*™ (www.iucnredlist.org), which contributes to understanding the conservation status of assessed species.

The *IUCN Red List Categories and Criteria* (IUCN, 2012a) are designed to determine the relative risk of extinction of a taxon, with the main purpose of cataloguing and highlighting those taxa that are facing a high risk of extinction. The IUCN Red List Categories are based on a set of quantitative criteria linked to population trends, size and structure, threats, and geographic ranges of species. When conducting regional or national assessments, the IUCN Red List Regional Guidelines (IUCN, 2012b) are applied to assign the IUCN Red List Categories (Figure 2).

As the extinction risk of a species can be assessed at global, regional or national levels, a species may have a different Red List Category on the global Red List than on the regional Red List. Logically, an endemic species should have the same Category at regional and global levels, as it is not present anywhere else in the world.

1.4 Objectives of the assessment

The European Red List of Mosses, Liverworts and Hornworts has four main objectives:

- to contribute to regional conservation planning through provision of a baseline dataset reporting the conservation status of European bryophyte species;
- to identify those priority geographic areas and habitats needing to be conserved to prevent extinctions and to ensure that European bryophytes reach and maintain a favourable conservation status;
- to identify the major threats and to propose potential mitigating measures and conservation actions to address them;
- to strengthen the network of experts focused on bryophyte conservation in Europe, so that the assessment information can be kept current and expertise can be targeted to address the highest conservation priorities.

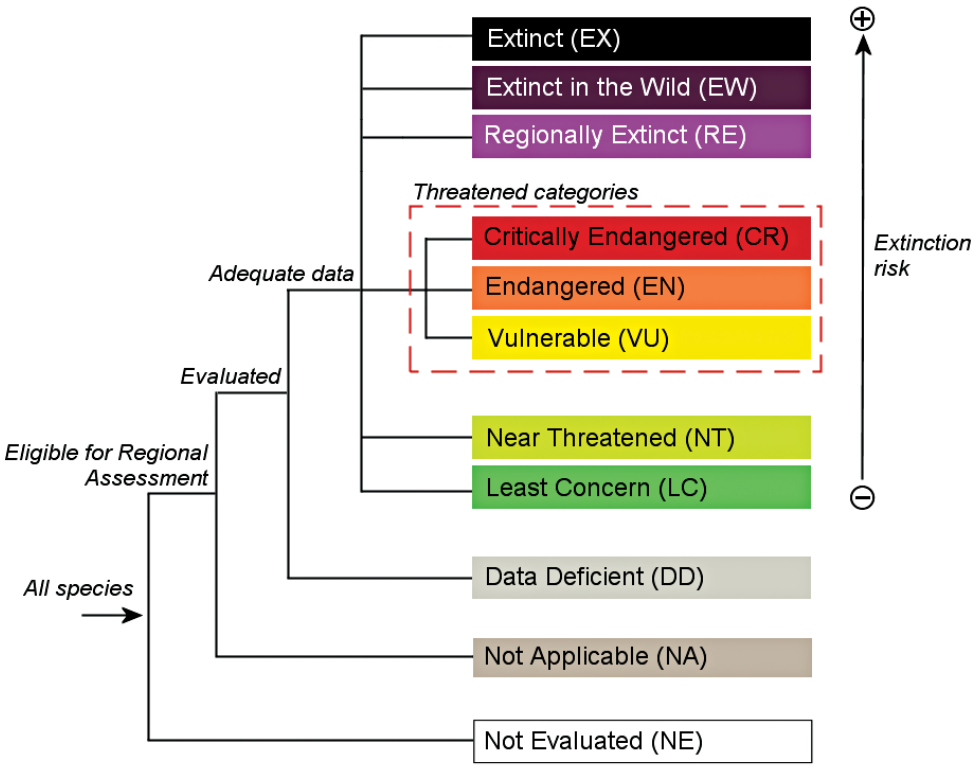

Figure 2. The IUCN Red List Categories at the regional scale.

The assessment provides three main outputs:

- summary reports on the status of all 1,817 European bryophyte species;
- a freely available database holding the baseline data on the status and distribution of European bryophytes;
- a website and data portal (http://ec.europa.eu/environment/nature/conservation/species/redlist and www.iucnredlist.org/initiatives/europe) showcasing these data in the form of species factsheets for all European bryophytes included in this study, along with background and other interpretative material.
- This Red List provides the first comprehensive, region-wide assessment of bryophytes and builds on the previous work of the European Committee for the Conservation of Bryophytes (ECCB). The enormous amount of new fieldwork, data and knowledge accumulated since then means that it should be much more robust and authoritative. Efforts will continue to update the database which will also be made freely and widely available.

Matted bryum *Bryum calophyllum* (Endangered moss) © Neil Lockhart

2. Assessment methodology

2.1 Geographic scope

The geographic scope is continent-wide, extending from Iceland in the west to the Urals in the east (including European parts of the Russian Federation), and from Franz Josef Land in the north to the Mediterranean in the south (Figure 3). The Canary Islands, Selvagens, Madeira, the Azores, Malta and Cyprus are also included. In the southeast, the Caucasus region and Anatolia are excluded.

Red List assessments were made at two regional levels: 1) for geographical Europe (limits described above); and 2) for the area of the 28 Member States of the European Union (EU 28) (as of 2018).

2.2 Taxonomic scope

The European Red List of Mosses, Liverworts and Hornworts has assessed the status of all bryophyte species considered native to or naturalised in Europe. The original list of species was based on Hodgetts (2015), which was in turn based on Hill et al. (2006) for the mosses and Söderström et al. (2007) for the liverworts and hornworts. The inclusion of newly described or species which have undergone taxonomic change (up to the end of 2018) was undertaken following consultation with the relevant experts. When there were discrepancies in the identity of a species, consultation was sought among the different specialists and decisions were made through consensus.

2.3 Assessment protocol

For all the bryophyte species assessments, the following data were compiled:

- taxonomic classification and notes
- geographic range and list of countries of occurrence (including a range map)

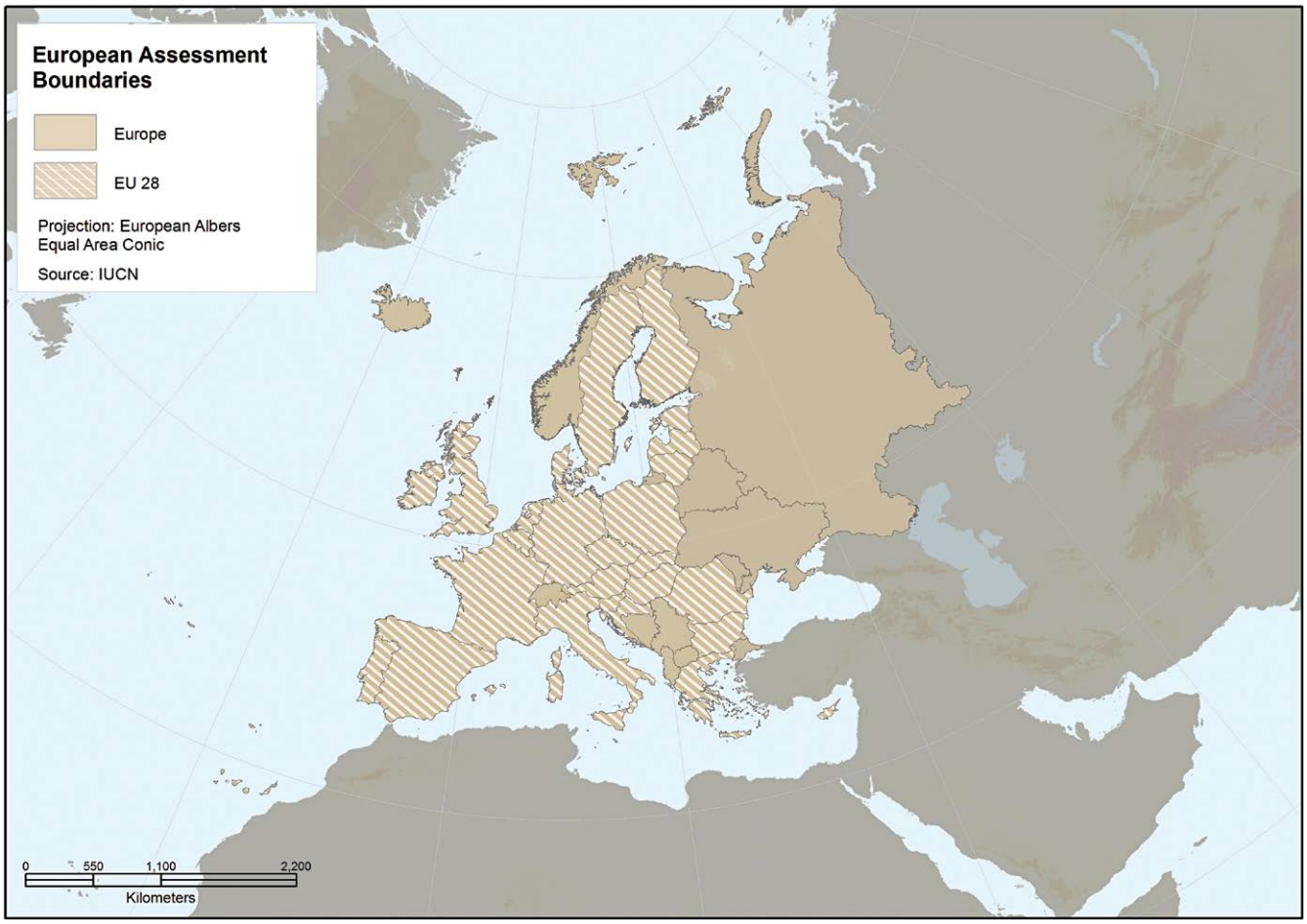

Figure 3. European assessment boundaries: regional assessments were made for two areas: geographical Europe and the EU 28.

- population information and overall population trends
- habitat preferences and primary ecological requirements, including pertinent biological information (for example, generation length, maximum size and age, etc.)
- species use and trade
- major threats
- research needs
- conservation measures (in place and needed)
- IUCN Red List Category and Criteria and rationale
- key literature references

Some critical terms like 'mature individual', 'generation length', and 'severely fragmented' had to be interpreted in a pragmatic way so that they became applicable to bryophytes. Work over several years (for example, Hallingbäck et al., 1998) and collaboration with the IUCN under this project, has culminated in a paper addressing these issues (Bergamini et al., 2019)[1].

The task of collecting the initial data was divided geographically between 11 Assessors (Appendix 1), and information on each species was based on published and unpublished data and expert knowledge. The IUCN Species Information Service (SIS) was used to enter and store all species data.

A training workshop was held in October 2015 in Paris (France) in order to train the experts on the IUCN Red List methodology. After the preliminary information was collected by the Lead Assessors, five assessment workshops were held to review and discuss the assessments and distribution maps, add new information to the assessments, and agree on the final IUCN Red List Category and Criteria for each species. The workshops took place at the Faculty of Sciences of the University of Lisbon (Portugal; December 2016), the Ministry of Environment of the Czech Republic (Prague; January 2017), the IUCN European Regional Office in Brussels (Belgium; February 2017), the National Botanical Gardens of Ireland (Dublin; April 2017), and ArtDatabanken at the Swedish University of Agricultural Sciences (Uppsala, June 2017). In addition, some discussions on the methodology were held at an external workshop in Ekenäs (Sweden). Overall, 60 experts participated in the assessment workshops.

1 The recommendations from this paper will need to be formally considered by the IUCN SSC Red List Standards and Petitions Committee, and if approved, incorporated into a future update of the Red List Guidelines. For the purposes of this project and for the publication of the assessments on the IUCN Red List website, the modified approach has been provisionally approved.

Following the workshops, the information was edited and any remaining questions were resolved through communications with the Lead Assessors. An additional peer-review process was carried out, with all assessments checked by external Reviewers who had not been previously involved in the assessment process. Consistency in the use of IUCN Categories and Criteria was systematically checked by IUCN staff. The resulting finalised IUCN Red List assessments are a product of scientific consensus concerning species status and are supported by relevant literature and data sources (see example in Appendix 2). The final list of species is found in Appendix 3.

2.4 Species mapping

Distribution data were mainly obtained from published literature, herbarium specimens, internet sources (for example, GBIF) and several global and regional citizen science projects. The species experts provided the distribution data to the Ministry of Environment of the Czech Republic (MZP) where Jan Vrba compiled the data in order to produce the final distribution maps.

Range maps were created using the distribution data available, which varied in terms of quality; for some regions, distributional data were available as point locality data (latitude/longitude) or in grid cell format, and were therefore spatially precise. Where point or grid data were available, these were projected in a Geographical Information System (GIS) (ESRI ArcMap). Polygons were then drawn manually, clustering occurrence data where appropriate. In some rare cases where no point data was available and it was only possible to assign presence at the country level, the distribution was mapped for the whole country.

The spatial analyses presented in this publication (see section 3.3) were done using a geodesic discrete global grid system, defined on an icosahedron and projected to the sphere using the inverse Icosahedral Snyder Equal Area (ISEA) Projection (S39). This corresponds to a hexagonal grid composed of individual units (cells) that retain their shape and area (864 km^2) throughout the globe. These are more suitable for a range of ecological applications rather than the most commonly used rectangular grids (S40). The known current distributions (IUCN, 2014) of extant and possibly extant species were converted to the hexagonal grid for the purposes of the analysis. Coastal cells were clipped to the coastline.

3. Results

3.1 Threat status

At the European level, 22.5% of bryophyte species are considered threatened (i.e., assessed as having an elevated risk of extinction). However, the proportion of threatened species is uncertain given the number of Data Deficient (DD) species and could lie between 21.4% (if all DD species are not threatened) and 26.6% (if all DD species are threatened) for Europe (IUCN, 2011; Table 1). The mid-point figure provides the best estimation of the proportion of threatened species (IUCN, 2011). In the EU 28, 24.3% of species are considered to be threatened, with the proportion of threatened species lying between 23.1% (if all DD species are not threatened) and 27.9% (if all DD species are threatened, Table 1). Appendix 3 provides an exhaustive list of all bryophyte species assessed under the current European Red List and corresponding conservation status in Europe, EU28 also indicating if the species is endemic or not to Europe.

In Europe, six species (0.3%) are assessed as Regionally Extinct, with two endemic species assessed as Extinct (0.1%). 59 species (3.3%) are Critically Endangered, 143 species (8%) are Endangered, and 180 species (10%) are Vulnerable (Table 2). A further 173 species (9.6%) are classified as Near Threatened. For 93 species (5.2%) there were insufficient data to evaluate their risk of extinction and so they were classified as Data Deficient (Table 2, Figure 4). There were 21 species that were classed as Not Applicable in Europe (species introduced after AD 1500 or species of marginal occurrence). As more data become available and taxonomic issues are clarified, it is possible that some of these species may also prove to be threatened.

In the EU 28, six species (0.3%) are assessed as Regionally Extinct, two are assessed as Extinct (0.1%). 65 species (3.8%) are Critically Endangered, 150 species (8.7%) are Endangered, and 183 species (10.6%) are Vulnerable. A further 173 species (10%) are classified as Near Threatened. For 82 species (4.8%) in the EU 28 there were insufficient data to evaluate their risk of extinction and so they were classified as Data Deficient (Table 2, Figure 4). Not Evaluated refers to species occurring at the European level that did not occur within the EU Member States (for example, only occurs in European Russia).

3.2 Status by taxonomic group

Table 3 presents the status of European bryophyte species organised by major group, split into mosses, liverworts and hornworts. It is not considered useful to break it down further into orders or families because the higher classification of bryophytes is continually changing with ongoing research. A stable consensus on the higher classification of bryophytes will probably not be reached for several years. There are many more species of mosses (1,327) than liverworts (461) and hornworts (8) in Europe.

The percentages of species in different threat categories are similar for mosses and liverworts. This similarity may reflect the fact that there is nothing particularly distinctive about their ecology or distribution that may influence extinction risk. Instead, different life strategies and ecologies are spread widely throughout both liverworts and mosses, with plants in closely related genera and families often having quite different ecological requirements. The percentage figure for hornworts cannot be directly compared with that for mosses or liverworts because there are only eight species occurring in Europe. Of these, only two species are considered endangered in Europe.

Table 1. Proportion of threatened mosses, liverworts and hornworts in Europe and EU 28.

	Europe % species threatened	**EU 28 % species threatened**
Lower bound (CR+EN+VU) / (assessed – EX)	21.4	23.1
Mid-point (CR+EN+VU) / (assessed – EX – DD)	**22.5**	**24.3**
Upper bound (CR+EN+VU+DD) / (assessed – EX)	26.6	27.9

Table 2. Summary of numbers of mosses, liverworts and hornworts within each Red List Category. Numbers of endemic species are shown in brackets

IUCN Red List Categories	No. species Europe (no. endemic species)	No. species EU 28 (no. endemic species)
Extinct (EX)	2 (2)	2 (2)
Extinct in the Wild (EW)	0 (0)	0 (0)
Regionally Extinct (RE)	6 (0)	6 (0)
Critically Endangered (CR)	59 (18)	65 (15)
Endangered (EN)	143 (40)	150 (28)
Vulnerable (VU)	180 (36)	183 (25)
Near Threatened (NT)	173 (33)	173 (22)
Least Concern (LC)	1140 (45)	1067 (13)
Data Deficient (DD)	93 (17)	82 (11)
Total number of species analysed	**1,796 (191)**	**1,728 (116)**
Not Applicable (NA)	21 (0)	20 (0)
Not Evaluated (NE)	-	69 (0)
Total number of species considered	**1,817 (191)**	**1,817 (116)**

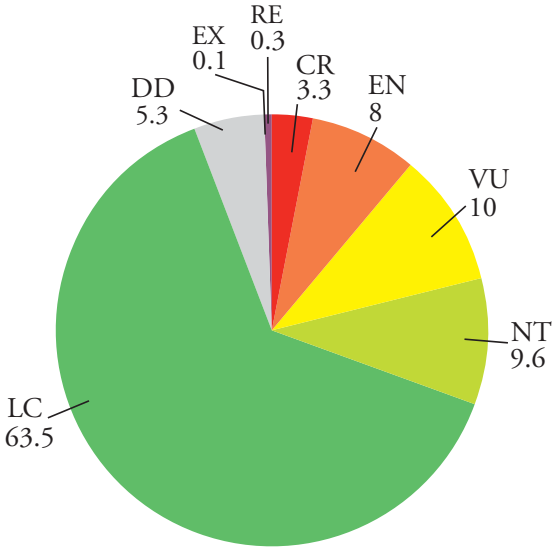

Figure 4. IUCN Red List status of mosses, liverworts and hornworts in Europe.

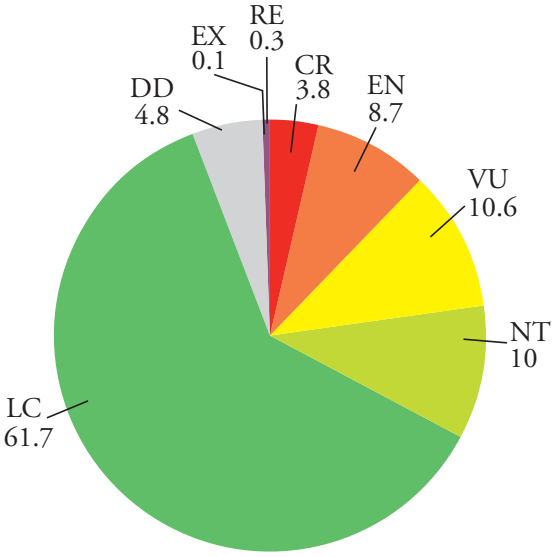

Figure 5. IUCN Red List status of mosses, liverworts and hornworts in the EU 28.

Table 3. IUCN Red List status (at the European level) of mosses, liverworts and hornworts.

	Total	CR	EN	VU	NT	LC	DD	EX or RE	Best estimate of % threatened*
Mosses	1,327	43 (3.2%)	103 (7.8%)	137 (10.3%)	120 (9.0%)	853 (64.3%)	64 (4.8%)	7 (0.5%)	22.5
Liverworts	461	16 (3.5%)	38 (8.2%)	43 (9.3%)	51 (11.1%)	283 (61.4%)	29 (6.3%)	1 (0.2%)	22.5
Hornworts	8	0	2 (25.0%)	0	2 (25.0%)	4 (50.0%)	0	0	25.0
Total	1,796	59 (3.3%)	143 (8.0%)	180 (10.0%)	173 (9.6%)	1,140 (63.5%)	93 (5.2%)	8 (0.4%)	22.5

*The percentage of threatened species provides the mid-point figure as the best estimation of extinction risk. In addition, 21 NA species were not included in this table.

False dog-tooth *Cynodontium fallax* (Near threatened moss) © Tomas Hallingbäck

Polytrichum juniperinum (Least Concern moss) © Lars Hedenäs

3.3 Spatial distribution of species

3.3.1. Species richness

The geographic distribution of bryophyte richness in Europe is shown in Figure 6 and is based on all native and naturalised species (post 1500 AD) with extant and possibly extant occurrence (1,796 species).

The areas with the highest species richness include central Europe, namely mountainous areas in the Alps, and to some degree in Scandinavia, Scotland, Wales, Pyrenees, and Eastern Europe, including the Carpathians. Species richness gradually declines towards the south and the east of Europe. It is clear that mountainous areas score most highly in terms of species richness. While there is some overlap of species, each of these areas has its own distinctive character, with the Scottish mountains, for example, supporting a high diversity of Atlantic species, in contrast to the Austrian Alps, where the flora is more continental (see Box 2).

3.3.2. Endemic and near-endemic species richness

In Figure 7, the richness of endemic European bryophyte species is shown based on the presence of 184 species (the analysis does not include species where their presence is uncertain).

The incidence of endemic species is fairly constant throughout most of Europe, with an increase in hyperoceanic and mountainous areas, particularly Macaronesia. Levels of endemism are low in bryophytes, relative to vascular plants, although recent studies are revealing an increasing number of previously unrecognised endemic species (for example, Carter *et al,*. 2016, Patino & Vanderpoorten, 2018). It is therefore more instructive to look at areas where there is high diversity and large numbers of ecologically specialised, disjunct and near-endemic species. Thus, the hyperoceanic parts of Europe, including Macaronesia, western Britain, Ireland, Norway, France (Brittany) and north-western Spain, support rich communities of oceanic species, few of which are endemic (except in Macaronesia) but many are globally rare and disjunct, elsewhere occurring only in widely-spaced but climatically similar areas, such as Yunnan in China and British Columbia in Canada (for example, Blockeel et al., 2014). This is largely because of the very efficient dispersal mechanisms in bryophytes, although some isolated and disjunct populations may be relict. For example, the large liverwort *Anastrophyllum alpinum* occurs in north-west

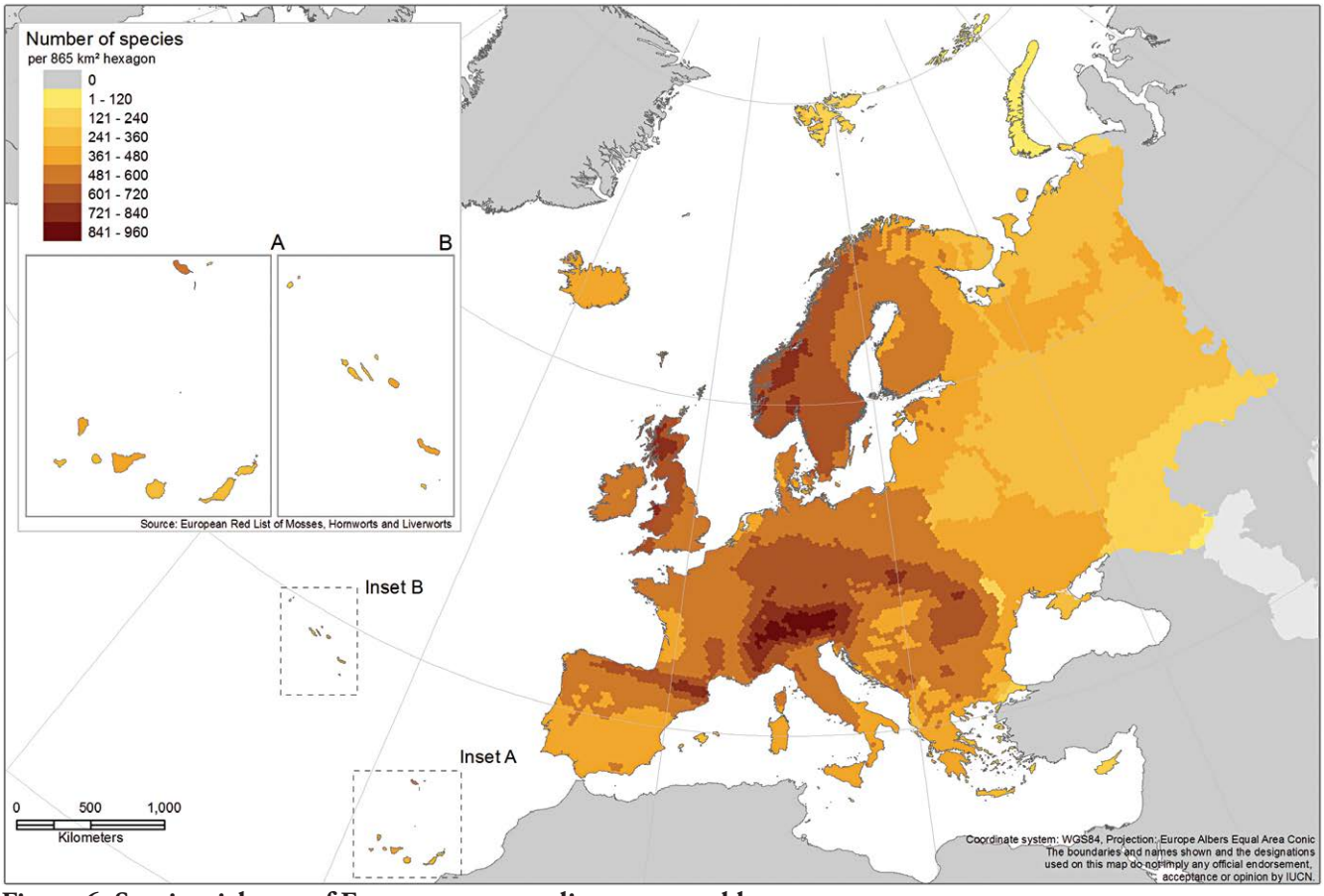

Figure 6. Species richness of European mosses, liverworts and hornworts.

