

BRYOPHYTE FLORA OF THE FORESTS OF VÉTYEM AND OLTÁRC PROTECTED AREAS (ZALA COUNTY, W HUNGARY)

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Abstract: Altogether 102 bryophyte taxa (13 liverworts and 89 mosses) were collected. Two species are protected in Hungary and included in the Red data book of European bryophytes. Several other species are red-listed in Hungary; one is in the data deficient (DD) category (without any recent records for almost 50 years), two are vulnerable (VU). Further 14 species are near threatened (NT), 14 are in the least concern-need attention (LC-att) category, and 20 species are regarded as indicators, which by their mere presence represents a greater level of conservation value of the habitat. From nature conservation aspect the most important habitats are the humid valleys with temporary watercourses and the forests with rich epiphyte bryophyte flora.

Key words: European red-listed species, liverworts, mosses, nationally protected species

INTRODUCTION

Exploration of the bryophyte flora was carried out in 2017 in some previously bryologically less studied territory of the Balaton-felvidék National Park namely the forests of Vétyem and Oltárc Natura 2000 protected areas in Zala County. Mainly beech, oak and hornbeam forests are developed on clay and sandy soils in these protected sites. Climate is moderately cold and moderately humid with 700–750 mm annual precipitation. The average annual temperature is 9–10 °C.

Szurkosárok valley at Vétyem (Tormafölde) was known as the site of *Dicranum viride*, a protected species in Hungary, which is included in the Annex II of the EU Habitat Directive, as well. The valley was visited by Ádám Boros on 12.07.1955, when the above mentioned species and another nationally protected, European red-listed species *Neckera pennata* were collected (BOROS 1955). He also visited next day some sites around Várfölde and Bázakerettye and he listed in his field diary altogether 24 species from this trip; 4 liverworts (*Conocephalum conicum*, *Frullania dilatata*, *Lophocolea heterophylla*, *Nowellia curvifolia*) and 20 mosses (*Amblystegium serpens*, *Brachythecium rutabulum*, *Dicranella heteromalla*, *Dicranum flagellare*, *D. montanum*, *D. viride*, *Diphyscium foliosum*, *Herzogiella*

seligeri, *Hypnum cupressiforme*, *Isothecium alopecuroides*, *Leucobryum glaucum*, *Neckera pennata*, *Plagiomnium undulatum*, *Platygyrium repens*, *Pleuridium subulatum*, *Pleurozium schreberi*, *Pohlia nutans*, *Pterigynandrum filiforme*, *Rhizomnium punctatum*, *Ulota crispa*).

Besides that very few, sporadic bryophyte collections were carried out in the area. Árpád Károlyi collected a few species in 1948 in 'Budafa-erdő' forest at Lisper and in forests around Lenti, and in 1949 around Várfölde. His material was identified by Ádám Boros and László Vajda. Later on, Tamás Pócs and Ilona Gelencsér visited some forests between Kiscsehi and Tormafölde in 1954. Each bryologist mentioned above spent only one day in the area. As a continuation we also worked only one day in 2001 around Vétyem in the Beech Forest Reserve area in the frame of the Hungarian Biodiversity-monitoring System searching for *Dicranum viride*, which is a target taxon of species monitoring in Hungary. We confirmed the presence of a small population on a decaying log at the edge of the forest reserve (PAPP *et al.* 2003).

In the present paper we give an overview on the bryophyte flora of the forests of Vétyem and Oltárc Natura 2000 protected areas with a special attention to the species of conservation interest.

METHODS

Investigation of the bryophyte flora was carried out in July and August 2017. The studied sites can be seen in Figures 1–3. Bryophytes were collected from soil, bark of trees and decaying wood, occasionally from artificial rock wall or concrete elements. Specimens are deposited in the Bryophyte Collection of the Hungarian Natural History Museum (BP). Nomenclature of bryophytes follows PAPP *et al.* (2010) with two exceptions (*Ulota crispula*, *U. intermedia*), where the publication of CAPARRÓS *et al.* (2016) was used.