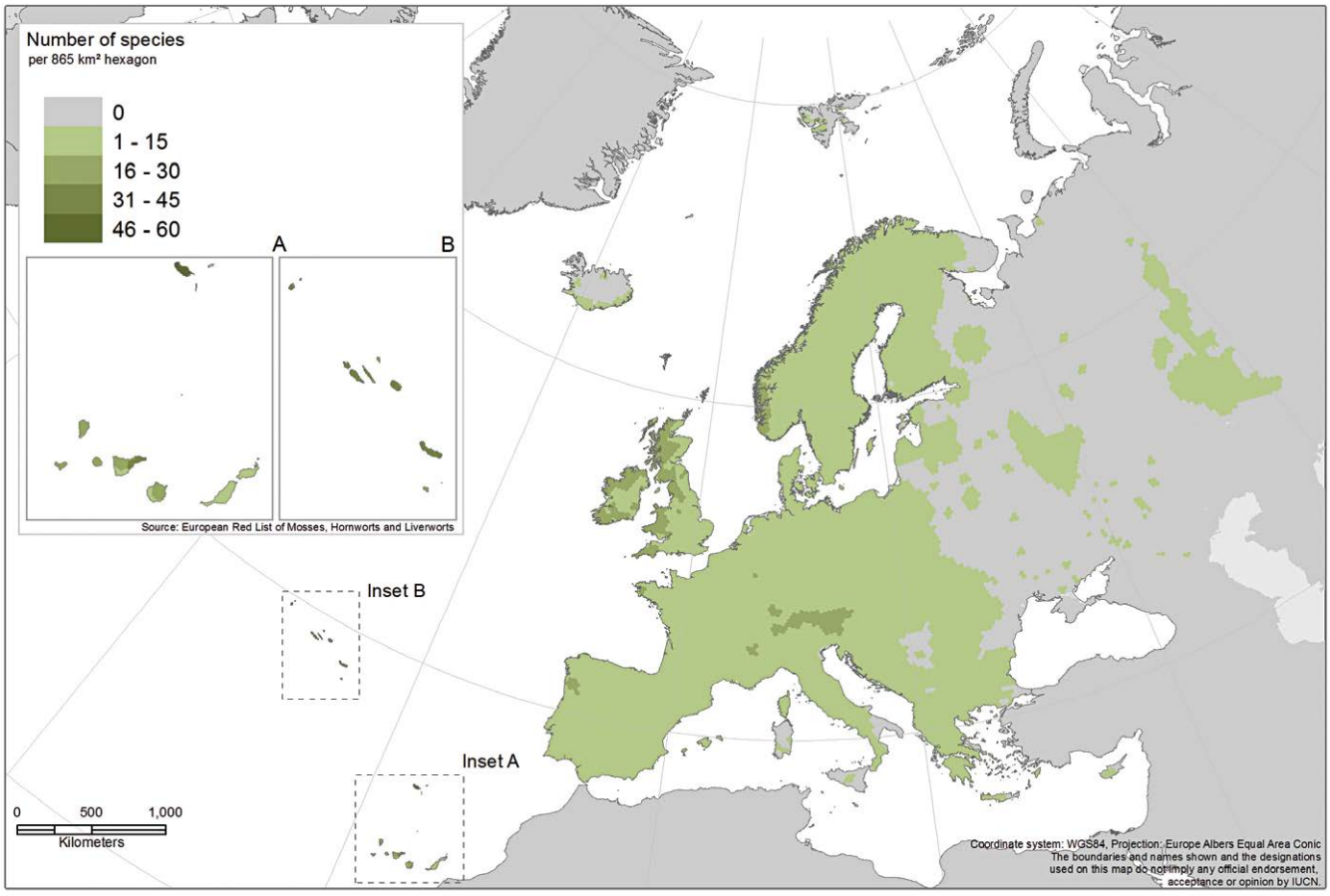

Figure 7. Distribution of endemic mosses, liverworts and hornworts in Europe.

Scotland, and elsewhere only in the Himalayas, Yunnan and the Aleutian Islands. Similarly, southern Europe supports a distinctive Mediterranean flora with many species restricted to the Mediterranean basin, but not necessarily endemic to Europe, occurring also in North Africa, Turkey and adjacent countries (for example, Ros et al., 2013). The tiny moss *Acaulon fontiquerianum* is a rare species of southern Europe and the Canary Islands that is also reported from Asiatic Turkey. There are few endemics in northern Scandinavia and Arctic Russia, but the bryophyte flora is very distinctive and largely restricted to the far north of Asia and North America, as well as Europe: *Drepanocladus arcticus* is a strictly Arctic moss confined to Svalbard, Arctic Russia (European and Asian) and Arctic North America.

3.3.3. Distribution of threatened species

In Figure 8, the distribution of threatened bryophytes in Europe is presented based on data for 374 threatened species (the analysis does not include species where their presence is uncertain).

Figure 8 displays the number of threatened species (CR, EN, VU) per unit area (865 km^2 hexagon). As for overall species richness (Figure 6), it shows a high number of species in the Alps, especially in the eastern Alps, followed by other mountainous areas, notably the Carpathians, the eastern Pyrenees and the Scandinavian mountains. This emphasises the importance of mountain habitats for threatened bryophytes and their conservation. It may also flag the impact of climate change on the mountainous bryophyte flora, and pressure from land use change and tourist developments in the high mountains. Furthermore, many mountainous species are naturally rare and therefore susceptible to stochastic events. Two regions notable for their numbers of threatened species are an area located in central Germany and Macaronesia (Figure 6). While the high numbers in central Germany are difficult to explain, the laurel forests of Macaronesian islands, which contain many rare, threatened and endemic (Figure 7) bryophytes, are under considerable threat from climate change, wildfires and forestry [see Box 2].

With the exception of these relatively restricted areas, numbers of threatened species are fairly constant throughout Europe. The map above (Figure 8) clearly illustrates regions with a concentration of threatened species, which deserve special attention for conservation implementation. They largely agree with the regions with

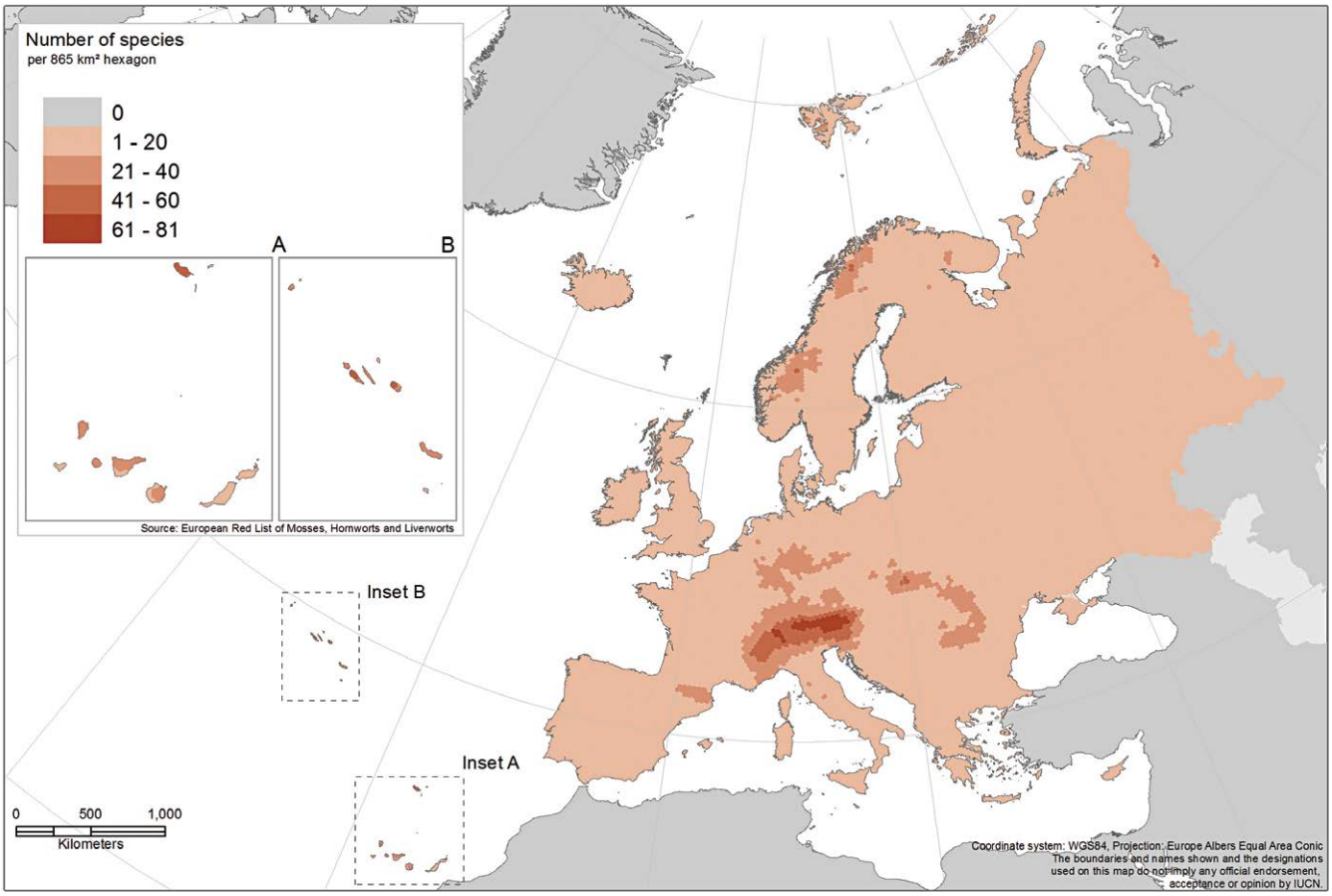

Figure 8. Distribution of threatened (CR, EN, VU) mosses, liverworts and hornworts in Europe.

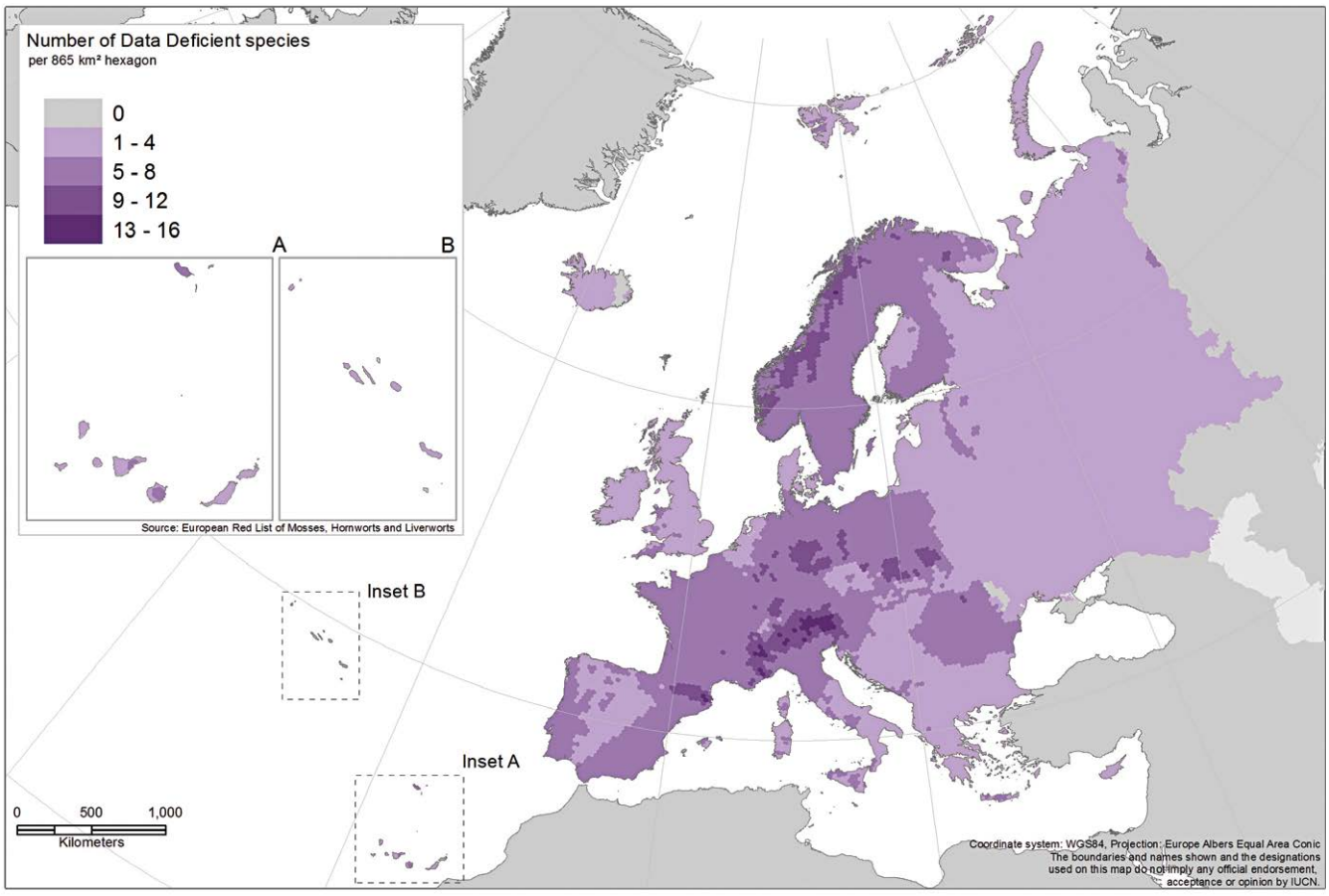

Figure 9. Distribution of Data Deficient mosses, liverworts and hornworts in Europe.

Box 2 - Taking a closer look: Atlantic bryophytes

The extreme west of Europe, where the climate is warm and wet, neither too hot nor too cold, supports a rich and varied selection of mosses and liverworts that are collectively referred to as oceanic or Atlantic. These were first defined (in western Britain and Ireland) by the late Derek Ratcliffe in 1968, who identified the species that are more or less confined to parts of Britain and Ireland which have more than 200 'wet days' per year, with wet days defined as days with over 1 mm of rain (Ratcliffe, 1968): in other words, the extreme west, where the influence of the Atlantic is at its strongest. The same suite of species extends to the Faroe Islands and, in less abundance, to western Norway, western France (Brittany) and north-western Spain.

A lowland ravine in western Scotland may support upwards of 200 species in its sheltered, humid interior, including many oceanic species. The Atlantic influence in Scotland extends into the mountains, where a community defined by Ratcliffe as the 'mixed hepatic mat' occurs in luxuriance in suitable north-east-facing corries. This consists of large leafy liverworts such as species of *Anastrophyllum*, *Bazzania*, *Herbertus*, *Plagiochila* and *Scapania*. Many of these species, as well as being strictly confined in Europe to the extreme west, are globally rare and more or less threatened.

Herbertus borealis (Vulnerable liverwort) is endemic to Scotland © Michael Lüth

The oceanic flora is even better developed in Macaronesia, where the native laurel forest supports a very rich assemblage of species, including a higher proportion of endemic species than is usual with bryophytes, especially in Madeira. The subtropical forest is more or less constantly humid and warm and the trees are festooned with mosses and liverworts, including tiny species of *Acrobolbus* and *Lejeunea*, as well as much larger *Plagiochila* and *Herbertus*. These small areas of forest are under great threat from climate change, wildfires and developments related to tourism.

Europe's Atlantic bryophytes have clear affinities with the tropical bryophyte flora of South America, and several species once thought to be European endemics are now known to be identical with South American plants: *Plagiochila bifaria*, for example, formerly known in Europe as *P. killarniensis* (Heinrichs et al., 1998). This is probably the result of long distance dispersal of some species from South America to Europe via Macaronesia.

high general species richness, and partly with regions of high levels of endemism (Figures 6 and 7).

However, it does not inform on relative regional threat pressures. For this, the number of threatened species would need to be represented as proportions of total species number per region, a level of analysis that should be done in future work. It is likely that lowland areas which have experienced massive changes in land use due to agricultural intensification and rural development since the early 20th Century, still face a greater negative impact than many mountainous areas; at least as long a climate change has not yet have full effect on population decline.

3.3.4. Distribution of Data Deficient species

In Figure 9, the distribution of Data Deficient (DD) species is presented based on data for 88 DD species (the analysis does not include species where their presence is uncertain). Some species are listed as DD because they have been recently described and there is no information to elucidate their trends, while others have been assessed as DD due to taxonomic uncertainty and the difficulty to differentiate between different species unless studied genetically.

The incidence of DD species is often high in mountainous areas, which could be attributed to the fact that they are the most species-rich areas (Figure 6), but could also be because they are usually more remote and difficult to survey than the lowlands. There are also more DD species in relatively under-recorded parts of Europe, such as Romania, than there are in well-recorded areas, such as Britain and Ireland. The low number of DD species throughout most of European Russia, may simply reflect the fact that much of it has low bryological diversity; alternatively, it might indicate that this is an area which is poorly surveyed and hence poorly known.

3.4 Major threats to moss, liverwort and hornwort species in Europe

A comprehensive overview of the threats to bryophytes in Europe is not possible, as some of the threats to the species remain unknown. In total, it was possible to identify threats for 1,099 species, often with multiple threats listed for a species. Based on the best available knowledge, 559 species are thought to have no current or major threats, and for 159 species the threats are unknown at present. Threats to bryophytes are complex and often difficult to categorise. There are sometimes synergistic effects between threats e.g., between climate change and increased fire frequency and it is hard to determine which threat is the key driver impacting a bryophyte. In other cases there may be several threats affecting an area e.g., climate change, increased fire frequency and unregulated planting of Eucalyptus and conifer plantations, etc., these threats are all closely linked and it is hard to identify which one is the key threat impacting a bryophyte species.

A summary of the major threats to threatened and not threatened (DD, LC and NT) species is shown in Figure 10.

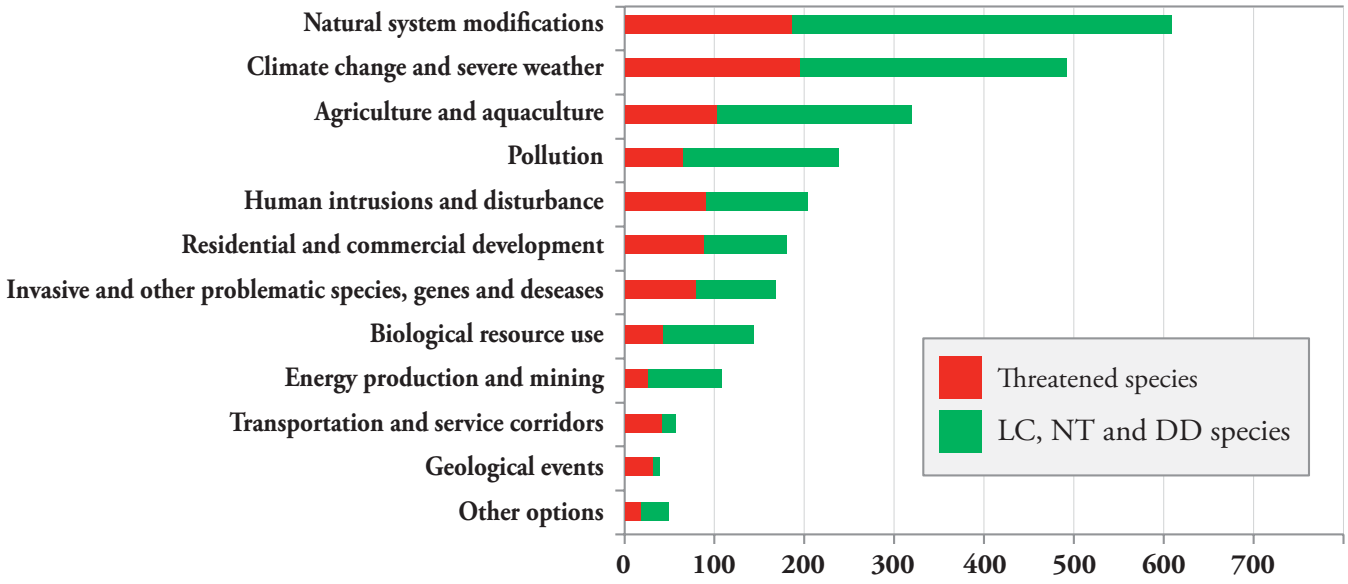

Figure 10. Major threats to all assessed mosses, liverworts and hornworts in Europe. *Note:* Species can be affected by more than one threat.

The main threat to both mosses and liverworts is natural system modification; 452 species of mosses and 180 species of liverworts are impacted by this driver of decline, of which 144 and 52 species, respectively, are threatened. For hornworts, the most prevalent threat is agriculture, affecting seven species (of which two are threatened). However, it should be noted that only eight hornwort species were assessed in total, so this result should be interpreted cautiously. Climate change ranked second in the list of threats to bryophytes in Europe.

3.4.1 Natural system modifications

A total of 234 species are affected by water management and use, including 83 species assessed as CR, EN or VU. This was considered the most common threat to bryophytes across Europe, including species assessed as threatened and species assessed as Near Threatened or Least Concern. This includes the abstraction of ground and surface water for different uses, including agricultural, commercial and domestic uses, and the construction of dams. Species that are water-dependent, such as *Campylophyllum montanum* and many of its relatives, and those that tend to grow in sites targeted for dam construction, such as *Bryum blindii*, are most at risk from these threats.

Bogs and fens are among the most threatened habitats in Europe (Janssen et al., 2016). In the lowlands, draining wetlands has led to a substantial decline in many bog and fen bryophyte species in central Europe (for example, *Sphagnum* spp., *Hamatocaulis vernicosus*, *Scorpidium scorpioides*, etc.), that are still quite common in the far north. Remaining bryophyte-rich wetland sites, particularly in central and southern Europe, face multiple threats, and all require protection. In the uplands, construction of large-scale dams and reservoirs has destroyed many rich sites, and continues to threaten the survival of many species, including those likely to be impacted by climate change (for example, *Andreaea crassinervia*).

257 species appear to be at risk of an increase in fire frequency and/or intensity. Out of these, 94 species are considered to be threatened. This threat is closely associated with climate change, and becomes more serious with a warmer and drier environment. The problem is particularly serious in the laurel forests of Macaronesia, where many rare and endemic species confined to these forests are threatened by the increasing incidence of wildfires. There is also a greater risk of wildfires where there has been large-scale planting of non-native Pinus and Eucalyptus, as in much of southern Portugal and northern Spain.

A total of 215 species are affected by a variety of other modifications to ecosystems, 75 of which have been assessed as threatened.

3.4.2 Climate change

A total of 493 species are affected by climate change and severe weather, of which 196 are threatened. Under this

Cheilolejeunea cedercreutzii (Endangered liverwort) © Tomas Hallingbäck

Echinodium renauldii (Endangered moss) © César Garcia

broad threat, 209 species are estimated to be or will be affected by droughts, including 146 threatened species. A total of 235 species are affected by habitat shifting and alteration, including 109 threatened species. 163 species are considered to be at risk from temperature extremes, of which 78 species are threatened. With increasing temperatures across Europe, as a result of climate change, periods of droughts are already increasing (Vicente-Serrano, 2014). The effects of climate change are often unpredictable but the threat will only become more prominent in the coming decades.

Some of the species most likely to be threatened by climate change are those confined to wetlands. Already greatly reduced, especially in central and southern Europe, due to land-use changes including agricultural expansion and intensification, drainage, pollution, construction activities and invasive species, the remaining wetlands are under extra pressure from desiccation caused by climate change. Species of bryophytes that are found at high elevations, and/or in northern environments, are probably significantly more prone to the impacts of climate change than other species, as they have nowhere else to go if temperatures increase significantly. For example, the survival of *Herbertus sendtneri*, a species of the high Austrian Alps, is very doubtful if the extent and duration of alpine snow-patches deteriorate significantly. On the other hand, at least the bryophytes of higher elevations are usually less at risk from other factors; for those that grow on lower mountains, climate change is just one more threat to add to the other pressures affecting them, such as land-use change.

The bryophytes of the laurel forests of Macaronesia are also at great risk through climate change (Patiño & Vanderpoorten 2018). The forests appear to be drying out, wildfires are becoming more frequent, and projections show a significantly increased risk of extinction for many of the special species of this habitat in the coming years, including endemic species such as *Cheilolejeunea cedercreutzii*.

The bryophytes of southern Europe in general are also at an increasingly higher risk of extinction as the climate becomes warmer and drier. Already some areas have been affected by desertification, and while many species have strategies for avoiding or tolerating drought (for example *Gigaspermum mouretii*, and many species in the family Pottiaceae), even these species will be unable to survive in conditions of more extreme desertification.

3.4.3 Agriculture and aquaculture

A total of 323 species are affected by agriculture and aquaculture, of which 102 are threatened. Under this broad threat, wood and pulp plantations affect 200 species of bryophyte in Europe, including 61 threatened species. Different species are impacted by plantations at different scales, but particularly by agro-industry plantations. At this scale, 124 species are at risk, of which 26 are threatened.

Dead wood is an important substrate for many specialised bryophytes; this old rotting tree trunk supports many species, including *Scapania apiculata* (Near Threatened liverwort) © Michael Lüth

Most plantations are on sites where there used to be natural or semi-natural forest, so the main species threatened by conversion of natural forest to plantation woodland are those dependent on the long ecological continuity provided by a stable, humid, natural forest. Specialists of dead wood such as *Scapania apiculata* have been particularly impacted, as amounts of deadwood are often very low in managed forests.

Generally, land-use conversion practices (including the intensification of agriculture and forestry) are considered the most common threat to biodiversity in undisturbed habitats (IPBES, 2018). These have been designed to increase the production of crops (for example, by increased fertilizer and pesticide applications), livestock, aquaculture, forest biomass, as well as urban development, and are highly detrimental to bryophytes.

A total of 151 species are affected by livestock farming and ranching, including 65 threatened species. This includes grazing at three scales; nomadic, small-holders and agro-industry. The majority of the species (95, of which 41 are threatened) are affected by small-holder grazing, ranching or farming. Overgrazing, under-grazing, and burning are all activities that may affect bryophytes. One activity that is particularly associated with livestock farming is the treatment of stock with ivermectins and other chemicals to treat parasite infestations. One of the unintended consequences of this is that it makes the dung of these animals effectively sterile, which has knock-on effects on the large numbers of organisms that depend on animal dung for survival. These include a unique suite of mosses - the dung mosses - that grow only on the dung (or sometime bones) of herbivores and which have an intimate relationship with dung invertebrates for the dispersal of their spores. Most of these species, some of them among our most attractive bryophytes (*Splachnum, Tetraplodon, Aplodon*, etc), have declined drastically in recent years (Porley & Hodgetts, 2005).

3.4.4 Other threats to bryophytes

Residential and commercial development

A total of 185 species are affected by residential and commercial development, of which 88 are threatened. Under the umbrella of residential and commercial development, a key threat to bryophytes in Europe was identified as the development of areas for tourism and recreation. 181 species in total are impacted by tourism and recreation, including 99 threatened species. Tourism encompasses many sorts of threat, including uncontrolled building of hotels and other tourist facilities in rich coastal or alpine habitats, water abstraction, disturbance through increasing numbers of people, etc. 'Urban sprawl' which occurs in order to accommodate the ever-increasing human population, often replaces woodland, species-rich grasslands and wetlands.

Pollution

A total of 240 species are affected by pollution, of which 66 are threatened. Under this broad threat, a total of 165

species are affected by agricultural and forestry effluents, including 58 threatened species. This includes 97 species (of which 34 of threatened) that are specifically at risk from nutrient loads, 29 species (of which ten are threatened) that are specifically at risk from herbicides and pesticides, and 16 species (of which ten are threatened) that are specifically at risk from soil erosion and sedimentation.

Bryophytes are also considered to be affected by other sorts of pollution in Europe. 78 species (of which 19 are threatened) are impacted by air-borne pollutants, for example acid rain and smog, and 32 species (of which nine are threatened) are impacted by waste water, such as run-off and sewage [see Box 3].

Invasive non-native/alien species/diseases

A total of 169 species are affected by invasive and other problematic species, genes and diseases, of which 79 are threatened. Under this broad threat, 161 species are affected by invasive alien species, including 79 threatened bryophytes. Most of these problematic species are unspecified, but 64 species (of which 40 are threatened) are affected by known species. One of the most problematic invasive plants for bryophytes in Europe is non-native rhododendron (*Rhododendron ponticum)*, which has spread from gardens and now covers large areas of hillside in oceanic areas, casting a deep shade and dropping very acid leaf litter that prevents anything else from growing. The effects of this invader on bryophytes are particularly bad in areas of the UK and Ireland. However, it is important to note that rhododendron (R. ponticum) is a native and non-invasive plant in ravines in southern Spain and Portugal; these rhododendron ravines are threatened habitats and rich in bryophytes. The aquatic environment is particularly sensitive to invasive species, and plants such as *Crassula helmsii* are as much a threat to aquatic bryophytes as they are to vascular plants. A minority of species may be under threat from invasive alien bryophytes: In north-western Europe, *Orthodonium gracile* appears to be a poor competitor against the invasive southern African species O. lineare.

Human intrusions and disturbance

A total of 204 species are affected by human intrusions and disturbance, of which 92 are threatened. Under this broad threat, human disturbance to areas where bryophytes grow, specifically for access to recreational activities, is considered to impact 159 species, of which 81 are threatened. This includes intrusions relating to, for example, erosion at popular tourist sites owing to the sheer numbers of people; mountain summits in tourist areas are particularly vulnerable in this respect. Some coastal cliff top paths in southern England with rare mosses are becoming increasingly eutrophicated by dog faeces, leading to loss of habitat. Hunting and shooting for sport is not a direct threat to bryophytes, but when important sites are managed primarily for these activities, it can result in loss and degradation of habitat, as has taken place on the grouse moors of Scotland, where large areas are regularly burned to encourage the growth of new heather (*Calluna vulgaris*) shoots, resulting not only in a species-poor monoculture, but also destabilisation of soils and increased erosion.

Additional threats

There are many other threats to European bryophytes. Biological resource use, which includes unintentional impacts of fishing, hunting and harvesting biological resources, affects 152 species, of which 46 are threatened. In addition, 116 species are threatened by industrial activities, such as energy production and mining, including 31 threatened species. Under this threat classification, most species (72, of which 12 are threatened) are at risk from mining and quarrying, although renewable energy production and oil and gas drilling also impact some species in Europe. In some areas, such as central Ireland, industrial-scale peat extraction for fuel has damaged or destroyed many important bryophyte sites. The remaining ones now receive statutory protection. Land-based wind farms often cause considerable damage, especially if sited on sensitive peaty substrates.

The establishment of transportation and service corridors, such as roads and service lines, affects 69 species, of which 54 are threatened.

3.5 Population trends

Documenting the population trend of a species provides key information when assessing its Red List status. As part of this process, the whole population of each species in Europe was assessed as declining, stable, increasing or unknown.

Overall, 17.1% (307 species) of bryophyte species in Europe are thought to be in decline, including 52.8% of threatened species (162 species). The majority of species (59.3%; 1,062 species) are considered to be stable, including 8.3% of threatened species (88 species), and 1.9% (34 species) are increasing (Figure 11), all of which

are LC. However, 21.7% of species (389 species) have unknown population trends, with 129 threatened species (33.2%).

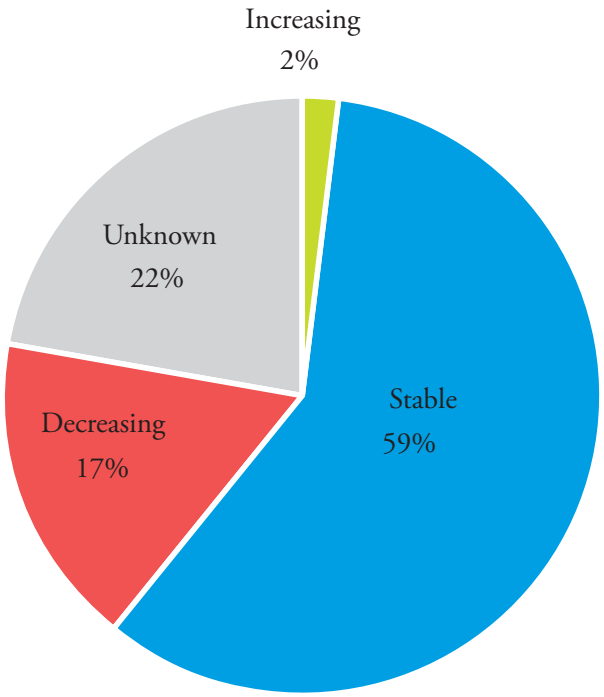

Figure 11. Population trends of European mosses, liverworts and hornworts.

3.6 Gaps in knowledge

While there was not enough information to assign a Red List Category to 93 species (hence considered as Data Deficient), the information collected was sufficient to identify the major knowledge gaps for bryophytes in Europe (Figure 12).

Overall, the absence of, or the existence of few, data on population size and distribution, as well as trends are systematically highlighted as a knowledge gap for bryophytes by the expert community assessing the conservation status of these species. This pattern affects both threatened and non-threatened taxa. Knowledge on habitats trends and impact of threats is also still incipient for the majority of these species, with particular regions severely understudied (for example, Russia).

While this pattern can be partially justified by the fact that some species have been recently described, and so there is no information available on these parameters, the reality is that monitoring efforts are becoming increasingly difficult to sustain and to fund. This, coupled with the absence of baseline data (for example, historical data) on species numbers and distribution, hamper a comprehensive understanding of the threats to

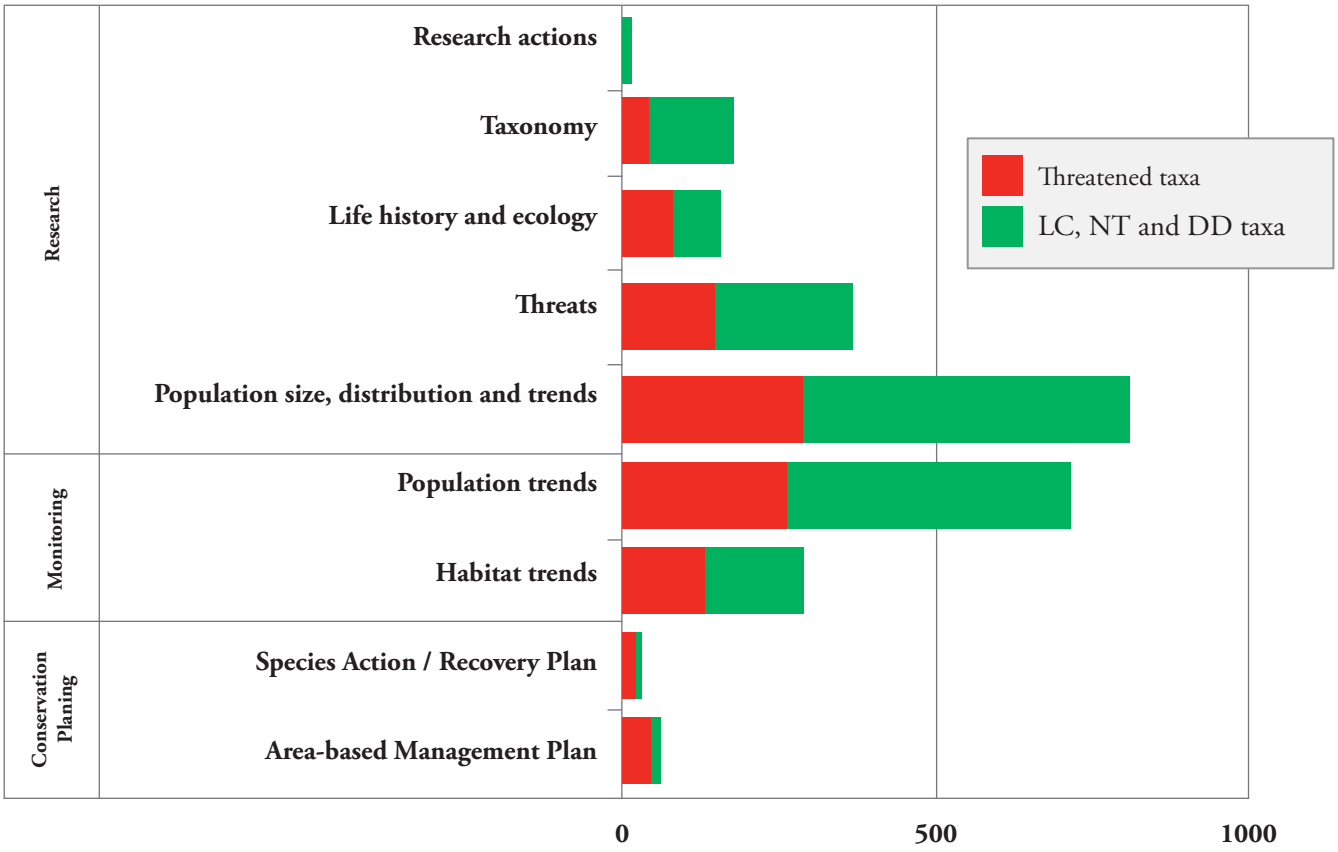

Figure 12. Research needs for European mosses, liverworts and hornworts. *Note:* Species can be included in more than one category.

these species in Europe, and how these stressors interact. Collecting information on these topics is paramount for sound conservation planning and effective recovery of threatened taxa, and will allow for more concrete messages to be mainstreamed to the most impactful sectors. The establishment of an expert network to facilitate information exchange would certainly help address the knowledge gaps identified for these species throughout their European range; the experts brought together through this project provide a good starting point to expand this network. In any case, relevant conservation and management measures should move ahead despite any current data gaps, while also considering taxonomic uncertainty where relevant.

Hymenoloma compactum (Data Deficient moss) © Tomas Hallingbäck

Box 3 - Poisoned bryophytes: the impact of over-fertilization

One of the major threats to bryophytes is habitat modification through intensification of agricultural practices and pollution (which may also come from agriculture). The greatest pollution threat in the 20th Century was sulphur dioxide pollution through the widespread burning of dirty coal. Many bryophytes, particularly epiphytic species, are very sensitive to sulphur dioxide (SO_2) levels, and these plants, such as species of *Orthotrichum* and *Ulota*, virtually disappeared from large areas of Europe. When legislation for clean air was introduced in the mid- to late-20th Century, these plants gradually, and later rapidly, began to recolonise. Nowadays, trees throughout most of Europe, even in areas formerly heavily impacted by SO_2 pollution, are covered with *Orthotrichum* and *Ulota* and other species.

Currently, the problem is nitrogen. Despite generally improving air quality in Europe, including reductions in nitrogen emissions, there is an ever-increasing amount of nitrogen in the environment because of agricultural practices and vehicle emissions. Locally, in agricultural areas, one can smell ammonia because of the enthusiastic spreading of manure, and observe the homogenous green of 'improved' pasture devoid of wild flowers or much natural interest at all. Vehicle emissions are a big source of pollution by nitrogen compounds in densely populated areas. However, the main cause is the worldwide increase in the very inefficient use of artificial nitrogen-rich fertilisers in agriculture. In Europe, fertilisers are still spread over fields, but more than half the nitrogen does not go into improved crop yields, it simply runs off into ditches, streams, rivers and ultimately the sea. Much of it, via the nitrogen cycle, is returned to the land through precipitation. The consequences for bryophytes are evident. All over Europe, even in remote upland areas, the natural species-rich bryophyte flora of streams is being replaced with a monocultural slime of green algae; even in bogs, in some areas *Sphagnum* hummocks are becoming overwhelmed by algal scum. On rock faces, a layer of green algae replaces the mosses and liverworts. In open habitats, the nutrient-poor 'bare ground' habitat of so many threatened species is disappearing, being overtaken by vigorous, nutrient-demanding grasses.

This is a worldwide problem that can only be addressed by worldwide solutions. Most agricultural land is currently over-fertilised (Pearce, 2018), and so possible solutions include more targeted, 'precision agriculture', distributing smaller amounts of nitrogen much more efficiently, so that it goes to plant roots and does not run off into the surrounding environment.

Urn bristle-moss *Orthotrichum urnigerum* (Vulnerable moss) © Michael Lüth

4. Conservation actions

4.1 Conservation of moss, liverwort and hornwort species in Europe

The results of this Red List assessment indicate that 88.2% of species (1,603 species, of which 319 are threatened) were recorded in at least one protected area (including national parks, Natura 2000 sites or nature reserves). This is positive, as site protection is the most commonly identified conservation action needed for European bryophytes (Figure 13). The second most important action is site/area management, and bryophytes are often not considered in management plans. Additional conservation measures proposed for European bryophytes are shown below (Figure 13).

The nature conservation policy of the European Union is based on two main pieces of EU legislation - the 1979 Birds Directive (Directive 79/409/EEC) and the 1992 Habitats Directive (Directive 92/43/EEC; jointly referred to as the Nature Directives). There are 32 bryophyte species currently listed in Annex II of the Habitats Directive, not all of which are endemic to Europe. No species of bryophytes is listed under Annex IV and only three genera are listed under Annex V of the Habitats Directive. The Bern Convention, on the other hand, is a binding international legal instrument that aims to conserve wild flora and fauna and their natural habitats and promote European cooperation towards that objective. It covers all European countries and some African states. In Appendix I of the Bern Convention (Strictly Protected Flora Species), a total of 26 bryophyte species are listed. Appendix 4 provides the full list of bryophytes species listed under the Habitats Directive and the Bern Convention, and the corresponding Red List status as determined by this assessment. Of the 1,729 bryophyte species present in the EU 28, 7.5% are endemic to the EU 28, highlighting the conservation responsibility of the EU towards these species. Some have made a remarkable recovery following listing under the Habitats Directive and the Bern Convention, and

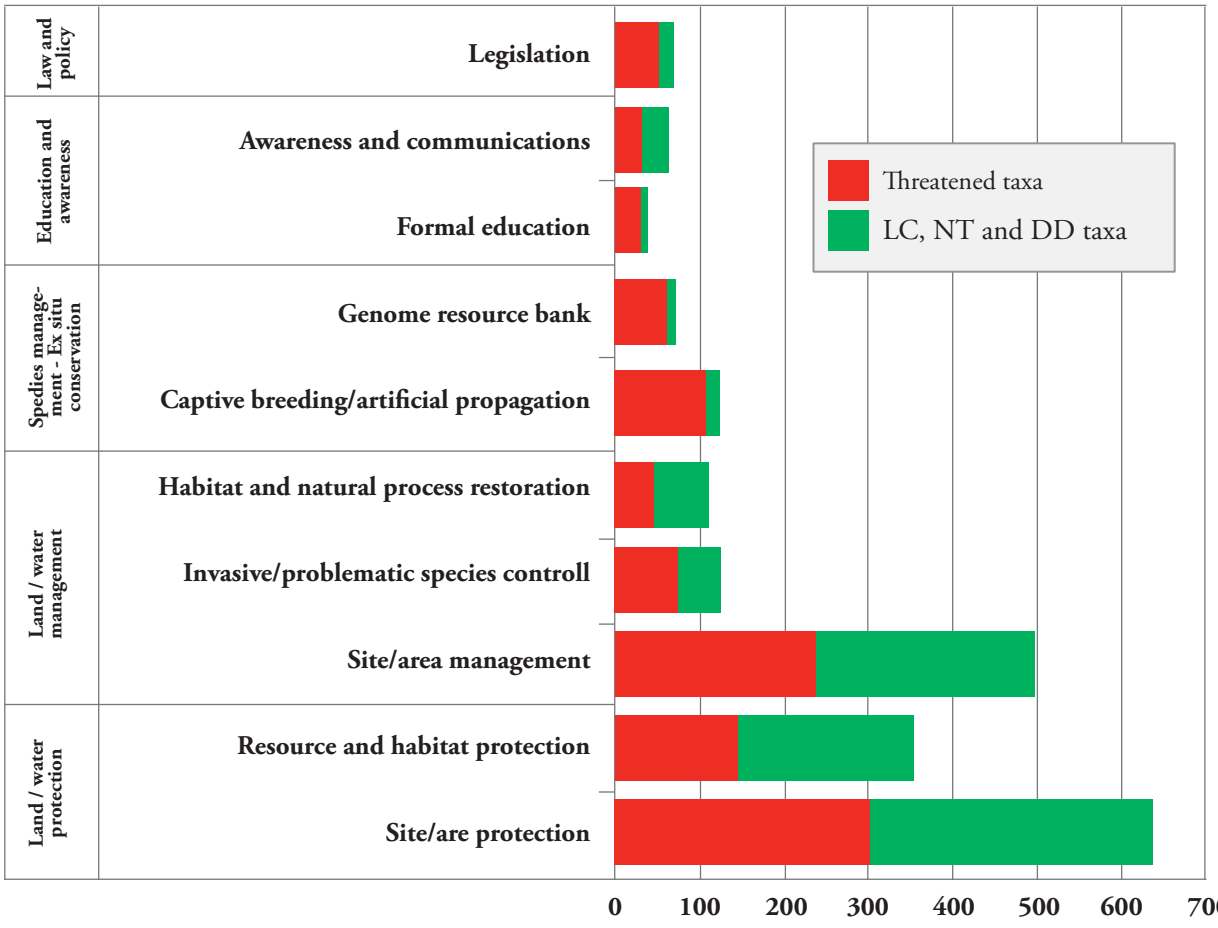

Figure 13. Main conservation actions needed identified for European mosses, liverworts and hornworts. Note: More than one conservation action was assigned to each species.

targeted conservation actions (for example, *Hamatocaulis vernicosus* - see Box 4).

One of the main tools to enhance and maintain biodiversity in Europe is the Natura 2000 network of protected areas, which currently consists of over 27,500 sites, it covers 18% of land territory but 27.5% land and marine area (EC, 2018). Natura 2000 sites provide an essential tool in conservation even if the sites were not specifically designated for the preservation of particular bryophyte species, as indirectly the general protection of habitats usually also benefits the bryophytes. However, it is sometimes necessary to target the ecological needs of these small plants more directly, which becomes challenging when conservation actions are usually targeted at more charismatic and well-known organisms. The well-supported agri-environmental schemes devised to promote sustainable farming across Europe are a good illustration of the limited effects on bryophytes of such widespread, untargeted conservation measures, particularly for rare bryophyte species (Valentini et al., 2016). Actions better tailored to promote bryophyte conservation include, for example, rotational set-aside and retention of winter stubbles in cereal, rape and linseed crops (Bosanquet, 2003; Bisang et al., 2009).

Many threatened bryophytes occur in protected areas, and depend, like other groups, on the conservation of multi-scale areas of semi-natural habitat. However, many species tend to grow in 'micro-habitats' in non-protected areas. This means that the sympathetic management of the wider countryside is particularly important for bryophytes. For example, the suite of species which have their main habitat in arable fields, such as the threatened hornwort Anthoceros neesii, are entirely dependent for their survival on overwintering stubble fields, so wider agricultural policy needs to promote agricultural practices that favour this habitat. Similarly, a certain amount of dead wood needs to be left in situ in managed forestry plantations, as well as in old-growth forest, in order to provide substrate for the many bryophytes that specialise in this habitat. While the Habitats Directive

Soft brook-moss *Platyhypnum molle* (Vulnerable moss) © Tomas Hallingbäck

and the Natura 2000 network are of vital importance, there needs to be much more coordination between different elements of policy, so that, to choose the most obvious example, policies contained within the Common Agricultural Policy (CAP) do not work against those in the Habitats Directive. Measures within other national or international policies, including Agri-Environmental Schemes that provide payments to farmers who subscribe, on a voluntary basis, to environmental commitments related to the preservation of the environment, need to be aligned with statutory protection for species to ensure that efforts to protect these species are synergistic and not in vain.

European countries and EU Member States are signatories to a number of important conventions aimed at conserving biodiversity, including the 1979 Bern Convention on the Conservation of European Wildlife and Natural Habitats, and the 1992 Convention on Biological Diversity (CBD). Through the CBD, the Strategic Plan 2011–2020 was established, which includes 20 targets (Aichi Targets) that guide the implementation of the CBD and all the other biodiversity conventions. In particular, Target 12 focuses on preventing the extinction of known threatened species and improving their status (CBD, 2011). The outcomes of this Red List project certainly help to measure the progress made towards meeting these targets, and the current results suggest that, for bryophytes, Europe is not on track to meet these targets.

The Global Strategy for Plant Conservation (GSPC) was adopted by the CBD at the 2002 Conference of the Parties and updated at the 10th Conference of the Parties. In order to coordinate the implementation of the GSPC at the regional level, the European Strategy for Plant Conservation (ESPC) was adopted. In particular, Target 2 (calling for an assessment of the conservation status of plant species), Target 5 (through the identification of Important Plant Areas), Target 7 (*in situ* conservation), Target 8 (*ex situ* conservation), Target 12 (preventing the extinction of known threatened species and improving their status), Target 13 (sustainable practices associated with plant use) and Target 14 (awareness raising) (CBD, 2011) are relevant for the conservation of bryophytes.

European countries across the continent endorsed the Pan-European 2020 Strategy for Biodiversity (UNEP, 2011), which re-focuses efforts to prevent further loss of biodiversity in the region. It also provides a European mechanism for supporting the implementation of the global Strategic Plan for Biodiversity. No native European bryophyte species are listed in the Appendices of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). The EU Water Framework Directive, adopted in 2000 and aimed at protecting European waters, can also be relevant for aquatic and water-dependant bryophyte species. A good ecological status of surface waters, as promoted by the

Grey-cushioned grimmia *Grimmia pulvinata* (Least Concern moss) © Michael Lüth

Tayloria rudolphiana (Near Threatened moss) © Norbert Schnyder

Directive, has positive effects on ecosystem function (Janauer et al., 2015).

Plant habitat conservation efforts have in part been focused through the identification of Important Plant Areas (IPAs). IPAs are internationally significant sites for wild plants and threatened habitats. Identified at a national level, they provide a framework for implementing Target 5 of the CBD GSPC, and are a tool for targeting conservation actions on wild plants and *in situ* habitat protection. IPAs contain over 700 of the most threatened species in Europe and include millions of hectares of the most threatened habitats. At least 1,770 IPAs have been identified in 16 European countries (Anderson & Radford, 2010). A first attempt was made to identify Important Bryophyte Areas in Europe during the production of the first Red List (European Committee for the Conservation of Bryophytes, 1995), and it is anticipated that the current Red List will facilitate an update of this initiative. These exercises are incredibly valuable to ensure species protection and a stepping stone to promote nature conservation in Europe.

The EU has committed to a long-term (2050) vision and mid-term headline target for biodiversity, which is "*To halt the loss of biodiversity and the degradation of ecosystem services in the EU by 2020 and restore them in so far as possible, while stepping up the EU contribution to averting global biodiversity loss.*" This target underpins the EU Biodiversity Strategy 2011–2020. The establishment of these policy instruments indicates the high political commitment to biodiversity and the need to monitor the status of biodiversity and to assess progress towards meeting conservation objectives and targets. Measuring whether policy targets have been met is only possible by establishing comprehensive monitoring programmes that allow the gathering of the necessary data for a reliable re-assessment in the coming years. The results of the present Red List assessment indicate that, for the bryophytes, Europe is currently not on track to meet these targets. For the latter to happen, immediate conservation action for species with a high extinction risk is needed.

Most European countries have developed specific actions at the national or regional level in order to enhance bryophyte populations. National Red Lists or Red Data Books of bryophyte species are available for the following countries: Austria, Bulgaria, Czechia, Estonia, Finland, Germany, Great Britain (excluding Northern Ireland), Hungary, Ireland (including Northern Ireland),

Italy (including Sardinia), Luxembourg, Montenegro, Netherlands, Norway, Poland, Portugal (including Madeira), Romania, Serbia, Slovakia, Slovenia, Spain and the Canary Islands, Sweden, and Switzerland.

However, there are some countries in which no national Red List has been developed (for example, France). It is also noteworthy that some national Red Lists are outdated and should be maintained and updated in order to remain relevant. In addition, several countries have developed management or action plans for several species, and have legislation in place to protect certain species legally (for example, Schedule 8 of the Wildlife & Countryside Act 1981 in the UK). Some examples of successful action plans include *Tayloria rudolphiana,* epiphytic species of central Europe for which several studies have been undertaken to count the sites or individuals of the plants (Hofmann et al., 2006; Hofmann et al., 2016; Müller, 2016; Kiebacher et al., 2018) and attempts have been made to protect the host trees and to increase awareness for this species. LIFE projects have been undertaken at the European level to enhance the status of certain habitats and species, some of which have focused on specific species bryophytes, or produced management plans as a result of these projects.

4.2 Red List versus priority for conservation action

Assessing the extinction risk and setting conservation priorities are related but distinct processes. The purpose of the IUCN Red List assessment is to produce an estimate of the likelihood of extinction of a species. On the other hand, setting conservation priorities also takes into account other factors such as ecological, phylogenetic, historical, economical or cultural preferences for some taxa over others. Also, the probability of success of conservation actions, availability of funds or personnel, cost-effectiveness and legal frameworks for the conservation of threatened taxa is taken into account. In the context of regional risk assessments, a number of additional pieces of information are valuable for setting conservation priorities. For example, it is important to consider not only conditions within the region, but also the Red List status of the taxon from a global perspective and the proportion of the global population that occurs within the region. The decision on how these three variables, and the other factors, are used for establishing conservation priorities is a matter for the regional authorities to determine, taking into account the Red List status of the species of concern.

Box 4 - Conservation works: bryophytes bounce back

For bryophytes, as for other organisms, conservation works. Bogs that have been damaged by peat-cutting or drainage can be restored or re-instated by blocking drains; degraded forest can be restored (eventually) merely by non-intervention; damaged wetlands can have a new lease of life through proper management. Giving species legal protection can be very effective. For example, Slender green feather-moss (*Hamatocaulis vernicosus*) was one of a small handful of species placed on Appendix I of the Bern Convention in the early 1990s. Along with most of the other Bern species, it was also included on Annex II of the EU Habitats Directive soon afterwards. This means that the signatory countries to these conventions have an obligation to protect it under the Natura 2000 network, with sites designated and managed for its protection. The results of this have been dramatic, with sites established for *Hamatocaulis* all over Europe, or at least within the EU, with several non-EU countries following suit. Because it is a key species of mineral-rich, mesotrophic mires, fens and flushes, this has meant that many important and threatened wetland sites that might otherwise have been destroyed now receive statutory protection. In other words, the conservation benefits of placing this moss on the protected species list extend much further than merely protecting the moss itself: whole habitats have been saved.

Furthermore, including *Hamatocaulis* on these international conventions has resulted in a massively increased programme of research to find out more about its distribution, abundance, ecology and conservation requirements. Recent research in Sweden has even found that what we call *H. vernicosus* actually comprises two cryptic species (genetically different but apparently morphologically identical), both of which occur in protected areas (Hedenäs, 2018). Paradoxically, an increase in survey and recording effort targeted at *H. vernicosus* means that it now seems to be more common than was once thought. This is not the case: we simply now know more about it, and the increase in records in recent years is entirely due to that increase in recording effort. If we had more baseline data going back through the decades it would certainly show a decline because of habitat destruction through drainage and other anthropogenic factors.

Slender green feather-moss *Hamatocaulis vernicosus* (Vulnerable moss) © Michael Lüth

5. Recommendations

5.1 Recommended actions

Currently, 22.5% of bryophytes are threatened at the European level. The most important threats to bryophytes in Europe come from natural systems modifications (i.e., habitat destruction and degradation), climate change, and current agricultural practices. Hence, improving the conservation status of bryophytes, and preventing current and future declines in Europe, requires increasing efforts and commitments from various parties, from the EU to regional assemblies, and from statutory bodies to conservation charities. Perhaps most importantly, measures for bryophyte conservation (and indeed for nature conservation generally) need to be integrated into regular planning and land management procedures and practices. Below, a series of recommendations are proposed to strengthen the long-term survival of European bryophytes:

Policy measures

- Use the European Red List as the scientific basis to inform regional/national lists of rare and threatened species and to identify priorities for conservation action in addition to the requirements of the Habitats Directive, thereby highlighting the conservation status of bryophytes at the regional/local level.
- Use the European Red List to support the integration of conservation policy with the Common Agricultural Policy (CAP) and other national and international policies. For example, CAP Strategic Plans should include biodiversity recovery commitments that could anticipate, among others, the creation of Important Bryophyte Areas. An increased involvement of national environmental agencies in the preparation of these strategic plans, and more broadly in ongoing discussions on the Future CAP Green Architecture, would likely also ensure the design of conservation measures better tailored to conserve bryophytes in agricultural landscapes.
- Update the European Red List every decade to ensure that the data remains current and relevant.
- Develop Key Biodiversity Areas for bryophytes in Europe with a view to ensuring adequate site-based protection for bryophytes.

Research and monitoring

- Use the European Red List as a basis for future targeted fieldwork on possibly extinct and understudied species.
- Establish a monitoring programme for targeted species (for example, threatened species and/or arable bryophytes).
- Use the European Red List to obtain funding for research into the biology and ecology of key targeted species.

Action on the ground

- Use the European Red List as evidence to support multi-scale conservation initiatives, including designation of protected areas, reform of agricultural practices and land management, habitat restoration and rewilding, and pollution reduction measures.
- Use the European Red List as a tool to target species that would benefit the most from the widespread implementation of the solutions offered by the 1991 Nitrates Directive (Council Directive 91/676/EEC), including the application of correct amounts of nutrients for each crop, only in periods of crop growth under suitable climatic conditions and never during periods of heavy rainfall or on frozen ground, and the creation of buffer zones to protect waters from run-off from the application of fertilizers.

Ex situ conservation

- Undertake ex situ conservation of species of conservation concern in botanic gardens and spore and gene banks, with a view to reintroduction where appropriate.

Awareness raising

Mosses and liverworts are small and do not impinge very much on the public consciousness, except as things to remove from the lawn or the roof. As an integral and important part of the natural world, they deserve better. There are now many attractive publications and websites that present bryophytes as beautiful and useful, and these should receive more publicity and promotion; for example, *Sphagnum mosses - The Stars of European Mires* (Laine et

Plagiomnium confertidens (*Vulnerable moss*) © Elvira Baisheva

al., 2018), Robert Muma's beautiful moss paintings and sketches (http://worldofmosses.com/paintings/index.html), Michael Lüth's amazing photographic collection (http://www.milueth.de/Moose/index.htm), to name but a few). Many nature reserves where bryophytes are important now have information boards and other material to promote bryophytes, and this should continue to be prioritised wherever appropriate.

In particular, this Red List should be used to publicise bryophytes and to obtain funding for future conservation work. For example, LIFE+ Nature and Biodiversity[2] provides targeted funding for species conservation actions, supporting projects aimed at conserving threatened species listed in the annexes of the EU Habitats Directive, Birds Directive and the European Red List.

5.2 Application of project outputs

The European Red List of mosses, liverworts and hornworts is part of a wider initiative aimed at assessing the status of all European species. It provides key resources for decision makers, policy makers, resource managers, environmental planners, NGOs and the concerned public by compiling large amounts of data on the population, ecology, habitats, threats and recommended conservation actions for each bryophyte species. Red List assessments are intended to be policy-relevant and can be used to inform conservation planning and priority setting processes. However, they are not intended to be policy-prescriptive and are not in themselves a system for setting biodiversity conservation priorities. These data are freely available on the IUCN Red List website (https://www.iucnredlist.org/regions/europe), on the European Commission's website (http://ec.europa.eu/environment/nature/conservation/species/redlist) and through paper publications (see the list of European Red Lists published at the end of this report).

Red Lists are a dynamic tool that will evolve with time as species are re-assessed according to new information or situations. They are aimed at stimulating and supporting research, monitoring and conservation action at local, regional and international levels, especially for threatened, Near Threatened and Data Deficient species.

Each species assessment lists the major threats affecting the specific bryophyte species and conservation actions that are in place or recommended. This is useful to inform the application of conservation actions for each species. The outputs of this project can be applied to inform policies and to identify priority sites for biodiversity and priority species to include in research and monitoring programmes.

5.3 Future work

Through the strong collaboration established between the ECCB and the IUCN SSC Bryophyte Specialist Group during this project, a network of European and national bryophyte experts, and their extensive knowledge and expertise, were mobilised that will persist long after the project ends and will be instrumental in defining priorities

2 http://ec.europa.eu/environment/life/project/Projects/index.cfm?fuseaction=home.getProjects&strandID=2

for bryophyte conservation in Europe. The project has benefited greatly from the work and information held by additional relevant organisations and stakeholders, such as national bryophyte societies, university research programmes and statutory and voluntary conservation bodies. The wealth of knowledge and data compiled during the elaboration of this European Red List will be invaluable to expand research efforts on bryophytes at the European level, ultimately benefiting their conservation. One aspect worth noting is that the assessment of the European endemics can be transcribed directly into the corresponding global Red List.

Through the process of compiling data for the European Red List, a number of knowledge gaps have been identified. Across Europe there are significant geographic, geopolitical and taxonomic biases in the quality of data available on the distribution and status of species, and these are the aspects that a unified knowledge network will need to overcome to advance bryophyte conservation in the region.

There is a clear need for drawing together information from all data compilation initiatives, under way or planned, and for a wider European bryophyte conservation action plan to be explored, developed and progressed. It is hoped that by presenting this assessment, local, national, regional and international research will be stimulated to provide new data and to improve on the quality of the current available data.

Key challenges for the future are to improve monitoring, research and data quality and dissemination so that the information and analyses presented here can be updated and improved. This will contribute to recommend conservation actions based on a solid scientific basis. The further dissemination of this information to concerned European citizens will also lead to progressive policies at various jurisdictional levels that promote conservation. There is also a need for education, both of the general public and those involved in nature conservation, to raise awareness and to take bryophytes into account in conservation initiatives.

If the bryophyte assessments are periodically updated, they will enable the changing status of these species to be tracked over time via the production of a Red List Index (Butchart et al., 2004; 2005; 2006; 2007). To date, this indicator has been produced for birds, mammals, amphibians and reptiles at the European level and has been adopted as one of the headline biodiversity indicators to monitor progress towards halting biodiversity loss in Europe by 2020 (EEA, 2007). The development of such an index will be important to evaluate progress towards meeting Target 6 of the EU Biodiversity Strategy and for discussions shaping the Post-2020 Biodiversity Framework in order for Europe to step up its contribution to averting global biodiversity loss, and Aichi Target 12 of the CBD, which focuses on preventing the extinction of known threatened species and improving their status.

Sphagnum arcticum (Near Threatened moss) © Michael Lüth

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Appendix 1. List of lead assessors by geographical region

- Central Europe: Norbert Schnyder and Christian Schröck
- Eastern Europe: Nadya Konstantinova and Elvira Baisheva
- Macaronesia: Manuela Sim Sim
- Northern Europe: Tomas Hallingbäck
- Northwestern Europe: Nick Hodgetts
- Southern Europe: Patrizia Campisi and Annalena Cogoni
- Southeastern Europe: Marko Sabovljevic
- Southwestern Europe: Cecilia Sérgio

Appendix 2. Example of species summary and distribution map

The Red List assessment of *Orthotrichum urnigerum* on the following pages provides an example of the information that has been compiled for all the European bryophyte species, including a distribution map. You can search for and download all the assessments and distribution maps from the European Red List website and data portal available online at http://ec.europa.eu/environment/nature/conservation/species/redlist/ and https://www.iucnredlist.org/regions/europe.

Encalypta mutica - I. Hagen

PLANTAE - BRYOPHYTA - BRYOPSIDA - ENCALYPTALES - ENCALYPTACEAE - Encalypta - mutica

Common Names: Trubbklockmossa (Swedish)
Synonyms: No Synonyms

Red List Status
VU - Vulnerable, C2a(i) (IUCN version 3.1)

Red List Assessment

Assessment Information

Reviewed?	Date of Review:	Status:	Reasons for Rejection:	Improvements Needed:
true	2017-07-26	Passed	-	-

Assessor(s): Hodgetts, N., Blockeel, T., Konstantinova, N., Lönnell, N., Papp, B., Schnyder, N., Schröck, C., Sergio, C. & Untereiner, A.
Reviewer(s): Wilbraham, J. & Cálix, M.

Assessment Rationale

European regional assessment: Vulnerable (VU)

EU 28 regional assessment: Vulnerable (VU)

Encalypta mutica is an essentially Arctic species that for a long time was thought to be a Scandinavian endemic, but it is now also known from Estonia and Arctic European Russia. This rare species is assessed as Vulnerable since it is estiated that there are fewer than 10,000 individual-equivalents in Europe and in the EU 28, and that each subpopulation has fewer than 1,000 individual-equivalents. One individual-equivalent (i.e., mature individual) is considered to be one square meter on which the species grows. In addition, the current population trend is decreasing slightly.

Although the threats to this species appear to be largely unknown, it is certainly threatened, as it is both rare and apparently declining. It appears that it may be threatened by a lack of grazing in some localities. In the south part of Scandinavia, it is affected by the overgrowing of higher vegetation. Three localities were taken under monitoring in Estonia, where either grazing or simulation of grazing is needed in order to re-create and preserve suitable open soil patches for this species. Similar management can be recommended elsewhere. Research into threats is also recommended.

Distribution

Geographic Range

Encalypta mutica is an essentially Arctic species that for a long time was thought to be a Scandinavian endemic, but it is now also known from Estonia and Arctic European Russia. The record from the Czech Republic was excluded in the 2003 edition of the Czech Red List (Kučera and Váňa 2003), but is considered at best uncertain in this assessment. Old records from Romania are probably errors (S. Stefanut pers. comm. 2016). There are also records from the lowlands of Ukraine but, without further details or specimens, these have to be regarded with scepticism. Elsewhere it occurs in Siberia, Greenland and northern North America. This species' area of occupancy (AOO) is estimated at 452 km², and its extent of occurrence (EOO) at *ca* 2.9 million km².

Elevation / Depth / Depth Zones

Elevation Lower Limit (in metres above sea level): 0
Elevation Upper Limit (in metres above sea level): 900

Map Status

Map Status	How the map was created, including data sources/methods used:	Please state reason for map not available:	Data Sensitive?	Justification	Geographic range this applies to:	Date restriction imposed:
Done	-	-	-	-	-	-

Biogeographic Realms

Biogeographic Realm: Palearctic

Occurrence

Countries of Occurrence

Country	Presence	Origin	Formerly Bred	Seasonality
Czechia	Presence Uncertain	Native	-	Resident
Estonia	Extant	Native	-	Resident
Finland	Extant	Native	-	Resident
Norway	Extant	Native	-	Resident
Romania	Presence Uncertain	Native	-	Resident
Russian Federation	Extant	Native	-	Resident
Russian Federation -> European Russia	Extant	Native	-	Resident
Russian Federation -> European Russia -> North European Russia	Extant	Native	-	Resident
Svalbard and Jan Mayen	Extant	Native	-	Resident
Sweden	Extant	Native	-	Resident
Ukraine	Presence Uncertain	Native	-	Resident
Ukraine -> Ukraine (main part)	Presence Uncertain	Native	-	Resident

Population

This species may have disappeared from some of its Norwegian localities, including the type locality near Trondheim (Hallingbäck et al. 2006). It seems to be threatened and declining in Estonia, where, in 2006, it was not found at one previously known locality (Vellak & Ingerpuu 2012). In Murmansk there is only one locality (where it is rare), and a single locality in Karelia and in the Polar Urals. The species is rather overlooked in the mountains where it is stable, although in the lowlands in can be declining in limestone quarries. The overall current population trend is considered to be decreasing slightly. The population is not severely fragmented. It is estimated that there are fewer than 10,000 individual-equivalents in Europe and in the EU 28, and that each subpopulation has fewer than 1,000 individual-equivalents. One individual-equivalent (i.e., mature individual) is considered to be one square meter on which the species grows.

Habitats and Ecology

This essentially Arctic species grows on bare calcareous, and periodically wet, soil, typically in very sun-exposed situations, for example on alvar heaths, in limestone quarries and on gravel produced by weathering at the base of south-facing, calcium-rich alpine slopes. Associates include *Ditrichum flexicaule*, *Encalypta vulgaris*, *Myurella julacea* and *Weissia controversa*. The altitudinal range is from sea level up to 900 m Asl.

IUCN Habitats Classification Scheme

Habitat	Season	Suitability	Major Importance?
4.2. Grassland -> Grassland - Subarctic	Resident	Suitable	Yes
6. Rocky areas (eg. inland cliffs, mountain peaks)	Resident	Suitable	Yes

Systems

System: Terrestrial

Use and Trade

General Use and Trade Information

This species is not utilised or traded.

Threats

Although the threats to this species appear to be largely unknown, it is certainly threatened, as it is both rare and apparently declining. It appears that it may be threatened by a lack of grazing in some localities. In the south part of Scandinavia, it is affected by the overgrowing of higher vegetation.

Conservation

Three localities were taken under monitoring in Estonia, where either grazing or simulation of grazing is needed (by breaking the sod and opening the soil artificially) in order to re-create and preserve suitable open soil patches for this species (Vellak and Ingerpuu 2012). Similar management can be recommended elsewhere. Research into threats is also recommended. It is listed as Endangered in Finland, Vulnerable in Norway and Near Threatened in Sweden (Hodgetts 2015). It is known to occur in protected areas.

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Encalypta mutica

Range

Extant (resident)

Presence Uncertain

Citation:
International Union for Conservation of Nature (IUCN) & GBIF

Map created 06/01/2019

European Commission

THE IUCN RED LIST OF THREATENED SPECIES™

LUOMUS
FINNISH MUSEUM OF NATURAL HISTORY

Appendix 3. Red List status of European mosses, liverworts and hornworts

Taxonomy	IUCN Red List Category (Europe)	IUCN Red List Criteria (Europe)	IUCN Red List Category (EU 28)	IUCN Red List Criteria (EU 28)	Endemic to Europe	Endemic to EU 28
ACROBOLBACEAE						
Acrobolbus azoricus	EN	B2ab(iii,iv,v)	EN	B2ab(iii,iv,v)	Yes	Yes
Acrobolbus madeirensis	EN	B1ab(ii,iii,iv,v)+2ab(ii,iii, iv,v); C2a(i)	EN	B2ab(ii,iii,iv,v); C2a(i)	Yes	Yes
Acrobolbus wilsonii	VU	D1	VU	D1	Yes	No
ADELANTHACEAE						
Adelanthus lindenbergianus	EN	C2a(i)	EN	C2a(i)	No	No
Pseudomarsupidium decipiens	LC		LC		No	No
AMBLYSTEGIACEAE						
Amblystegium serpens	LC		LC		No	No
Anacamptodon splachnoides	NT	B2b(iii)	NT	B2b(iii)	No	No
Arvernella microclada	EN	D	EN	D	Yes	Yes
Campyliadelphus chrysophyllus	LC		LC		No	No
Campyliadelphus elodes	NT	A2c	NT	A2c	No	No
Campylium laxifolium	LC		LC		No	No
Campylium longicuspis	VU	D1	CR	D	No	No
Campylium protensum	LC		LC		No	No
Campylium stellatum	LC		LC		No	No
Campylophyllopsis calcarea	LC		LC		No	No
Campylophyllopsis sommerfeltii	LC		LC		No	No
Conardia compacta	NT	D1	NT	D1	No	No
Cratoneuron curvicaule	LC		LC		No	No
Cratoneuron filicinum	LC		LC		No	No
Drepanocladus aduncus	LC		LC		No	No
Drepanocladus angustifolius	VU	B2ab(iii)	VU	B2ab(iii); C2a (i)	No	No
Drepanocladus arcticus	NT	B2b(iii)	NE		No	No
Drepanocladus brevifolius	LC		NE		No	No
Drepanocladus capillifolius	NT	B1b(iii,v)	NT		No	No
Drepanocladus lycopodioides	VU	A2c; B2ab(ii,iii,iv,v)	VU	A2c; B2ab(ii,iii,iv,v)	No	No
Drepanocladus polygamus	LC		LC		No	No
Drepanocladus sendtneri	VU	A2c; B2ab(ii,iii,iv,v); C2a(i)	VU	A2c; B2ab(ii,iii,iv,v); C2a(i)	No	No
Drepanocladus sordidus	NT	B2ab(i)	NT		No	No
Drepanocladus trifarius	LC		LC		No	No
Drepanocladus turgescens	LC		VU	C2a(i)	No	No
Hygroamblystegium fluviatile	LC		LC		No	No
Hygroamblystegium humile	LC		LC		No	No
Hygroamblystegium tenax	LC		LC		No	No
Hygroamblystegium varium	LC		LC		No	No
Hygrohypnella ochracea	LC		LC		No	No
Hygrohypnella polaris	LC		NT		No	No

Taxonomy	IUCN Red List Category (Europe)	IUCN Red List Criteria (Europe)	IUCN Red List Category (EU 28)	IUCN Red List Criteria (EU 28)	Endemic to Europe	Endemic to EU 28
Hygrohypnum luridum	LC		LC		No	No
Hygrohypnum styriacum	EN	B2ab(iii); C2a(i)	EN	B2ab(iii); C2a(i)	No	No
Leptodictyum riparium	LC		LC		No	No
Ochyraea tatrensis	CR	B1ab(iii,v)+2ab(iii,v); C2a(i); D	CR	B1ab(iii)+2ab(iii); C2a(i); D	No	No
Palustriella commutata	LC		LC		No	No
Palustriella decipiens	LC		LC		No	No
Palustriella falcata	LC		LC		No	No
Platydictya jungermannioides	LC		LC		No	No
Platyhypnum alpestre	LC		LC		No	No
Platyhypnum alpinum	LC		LC		No	No
Platyhypnum cochlearifolium	EN	C2a(i)	EN	C2a (i)	No	No
Platyhypnum duriusculum	LC		LC		No	No
Platyhypnum molle	VU	C2a(i)	VU	C2a(i)	No	No
Platyhypnum norvegicum	VU	D1	EN	D	No	No
Platyhypnum smithii	LC		LC		No	No
Pseudoamblystegium subtile	LC		LC		No	No
Pseudocampylium radicale	LC		LC		No	No
Pseudohygrohypnum eugyrium	LC		LC		No	No
Pseudohygrohypnum subeugyrium	NT	D1	VU	D1	No	No
Sanionia nivalis	NT	B2b(iii)	NT		No	No
Sanionia orthothecioides	LC		LC		No	No
Sanionia uncinata	LC		LC		No	No
Serpoleskea confervoides	LC		LC		No	No
ANASTROPHYLLACEAE						
Biantheridion undulifolium	EN	B2ab(i,ii,iii,iv,v); C2a(i)	EN	B2ab(i,ii,iii,iv,v); C2a(i)	No	No
Crossocalyx hellerianus	LC		LC		No	No
Neoorthocaulis attenuatus	LC		LC		No	No
Neoorthocaulis binsteadii	LC		LC		No	No
Neoorthocaulis floerkei	LC		LC		No	No
Neoorthocaulis hyperboreus	VU	D1	NE		No	No
Orthocaulis atlanticus	LC		LC		No	No
Orthocaulis cavifolius	DD		DD		No	No
Schljakovia kunzeana	LC		LC		No	No
Schljakovianthus quadrilobus	LC		LC		No	No
Tetralophozia filiformis	CR	D	CR	D	No	No
Tetralophozia setiformis	LC		NT		No	No
ANDREAEACEAE						
Andreaea alpestris	DD		DD		Yes	No
Andreaea alpina	LC		LC		No	No
Andreaea blyttii	NT	A3c; B2b(iii,iv,v)	NT		No	No
Andreaea crassinervia	EN	C2a(i)	EN	C2a(i)	No	No
Andreaea flexuosa	EN	B1ab(ii,iii,iv,v)+2ab(ii, iii,iv,v)	EN	B1ab(ii,iii,iv,v)+2ab(ii,iii,iv,v)	No	No
Andreaea frigida	VU	C1	VU	C1	Yes	No
Andreaea heinemannii	NT	B2a	NT	B2a	No	No
Andreaea hookeri	LC		LC		No	No

Taxonomy	IUCN Red List Category (Europe)	IUCN Red List Criteria (Europe)	IUCN Red List Category (EU 28)	IUCN Red List Criteria (EU 28)	Endemic to Europe	Endemic to EU 28
Andreaea megistospora	LC		LC		No	No
Andreaea mutabilis	LC		LC		No	No
Andreaea nivalis	NT		LC		No	No
Andreaea rothii	LC		LC		No	No
Andreaea rupestris	LC		LC		No	No
Andreaea sinuosa	VU	D1+2	VU	D1+2	No	No
ANEURACEAE						
Aneura latissima	EN	B2ab(ii,iii)	EN	B2ab(ii,iii)	No	No
Aneura maxima	DD		DD		No	No
Aneura mirabilis	NT	D1	NT		No	No
Aneura pinguis	LC		LC		No	No
Riccardia chamedryfolia	LC		LC		No	No
Riccardia incurvata	LC		LC		No	No
Riccardia latifrons	LC		LC		No	No
Riccardia multifida	LC		LC		No	No
Riccardia palmata	LC		LC		No	No
ANOMODONTACEAE						
Anomodon attenuatus	LC		LC		No	No
Anomodon longifolius	LC		LC		No	No
Anomodon rugelii	NT	D1	VU	D1	No	No
Anomodon tristis	VU	D1	VU		No	No
Anomodon viticulosus	LC		LC		No	No
ANTHELIACEAE						
Anthelia julacea	LC		LC		No	No
Anthelia juratzkana	LC		LC		No	No
ANTHOCEROTACEAE						
Anthoceros agrestis	NT	A2c+3c	NT	A2c+3c	No	No
Anthoceros caucasicus	LC		LC		No	No
Anthoceros neesii	EN	B2ab(iii)	EN	B2ab(iii)	Yes	Yes
Anthoceros punctatus	LC		LC		No	No
ARCHIDIACEAE						
Archidium alternifolium	LC		LC		No	No
ARNELLIACEAE						
Arnellia fennica	LC		NT		No	No
Gongylanthus ericetorum	LC		LC		No	No
Southbya nigrella	LC		LC		No	No
Southbya tophacea	LC		LC		No	No
AULACOMNIACEAE						
Aulacomnium androgynum	LC		LC		No	No
Aulacomnium palustre	LC		LC		No	No
Aulacomnium turgidum	LC		LC		No	No
AYTONIACEAE						
Asterella africana	VU	C2a(i)	VU	C2a(i)	No	No
Asterella lindenbergiana	LC		LC		No	No
Asterella saccata	EN	B2ab(iii,iv,v)	EN	B2ab(iii,iv,v)	No	No
Mannia androgyna	LC		LC		No	No
Mannia californica	EN	D	EN	D	No	No

Taxonomy	IUCN Red List Category (Europe)	IUCN Red List Criteria (Europe)	IUCN Red List Category (EU 28)	IUCN Red List Criteria (EU 28)	Endemic to Europe	Endemic to EU 28
Mannia controversa	EN	D	EN	D	No	No
Mannia fragrans	VU	A2c	VU	A2c	No	No
Mannia gracilis	LC		LC		No	No
Mannia pilosa	LC		LC		No	No
Mannia sibirica	CR	D	CR	D	No	No
Mannia triandra	VU	D1	VU	D1	No	No
Plagiochasma appendiculatum	VU	D2	VU	D2	No	No
Plagiochasma rupestre	LC		LC		No	No
Reboulia hemisphaerica	LC		LC		No	No
BARTRAMIACEAE						
Anacolia menziesii	VU	D1	VU	D1	No	No
Anacolia webbii	LC		LC		No	No
Bartramia aprica	LC		LC		No	No
Bartramia breviseta	VU	D1	NE		No	No
Bartramia halleriana	LC		LC		No	No
Bartramia ithyphylla	LC		LC		No	No
Bartramia laevisphaera	EN	D	EN	D	No	No
Bartramia pomiformis	LC		LC		No	No
Bartramia subulata	EN	D	EN	D	No	No
Breutelia azorica	EN	A3c; B2ab(iii,v)	EN	A3c; B2ab(iii,v)	Yes	Yes
Breutelia chrysocoma	LC		LC		Yes	No
Conostomum tetragonum	LC		LC		No	No
Philonotis caespitosa	LC		LC		No	No
Philonotis calcarea	NT	A3c	NT	A3c	No	No
Philonotis capillaris	LC		LC		No	No
Philonotis cernua	CR	B1ab(i,ii,iii,iv,v)+2ab(i,ii, iii,iv,v); C2a(i); D	CR	B2ab(i,ii,iii,iv,v); C2a(i); D	No	No
Philonotis fontana	LC		LC		No	No
Philonotis hastata	NT	B2ab(iii)	NT	B2ab(iii)	No	No
Philonotis marchica	EN	C2a(i)	EN	C2a(i)	No	No
Philonotis rigida	VU	C2a(i)	VU	C2a(i)	No	No
Philonotis seriata	LC		LC		No	No
Philonotis tomentella	LC		NT		No	No
Philonotis uncinata	VU	B2ab(iii)	VU	B2ab(iii)	No	No
Plagiopus oederianus	LC		LC		No	No
BLASIACEAE						
Blasia pusilla	LC		LC		No	No
BRACHYTHECIACEAE						
Brachytheciastrum collinum	LC		NT	D1	No	No
Brachytheciastrum dieckei	LC		LC		No	No
Brachytheciastrum olympicum	VU	B2ab(ii,iv)	VU	B2ab(ii,iv)	No	No
Brachytheciastrum trachypodium	LC		LC		No	No
Brachytheciastrum vanekii	EN	B1ab(iii,iv,v)+2ab(iii,iv,v)	EN	B1ab(iii,iv,v)+ 2ab(iii,iv,v)	Yes	Yes
Brachytheciastrum velutinum	LC		LC		No	No
Brachythecium albicans	LC		LC		No	No
Brachythecium buchananii	EN	B2ab(iii); D	NE		No	No
Brachythecium campestre	LC		LC		No	No
Brachythecium capillaceum	LC		DD		No	No

Taxonomy	IUCN Red List Category (Europe)	IUCN Red List Criteria (Europe)	IUCN Red List Category (EU 28)	IUCN Red List Criteria (EU 28)	Endemic to Europe	Endemic to EU 28
Brachythecium cirrosum	LC		LC		No	No
Brachythecium erythrorrhizon	LC		LC		No	No
Brachythecium funkii	VU	D1	VU	D1	Yes	Yes
Brachythecium geheebii	VU	D1	VU	D1	Yes	No
Brachythecium glareosum	LC		LC		No	No
Brachythecium japygum	LC		LC		Yes	No
Brachythecium laetum	LC		LC		No	No
Brachythecium mildeanum	LC		LC		No	No
Brachythecium novae-angliae	LC		VU	D1	No	No
Brachythecium rivulare	LC		LC		No	No
Brachythecium rutabulum	LC		LC		No	No
Brachythecium salebrosum	LC		LC		No	No
Brachythecium tauriscorum	LC		LC		No	No
Brachythecium tenuicaule	LC		LC		Yes	No
Brachythecium tommasinii	LC		LC		No	No
Brachythecium turgidum	LC		LC		No	No
Brachythecium udum	LC		LC		No	No
Cirriphyllum crassinervium	LC		LC		No	No
Cirriphyllum piliferum	LC		LC		No	No
Clasmatodon parvulus	RE		RE		No	No
Eurhynchiastrum pulchellum	LC		LC		No	No
Eurhynchium angustirete	LC		LC		No	No
Eurhynchium striatum	LC		LC		No	No
Hedenasiastrum percurrens	EN	A3c	EN	A3c	Yes	Yes
Homalothecium aureum	LC		LC		No	No
Homalothecium lutescens	LC		LC		No	No
Homalothecium mandonii	VU	A3c	VU	A3c	No	No
Homalothecium meridionale	LC		LC		Yes	No
Homalothecium philippeanum	LC		LC		No	No
Homalothecium sericeum	LC		LC		No	No
Kindbergia praelonga	LC		LC		No	No
Microeurhynchium pumilum	LC		LC		No	No
Myuroclada longiramea	DD		NA		No	No
Myuroclada maximowiczii	NA		NE		No	No
Nobregaea latinervis	EX		EX		Yes	Yes
Oxyrrhynchium hians	LC		LC		No	No
Oxyrrhynchium schleicheri	LC		LC		No	No
Oxyrrhynchium speciosum	LC		LC		No	No
Palamocladium euchloron	EN	B2ab(iii); D	CR	D	No	No
Platyhypnidium grolleanum	DD		DD		Yes	Yes
Pseudorhynchostegiella duriaei	NT		NT		No	No
Pseudoscleropodium purum	LC		LC		No	No
Rhynchostegiella azorica	NT	B1a+2a	NT	B1a+2a	Yes	Yes
Rhynchostegiella bourgaeana	EN	A3c; B2ab(iii)	EN	A3c; B2ab(iii)	Yes	Yes
Rhynchostegiella curviseta	LC		LC		No	No
Rhynchostegiella litorea	LC		LC		No	No

Taxonomy	IUCN Red List Category (Europe)	IUCN Red List Criteria (Europe)	IUCN Red List Category (EU 28)	IUCN Red List Criteria (EU 28)	Endemic to Europe	Endemic to EU 28
Rhynchostegiella pseudolitorea	NT	B2b(iii)	NT	B2b(iii)	Yes	Yes
Rhynchostegiella tenella	LC		LC		No	No
Rhynchostegiella teneriffae	LC		LC		No	No
Rhynchostegiella trichophylla	VU	A3c	VU	A3c	Yes	Yes
Rhynchostegiella tubulosa	DD		DD		Yes	Yes
Rhynchostegium alopecuroides	LC		LC		Yes	No
Rhynchostegium confertum	LC		LC		No	No
Rhynchostegium confusum	VU	D1	VU	D1	Yes	Yes
Rhynchostegium megapolitanum	LC		LC		No	No
Rhynchostegium murale	LC		LC		No	No
Rhynchostegium riparioides	LC		LC		No	No
Rhynchostegium rotundifolium	LC		LC		No	No
Rhynchostegium strongylense	EN	D	EN	D	Yes	Yes
Sciuro-hypnum curtum	LC		LC		No	No
Sciuro-hypnum dovrense	VU	C2a(i)	EN	C2a(i)	No	No
Sciuro-hypnum flotowianum	LC		LC		No	No
Sciuro-hypnum glaciale	LC		LC		No	No
Sciuro-hypnum latifolium	LC		NT		No	No
Sciuro-hypnum oedipodium	DD		NE		No	No
Sciuro-hypnum ornellanum	EN	D	EN	D	No	No
Sciuro-hypnum plumosum	LC		LC		No	No
Sciuro-hypnum populeum	LC		LC		No	No
Sciuro-hypnum reflexum	LC		LC		No	No
Sciuro-hypnum starkei	LC		LC		No	No
Sciuro-hypnum tromsoeense	LC		LC		No	No
Scleropodium cespitans	LC		LC		No	No
Scleropodium touretii	LC		LC		No	No
Scorpiurium circinatum	LC		LC		No	No
Scorpiurium deflexifolium	LC		LC		No	No
Scorpiurium sendtneri	LC		LC		No	No
Tomentypnum nitens	NT	A2c	NT		No	No
BRUCHIACEAE						
Bruchia flexuosa	CR	D	CR	D	No	No
Bruchia vogesiaca	EN	B2ab(ii,iii,iv)	EN	B2ab(ii,iii,iv)	No	No
Trematodon ambiguus	LC		LC		No	No
Trematodon brevicollis	VU	D1	VU	D1	No	No
Trematodon laetevirens	EN	D	EN	D	No	No
Trematodon longicollis	VU	D1	VU	D1	No	No
Trematodon perssoniorum	CR	B1ab(iii)	CR	B1ab(iii)	Yes	Yes
BRYACEAE						
Anomobryum bavaricum	VU	D1	VU	D1	No	No
Anomobryum concinnatum	LC		LC		No	No
Anomobryum julaceum	LC		LC		No	No
Anomobryum lusitanicum	VU	D1	VU	D1	Yes	Yes
Brachymenium notarisii	NT	B2b(iii,iv,v)	NT	B2b(iii,iv,v)	No	No
Brachymenium paradoxum	DD		NE		Yes	No
Brachymenium philonotula	RE		RE		No	No

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Bryum apiculatum	LC		LC		No	No
Bryum argenteum	LC		LC		No	No
Bryum austriacum	VU	D1	VU	D1	Yes	No
Bryum blindii	EN	D	EN	D	No	No
Bryum calophyllum	EN	B2ab(ii,iii,iv,v)	EN	B2ab(ii,iii,iv,v)	No	No
Bryum canariense	LC		LC		No	No
Bryum cellulare	EN	B2ab(iii)	EN	B2ab(iii)	No	No
Bryum cryophilum	NT	B2b(i,ii,iii,iv,v)	VU	C2a(i)	No	No
Bryum demaretianum	DD		DD		Yes	No
Bryum dichotomum	LC		LC		No	No
Bryum dixonii	NT	D1	NT	D1	Yes	No
Bryum dyffrynense	NT	B2b(iii,iv,v)	NT	B2b(iii,iv,v)	Yes	No
Bryum elegans	LC		LC		No	No
Bryum funkii	VU	B2ab(iii)	EN	B2ab(iii)	No	No
Bryum gemmiferum	LC		LC		No	No
Bryum gemmilucens	LC		LC		No	No
Bryum gemmiparum	LC		LC		No	No
Bryum intermedium	DD		DD		No	No
Bryum klinggraeffii	LC		LC		No	No
Bryum knowltonii	VU	C2a(i)	VU	C2a(i)	No	No
Bryum kunzei	LC		LC		No	No
Bryum marratii	EN	B2ab(ii,iii,iv,v)	EN	B2ab(ii,iii,iv,v)	No	No
Bryum miniatum	VU	D1	NE		No	No
Bryum minii	LC		LC		Yes	Yes
Bryum oblongum	NT	C2a(i)	VU	C2a(i)	No	No
Bryum radiculosum	LC		LC		No	No
Bryum riparium	VU	D1	VU	D1	No	No
Bryum ruderale	LC		LC		No	No
Bryum salinum	VU	C2a(i)	EN	C2a(i)	No	No
Bryum sauteri	LC		LC		No	No
Bryum schleicheri	LC		LC		No	No
Bryum subapiculatum	LC		LC		No	No
Bryum tenuisetum	LC		LC		No	No
Bryum turbinatum	VU	C2a(i)	VU	C2a(i)	No	No
Bryum valparaisense	VU	D1	VU	D1	No	No
Bryum versicolor	EN	B2b(ii,iii,iv,v)c(iii,iv)	EN	B2b(ii,iii,iv,v)c(iii,iv)	Yes	No
Bryum violaceum	LC		LC		No	No
Bryum warneum	VU	B2ab(i,ii,iii,iv,v)	VU	B2ab(i,ii,iii,iv,v)	No	No
Bryum weigelii	LC		LC		No	No
Bryum wrightii	NT		VU	D1	No	No
Imbribryum alpinum	LC		LC		No	No
Imbribryum mildeanum	LC		LC		No	No
Imbribryum muehlenbeckii	LC		LC		No	No
Ptychostomum arcticum	LC		LC		No	No
Ptychostomum bornholmense	LC		LC		Yes	No
Ptychostomum capillare	LC		LC		No	No

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Ptychostomum cernuum	EN	B2ab(i,ii,iii,iv,v)	EN	B2ab(i,ii,iii,iv,v)	No	No
Ptychostomum compactum	LC		LC		No	No
Ptychostomum creberrimum	LC		LC		No	No
Ptychostomum cyclophyllum	LC		LC		No	No
Ptychostomum demissum	EN	C2a(i)	EN	C2a(i)	No	No
Ptychostomum donianum	LC		LC		No	No
Ptychostomum imbricatulum	LC		LC		No	No
Ptychostomum inclinatum	LC		LC		No	No
Ptychostomum longisetum	CR	C2a(i)	CR	C2a(i)	No	No
Ptychostomum moravicum	LC		LC		No	No
Ptychostomum pallens	LC		LC		No	No
Ptychostomum pallescens	LC		LC		No	No
Ptychostomum pseudotriquetrum	LC		LC		No	No
Ptychostomum rubens	LC		LC		No	No
Ptychostomum torquescens	LC		LC		No	No
Ptychostomum zieri	LC		LC		No	No
Rhodobryum ontariense	LC		LC		No	No
Rhodobryum roseum	LC		LC		No	No
BRYOXIPHIACEAE						
Bryoxiphium madeirense	EN	A3c	EN	A3c	No	No
Bryoxiphium norvegicum	LC		CR	B1ab(iii)+2ab(iii); D	No	No
BUXBAUMIACEAE						
Buxbaumia aphylla	LC		LC		No	No
Buxbaumia viridis	LC		LC		No	No
CALLIERGONACEAE						
Calliergon cordifolium	LC		LC		No	No
Calliergon giganteum	LC		LC		No	No
Calliergon megalophyllum	LC		LC		No	No
Calliergon richardsonii	LC		LC		No	No
Hamatocaulis lapponicus	EN	B2ab(i,ii,iii,iv,v)	EN	B2ab(i,ii,iii,iv,v)	No	No
Hamatocaulis vernicosus	VU	A2c	VU	A2c	No	No
Loeskypnum badium	LC		LC		No	No
Sarmentypnum exannulatum	LC		LC		No	No
Sarmentypnum sarmentosum	LC		LC		No	No
Straminergon stramineum	LC		LC		No	No
Warnstorfia fluitans	LC		LC		No	No
Warnstorfia procera	LC		LC		No	No
Warnstorfia pseudostraminea	LC		LC		No	No
Warnstorfia trichophylla	LC		LC		No	No
Warnstorfia tundrae	LC		LC		No	No
CALYCULARIACEAE						
Calycularia laxa	CR	D	NE		No	No
CALYMPERACEAE						
Calymperes erosum	CR	D	CR	D	No	No
CALYPOGEIACEAE						
Calypogeia arguta	LC		LC		No	No
Calypogeia azorica	EN	B2ab(ii,iii)	EN	B2ab(ii,iii)	Yes	Yes

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Calypogeia azurea	LC		LC		No	No
Calypogeia fissa	LC		LC		No	No
Calypogeia integristipula	LC		LC		No	No
Calypogeia muelleriana	LC		LC		No	No
Calypogeia neesiana	LC		LC		No	No
Calypogeia sphagnicola	LC		LC		No	No
Calypogeia suecica	LC		LC		No	No
Mnioloma fuscum	VU	C2a(i)	VU	C2a(i)	No	No
CATOSCOPIACEAE						
Catoscopium nigritum	LC		LC		No	No
CEPHALOZIACEAE						
Cephalozia ambigua	LC		LC		No	No
Cephalozia bicuspidata	LC		LC		No	No
Cephalozia lacinulata	CR	C2a(i); D	CR	C2a(i); D	No	No
Cephalozia macounii	CR	D	CR	D	No	No
Fuscocephaloziopsis affinis	NT		NT		No	No
Fuscocephaloziopsis albescens	LC		NT		No	No
Fuscocephaloziopsis catenulata	LC		LC		No	No
Fuscocephaloziopsis connivens	LC		LC		No	No
Fuscocephaloziopsis crassifolia	LC		LC		No	No
Fuscocephaloziopsis leucantha	LC		LC		No	No
Fuscocephaloziopsis loitlesbergeri	LC		LC		No	No
Fuscocephaloziopsis lunulifolia	LC		LC		No	No
Fuscocephaloziopsis macrostachya	LC		LC		No	No
Fuscocephaloziopsis pleniceps	LC		LC		No	No
Hygrobiella laxifolia	LC		LC		No	No
Nowellia curvifolia	LC		LC		No	No
Odontoschisma denudatum	LC		LC		No	No
Odontoschisma elongatum	LC		LC		No	No
Odontoschisma fluitans	LC		LC		No	No
Odontoschisma francisci	NT	C2a(i)	VU	C2a(i)	No	No
Odontoschisma macounii	LC		LC		No	No
Odontoschisma sphagni	LC		LC		No	No
CEPHALOZIELLACEAE						
Cephaloziella arctogena	VU	D1	EN	D	No	No
Cephaloziella aspericaulis	CR	D	DD		No	No
Cephaloziella baumgartneri	LC		LC		No	No
Cephaloziella calyculata	NT		NT		No	No
Cephaloziella dentata	EN	B2ab(iii,v)	EN	B2ab(iii,v)	No	No
Cephaloziella divaricata	LC		LC		No	No
Cephaloziella elachista	VU	C2a(i)	VU	C2a(i)	No	No
Cephaloziella elegans	DD		DD		No	No
Cephaloziella granatensis	EN	B1ab(iii,iv)+2ab(iii,iv)	EN	B1ab(iii,iv +2ab(iii,iv)	No	No
Cephaloziella grimsulana	DD		DD		No	No
Cephaloziella hampeana	LC		LC		No	No
Cephaloziella integerrima	EN	B2ab(iii,v); C2a(i)	EN	B2ab(iii,v); C2a(i)	No	No

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Cephaloziella massalongi	EN	B2ab(ii,iii,iv,v)	EN	B2ab(ii,iii,iv,v)	No	No
Cephaloziella nicholsonii	EN	C2a(i)	EN	C2a(i)	Yes	Yes
Cephaloziella phyllacantha	CR	D	CR	D	No	No
Cephaloziella polystratosa	EN	D	NE		No	No
Cephaloziella rubella	LC		LC		No	No
Cephaloziella spinigera	NT	B2b(iv,v)	NT		No	No
Cephaloziella stellulifera	LC		LC		No	No
Cephaloziella turneri	LC		LC		No	No
Cephaloziella uncinata	NT	B2b(iii,iv)	DD		No	No
Cephaloziella varians	LC		LC		No	No
CINCLIDOTACEAE						
Cinclidotus aquaticus	LC		LC		No	No
Cinclidotus danubicus	LC		LC		No	No
Cinclidotus fontinaloides	LC		LC		No	No
Cinclidotus riparius	LC		LC		No	No
Cinclidotus vivesii	DD		DD		Yes	Yes
CLEVEACEAE						
Clevea hyalina	LC		LC		No	No
Clevea spathysii	NT		NT		No	No
Peltolepis quadrata	LC		LC		No	No
Sauteria alpina	LC		LC		No	No
CLIMACIACEAE						
Climacium dendroides	LC		LC		No	No
CONOCEPHALACEAE						
Conocephalum conicum	LC		LC		No	No
Conocephalum salebrosum	LC		LC		No	No
CORSINIACEAE						
Corsinia coriandrina	LC		LC		No	No
CRYPHAEACEAE						
Cryphaea heteromalla	LC		LC		No	No
Dendrocryphaea lamyana	NT		LC		Yes	Yes
CYATHODIACEAE						
Cyathodium foetidissimum	CR	D	CR	D	No	No
DALTONIACEAE						
Achrophyllum dentatum	NA		NA		No	No
Calyptrochaeta apiculata	NA		NA		No	No
Daltonia splachnoides	LC		LC		No	No
Daltonia stenophylla	EN	B2ab(iii)	EN	B2ab(iii)	No	No
Distichophyllum carinatum	CR	C2a(i); D	CR	C2a(i); D	No	No
DELAVAYELLACEAE						
Liochlaena lanceolata	LC		LC		No	No
Liochlaena subulata	NT		NT		No	No
DICRANACEAE						
Aongstroemia longipes	LC		LC		No	No
Cnestrum alpestre	LC		NT		No	No
Cnestrum glaucescens	NT		VU	D1	No	No
Cnestrum schisti	LC		LC		No	No

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Dicranella cerviculata	LC		LC		No	No
Dicranella crispa	LC		LC		No	No
Dicranella grevilleana	LC		LC		No	No
Dicranella heteromalla	LC		LC		No	No
Dicranella howei	LC		LC		No	No
Dicranella humilis	LC		LC		No	No
Dicranella rufescens	LC		LC		No	No
Dicranella schreberiana	LC		LC		No	No
Dicranella staphylina	LC		LC		No	No
Dicranella subulata	LC		LC		No	No
Dicranella varia	LC		LC		No	No
Dicranum acutifolium	LC		LC		No	No
Dicranum angustum	LC		LC		No	No
Dicranum bardunovii	DD		NE		No	No
Dicranum bonjeanii	LC		LC		No	No
Dicranum brevifolium	LC		LC		No	No
Dicranum crassifolium	NT	B2b(i)	LC		Yes	Yes
Dicranum dispersum	EN	D	EN	D	No	No
Dicranum drummondii	LC		NT		No	No
Dicranum elongatum	LC		LC		No	No
Dicranum flagellare	LC		LC		No	No
Dicranum flexicaule	LC		LC		No	No
Dicranum fragilifolium	LC		NT		No	No
Dicranum fulvum	LC		LC		No	No
Dicranum fuscescens	LC		LC		No	No
Dicranum groenlandicum	LC		NT		No	No
Dicranum laevidens	LC		VU	D	No	No
Dicranum leioneuron	LC		LC		No	No
Dicranum majus	LC		LC		No	No
Dicranum montanum	LC		LC		No	No
Dicranum muehlenbeckii	VU	C2a(i)	VU	C2a(i)	No	No
Dicranum polysetum	LC		LC		No	No
Dicranum schljakovii	DD		NE		No	No
Dicranum scoparium	LC		LC		No	No
Dicranum scottianum	LC		LC		Yes	No
Dicranum septentrionale	NT		NT		No	No
Dicranum spadiceum	LC		LC		No	No
Dicranum spurium	LC		LC		No	No
Dicranum tauricum	LC		LC		No	No
Dicranum transsylvanicum	CR	D	CR	D	No	No
Dicranum undulatum	LC		LC		No	No
Dicranum viride	LC		LC		No	No
Diobelonella palustris	LC		LC		No	No
Paraleucobryum enerve	LC		LC		No	No
Paraleucobryum longifolium	LC		LC		No	No
Paraleucobryum sauteri	NT	B2b(iii,v); C2a(i)	NT	B2b(iii,v); C2a(i)	No	No
Pseudephemerum nitidum	LC		LC		No	No

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DIPHYSCIACEAE						
Diphyscium foliosum	LC		LC		No	No
DISCELIACEAE						
Discelium nudum	LC		LC		No	No
DITRICHACEAE						
Ceratodon conicus	NT	D1	NT	D1	No	No
Ceratodon purpureus	LC		LC		No	No
Cheilothela chloropus	LC		LC		No	No
Cleistocarpidium palustre	VU	C2a(i)	VU	C2a(i)	No	No
Distichium capillaceum	LC		LC		No	No
Distichium hagenii	NT	D1	EN	D	No	No
Distichium inclinatum	LC		LC		No	No
Ditrichum cornubicum	CR	D	CR	D	Yes	Yes
Ditrichum heteromallum	LC		LC		No	No
Ditrichum lineare	LC		LC		No	No
Ditrichum pallidum	NT	B2b(iii); D1	NT	B2b(iii); D1	No	No
Ditrichum plumbicola	EN	B2ab(iii,iv,v)c(iv)	EN	B2ab(iii,iv,v)c(iv)	Yes	Yes
Ditrichum punctulatum	NT	B2ab(iii)	NT	B2ab(iii)	No	No
Ditrichum pusillum	LC		LC		No	No
Ditrichum subulatum	LC		LC		No	No
Ditrichum zonatum	LC		LC		No	No
Pleuridium acuminatum	LC		LC		No	No
Pleuridium subulatum	LC		LC		No	No
Rhamphidium purpuratum	NT	B2b(iii)	NT	B2b(iii)	Yes	Yes
Saelania glaucescens	LC		LC		No	No
Trichodon cylindricus	LC		LC		No	No
DUMORTIERACEAE						
Dumortiera hirsuta	NT	C2a(i)	NT	C2a(i)	No	No
ECHINODIACEAE						
Echinodium renauldii	EN	A3c; C2a(i)	EN	A3c; C2a(i)	No	No
Echinodium setigerum	EN	A3c; C2a(i)	EN	A3c; C2a(i)	Yes	Yes
Echinodium spinosum	EN	A3c; C2a(i)	EN	A3c; C2a(i)	Yes	Yes
ENCALYPTACEAE						
Bryobrittonia longipes	VU	D2	NE		No	No
Encalypta affinis	DD		DD		No	No
Encalypta alpina	LC		LC		No	No
Encalypta brevicolla	LC		NT		No	No
Encalypta brevipes	EN	D	CR	D	No	No
Encalypta ciliata	LC		LC		No	No
Encalypta longicolla	LC		LC		No	No
Encalypta microstoma	LC		LC		No	No
Encalypta mutica	VU	C2a(i)	VU	C2a(i)	No	No
Encalypta pilifera	LC		LC		No	No
Encalypta procera	LC		LC		No	No
Encalypta rhaptocarpa	LC		LC		No	No
Encalypta spathulata	VU	D1	EN	D	No	No
Encalypta streptocarpa	LC		LC		No	No

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Encalypta vulgaris	LC		LC		No	No
ENDOGEMMATACEAE						
Endogemma caespiticia	LC		NT		No	No
ENTODONTACEAE						
Entodon cladorrhizans	DD		DD		No	No
Entodon concinnus	LC		LC		No	No
Entodon schleicheri	LC		LC		No	No
EPHEMERACEAE						
Ephemerum cohaerens	VU	B2b(i,ii,iii,iv,v)c(iii,iv)	VU	B2b(i,ii,iii,iv,v) c(iii,iv)	No	No
Ephemerum crassinervium	NT	B2b(iii,v)	NT	B2b(iii,v)	No	No
Ephemerum minutissimum	LC		LC		No	No
Ephemerum recurvifolium	NT	B2b(iii,v)	NT	B2b(iii,v)	No	No
Ephemerum serratum	LC		LC		No	No
Ephemerum spinulosum	DD		DD		No	No
Micromitrium tenerum	EN	B2ab(iii)c(iii,iv)	EN	B2ab(iii)c(iii,iv)	No	No
EXORMOTHECACEAE						
Exormotheca pustulosa	NT	B2b(iii)	NT	B2b(iii)	No	No
Exormotheca welwitschii	EN	B2ab(iii,v)	EN	B2ab(iii,v)	No	No
FABRONIACEAE						
Fabronia ciliaris	VU	D1	VU	D1	No	No
Fabronia pusilla	LC		LC		No	No
FISSIDENTACEAE						
Fissidens adianthoides	LC		LC		No	No
Fissidens arcticus	EN	D	NE		No	No
Fissidens arnoldii	VU	D1	VU	D1	No	No
Fissidens asplenioides	LC		LC		No	No
Fissidens azoricus	CR	B1ab(iii)+2ab(iii); D	CR	B1ab(iii)+2ab(iii); D	Yes	Yes
Fissidens bryoides	LC		LC		No	No
Fissidens celticus	LC		LC		Yes	No
Fissidens coacervatus	NT	B2b(iii)	NT	B2b(iii)	Yes	Yes
Fissidens crassipes	LC		LC		No	No
Fissidens crispus	LC		LC		No	No
Fissidens curvatus	DD		DD		No	No
Fissidens dubius	LC		LC		No	No
Fissidens exilis	LC		LC		No	No
Fissidens fontanus	LC		LC		No	No
Fissidens gracilifolius	LC		LC		No	No
Fissidens grandifrons	LC		LC		No	No
Fissidens gymnandrus	LC		LC		No	No
Fissidens jansenii	CR	B1ab(iii)+2ab(iii); D	CR	B1ab(iii)+2ab(iii); D	Yes	Yes
Fissidens microstictus	EX		EX		Yes	Yes
Fissidens monguillonii	DD		DD		No	No
Fissidens nobreganus	EN	C2a(i)	EN	C2a(i)	Yes	Yes
Fissidens osmundoides	LC		LC		No	No
Fissidens ovatifolius	DD		DD		No	No
Fissidens polyphyllus	LC		LC		No	No

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Fissidens pusillus	LC		LC		No	No
Fissidens rivularis	NT	B2b(iii)	NT	B2b(iii)	No	No
Fissidens rufulus	LC		LC		No	No
Fissidens serratus	EN	C2a(i)	EN	C2a(i)	No	No
Fissidens serrulatus	LC		LC		No	No
Fissidens sublimbatus	DD		DD		No	No
Fissidens sublineaefolius	NT	B2b(iii)	NT	B2b(iii)	Yes	Yes
Fissidens taxifolius	LC		LC		No	No
Fissidens viridulus	LC		LC		No	No
FLEXITRICHACEAE						
Flexitrichum flexicaule	LC		LC		No	No
Flexitrichum gracile	LC		LC		No	No
FONTINALACEAE						
Dichelyma capillaceum	NT	C2a(i)	NT		No	No
Dichelyma falcatum	LC		LC		No	No
Fontinalis antipyretica	LC		LC		No	No
Fontinalis dalecarlica	NT	B2b(iii)	NT		No	No
Fontinalis dichelymoides	NT		NT		Yes	No
Fontinalis hypnoides	LC		LC		No	No
Fontinalis squamosa	LC		LC		No	No
FOSSOMBRONIACEAE						
Fossombronia angulosa	LC		LC		No	No
Fossombronia caespitiformis	LC		LC		No	No
Fossombronia echinata	NT		NT		No	No
Fossombronia fimbriata	LC		LC		Yes	Yes
Fossombronia fleischeri	DD		DD		Yes	Yes
Fossombronia fleischeri	DD		DD		Yes	Yes
Fossombronia foveolata	LC		NT		No	No
Fossombronia incurva	LC		LC		Yes	No
Fossombronia leucoxantha	NT	B2b(iii)	NT	B2b(iii)	No	No
Fossombronia maritima	LC		LC		Yes	No
Fossombronia mittenii	DD		DD		No	No
Fossombronia pusilla	LC		LC		No	No
Fossombronia wondraczekii	LC		LC		No	No
FRULLANIACEAE						
Frullania acicularis	NT	B2b(iii)	NT	B2b(iii)	Yes	Yes
Frullania azorica	LC		LC		Yes	Yes
Frullania bolanderi	NT		CR	B2ab(iii)	No	No
Frullania calcarifera	NT	B2b(iii)	NT	B2b(iii)	No	No
Frullania dilatata	LC		LC		No	No
Frullania ericoides	LC		LC		No	No
Frullania fragilifolia	LC		LC		No	No
Frullania inflata	EN	B2ab(iii)	EN	B2ab(iii)	No	No
Frullania jackii	VU	D1	VU	D1	Yes	No
Frullania microphylla	LC		LC		Yes	No
Frullania oakesiana	EN	C2a(i)	EN	C2a(i)	No	No
Frullania parvistipula	CR	C2a(i)	CR	C2a(i)	No	No

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Frullania polysticta	VU	A3c	VU	A3c	No	No
Frullania riparia	EN	B2ab(iii); D	EN	B2ab(iii); D	No	No
Frullania sergiae	CR	D	CR	D2	No	No
Frullania subarctica	DD		NE		No	No
Frullania tamarisci	LC		LC		No	No
Frullania teneriffae	LC		LC		No	No
FUNARIACEAE						
Entosthodon attenuatus	LC		LC		No	No
Entosthodon commutatus	EN	B2ab(iii,v)	EN	B2ab(iii,v)	No	No
Entosthodon convexus	LC		LC		No	No
Entosthodon duriaei	NT		NT		No	No
Entosthodon fascicularis	LC		LC		No	No
Entosthodon hungaricus	LC		LC		No	No
Entosthodon kroonkurk	LC		LC		Yes	Yes
Entosthodon mouretii	NT		NT		No	No
Entosthodon muhlenbergii	NT	B2b(iii,v)	NT	B2b(iii,v)	No	No
Entosthodon obtusus	LC		LC		No	No
Entosthodon pulchellus	LC		LC		No	No
Entosthodon schimperi	NT	B2b(iii,v)	NT	B2b(iii,v)	No	No
Funaria arctica	VU	D1	DD		No	No
Funaria hygrometrica	LC		LC		No	No
Funaria microstoma	DD		DD		No	No
Funariella curviseta	VU	B2ab(iii,v)	VU	B2ab(iii,v)	No	No
Goniomitrium seroi	NT	B2b(iii)	NT	B2b(iii)	Yes	Yes
Physcomitrella patens	LC		LC		No	No
Physcomitridium readeri	VU	D1	VU	D1	No	No
Physcomitrium arenicola	EN	B2ac(iv)	NE		Yes	No
Physcomitrium eurystomum	VU	B2b(ii,iii)c(iii,iv)	EN	B2b(ii,iii)c(iii,iv)	No	No
Physcomitrium pyriforme	LC		LC		No	No
Physcomitrium sphaericum	VU	B2b(ii,iii)c(iii,iv)	VU	B2b(ii,iii)c(iii,iv)	No	No
Pyramidula tetragona	EN	B2ab(iii)	EN	B2ab(iii)	No	No
GEOCALYCACEAE						
Geocalyx graveolens	NT	C2a(i)	NT		No	No
Harpanthus flotovianus	LC		LC		No	No
Harpanthus scutatus	LC		LC		No	No
Saccogyna viticulosa	LC		LC		No	No
GIGASPERMACEAE						
Gigaspermum mouretii	NT	B2b(iii)	NT	B2b(iii)	No	No
Oedipodiella australis	EN	B2ab(i,ii,iii,v); D	EN	B2b(i,ii,iii,v); D1	No	No
GRIMMIACEAE						
Coscinodon cribrosus	LC		LC		No	No
Coscinodon horridus	DD		DD		Yes	Yes
Coscinodon humilis	DD		DD		Yes	No
Coscinodon monchiquensis	CR	B1ab(iii)+2ab(iii)	CR	B1ab(iii)+2ab(iii)	Yes	Yes
Grimmia alpestris	LC		LC		No	No
Grimmia anodon	LC		LC		No	No
Grimmia anomala	LC		LC		No	No

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Grimmia arenaria	DD		DD		Yes	No
Grimmia atrata	LC		LC		No	No
Grimmia caespiticia	LC		LC		No	No
Grimmia capillata	VU	D1	VU	D1	No	No
Grimmia crinita	VU	C2a(i)	VU	C2a(i)	No	No
Grimmia crinitoleucophaea	LC		LC		No	No
Grimmia curviseta	VU	D2	VU	D2	Yes	Yes
Grimmia decipiens	LC		LC		No	No
Grimmia dissimulata	LC		LC		No	No
Grimmia donniana	LC		LC		No	No
Grimmia elatior	LC		LC		No	No
Grimmia elongata	LC		LC		No	No
Grimmia funalis	LC		LC		No	No
Grimmia fuscolutea	VU	D1	VU	D1	No	No
Grimmia hartmanii	LC		LC		No	No
Grimmia incurva	LC		LC		No	No
Grimmia laevigata	LC		LC		No	No
Grimmia lisae	LC		LC		No	No
Grimmia longirostris	LC		LC		No	No
Grimmia meridionalis	LC		LC		No	No
Grimmia mollis	VU	D1	VU	D1	No	No
Grimmia montana	LC		LC		No	No
Grimmia muehlenbeckii	LC		LC		No	No
Grimmia nutans	EN	B2ab(iii); D	EN	B2ab(iii); D	No	No
Grimmia orbicularis	LC		LC		No	No
Grimmia ovalis	LC		LC		No	No
Grimmia plagiopodia	VU	D1	VU	D1	No	No
Grimmia pulvinata	LC		LC		No	No
Grimmia ramondii	LC		LC		No	No
Grimmia reflexidens	LC		LC		No	No
Grimmia teretinervis	NT	B2a; D1	VU	D1	No	No
Grimmia tergestina	LC		LC		No	No
Grimmia torquata	LC		LC		No	No
Grimmia trichophylla	LC		LC		No	No
Grimmia triformis	DD		DD		No	No
Grimmia ungeri	EN	D	EN	D	No	No
Grimmia unicolor	LC		LC		No	No
Racomitrium aciculare	LC		LC		No	No
Racomitrium affine	LC		LC		No	No
Racomitrium aquaticum	LC		LC		No	No
Racomitrium canescens	LC		LC		No	No
Racomitrium ellipticum	LC		LC		No	No
Racomitrium elongatum	LC		LC		No	No
Racomitrium ericoides	LC		LC		No	No
Racomitrium fasciculare	LC		LC		No	No
Racomitrium hespericum	NT		NT		Yes	Yes

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Racomitrium heterostichum	LC		LC		No	No
Racomitrium himalayanum	VU	D1	VU	D1	No	No
Racomitrium lamprocarpum	NT	B2b(ii,iii)	NT		No	No
Racomitrium lanuginosum	LC		LC		No	No
Racomitrium lusitanicum	EN	B2ab(iii,v)	EN	B2ab(iii)	Yes	Yes
Racomitrium macounii	LC		LC		No	No
Racomitrium microcarpon	LC		LC		No	No
Racomitrium nivale	VU	D1	VU	D1	Yes	No
Racomitrium obtusum	LC		LC		Yes	No
Racomitrium panschii	LC		NE		No	No
Racomitrium sudeticum	LC		LC		No	No
Schistidium abrupticostatum	LC		DD		No	No
Schistidium agassizii	LC		LC		No	No
Schistidium andreaeopsis	DD		NE		No	No
Schistidium apocarpum	LC		LC		No	No
Schistidium atrofuscum	LC		LC		No	No
Schistidium boreale	LC		LC		No	No
Schistidium brunnescens	LC		LC		No	No
Schistidium bryhnii	VU	D1	NE		Yes	No
Schistidium canadense	DD		NE		No	No
Schistidium confertum	LC		LC		No	No
Schistidium confusum	LC		LC		No	No
Schistidium crassipilum	LC		LC		No	No
Schistidium crenatum	LC		LC		No	No
Schistidium dupretii	LC		LC		No	No
Schistidium echinatum	EN	D	EN	D	No	No
Schistidium elegantulum	LC		LC		No	No
Schistidium flaccidum	VU	C2a(i)	VU	C2a(i)	No	No
Schistidium flexipile	LC		LC		No	No
Schistidium frigidum	LC		LC		No	No
Schistidium frisvollianum	VU	D1	VU	D1	No	No
Schistidium grande	VU	D1	VU	D1	Yes	No
Schistidium grandirete	VU	D1	VU	D1	No	No
Schistidium helveticum	LC		LC		No	No
Schistidium holmenianum	CR	C2a(i)	NE		No	No
Schistidium lancifolium	LC		LC		No	No
Schistidium maritimum	LC		LC		No	No
Schistidium obscurum	DD		DD		No	No
Schistidium occidentale	CR	D	CR	D	No	No
Schistidium papillosum	LC		LC		No	No
Schistidium platyphyllum	LC		LC		No	No
Schistidium poeltii	LC		LC		No	No
Schistidium pruinosum	LC		LC		No	No
Schistidium pulchrum	LC		LC		No	No
Schistidium recurvum	LC		LC		No	No
Schistidium rivulare	LC		LC		No	No

Taxonomy	IUCN Red List Category (Europe)	IUCN Red List Criteria (Europe)	IUCN Red List Category (EU 28)	IUCN Red List Criteria (EU 28)	Endemic to Europe	Endemic to EU 28
Schistidium robustum	LC		LC		No	No
Schistidium scandicum	LC		LC		Yes	No
Schistidium sibiricum	VU	D1	DD		No	No
Schistidium sinensiapocarpum	LC		LC		No	No
Schistidium sordidum	LC		DD		No	No
Schistidium spinosum	CR	C2a(i)	CR	C2a(i)	Yes	No
Schistidium strictum	LC		LC		No	No
Schistidium subflaccidum	LC		LC		No	No
Schistidium subjulaceum	LC		LC		No	No
Schistidium submuticum	LC		VU	D1	Yes	No
Schistidium tenerum	VU	D1	EN	D	No	No
Schistidium trichodon	LC		LC		No	No
Schistidium umbrosum	LC		DD		No	No
Schistidium venetum	LC		VU	D1	No	No
GYMNOMITRIACEAE						
Gymnomitrion adustum	LC		LC		Yes	No
Gymnomitrion alpinum	VU	C2a(i)	VU	C2a(i)	No	No
Gymnomitrion brevissimum	LC		LC		No	No
Gymnomitrion commutatum	LC		LC		No	No
Gymnomitrion concinnatum	LC		LC		No	No
Gymnomitrion corallioides	LC		LC		No	No
Gymnomitrion crenulatum	LC		LC		Yes	No
Gymnomitrion obtusum	LC		LC		No	No
Gymnomitrion revolutum	NT	D1	VU	D1	No	No
Marsupella andreaeoides	NT		NE		Yes	No
Marsupella apiculata	LC		LC		No	No
Marsupella aquatica	LC		LC		No	No
Marsupella arctica	VU	D1	EN	D	No	No
Marsupella boeckii	LC		VU	D1	No	No
Marsupella condensata	VU	C2a(i)	EN	C2a(i)	No	No
Marsupella emarginata	LC		LC		No	No
Marsupella funckii	LC		LC		No	No
Marsupella profunda	VU	D1	VU	D1	No	No
Marsupella sparsifolia	NT	B2b(iii)	VU	B2a,b(ii,iii)	No	No
Marsupella sphacelata	LC		LC		No	No
Marsupella spiniloba	DD		DD		No	No
Marsupella sprucei	LC		LC		No	No
Marsupella stableri	NT	B2b(iii,v)	NT	B2b(iii,v)	No	No
Prasanthus suecicus	LC		LC		No	No
HAPLOMITRIACEAE						
Haplomitrium hookeri	LC		LC		No	No
HEDWIGIACEAE						
Braunia alopecura	VU	D1	VU	D1	No	No
Braunia imberbis	NT	C2a(i)	LC		No	No
Hedwigia ciliata	LC		LC		No	No
Hedwigia mollis	LC		NE		No	No
Hedwigia nemoralis	DD		NE		No	No

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Hedwigia stellata	LC		LC		No	No
Hedwigia striata	NT	B2a	NT		No	No
HELODIACEAE						
Helodium blandowii	NT	A2c	NT	A2c	No	No
HERBERTACEAE						
Herbertus azoricus	EN	B2ab(iii)	EN	B2ab(iii)	Yes	Yes
Herbertus borealis	VU	D2	VU	D2	Yes	Yes
Herbertus hutchinsiae	NT	B2b(iii,v)	NT	B2b(iii,v)	Yes	No
Herbertus norenus	VU	D1	EN	D	Yes	No
Herbertus sendtneri	EN	C2a(i)	EN	C2a(i)	No	No
Herbertus stramineus	LC		LC		No	No
HOOKERIACEAE						
Hookeria lucens	LC		LC		No	No
HYLOCOMIACEAE						
Hylocomiastrum pyrenaicum	LC		LC		No	No
Hylocomiastrum umbratum	LC		LC		No	No
Hylocomium splendens	LC		LC		No	No
Hyocomium armoricum	LC		LC		No	No
Loeskeobryum brevirostre	LC		LC		No	No
Pleurozium schreberi	LC		LC		No	No
Rhytidiadelphus loreus	LC		LC		No	No
Rhytidiadelphus squarrosus	LC		LC		No	No
Rhytidiadelphus subpinnatus	LC		LC		No	No
Rhytidiadelphus triquetrus	LC		LC		No	No
HYPNACEAE						
Andoa berthelotiana	VU	A3c	VU	A3c	Yes	Yes
Breidleria pratensis	LC		NT		No	No
Callicladium haldanianum	LC		LC		No	No
Calliergonella cuspidata	LC		LC		No	No
Calliergonella lindbergii	LC		LC		No	No
Campylophyllum halleri	LC		LC		No	No
Campylophyllum montanum	VU	C2a(i)	VU	C2a(i), D1	No	No
Ctenidium molluscum	LC		LC		No	No
Hageniella micans	NT	B2b(iii,v)	NT	B2b(iii,v)	No	No
Herzogiella seligeri	LC		LC		No	No
Herzogiella striatella	LC		LC		No	No
Herzogiella turfacea	NT		VU	C2a(i)	No	No
Homomallium incurvatum	LC		LC		No	No
Hypnum aemulans	DD		DD		Yes	No
Hypnum andoi	LC		LC		No	No
Hypnum bambergeri	LC		LC		No	No
Hypnum callichroum	LC		LC		No	No
Hypnum cupressiforme	LC		LC		No	No
Hypnum fertile	CR	C2a(i)	CR	C2a(i)	Yes	No
Hypnum hamulosum	LC		LC		No	No
Hypnum holmenii	VU	D1	VU	D1	No	No
Hypnum imponens	NT	B2ab(iii)	NT	B2ab(iii)	No	No
Hypnum jutlandicum	LC		LC		No	No
Hypnum pallescens	LC		LC		No	No
Hypnum plicatulum	CR	C2a(i); D	CR	C2a(i); D	No	No

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Hypnum recurvatum	LC				No	No
Hypnum sauteri	LC		LC		Yes	No
Hypnum subimponens	EN	B2ab(i,ii,iii,iv,v)	EN	B2ab(i,ii,iii,iv,v)	No	No
Hypnum uncinulatum	LC		LC		No	No
Isopterygium tenerum	EN	B2ab(ii); D	EN	B2ab(ii); D	No	No
Orthothecium chryseon	NT	B2b(i,ii,iii,iv,v); C2a(i)	VU	C2a(i)	No	No
Orthothecium intricatum	LC		LC		No	No
Orthothecium lapponicum	VU	D1	EN	D	No	No
Orthothecium rufescens	LC		LC		No	No
Orthothecium strictum	LC		NT		No	No
Platygyrium repens	LC		LC		No	No
Pseudotaxiphyllum elegans	LC		LC		No	No
Pseudotaxiphyllum laetevirens	NT	B2b(iii)	NT	B2b(iii)	Yes	Yes
Ptilium crista-castrensis	LC		LC		No	No
Pylaisia polyantha	LC		LC		No	No
Pylaisia selwynii	LC		NE		No	No
Taxiphyllum densifolium	EN	B2ab(v)	EN	B2ab(v)	No	No
Taxiphyllum wissgrillii	LC		LC		No	No
HYPOPTERYGIACEAE						
Hypopterygium tamarisci	NA		NA		No	No
JAMESONIELLACEAE						
Syzygiella autumnalis	LC		LC		No	No
Syzygiella rubricaulis	EN	B1ab(iii)+2ab(iii)	EN	B1ab(iii)+2ab(iii)	No	No
JUBULACEAE						
Jubula hutchinsiae	LC		LC		No	No
JUNGERMANNIACEAE						
Eremonotus myriocarpus	NT	D1	VU	D1	No	No
Heterogemma capitata	VU	C2a(i)	VU	C2a(i)	No	No
Heterogemma laxa	VU	C2a(i)	EN	C2a(i)	No	No
Jungermannia atrovirens	LC		LC		No	No
Jungermannia borealis	LC		NT		No	No
Jungermannia calcicola	DD		DD		No	No
Jungermannia exsertifolia	LC		LC		No	No
Jungermannia polaris	LC		VU	D1	No	No
Jungermannia polaris	LC		VU	D1	No	No
Jungermannia pumila	LC		LC		No	No
Lophoziopsis excisa	LC		LC		No	No
Lophoziopsis longidens	LC		LC		No	No
Lophoziopsis pellucida	VU	D1	EN	D	No	No
Lophoziopsis polaris	LC		NT		No	No
Lophoziopsis propagulifera	LC		VU	D1	No	No
Lophoziopsis rubrigemma	DD		NE		No	No
Mesoptychia badensis	LC		LC		No	No
Mesoptychia bantriensis	LC		LC		No	No
Mesoptychia collaris	LC		LC		No	No
Mesoptychia fitzgeraldiae	NT	D1	NT	D1	Yes	Yes
Mesoptychia gillmanii	VU	C2a(i)	VU	C2a(i)	No	No
Mesoptychia heterocolpos	LC		LC		No	No
Mesoptychia rutheana	NT	A2c	NT	A2c	No	No
Mesoptychia sahlbergii	DD		NE		No	No
Mesoptychia turbinata	LC		LC		No	No

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Obtusifolium obtusum	LC		LC		No	No
Protolophozia elongata	VU	D1	DD		No	No
Protolophozia herzogiana	CR	D	CR	D	No	No
Pseudotritomaria heterophylla	DD		NE		No	No
Saccobasis polita	LC		LC		No	No
Saccobasis polymorpha	LC		NE		No	No
Schizophyllopsis sphenoloboides	EN	D	CR	D	No	No
LEJEUNEACEAE						
Acanthocoleus aberrans	EN	B2ab(iii,iv,v)	EN	B2ab(iii,iv,v)	No	No
Cheilolejeunea cedercreutzii	EN	B2ab(ii,iii); C2a(i)	EN	B2ab(ii,iii); C2a(i)	Yes	Yes
Cololejeunea azorica	VU	C2a(i)	VU	C2a(i)	No	No
Cololejeunea calcarea	LC		LC		No	No
Cololejeunea madeirensis	EN	B2ab(iii,v); C2a(i)	EN	B2ab(iii,v); C2a(i)	Yes	Yes
Cololejeunea microscopica	LC		LC		No	No
Cololejeunea rossettiana	LC		LC		No	No
Cololejeunea schaeferi	VU	A3c	VU	A3c	Yes	Yes
Cololejeunea sintenisii	EN	B2ab(ii,iii,v)	EN	B2ab(ii,iii,v)	No	No
Colura calyptrifolia	LC		LC		No	No
Drepanolejeunea hamatifolia	LC		LC		No	No
Harpalejeunea molleri	LC		LC		No	No
Lejeunea canariensis	VU	B2ab(iii)	VU	B2ab(iii)	Yes	Yes
Lejeunea cavifolia	LC		LC		No	No
Lejeunea eckloniana	LC		LC		No	No
Lejeunea flava	NT	B2b(iii)	NT	B2b(iii)	No	No
Lejeunea hibernica	NT	B2ab(iii)	NT	B2ab(iii)	Yes	Yes
Lejeunea lamacerina	LC		LC		No	No
Lejeunea mandonii	VU	B2ab(iii,v)	VU	B2ab(iii,v)	Yes	Yes
Lejeunea patens	LC		LC		No	No
Marchesinia mackaii	LC		LC		No	No
Microlejeunea ulicina	LC		LC		No	No
Myriocoleopsis minutissima	LC		LC		No	No
LEMBOPHYLLACEAE						
Isothecium algarvicum	LC		LC		No	No
Isothecium alopecuroides	LC		LC		No	No
Isothecium holtii	LC		LC		No	No
Isothecium montanum	CR	B1ab(i,ii,iii,iv,v)+2ab(i,ii, iii,iv,v); C2a(i); D	CR	B1ab(i,ii,iii,iv,v) +2ab(i,ii,iii,iv,v); C2a(i); D	Yes	Yes
Isothecium myosuroides	LC		LC		No	No
Isothecium prolixum	VU	A3c	VU	A3c	Yes	Yes
Plasteurhynchium meridionale	LC		LC		No	No
Plasteurhynchium striatulum	LC		LC		No	No
LEPIDOZIACEAE						
Bazzania azorica	EN	A3c; B2ab(ii,iii,iv,v)	EN	A3c; B2ab(ii,iii,iv,v)	Yes	Yes
Bazzania flaccida	LC		LC		No	No
Bazzania pearsonii	NT	B2b(iii,iv,v)	NT	B2b(iii,iv,v)	No	No
Bazzania tricrenata	LC		LC		No	No
Bazzania trilobata	LC		LC		No	No
Kurzia pauciflora	LC		LC		No	No
Kurzia sylvatica	LC		LC		No	No
Kurzia trichoclados	LC		LC		No	No

Taxonomy	IUCN Red List Category (Europe)	IUCN Red List Criteria (Europe)	IUCN Red List Category (EU 28)	IUCN Red List Criteria (EU 28)	Endemic to Europe	Endemic to EU 28
Lepidozia cupressina	LC		LC		No	No
Lepidozia pearsonii	LC		LC		No	No
Lepidozia reptans	LC		LC		No	No
Lepidozia stuhlmannii	EN	B1ab(iii)+2ab(iii)	EN	B1ab(iii)+2ab(iii)	No	No
Telaranea azorica	EN	B2ab(iii)	EN	B2ab(iii)	Yes	Yes
Telaranea europaea	LC		LC		Yes	Yes
Tricholepidozia tetradactyla	NA		NA		No	No
LEPTODONTACEAE						
Leptodon corsicus	CR	D	CR	D	Yes	Yes
Leptodon longisetus	VU	A3c	VU	A3c	Yes	Yes
Leptodon smithii	LC		LC		No	No
LESKEACEAE						
Lescuraea incurvata	LC		LC		No	No
Lescuraea mutabilis	LC		LC		No	No
Lescuraea patens	LC		LC		No	No
Lescuraea plicata	LC		LC		No	No
Lescuraea radicosa	LC		LC		No	No
Lescuraea saviana	LC		LC		No	No
Lescuraea saxicola	LC		LC		No	No
Lescuraea secunda	VU	D1	NE		No	No
Leskea polycarpa	LC		LC		No	No
Pseudoleskea artariae	EN	D	EN	D	No	No
Pseudoleskeella catenulata	LC		LC		No	No
Pseudoleskeella nervosa	LC		LC		No	No
Pseudoleskeella papillosa	VU	D1	VU	D1	No	No
Pseudoleskeella rupestris	LC		LC		No	No
Pseudoleskeella tectorum	LC		LC		No	No
LEUCOBRYACEAE						
Atractylocarpus alpinus	CR	C2a(i); D	CR	C2a(i); D	No	No
Campylopus atrovirens	LC		LC		No	No
Campylopus brevipilus	LC		LC		No	No
Campylopus cygneus	LC		LC		No	No
Campylopus flaccidus	EN	B2ab(i,ii,iii,iv,v); C2a(i)	EN	B2ab(i,ii,iii,iv,v); C2a(i)	No	No
Campylopus flexuosus	LC		LC		No	No
Campylopus fragilis	LC		LC		No	No
Campylopus gracilis	LC		LC		No	No
Campylopus incrassatus	LC		LC		No	No
Campylopus introflexus	NA		NA		No	No
Campylopus oerstedianus	DD		DD		No	No
Campylopus pilifer	LC		LC		No	No
Campylopus pyriformis	LC		LC		No	No
Campylopus schimperi	LC		LC		No	No
Campylopus setifolius	LC		LC		Yes	Yes
Campylopus shawii	LC		LC		No	No
Campylopus subporodictyon	VU	D1	VU	D1	No	No
Campylopus subulatus	DD		DD		No	No
Dicranodontium asperulum	LC		LC		No	No
Dicranodontium denudatum	LC		LC		No	No
Dicranodontium uncinatum	LC		LC		No	No
Leucobryum albidum	DD		DD		No	No

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Leucobryum glaucum	LC		LC		No	No
Leucobryum juniperoideum	LC		LC		No	No
Microcampylopus laevigatus	NT	B2b(iii)	NT	B2b(iii)	No	No
LEUCODONTACEAE						
Antitrichia californica	LC		LC		No	No
Antitrichia curtipendula	LC		LC		No	No
Leucodon canariensis	NT	B2b(iii)	NT	B2b(iii)	Yes	Yes
Leucodon pendulus	NA		NE		No	No
Leucodon sciuroides	LC		LC		No	No
Leucodon treleasei	VU	C2a(i)	VU	C2a(i)	Yes	Yes
Nogopterium gracile	LC		LC		No	No
LEUCOMIACEAE						
Tetrastichium fontanum	VU	B2ab(iii,v); C2a(i); D1	VU	B2ab(iii,v); C2a(i); D1	Yes	Yes
Tetrastichium virens	NT	B2b(iii)	NT	B2b(iii)	Yes	Yes
LOPHOCOLEACEAE						
Chiloscyphus pallescens	LC		LC		No	No
Chiloscyphus polyanthos	LC		LC		No	No
Heteroscyphus denticulatus	NT	B2b(iii)	NT	B2b(iii)	Yes	Yes
Heteroscyphus fissistipus	NA		NA		No	No
Leptoscyphus cuneifolius	LC		LC		No	No
Leptoscyphus porphyrius	EN	B2ab(ii,iii,iv,v)	EN	B2ab(ii,iii,iv,v)	No	No
Lophocolea bidentata	LC		LC		No	No
Lophocolea bispinosa	NA		NA		No	No
Lophocolea brookwoodiana	DD		DD		Yes	Yes
Lophocolea coadunata	LC		LC		No	No
Lophocolea fragrans	LC		LC		No	No
Lophocolea heterophylla	LC		LC		No	No
Lophocolea minor	LC		LC		No	No
Lophocolea semiteres	NA		NA		No	No
LOPHOZIACEAE						
Lophozia ascendens	LC		LC		No	No
Lophozia ciliata	NT	C2a(i)	NT		No	No
Lophozia guttulata	LC		LC		No	No
Lophozia longiflora	LC		NT		No	No
Lophozia murmanica	DD		NE		No	No
Lophozia savicziae	VU	D1	EN	D	No	No
Lophozia schusteriana	LC		NE		No	No
Lophozia silvicoloides	DD		NE		No	No
Lophozia subapiculata	DD		NE		No	No
Lophozia ventricosa	LC		LC		No	No
Lophozia wenzelii	LC		LC		No	No
Oleolophozia perssonii	LC		LC		No	No
Trilophozia quinquedentata	LC		LC		No	No
Tritomaria exsecta	LC		LC		No	No
Tritomaria exsectiformis	LC		LC		No	No
Tritomaria scitula	LC		LC		No	No
LUNULARIACEAE						
Lunularia cruciata	LC		LC		No	No
MARCHANTIACEAE						
Marchantia paleacea	VU	D1	VU	D1	No	No

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Marchantia polymorpha	LC		LC		No	No
Marchantia quadrata	LC		LC		No	No
Marchantia romanica	VU	D1	VU	D1	No	No
MASTIGOPHORACEAE						
Mastigophora woodsii	NT	B2b(iii)	NT	B2b(iii)	No	No
MEESIACEAE						
Amblyodon dealbatus	LC		LC		No	No
Leptobryum pyriforme	LC		LC		No	No
Meesia hexasticha	VU	D1	VU	D1	No	No
Meesia longiseta	VU	C2a(i)	VU	C2a(i)	No	No
Meesia triquetra	NT	C2a(i)	VU	C2a(i)	No	No
Meesia uliginosa	LC		LC		No	No
Paludella squarrosa	LC		NT	A2c	No	No
METZGERIACEAE						
Metzgeria conjugata	LC		LC		No	No
Metzgeria consanguinea	LC		LC		No	No
Metzgeria furcata	LC		LC		No	No
Metzgeria leptoneura	LC		LC		No	No
Metzgeria pubescens	LC		LC		No	No
Metzgeria simplex	DD		DD		No	No
Metzgeria violacea	LC		LC		No	No
MNIACEAE						
Cinclidium arcticum	LC		NT		No	No
Cinclidium latifolium	NT		NE		No	No
Cinclidium stygium	LC		NT		No	No
Cinclidium subrotundum	LC		LC		No	No
Cyrtomnium hymenophylloides	LC		NT		No	No
Cyrtomnium hymenophyllum	LC		NT		No	No
Epipterygium tozeri	LC		LC		No	No
Mielichhoferia elongata	VU	D1	VU	D1	No	No
Mielichhoferia mielichhoferiana	NT	D1	VU	D1	No	No
Mnium blyttii	LC		LC		No	No
Mnium heterophyllum	RE		NE		No	No
Mnium hornum	LC		LC		No	No
Mnium lycopodioides	LC		LC		No	No
Mnium marginatum	LC		LC		No	No
Mnium spinosum	LC		LC		No	No
Mnium spinulosum	LC		LC		No	No
Mnium stellare	LC		LC		No	No
Mnium thomsonii	LC		LC		No	No
Plagiomnium affine	LC		LC		No	No
Plagiomnium confertidens	VU	D1	NE		No	No
Plagiomnium curvatulum	LC		NT	D1	No	No
Plagiomnium cuspidatum	LC		LC		No	No
Plagiomnium drummondii	EN	B2ab(ii,iii,iv)	EN	B2ab(ii,iii,iv)	No	No
Plagiomnium elatum	LC		LC		No	No
Plagiomnium ellipticum	LC		LC		No	No
Plagiomnium medium	LC		LC		No	No
Plagiomnium rostratum	LC		LC		No	No
Plagiomnium undulatum	LC		LC		No	No
Pohlia andalusica	LC		LC		No	No

Taxonomy	IUCN Red List Category (Europe)	IUCN Red List Criteria (Europe)	IUCN Red List Category (EU 28)	IUCN Red List Criteria (EU 28)	Endemic to Europe	Endemic to EU 28
Pohlia andrewsii	NT	D1	NT		No	No
Pohlia annotina	LC		LC		No	No
Pohlia atropurpurea	NT	D1	VU	D1	No	No
Pohlia beringiensis	CR	B2ab(iii); D	NE		No	No
Pohlia bolanderi	EN	B2ab(iii)	EN	B2ab(iii)	No	No
Pohlia bulbifera	LC		LC		No	No
Pohlia camptotrachela	LC		LC		No	No
Pohlia cruda	LC		LC		No	No
Pohlia crudoides	VU	D1	VU	D1	No	No
Pohlia drummondii	LC		LC		No	No
Pohlia elongata	LC		LC		No	No
Pohlia erecta	EN	C2a(i)	CR	C2a(i,ii); D	No	No
Pohlia filum	LC		LC		No	No
Pohlia flexuosa	LC		LC		No	No
Pohlia lescuriana	LC		LC		No	No
Pohlia longicolla	LC		LC		No	No
Pohlia ludwigii	LC		LC		No	No
Pohlia lutescens	LC		LC		No	No
Pohlia melanodon	LC		LC		No	No
Pohlia nutans	LC		LC		No	No
Pohlia obtusifolia	LC		LC		No	No
Pohlia proligera	LC		LC		No	No
Pohlia scotica	LC		LC		Yes	Yes
Pohlia sphagnicola	DD		DD		No	No
Pohlia tundrae	DD		DD		No	No
Pohlia vexans	EN	B2ab(ii,iii,iv,v)	EN	B2ab(ii,iii,iv,v)	No	No
Pohlia wahlenbergii	LC		LC		No	No
Pseudobryum cinclidioides	LC		LC		No	No
Rhizomnium andrewsianum	EN	B2ab(iii); C2a(i)	EN	EN B2ab (iii); C2a (i)	No	No
Rhizomnium gracile	CR	D	CR	D	No	No
Rhizomnium magnifolium	LC		LC		No	No
Rhizomnium pseudopunctatum	LC		LC		No	No
Rhizomnium punctatum	LC		LC		No	No
Schizymenium pontevedrense	VU	C2a(i)	VU	C2a(i)	Yes	Yes
MOERCKIACEAE						
Moerckia blyttii	VU	B2ab(iii)	VU	B2ab(iii)	No	No
Moerckia flotoviana	NT	B2b(iii)	NT		No	No
Moerckia hibernica	VU	D1	VU	D1	No	No
MYLIACEAE						
Mylia anomala	LC		LC		No	No
Mylia taylorii	LC		LC		No	No
MYRINIACEAE						
Helicodontium capillare	RE		RE		No	No
Myrinia pulvinata	NT	B2b(iii)	VU	C2a(i)	No	No
MYURIACEAE						
Myurium hochstetteri	LC		LC		Yes	Yes
NECKERACEAE						
Alleniella besseri	LC		LC		No	No
Alleniella complanata	LC		LC		No	No
Exsertotheca baetica	EN	D	EN	D	Yes	Yes

Taxonomy	IUCN Red List Category (Europe)	IUCN Red List Criteria (Europe)	IUCN Red List Category (EU 28)	IUCN Red List Criteria (EU 28)	Endemic to Europe	Endemic to EU 28
Exsertotheca crispa	LC		LC		No	No
Exsertotheca intermedia	VU	A3c	VU	A3c	Yes	Yes
Homalia lusitanica	NT	B2b(iii)	NT	B2b(iii)	No	No
Homalia trichomanoides	LC		LC		No	No
Homalia webbiana	EN	B2ab(iii,v)	EN	B2ab(iii,v)	Yes	No
Neckera cephalonica	NT	B2ab(iii)	NT	B2ab(iii)	Yes	No
Neckera menziesii	LC		LC		No	No
Neckera oligocarpa	LC		NT		No	No
Neckera pennata	LC		VU	C2a(i)	No	No
Neckera pumila	LC		LC		No	No
Thamnobryum alopecurum	LC		LC		No	No
Thamnobryum angustifolium	CR	D	CR	D	Yes	Yes
Thamnobryum cataractarum	CR	D	CR	D	Yes	Yes
Thamnobryum fernandesii	VU	B1ab(iii)+2ab(iii)	VU	B1ab(iii)+2ab(iii)	Yes	Yes
Thamnobryum maderense	NT	B2ab(iii)	NT	B2ab(iii)	No	No
Thamnobryum neckeroides	VU	D1	VU	D1	No	No
Thamnobryum rudolphianum	EN	B2ab(iii)	EN	B2ab(iii)	Yes	Yes
Thamnobryum subserratum	EN	D	EN	D	No	No
NOTOTHYLADACEAE						
Notothylas orbicularis	EN	B2ab(ii,iii,v)	EN	B2ab(ii,iii,v)	No	No
Phaeoceros carolinianus	NT	A2c	NT	A2c	No	No
Phaeoceros laevis	LC		LC		No	No
OEDIPODIACEAE						
Oedipodium griffithianum	NT		NT		No	No
ORTHODONTIACEAE						
Leptotheca gaudichaudii	NA		NA		No	No
Orthodontium gracile	CR	C2a(i)	CR	C2a(i)	No	No
Orthodontium lineare	NA		NA		No	No
Orthodontium pellucens	VU	B1ab(iii)+2ab(iii); D2	VU	B1ab(iii)+2ab(iii); D2	No	No
ORTHOTRICHACEAE						
Codonoblepharon forsteri	EN	B2ab(ii,iii)	NT		No	No
Lewinskya acuminata	LC		LC		No	No
Lewinskya affinis	LC		LC		No	No
Lewinskya breviseta	LC		LC		No	No
Lewinskya iberica	LC		LC		No	No
Lewinskya laevigata	VU	D1	EN	D	No	No
Lewinskya pylaisii	LC		NT		No	No
Lewinskya rupestris	LC		LC		No	No
Lewinskya shawii	LC		LC		No	No
Lewinskya sordida	DD		NE		No	No
Lewinskya speciosa	LC		LC		No	No
Lewinskya striata	LC		LC		No	No
Lewinskya tortidontia	LC		LC		No	No
Nyholmiella gymnostoma	LC		LC		No	No
Nyholmiella obtusifolia	LC		LC		No	No
Orthotrichum alpestre	LC		LC		No	No
Orthotrichum anomalum	LC		LC		No	No
Orthotrichum callistomum	RE		NE		No	No
Orthotrichum cambrense	DD		DD		Yes	Yes
Orthotrichum casasianum	CR	B1ab(iii)+2ab(iii)	CR	B1ab(iii)+2ab(iii)	Yes	Yes

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Orthotrichum columbicum	LC		DD		No	No
Orthotrichum comosum	LC		LC		No	No
Orthotrichum consobrinum	CR	D	CR	D	No	No
Orthotrichum crenulatum	VU	D1	VU	D1	No	No
Orthotrichum cupulatum	LC		LC		No	No
Orthotrichum dentatum	VU	D1	VU	D1	Yes	No
Orthotrichum diaphanum	LC		LC		No	No
Orthotrichum handiense	CR	B1ab(iii,v)+2ab(iii,v); C2a(i,ii); D	CR	B1ab(iii,v)+2ab(iii,v); C2a(i,ii); D	Yes	Yes
Orthotrichum hispanicum	NT		NT		No	No
Orthotrichum macrocephalum	LC		LC		No	No
Orthotrichum microcarpum	VU	D1	EN	D	No	No
Orthotrichum moravicum	DD		DD		No	No
Orthotrichum pallens	LC		LC		No	No
Orthotrichum patens	LC		LC		No	No
Orthotrichum pellucidum	VU	C2a(i)	CR	C2a(i)	No	No
Orthotrichum philibertii	LC		LC		No	No
Orthotrichum pulchellum	LC		LC		No	No
Orthotrichum pumilum	LC		LC		No	No
Orthotrichum rivulare	LC		LC		No	No
Orthotrichum rogeri	LC		LC		No	No
Orthotrichum scanicum	LC		LC		No	No
Orthotrichum schimperi	LC		LC		No	No
Orthotrichum sibiricum	DD		NE		No	No
Orthotrichum sprucei	LC		LC		No	No
Orthotrichum stellatum	VU	D1	VU	D1	No	No
Orthotrichum stramineum	LC		LC		No	No
Orthotrichum tenellum	LC		LC		No	No
Orthotrichum urnigerum	VU	D1	VU	D1	No	No
Orthotrichum vittii	NT		NT		No	No
Plenogemma phyllantha	LC		LC		No	No
Pulvigera lyellii	LC		LC		No	No
Ulota bruchii	LC		LC		Yes	No
Ulota calvescens	LC		LC		Yes	No
Ulota coarctata	LC		LC		No	No
Ulota crispa	LC		LC		No	No
Ulota crispula	LC		LC		No	No
Ulota curvifolia	LC		LC		No	No
Ulota drummondii	LC		LC		No	No
Ulota hutchinsiae	LC		LC		No	No
Ulota intermedia	LC		LC		No	No
Ulota macrospora	EN	D	EN	D	Yes	No
Ulota rehmannii	CR	D	CR	D	No	No
Zygodon catarinoi	LC		LC		No	No
Zygodon conoideus	LC		LC		No	No
Zygodon dentatus	LC		LC		No	No
Zygodon gracilis	VU	D1	VU	D1	No	No
Zygodon rupestris	LC		LC		No	No
Zygodon sibiricus	DD		NE		No	No
Zygodon stirtonii	LC		LC		No	No
Zygodon viridissimus	LC		LC		No	No

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OXYMITRACEAE						
Oxymitra incrassata	LC		LC		No	No
PALLAVICINIACEAE						
Pallavicinia lyellii	VU	B2ab(ii,iii,iv,v)	VU	B2ab(ii,iii,iv,v)	No	No
PELLIACEAE						
Apopellia endiviifolia	LC		LC		No	No
Pellia epiphylla	LC		LC		No	No
Pellia neesiana	LC		LC		No	No
PETALOPHYLLACEAE						
Petalophyllum ralfsii	LC		LC		No	No
PHYMATOCEROTACEAE						
Phymatoceros bulbiculosus	LC		LC		No	No
PILOTRICHACEAE						
Cyclodictyon laetevirens	LC		LC		No	No
PLAGIOCHILACEAE						
Pedinophyllum interruptum	LC		LC		No	No
Plagiochila arctica	DD		NE		No	No
Plagiochila asplenioides	LC		LC		No	No
Plagiochila bifaria	LC		LC		No	No
Plagiochila britannica	LC		LC		Yes	No
Plagiochila carringtonii	NT	B2b(iii,iv,v)	NT	B2b(iii,iv,v)	No	No
Plagiochila exigua	LC		LC		No	No
Plagiochila heterophylla	LC		LC		No	No
Plagiochila longispina	EN	A3c	EN	A3c	No	No
Plagiochila maderensis	EN	A3c	EN	A3c	Yes	Yes
Plagiochila papillifolia	CR	B1ab(iii,v)+2ab(iii,v); C2a(ii)	CR	B1ab(iii,v)+2ab(iii,v); C2a(ii)	No	No
Plagiochila porelloides	LC		LC		No	No
Plagiochila punctata	LC		LC		No	No
Plagiochila retrorsa	EN	A3c	EN	A3c	No	No
Plagiochila spinulosa	LC		LC		Yes	No
Plagiochila stricta	EN	A3c	EN	A3c	No	No
Plagiochila virginica	EN	A3c; C2a(i)	EN	A3c; C2a(i)	No	No
PLAGIOTHECIACEAE						
Isopterygiopsis alpicola	EN	D	CR	D	No	No
Isopterygiopsis muelleriana	LC		LC		No	No
Isopterygiopsis pulchella	LC		LC		No	No
Plagiothecium berggrenianum	VU	D1	NE		No	No
Plagiothecium cavifolium	LC		LC		No	No
Plagiothecium curvifolium	LC		LC		No	No
Plagiothecium denticulatum	LC		LC		No	No
Plagiothecium handelii	VU	D1	VU	D1	No	No
Plagiothecium laetum	LC		LC		No	No
Plagiothecium latebricola	LC		LC		No	No
Plagiothecium neckeroideum	VU	D1	VU	D1	No	No
Plagiothecium nemorale	LC		LC		No	No
Plagiothecium piliferum	LC		LC		No	No
Plagiothecium platyphyllum	LC		LC		No	No
Plagiothecium succulentum	LC		LC		No	No
Plagiothecium svalbardense	DD		NE		No	No
Plagiothecium undulatum	LC		LC		No	No

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PLEUROZIACEAE						
Pleurozia purpurea	LC		LC		No	No
POLYTRICHACEAE						
Alophosia azorica	NT	A3c; B2b(iii)	NT	A3c; B2b(iii)	Yes	Yes
Atrichum androgynum	NT	B2b(iii)	NT	B2b(iii)	No	No
Atrichum angustatum	VU	B2ab(ii,iii,iv,v)	EN	B2ab(ii,iii,iv,v)	No	No
Atrichum crispum	NA		NA		No	No
Atrichum flavisetum	LC		DD		No	No
Atrichum tenellum	LC		LC		No	No
Atrichum undulatum	LC		LC		No	No
Oligotrichum hercynicum	LC		LC		No	No
Pogonatum aloides	LC		LC		No	No
Pogonatum dentatum	LC		LC		No	No
Pogonatum nanum	LC		LC		No	No
Pogonatum urnigerum	LC		LC		No	No
Polytrichastrum alpinum	LC		LC		No	No
Polytrichastrum altaicum	DD		DD		No	No
Polytrichastrum fragile	DD		NE		No	No
Polytrichastrum septentrionale	DD		DD		No	No
Polytrichastrum sexangulare	NT	A3c	VU	A3c	No	No
Polytrichastrum sphaerothecium	VU	D1	NE		No	No
Polytrichum commune	LC		LC		No	No
Polytrichum densifolium	LC		DD		No	No
Polytrichum formosum	LC		LC		No	No
Polytrichum hyperboreum	LC		NT		No	No
Polytrichum jensenii	LC		LC		No	No
Polytrichum juniperinum	LC		LC		No	No
Polytrichum longisetum	LC		LC		No	No
Polytrichum pallidisetum	NT		EN	B2ab(ii,iii)	No	No
Polytrichum piliferum	LC		LC		No	No
Polytrichum strictum	LC		LC		No	No
Polytrichum swartzii	LC		DD		No	No
Psilopilum cavifolium	NT	B2b(iii)	EN	B2ab(iii)	No	No
Psilopilum laevigatum	LC		VU	D1	No	No
PORELLACEAE						
Porella arboris-vitae	NT	C2a(i)	NT	C2a(i)	No	No
Porella baueri	DD		DD		No	No
Porella canariensis	LC		LC		No	No
Porella cordaeana	LC		LC		No	No
Porella inaequalis	EN	C2a(i)	EN	C2a(i)	Yes	Yes
Porella obtusata	LC		LC		No	No
Porella pinnata	LC		LC		No	No
Porella platyphylla	LC		LC		No	No
POTTIACEAE						
Acaulon casasianum	NT		NT		Yes	Yes
Acaulon fontiquerianum	NT	B2a	NT		No	No
Acaulon mediterraneum	NT	B2a	NT	B2a	No	No
Acaulon muticum	NT	B2b(i,ii,iii,iv,v)	NT	B2b(i,ii,iii,iv,v)	No	No
Acaulon piligerum	DD		DD		Yes	Yes
Acaulon triquetrum	LC		LC		No	No
Aloina aloides	LC		LC		No	No

Taxonomy	IUCN Red List Category (Europe)	IUCN Red List Criteria (Europe)	IUCN Red List Category (EU 28)	IUCN Red List Criteria (EU 28)	Endemic to Europe	Endemic to EU 28
Aloina ambigua	LC		LC		No	No
Aloina bifrons	NT	B2a	LC		No	No
Aloina brevirostris	LC		LC		No	No
Aloina humilis	DD		DD		Yes	Yes
Aloina obliquifolia	LC		LC		No	No
Aloina rigida	LC		LC		No	No
Anoectangium aestivum	LC		LC		No	No
Aschisma carniolicum	EN	B2ab(iii)	EN	B2b(iii)	No	No
Aschisma cuynetii	VU	D1	VU	D1	Yes	Yes
Barbula unguiculata	LC		LC		No	No
Bryoerythrophyllum alpigenum	VU	D1	VU	D1	No	No
Bryoerythrophyllum caledonicum	VU	D1	VU	D1	Yes	Yes
Bryoerythrophyllum campylocarpum	VU	B2ab(ii,iii,iv,v)	VU	B2ab(ii,iii,iv,v)	No	No
Bryoerythrophyllum duellii	VU	D1	VU	D1	Yes	Yes
Bryoerythrophyllum ferruginascens	LC		LC		No	No
Bryoerythrophyllum inaequalifolium	VU	D1	VU	D1	No	No
Bryoerythrophyllum recurvirostrum	LC		LC		No	No
Bryoerythrophyllum rubrum	NT	D1	NT	D1	No	No
Chionoloma daldinianum	LC		LC		No	No
Chionoloma hibernicum	LC		LC		Yes	No
Chionoloma minus	DD		DD		Yes	No
Chionoloma recurvifolium	NT	B2b(iii)	NT	B2b(iii)	No	No
Chionoloma tenuirostre	LC		LC		No	No
Crossidium aberrans	LC		LC		No	No
Crossidium crassinervium	LC		LC		No	No
Crossidium davidai	LC		LC		No	No
Crossidium geheebii	NT		NT		No	No
Crossidium laevipilum	NT		NT		No	No
Crossidium laxefilamentosum	EN	B2ab(iii)	EN	B2ab(iii)	No	No
Crossidium squamiferum	LC		LC		No	No
Dialytrichia mucronata	LC		LC		No	No
Dialytrichia saxicola	LC		LC		Yes	Yes
Didymodon acutus	LC		LC		No	No
Didymodon asperifolius	NT	B2ab(iii,v); D1	VU	D1	No	No
Didymodon australasiae	LC		LC		No	No
Didymodon bistratosus	LC		LC		No	No
Didymodon brachyphyllus	EN	D	CR	D	No	No
Didymodon cordatus	LC		LC		No	No
Didymodon eckeliae	LC		LC		No	No
Didymodon fallax	LC		LC		No	No
Didymodon ferrugineus	LC		LC		No	No
Didymodon giganteus	LC		LC		No	No
Didymodon glaucus	VU	D1	VU	D1	No	No
Didymodon icmadophilus	LC		LC		No	No
Didymodon insulanus	LC		LC		No	No
Didymodon johansenii	VU	D1	VU	D1	No	No
Didymodon luridus	LC		LC		No	No
Didymodon maschalogenus	EN	D	EN	D	No	No
Didymodon maximus	VU	D1	VU	D1	No	No
Didymodon nicholsonii	LC		LC		No	No
Didymodon rigidulus	LC		LC		No	No

Taxonomy	IUCN Red List Category (Europe)	IUCN Red List Criteria (Europe)	IUCN Red List Category (EU 28)	IUCN Red List Criteria (EU 28)	Endemic to Europe	Endemic to EU 28
Didymodon sinuosus	LC		LC		No	No
Didymodon spadiceus	LC		LC		No	No
Didymodon subandreaeoides	NT	B2a; D1	NT	B2a; D1	No	No
Didymodon tomaculosus	LC		LC		Yes	Yes
Didymodon tophaceus	LC		LC		No	No
Didymodon umbrosus	LC		LC		No	No
Didymodon validus	VU	D1	VU	D1	No	No
Didymodon vinealis	LC		LC		No	No
Eucladium verticillatum	LC		LC		No	No
Gymnobarbula bicolor	VU	D1	VU	D1	Yes	No
Gymnostomum aeruginosum	LC		LC		No	No
Gymnostomum calcareum	LC		LC		No	No
Gymnostomum viridulum	LC		LC		No	No
Gyroweisia reflexa	NT	B2a	NT	B2a	No	No
Gyroweisia tenuis	LC		LC		No	No
Hennediella heimii	LC		LC		No	No
Hennediella macrophylla	NA		NA		No	No
Hennediella stanfordensis	NA		NA		No	No
Hilpertia velenovskyi	CR	C2a(i); D	CR	C2a(i); D	No	No
Hydrogonium amplexifolium	LC		LC		No	No
Hydrogonium bolleanum	DD		DD		No	No
Hydrogonium consanguineum	DD		DD		No	No
Hydrogonium croceum	LC		LC		No	No
Hymenostylium gracillimum	EN	D	EN	D	Yes	No
Hymenostylium recurvirostrum	LC		LC		No	No
Hymenostylium xerophilum	LC		LC		No	No
Hyophila involuta	VU	C2a(i)	VU	C2a(i)	No	No
Leptobarbula berica	LC		LC		No	No
Leptodontium flexifolium	NT	B2b(ii,iv,v)	NT	B2b(ii,iv,v)	No	No
Leptodontium gemmascens	VU	D1	VU	D1	No	No
Leptodontium proliferum	NA		NA		No	No
Leptodontium styriacum	VU	D1	VU	D1	No	No
Leptophascum leptophyllum	LC		LC		No	No
Microbryum curvicollum	LC		LC		No	No
Microbryum davallianum	LC		LC		No	No
Microbryum floerkeanum	LC		NT	B2b(ii,iii,v)	No	No
Microbryum fosbergii	NT	B2b(iii)	NT	B2b(iii)	No	No
Microbryum longipes	VU	D1	VU	D1	Yes	Yes
Microbryum rectum	LC		LC		No	No
Microbryum starckeanum	LC		LC		No	No
Molendoa hornschuchiana	VU	D1	VU	D1	No	No
Molendoa schliephackei	EN	D	EN	D	No	No
Molendoa taeniatifolia	EN	D	EN	D	Yes	No
Molendoa warburgii	LC		LC		No	No
Pottiopsis caespitosa	VU	C2a(i)	VU	C2a(i)	No	No
Pseudocrossidium hornschuchianum	LC		LC		No	No
Pseudocrossidium obtusulum	DD		DD		No	No
Pseudocrossidium replicatum	EN	D	EN	D	No	No
Pseudocrossidium revolutum	LC		LC		No	No
Pterygoneurum kozlovii	CR	D	CR	D	No	No
Pterygoneurum lamellatum	LC		LC		No	No

Taxonomy	IUCN Red List Category (Europe)	IUCN Red List Criteria (Europe)	IUCN Red List Category (EU 28)	IUCN Red List Criteria (EU 28)	Endemic to Europe	Endemic to EU 28
Pterygoneurum ovatum	LC		LC		No	No
Pterygoneurum papillosum	DD		DD		Yes	Yes
Pterygoneurum sampaianum	NT		NT		No	No
Pterygoneurum subsessile	LC		NT		No	No
Scopelophila cataractae	EN	B2ab(ii,iii,iv,v)	EN	B2ab(ii,iii,iv,v)	No	No
Scopelophila ligulata	NT	B2b(iii)	NT	B2b(iii)	No	No
Stegonia latifolia	NT	C2a(i)	VU	C2a(i)	No	No
Streblotrichum commutatum	LC		LC		No	No
Streblotrichum convolutum	LC		LC		No	No
Streblotrichum enderesii	VU	D1	VU	D1	No	No
Syntrichia bogotensis	EN	B1ab(ii,iii,iv)+ 2ab(ii,iii,iv)	EN	B1ab(ii,iii,iv)+ 2ab(ii,iii,iv)	No	No
Syntrichia calcicola	LC		LC		No	No
Syntrichia caninervis	LC		LC		No	No
Syntrichia echinata	VU	D1	VU	D1	No	No
Syntrichia fragilis	LC		LC		No	No
Syntrichia handelii	DD		DD		No	No
Syntrichia laevipila	LC		LC		No	No
Syntrichia latifolia	LC		LC		No	No
Syntrichia minor	DD		DD		No	No
Syntrichia montana	LC		LC		No	No
Syntrichia norvegica	LC		LC		No	No
Syntrichia papillosa	LC		LC		No	No
Syntrichia papillosissima	LC		LC		No	No
Syntrichia princeps	LC		LC		No	No
Syntrichia rigescens	CR	D	CR	D	No	No
Syntrichia ruralis	LC		LC		No	No
Syntrichia sinensis	VU	D1	VU	D1	No	No
Syntrichia subpapillosissima	DD		DD		No	No
Syntrichia virescens	LC		LC		No	No
Timmiella anomala	LC		LC		No	No
Timmiella barbuloides	LC		LC		No	No
Timmiella flexiseta	DD		DD		No	No
Tortella alpicola	LC		LC		No	No
Tortella cuspidatissima	EN	B2ab(ii,iii,iv)	CR	B2ab(ii,iii,iv)	No	No
Tortella fasciculata	LC		LC		Yes	No
Tortella flavovirens	LC		LC		No	No
Tortella fragilis	LC		LC		No	No
Tortella humilis	LC		LC		No	No
Tortella inclinata	LC		LC		No	No
Tortella inflexa	LC		LC		No	No
Tortella limbata	VU	B2ab(iii)	VU	B2ab(iii)	Yes	Yes
Tortella nitida	LC		LC		No	No
Tortella pseudofragilis	LC		LC		Yes	No
Tortella rigens	LC		LC		No	No
Tortella spitsbergensis	EN	B2ab(i,ii,iii,iv,v)	NE		No	No
Tortella squarrosa	LC		LC		No	No
Tortella tortuosa	LC		LC		No	No
Tortula acaulon	LC		LC		No	No
Tortula amplexa	NA		NA		No	No
Tortula ampliretis	LC		LC		Yes	Yes

Taxonomy	IUCN Red List Category (Europe)	IUCN Red List Criteria (Europe)	IUCN Red List Category (EU 28)	IUCN Red List Criteria (EU 28)	Endemic to Europe	Endemic to EU 28
Tortula atrovirens	LC		LC		No	No
Tortula bogosica	NT	B2b(iii)	NT	B2b(iii)	No	No
Tortula bolanderi	EN	B2ab(iii)	EN	B2ab(iii)	No	No
Tortula brevissima	LC		LC		No	No
Tortula canescens	LC		LC		No	No
Tortula caucasica	LC		LC		No	No
Tortula cernua	VU	C2a(i)	VU	C2a(i)	No	No
Tortula cuneifolia	LC		LC		No	No
Tortula freibergii	LC		LC		No	No
Tortula guepinii	LC		NT		No	No
Tortula hoppeana	LC		LC		No	No
Tortula inermis	LC		LC		No	No
Tortula israelis	LC		LC		No	No
Tortula laureri	CR	C2a(i)	EN	C2a(i)	No	No
Tortula leucostoma	EN	D	EN	D	No	No
Tortula lindbergii	LC		LC		No	No
Tortula lingulata	VU	D1	VU	D1	No	No
Tortula marginata	LC		LC		No	No
Tortula mucronifolia	NT		NT		No	No
Tortula muralis	LC		LC		No	No
Tortula pallida	LC		LC		No	No
Tortula protobryoides	LC		NT		No	No
Tortula randii	EN	B2ab(iv); C2a(i)	EN	B2ab(iv); C2a(i)	No	No
Tortula revolvens	LC		LC		No	No
Tortula schimperi	LC		LC		No	No
Tortula solmsii	LC		LC		No	No
Tortula subulata	LC		LC		No	No
Tortula systylia	EN	B2ab(iii,iv)	VU	B2b(ii,iii)	No	No
Tortula truncata	LC		LC		No	No
Tortula ucrainica	DD		NE		No	No
Tortula vahliana	LC		LC		No	No
Tortula viridifolia	LC		LC		No	No
Tortula vlassovii	EN	B2ab(ii,iii,iv); D	EN	B2ab(ii,iii,iv); D	No	No
Tortula wilsonii	LC		LC		No	No
Trichostomum brachydontium	LC		LC		No	No
Trichostomum crispulum	LC		LC		No	No
Triquetrella arapilensis	NT		NT		Yes	Yes
Weissia brachycarpa	LC		LC		No	No
Weissia condensa	LC		LC		No	No
Weissia controversa	LC		LC		No	No
Weissia levieri	LC		LC		No	No
Weissia longifolia	LC		LC		No	No
Weissia multicapsularis	DD		DD		Yes	Yes
Weissia perssonii	LC		LC		Yes	No
Weissia rostellata	NT	C2a(i)	VU	C2a(i)	Yes	No
Weissia rutilans	LC		LC		No	No
Weissia squarrosa	VU	B2ab(ii,iii)	VU	B2ab(ii,iii)	Yes	No
Weissia sterilis	NT	B2b(iii)	NT	B2b(iii)	Yes	Yes
Weissia wimmeriana	LC		LC		No	No
PSEUDOLEPICOLEACEAE						
Blepharostoma trichophyllum	LC		LC		No	No

Taxonomy	IUCN Red List Category (Europe)	IUCN Red List Criteria (Europe)	IUCN Red List Category (EU 28)	IUCN Red List Criteria (EU 28)	Endemic to Europe	Endemic to EU 28
PTERIGYNANDRACEAE						
Habrodon perpusillus	LC		LC		No	No
Heterocladium dimorphum	LC		LC		No	No
Heterocladium flaccidum	LC		LC		Yes	No
Heterocladium heteropterum	LC		LC		No	No
Heterocladium wulfsbergii	LC		LC		Yes	No
Iwatsukiella leucotricha	LC		NE		No	No
Myurella julacea	LC		LC		No	No
Myurella sibirica	VU	B2ab(ii,iii,iv)	VU	B2ab (ii, iii, iv).	No	No
Myurella tenerrima	LC		LC		No	No
Pterigynandrum filiforme	LC		LC		No	No
PTILIDIACEAE						
Ptilidium ciliare	LC		LC		No	No
Ptilidium pulcherrimum	LC		LC		No	No
PTYCHOMITRIACEAE						
Campylostelium pitardii	EN	D	EN	D	No	No
Campylostelium saxicola	VU	C2a(i)	VU	C2a(i)	No	No
Campylostelium strictum	EN	B2ab(iii)	EN	B2ab(ii,iii)	No	No
Ptychomitrium incurvum	CR	B2ab(ii,iv,v)	CR	B2ab(ii,iv,v)	No	No
Ptychomitrium nigrescens	LC		LC		No	No
Ptychomitrium polyphyllum	LC		LC		Yes	No
PYLAISIACEAE						
Buckia vaucheri	LC		LC		No	No
Pseudostereodon procerrimus	LC		LC		No	No
Roaldia revoluta	LC		LC		No	No
PYLAISIADELPHACEAE						
Heterophyllium affine	DD		DD		No	No
RADULACEAE						
Radula aquilegia	LC		LC		No	No
Radula carringtonii	NT	B2ab(iii)	NT	B2ab(iii)	Yes	Yes
Radula complanata	LC		LC		No	No
Radula holtii	NT	B2ab(iii)	NT	B2ab(iii)	Yes	Yes
Radula jonesii	EN	C2a(i)	EN	C2a(i)	Yes	Yes
Radula lindenbergiana	LC		LC		No	No
Radula nudicaulis	VU	C2a(i)	VU	C2a(i)	No	No
Radula visianica	CR	D	CR	D	Yes	Yes
Radula voluta	NT	D1	NT	D1	No	No
Radula wichurae	NT	A3c	NT	A3c	Yes	Yes
RHABDOWEISIACEAE						
Amphidium curvipes	NT	B2b(iii)	NT	B2b(iii)	Yes	Yes
Amphidium lapponicum	LC		LC		No	No
Amphidium mougeotii	LC		LC		No	No
Arctoa anderssonii	VU	D1	EN	D	No	No
Arctoa fulvella	LC		LC		No	No
Arctoa hyperborea	VU	D1	VU	D1	No	No
Cynodontium asperifolium	NT	B2a	NE		No	No
Cynodontium bruntonii	LC		LC		No	No
Cynodontium fallax	NT	D1	VU	D1	No	No
Cynodontium gracilescens	LC		LC		No	No
Cynodontium jenneri	LC		LC		No	No
Cynodontium polycarpon	LC		LC		No	No

Taxonomy	IUCN Red List Category (Europe)	IUCN Red List Criteria (Europe)	IUCN Red List Category (EU 28)	IUCN Red List Criteria (EU 28)	Endemic to Europe	Endemic to EU 28
Cynodontium strumiferum	LC		LC		No	No
Cynodontium suecicum	LC		LC		Yes	No
Cynodontium tenellum	LC		LC		No	No
Dichodontium flavescens	DD		DD		No	No
Dichodontium pellucidum	LC		LC		No	No
Dicranoweisia cirrata	LC		LC		No	No
Glyphomitrium daviesii	LC		LC		Yes	No
Hymenoloma compactum	DD		DD		No	No
Hymenoloma crispulum	LC		LC		No	No
Hymenoloma mulahaceni	DD		DD		No	No
Kiaeria blyttii	LC		LC		No	No
Kiaeria falcata	LC		NT		No	No
Kiaeria glacialis	LC		NT		No	No
Kiaeria riparia	CR	C2a(i)	CR	C2a(i); D	No	No
Kiaeria starkei	LC		NT		No	No
Oncophorus demetrii	LC		LC		No	No
Oncophorus dendrophilus	CR	D	CR	D	No	No
Oncophorus elongatus	LC		LC		No	No
Oncophorus integerrimus	LC		LC		Yes	No
Oncophorus virens	LC		LC		No	No
Oncophorus wahlenbergii	LC		LC		No	No
Oreas martiana	VU	D1	VU	D1	No	No
Oreoweisia torquescens	VU	D1	VU	D1	No	No
Rhabdoweisia crenulata	LC		LC		No	No
Rhabdoweisia crispata	LC		LC		No	No
Rhabdoweisia fugax	LC		LC		No	No
RHIZOGONIACEAE						
Calomnion complanatum	NA		NA		No	No
RHYTIDIACEAE						
Rhytidium rugosum	LC		LC		No	No
RICCIACEAE						
Riccia atlantica	CR	C2a(i)	CR	C2a(i)	Yes	Yes
Riccia atromarginata	EN	B2ab(iii)	EN	B2ab(iii)	No	No
Riccia beyrichiana	LC		LC		No	No
Riccia bicarinata	LC		LC		No	No
Riccia bifurca	LC		LC		No	No
Riccia breidleri	VU	D1	VU	D1	No	No
Riccia canaliculata	LC		LC		No	No
Riccia cavernosa	LC		LC		No	No
Riccia ciliata	DD		DD		No	No
Riccia ciliifera	LC		LC		No	No
Riccia crinita	LC		LC		No	No
Riccia crozalsii	LC		LC		No	No
Riccia crustata	VU	B2ab(i,iii)	NT		No	No
Riccia crystallina	LC		LC		No	No
Riccia duplex	DD		DD		No	No
Riccia fluitans	LC		LC		No	No
Riccia frostii	LC		LC		No	No
Riccia glauca	LC		LC		No	No
Riccia gothica	NT	D1	NT		Yes	No
Riccia gougetiana	LC		LC		No	No

Taxonomy	IUCN Red List Category (Europe)	IUCN Red List Criteria (Europe)	IUCN Red List Category (EU 28)	IUCN Red List Criteria (EU 28)	Endemic to Europe	Endemic to EU 28
Riccia huebeneriana	LC		LC		No	No
Riccia lamellosa	LC		LC		No	No
Riccia ligula	EN	B2ab(v)	EN	B2ab(v)	No	No
Riccia macrocarpa	LC		LC		No	No
Riccia michelii	LC		LC		No	No
Riccia nigrella	LC		LC		No	No
Riccia papillosa	LC		LC		No	No
Riccia perennis	LC		LC		No	No
Riccia rhenana	LC		LC		No	No
Riccia sommieri	NT	B2b(iii,v)	NT	B2b(iii,v)	No	No
Riccia sorocarpa	LC		LC		No	No
Riccia subbifurca	LC		LC		No	No
Riccia trabutiana	LC		LC		No	No
Riccia warnstorfii	VU	C2a(i)	VU	C2a(i)	No	No
Ricciocarpos natans	LC		LC		No	No
RIELLACEAE						
Riella affinis	EN	B1ab(iii)+2ab(iii)	EN	B1ab(iii)+2ab(iii)	No	No
Riella bialata	DD		DD		No	No
Riella cossoniana	NT		NT		No	No
Riella echinata	EN	B2ab(iii,v)	EN	B2ab(iii,v)	No	No
Riella helicophylla	NT	B2b(iii)	NT	B2b(iii)	No	No
Riella mediterranea	DD		DD		No	No
Riella notarisii	NT	B2b(iii)	NT	B2b(iii)	No	No
Riella parisii	RE		RE		No	No
SCAPANIACEAE						
Anastrepta orcadensis	LC		LC		No	No
Anastrophyllum alpinum	NT	D1	NT	D1	No	No
Anastrophyllum assimile	LC		VU	D1	No	No
Anastrophyllum donnianum	NT		NT		No	No
Anastrophyllum joergensenii	VU	D1	VU	D1	No	No
Anastrophyllum michauxii	NT		NT		No	No
Barbilophozia barbata	LC		LC		No	No
Barbilophozia hatcheri	LC		LC		No	No
Barbilophozia lycopodioides	LC		LC		No	No
Barbilophozia rubescens	DD		DD		No	No
Barbilophozia sudetica	LC		LC		No	No
Diplophyllum albicans	LC		LC		No	No
Diplophyllum obtusatum	DD		DD		No	No
Diplophyllum obtusifolium	LC		LC		No	No
Diplophyllum taxifolium	LC		LC		No	No
Douinia ovata	LC		LC		No	No
Gymnocolea borealis	LC		LC		No	No
Gymnocolea fascinifera	DD		NE		No	No
Gymnocolea inflata	LC		LC		No	No
Isopaches alboviridis	DD		NE		No	No
Isopaches bicrenatus	LC		LC		No	No
Isopaches decolorans	VU	D1	EN	D	No	No
Scapania aequiloba	LC		LC		No	No
Scapania apiculata	NT		NT		No	No
Scapania aspera	LC		LC		No	No
Scapania brevicaulis	VU	C2a(i)	VU	C2a(i)	No	No

Taxonomy	IUCN Red List Category (Europe)	IUCN Red List Criteria (Europe)	IUCN Red List Category (EU 28)	IUCN Red List Criteria (EU 28)	Endemic to Europe	Endemic to EU 28
Scapania calcicola	LC		LC		No	No
Scapania carinthiaca	EN	C2a(i)	EN	C2a(i)	No	No
Scapania compacta	LC		LC		No	No
Scapania crassiretis	LC		VU	D1	No	No
Scapania curta	LC		LC		No	No
Scapania cuspiduligera	LC		LC		No	No
Scapania degenii	NT		NT		No	No
Scapania glaucocephala	EN	B2ab(ii,iii,iv,v); C2a(i)	CR	C2a(i)	No	No
Scapania gracilis	LC		LC		No	No
Scapania gymnostomophila	LC		VU	C2a(i)	No	No
Scapania helvetica	LC		LC		No	No
Scapania hyperborea	LC		LC		No	No
Scapania irrigua	LC		LC		No	No
Scapania kaurinii	VU	D1	VU	D1	No	No
Scapania ligulifolia	DD		NE		No	No
Scapania lingulata	NT	D1	NT		No	No
Scapania mucronata	LC		LC		No	No
Scapania nemorea	LC		LC		No	No
Scapania nimbosa	NT	B2b(iii)	NT	B2b(iii)	No	No
Scapania obcordata	LC		DD		No	No
Scapania obscura	DD		DD		No	No
Scapania ornithopodioides	NT	B2b(iii,iv,v)	NT	B2b(iii,iv,v)	No	No
Scapania paludicola	LC		LC		No	No
Scapania paludosa	LC		LC		No	No
Scapania parvifolia	NT	D1	VU	D1	No	No
Scapania praetervisa	LC		LC		No	No
Scapania scandica	LC		LC		No	No
Scapania scapanioides	CR	D	CR	D	Yes	No
Scapania simmonsii	VU	D2	NE		No	No
Scapania sphaerifera	CR	D	NE		No	No
Scapania spitsbergensis	VU	B2ab(iii,iv,v)	EN	B2ab(iii,iv,v); C2a(i)	No	No
Scapania subalpina	LC		LC		No	No
Scapania tundrae	LC		LC		No	No
Scapania uliginosa	LC		LC		No	No
Scapania umbrosa	LC		LC		No	No
Scapania undulata	LC		LC		No	No
Scapania verrucosa	VU	D1	VU	D1	No	No
Scapania zemliae	DD		NE		No	No
Schistochilopsis grandiretis	LC		VU	B2ab(ii,iii,iv,v); C2a(i)	No	No
Schistochilopsis hyperarctica	DD		NE		No	No
Schistochilopsis incisa	LC		LC		No	No
Schistochilopsis opacifolia	LC		LC		No	No
Sphenolobopsis pearsonii	LC		LC		No	No
Sphenolobus minutus	LC		LC		No	No
Sphenolobus saxicola	LC		LC		No	No
SCHISTOSTEGACEAE						
Schistostega pennata	LC		LC		No	No
SCORPIDIACEAE						
Scorpidium cossonii	LC		LC		No	No
Scorpidium revolvens	LC		LC		No	No

Taxonomy	IUCN Red List Category (Europe)	IUCN Red List Criteria (Europe)	IUCN Red List Category (EU 28)	IUCN Red List Criteria (EU 28)	Endemic to Europe	Endemic to EU 28
Scorpidium scorpioides	NT		NT		No	No
SELIGERIACEAE						
Blindia acuta	LC		LC		No	No
Blindia caespiticia	LC		LC		No	No
Blindiadelphus campylopodus	NT	B2b(ii,iii,iv,v); C2a(i)	NT		No	No
Blindiadelphus diversifolius	NT	D1	VU	D1	No	No
Blindiadelphus polaris	VU	D1	NE		No	No
Blindiadelphus recurvatus	LC		LC		No	No
Blindiadelphus subimmersus	EN	D	EN	D	No	No
Brachydontium trichodes	LC		LC		No	No
Seligeria acutifolia	LC		LC		No	No
Seligeria austriaca	VU	D1	VU	D1	No	No
Seligeria brevifolia	LC		LC		No	No
Seligeria calcarea	LC		LC		No	No
Seligeria calycina	LC		LC		Yes	No
Seligeria carniolica	EN	D	EN	D	Yes	No
Seligeria donniana	LC		LC		No	No
Seligeria irrigata	VU	D1	VU	D1	Yes	Yes
Seligeria oelandica	NT	D1	VU	D1	No	No
Seligeria patula	LC		LC		No	No
Seligeria pusilla	LC		LC		No	No
Seligeria trifaria	DD		DD		No	No
Seligeria tristichoides	NT	D1	VU	D1	No	No
SEMATOPHYLLACEAE						
Brotherella lorentziana	NT	D1	VU	D1	Yes	No
Sematophyllum adnatum	NA		NA		No	No
Sematophyllum demissum	LC		LC		No	No
Sematophyllum substrumulosum	LC		LC		No	No
SOLENOSTOMATACEAE						
Cryptocolea imbricata	CR	D	RE		No	No
Nardia breidleri	LC		VU	C2ai	No	No
Nardia compressa	LC		LC		No	No
Nardia geoscyphus	LC		LC		No	No
Nardia insecta	LC		LC		No	No
Nardia japonica	LC		DD		No	No
Nardia scalaris	LC		LC		No	No
Solenostoma callithrix	NT	B2ab(iii,v)	NT	B2ab(iii,v)	No	No
Solenostoma confertissimum	LC		LC		No	No
Solenostoma gracillimum	LC		LC		No	No
Solenostoma handelii	CR	C2a(i); D	CR	C2a(i); D	No	No
Solenostoma hyalinum	LC		LC		No	No
Solenostoma obovatum	LC		LC		No	No
Solenostoma paroicum	LC		LC		Yes	No
Solenostoma sphaerocarpum	LC		LC		No	No
SPHAEROCARPACEAE						
Sphaerocarpos europaeus	LC		LC		No	No
Sphaerocarpos michelii	LC		LC		No	No
Sphaerocarpos stipitatus	NA		NA		No	No
SPHAGNACEAE						
Sphagnum affine	LC		NT		No	No
Sphagnum angermanicum	LC		NT		No	No

Taxonomy	IUCN Red List Category (Europe)	IUCN Red List Criteria (Europe)	IUCN Red List Category (EU 28)	IUCN Red List Criteria (EU 28)	Endemic to Europe	Endemic to EU 28
Sphagnum angustifolium	LC		LC		No	No
Sphagnum annulatum	LC		LC		No	No
Sphagnum aongstroemii	LC		LC		No	No
Sphagnum arcticum	NT	D1	NE		No	No
Sphagnum auriculatum	LC		LC		No	No
Sphagnum austinii	NT	A3c	NT	A3c	No	No
Sphagnum balticum	LC		LC		No	No
Sphagnum beothuk	LC		NT		No	No
Sphagnum capillifolium	LC		LC		No	No
Sphagnum centrale	LC		LC		No	No
Sphagnum compactum	LC		LC		No	No
Sphagnum contortum	LC		LC		No	No
Sphagnum cuspidatum	LC		LC		No	No
Sphagnum divinum	LC		LC		No	No
Sphagnum fallax	LC		LC		No	No
Sphagnum fimbriatum	LC		LC		No	No
Sphagnum flexuosum	LC		LC		No	No
Sphagnum fuscum	LC		NT		No	No
Sphagnum girgensohnii	LC		LC		No	No
Sphagnum inundatum	LC		LC		No	No
Sphagnum jensenii	LC		LC		No	No
Sphagnum lenense	NT	B2b(iii)	NE		No	No
Sphagnum lindbergii	LC		LC		No	No
Sphagnum majus	LC		LC		No	No
Sphagnum medium	LC		LC		No	No
Sphagnum molle	LC		LC		No	No
Sphagnum nitidulum	CR	B1ab(iii)	CR	B1ab(iii)	Yes	Yes
Sphagnum obtusum	LC		LC		No	No
Sphagnum olafii	VU	D1	NE		No	No
Sphagnum palustre	LC		LC		No	No
Sphagnum papillosum	LC		LC		No	No
Sphagnum platyphyllum	LC		LC		No	No
Sphagnum pulchrum	LC		LC		No	No
Sphagnum pylaesii	EN	B2ab(iii)	EN	B2ab(iii)	No	No
Sphagnum quinquefarium	LC		LC		No	No
Sphagnum recurvum	EN	B1ab(iii)+2ab(iii)	EN	B1ab(iii)+2ab(iii)	No	No
Sphagnum riparium	LC		NT		No	No
Sphagnum rubellum	LC		LC		No	No
Sphagnum rubiginosum	LC		NE		No	No
Sphagnum russowii	LC		LC		No	No
Sphagnum skyense	LC		LC		Yes	Yes
Sphagnum squarrosum	LC		LC		No	No
Sphagnum strictum	LC		LC		No	No
Sphagnum subfulvum	LC		LC		No	No
Sphagnum subnitens	LC		LC		No	No
Sphagnum subsecundum	LC		LC		No	No
Sphagnum tenellum	LC		LC		No	No
Sphagnum teres	LC		LC		No	No
Sphagnum troendelagicum	EN	B2ab(iii); C2a(i)	NE		Yes	No
Sphagnum tundrae	NT	D1	NE		No	No
Sphagnum venustum	DD		NE		No	No

Taxonomy	IUCN Red List Category (Europe)	IUCN Red List Criteria (Europe)	IUCN Red List Category (EU 28)	IUCN Red List Criteria (EU 28)	Endemic to Europe	Endemic to EU 28
Sphagnum warnstorfii	LC		LC		No	No
Sphagnum wulfianum	LC		LC		No	No
SPLACHNACEAE						
Aplodon wormskioldii	LC		NT		No	No
Splachnum ampullaceum	NT		VU	C2a(i)b	No	No
Splachnum luteum	LC		LC		No	No
Splachnum melanocaulon	EN	C2a(i)	EN	C2a(i)	Yes	No
Splachnum pensylvanicum	DD		DD		No	No
Splachnum rubrum	LC		LC		No	No
Splachnum sphaericum	LC		LC		No	No
Splachnum vasculosum	LC		LC		No	No
Tayloria acuminata	VU	D1	CR	D	No	No
Tayloria froelichiana	NT	B2b(iii)	NT	B2b(iii)	No	No
Tayloria hornschuchii	EN	D	EN	D	No	No
Tayloria lingulata	LC		LC		No	No
Tayloria rudolphiana	EN	B2ab(i,ii,iii,iv,v); C2a(i)	EN	B2ab(i,ii,iii,iv,v); C2a(i)	No	No
Tayloria serrata	NT	B2b(iii,v)	NT		No	No
Tayloria splachnoides	LC		LC		No	No
Tayloria tenuis	VU	C2a(i)	EN	C2a(i)	No	No
Tetraplodon angustatus	LC		LC		No	No
Tetraplodon blyttii	EN	D	RE		Yes	No
Tetraplodon mnioides	LC		LC		No	No
Tetraplodon pallidus	LC		LC		No	No
Tetraplodon paradoxus	VU	D1	EN	D	No	No
Tetraplodon urceolatus	EN	D	EN	D	No	No
Voitia hyperborea	VU	D1	NE		No	No
Voitia nivalis	CR	C2a(i); D	CR	C2a(i); D	No	No
SPLACHNOBRYACEAE						
Splachnobryum obtusum	VU	D1	VU	D1	No	No
TARGIONIACEAE						
Targionia hypophylla	LC		LC		No	No
Targionia lorbeeriana	LC		LC		No	No
TETRAPHIDACEAE						
Tetraphis pellucida	LC		LC		No	No
Tetrodontium brownianum	LC		LC		No	No
Tetrodontium ovatum	NT	B2b(iii,iv)	NT		No	No
Tetrodontium repandum	LC		NT		No	No
THUIDIACEAE						
Abietinella abietina	LC		LC		No	No
Claopodium rostratum	VU	D1	VU	D1	No	No
Claopodium whippleanum	LC		LC		No	No
Haplocladium angustifolium	DD		DD		No	No
Haplocladium microphyllum	CR	C2a(i); D	DD		No	No
Haplocladium virginianum	CR	D	CR	D	No	No
Pelekium atlanticum	EN	C2a(i)	EN	C2a(i)	Yes	Yes
Pelekium minutulum	EN	B2ab(iii,v); C2a(i)	EN	B2ab(i, ii, iii, iv), C2a(i)	No	No
Thuidiopsis sparsa	NA		NA		No	No
Thuidium assimile	LC		LC		No	No
Thuidium delicatulum	LC		LC		No	No

Taxonomy	IUCN Red List Category (Europe)	IUCN Red List Criteria (Europe)	IUCN Red List Category (EU 28)	IUCN Red List Criteria (EU 28)	Endemic to Europe	Endemic to EU 28
Thuidium recognitum	LC		LC		No	No
Thuidium tamariscinum	LC		LC		No	No
TIMMIACEAE						
Timmia austriaca	LC		LC		No	No
Timmia bavarica	LC		LC		No	No
Timmia comata	LC		VU	D1	No	No
Timmia megapolitana	LC		NT		No	No
Timmia norvegica	LC		LC		No	No
Timmia sibirica	EN	B2ab(iii,v); C2a(i)	CR	B2ab(iii,v); C2a(i,ii); D	No	No
TRICHOCOLEACEAE						
Trichocolea tomentella	NT	A2c	NT	A2c	No	No

Appendix 4. Listing of bryophyte species under Annex II and Annex V of the Habitats Directive, Appendix I of the Bern Convention, and the Red List status on the current European Red List

Species protected under the:	Habitats Directive		Bern Convention	Red List Status
	ANNEX II	ANNEX V	APPENDIX I	
Bruchia vogesiaca Schwaegr.	√		√	EN
Brachythecium novae-angliae (Sull & Lesq.) A.Jaeger *(Bryhnia novae-angliae* (Sull & Lesq.) Grou)	√			LC
Bryoerythrophyllum campylocarpum (C. Müll.) Crum. (*Bryoerythrophyllum machadoanum* (Sergio) M.O. Hill)	√		√	VU
Buxbaumia viridis (Moug.) Moug. & Nestl.	√		√	LC
Cephalozia macounii (Aust.) Aust.	√		√	CR
Cynodontium suecicum (H. Arn. & C. Jens.) I. Hag.	√		√	LC
Dichelyma capillaceum (Dicks) Myr.	√		√	NT
Dicranum viride (Sull. & Lesq.) Lindb.	√		√	LC
Distichophyllum carinatum Dix. & Nich.	√		√	CR
Hamatocaulis (Drepanocladus) vernicosus (Mitt.) Hedenäs.	√		√	VU
Encalypta mutica (I. Hagen)	√			VU
Hamatocaulis lapponicus (Norrl.) Hedenäs	√			EN
Herzogiella turfacea (Lindb.) I. Wats.	√			NT
Hygrohypnum montanum (Lindb.) Broth.	√			VU
Jungermannia handelii (Schiffn.) Amak.	√		√	CR
Mannia triandra (Scop.) Grolle	√		√	VU
Marsupella profunda Lindb.	√		√	VU
Meesia longiseta Hedw.	√		√	VU
Notothylas orbicularis (Schwein.) Sull.*	√		√	EN
Ochyraea tatrensis Vana	√			CR
Orthothecium lapponicum (Schimp.) C. Hartm.	√			VU
Orthotrichum rogeri Brid.	√		√	LC
Petalophyllum ralfsii (Wils.) Nees & Gott.	√		√	LC
Plagiomnium drummondii (Bruch & Schimp.) T. Kop.	√			EN
Riccia breidleri Jur.	√		√	VU
Riella helicophylla (Bory & Mont.) Mont.	√		√	NT
Scapania carinthiaca J.B. Jack ex Lindb. *(Scapania massolongi* (K. Müll.) K. Müll.)	√		√	EN
Sphagnum pylaesii Brid. *(Sphagnum pylaisii* Brid.)	√		√	EN
Tayloria rudolphiana (Garov) B. & S.	√		√	EN
Tortella rigens (N. Alberts)	√			LC

Species protected under the:	Habitats Directive		Bern Convention	Red List Status
	ANNEX II	ANNEX V	APPENDIX I	
Echinodium spinosum (Mitt.) Jur.	√		√	EN
Thamnobryum fernandesii Sergio	√		√	VU
MUSCI		√		All species under this genus, as stated in Appendix 3
LEUCOBRYACEAE *Leucobryum glaucum* (Hedw.) AAngstr.		√		LC
SPHAGNACEAE *Sphagnum L.* spp. (except *Sphagnum pylaisii* Brid.)		√		All species under this genus (except *Sphagnum pylaisii* Brid.), as stated in Appendix 3
Frullania parvistipula Steph.			√	CR
Atractylocarpus alpinus (Schimp. ex Milde) Lindb.			√	CR
Pyramidula tetragona (Brid.) Brid.			√	EN

IUCN Red List of Threatened Species™ – European Regional Assessment Reports

- ***The Status and Distribution of European Mammals***. Temple and Terry (compilers), 2007. https://portals.iucn.org/library/node/9047
- ***European Red List of Reptiles***. Cox and Temple (compilers), 2009. https://doi.org/10.2779/74504
- ***European Red List of Amphibians***. Temple and Cox (compilers), 2009. https://doi.org/10.2779/73661
- ***European Red List of Dragonflies***. Kalkman et al. (compilers), 2010. https://doi.org/10.2779/84650
- ***European Red List of Saproxylic Beetles***. Nieto and Alexander (compilers), 2010. https://doi.org/10.2779/84561
- ***European Red List of Butterflies***. van Swaay et al. (compilers), 2010. https://doi.org/10.2779/83897
- ***European Red List of Non-marine Molluscs***. Cuttelod et al., 2011. https://doi.org/10.2779/84538
- ***European Red List of Freshwater Fishes***. Freyhof and Brooks, 2011. https://doi.org/10.2779/85903
- ***European Red List of Vascular Plants***. Bilz et al., 2011. https://doi.org/10.2779/8515
- ***European Red List of Medicinal Plants***. Allen et al., 2014. https://doi.org/10.2779/907382
- ***European Red List of Bees***. Nieto et al., 2014. https://doi.org/10.2779/51181
- ***European Red List of Birds***. BirdLife International, 2015. https://doi.org/10.2779/975810
- ***European Red List of Marine Fishes***. Nieto et al., 2015. https://doi.org/10.2779/082723
- ***European Red List of Grasshoppers, Crickets and Bush-Crickets***. Hochkirch et al., 2016. https://doi.org/10.2779/60944
- ***European Red List of Lycopods and Ferns***. García Criado et al., 2017. https://doi.org/10.2305/IUCN.CH.2017.ERL.1.en
- ***European Red List of Saproxylic Beetles***. Cálix et al., 2018. Update to Nieto and Alexander, (2010). https://portals.iucn.org/library/node/47296
- ***A miniature world in decline: European Red List of Mosses, Liverworts and Hornworts***. Hodgetts et al., 2019. https://doi.org/10.2305/IUCN.CH.2019.ERL.2.en
- ***European Red List of Trees***. Rivers et al., 2019. https://doi.org/10.2305/IUCN.CH.2019.ERL.1.en
- ***European Red List of Terrestrial Molluscs: Snails, slugs, and semi-slugs.*** Neubert et al., 2019. Update to Cuttelod et al., 2011. https://portals.iucn.org/library/node/48439
- ***European Red List of Selected Endemic Shrubs.*** Wilson et al., 2019. https://portals.iucn.org/library/node/48438

The European Red List is a review of the status of European species according to IUCN regional Red Listing guidelines. It identifies those species that are threatened with extinction at the regional level – in order that appropriate conservation action can be taken to improve their status.

This publication summarises results for all Europe's native species of mosses, liverworts and hornworts (1,817 species). 22.5% of species are threatened with extinction at the European level mainly due to human-induced modifications to natural systems, climate change, and agriculture.

The European Red List was compiled by IUCN with support from the IUCN Species Survival Commission and other experts. It is the product of a LIFE project funded by the European Commission (LIFE14 PRE BE 001).

It is available online at
http://ec.europa.eu/environment/nature/conservation/species/redlist
and
https://www.iucnredlist.org/regions/europe