Collecting sites are the following:

1. Vétyem Protected Area, 'Bikacsa' forest, Kiscsehi, 46.50489° N, 16.66681° E, 180 m, 03.07.2017.
2. Vétyem Protected Area, 'Hosszú-hegyhát', Kiscsehi, 46.50778° N, 16.65131° E, 250 m, 04.07.2017.
3. Vétyem Protected Area, 'Hosszú-hegyhát', Kiscsehi, 46.50214° N, 16.64792° E, 185 m, 04.07.2017.
4. Vétyem Protected Area, 'Hegy-erdő' forest, Maróc, 46.53331° N, 16.64453° E, 300 m, 04.07.2017.
5. Vétyem Protected Area, 'Nagy-völgy' valley, Vétyempuszta, at an artificial lake, 46.55408° N, 16.64781° E, 285 m, 23.08.2017.

6. Vétyem Protected Area, 'Hottói-erdő' forest, between Vétyempuszta and Maróc, 46.56206° N, 16.65194° E, 315 m, 23.08.2017.

7. Vétyem Protected Area, 'Pál-völgy' valley, 'Hottói-erdő' forest, Maróc, 46.56139° N, 16.65650° E, 225 m, 23.08.2017.

8. Oltárc Protected Area, 'Haraszti-erdő' forest, Borsfa, 46.52608° N, 16.78381° E, 185 m, 04.07.2017.

9. Oltárc Protected Area, 'Dalfi-erdő' forest, between Söjtör and Hahót, 46.64358° N, 16.87469° E, 300 m, 22.08.2017.

10. Oltárc Protected Area, 'Márton-erdő' forest, Söjtör and Hahót, at an artificial lake, 46.63908° N, 16.87975° E, 300 m, 22.08.2017.

11. Oltárc Protected Area, 'Mackó-forrás' source, Söjtör and Hahót, 46.64903° N, 16.87864° E, 300 m, 22.08.2017.

12. Oltárc Protected Area, 'Szuloki-forrás' source, Valkonya, 46.49839° N, 16.83042° E, 250 m, 24.08.2017.

13. Oltárc Protected Area, artificial lake downstream of 'Szuloki-forrás', Valkonya, 46.49197° N, 16.83222° E, 230 m, 24.08.2017.

14. Oltárc Protected Area, 'Csuszigáló', between Valkonya and Rigyác, 46.49817° N, 16.84117° E, 200 m, 24.08.2017.

15. Oltárc Protected Area, east of 'Csuszigáló' at Rigyác, 46.50131° N, 16.85092° E, 225 m, 24.08.2017.

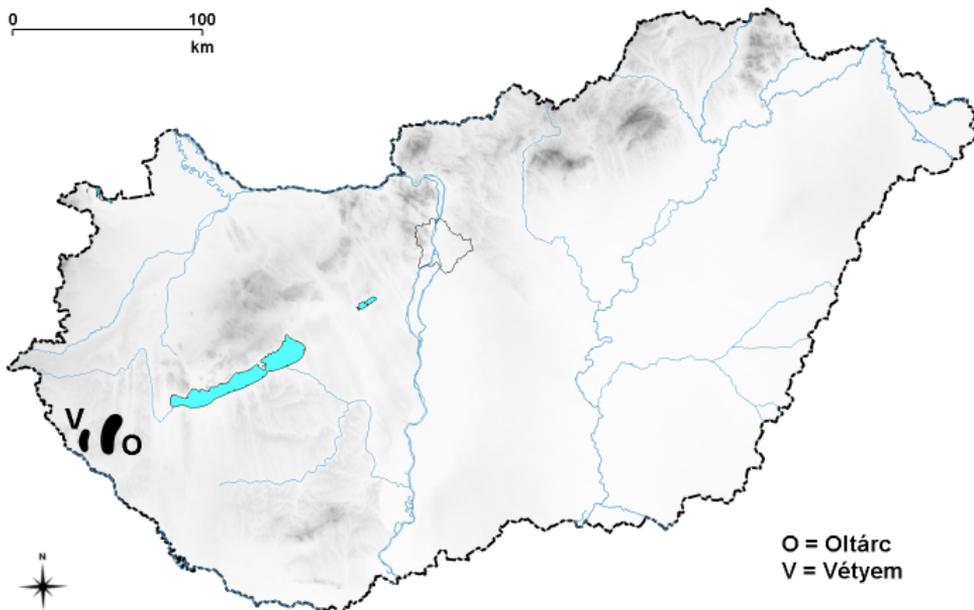


Fig. 1. Oltárc and Vétyem Natura2000 protected areas.



Fig. 2. Location of the studied forests in Oltár Protected Area.

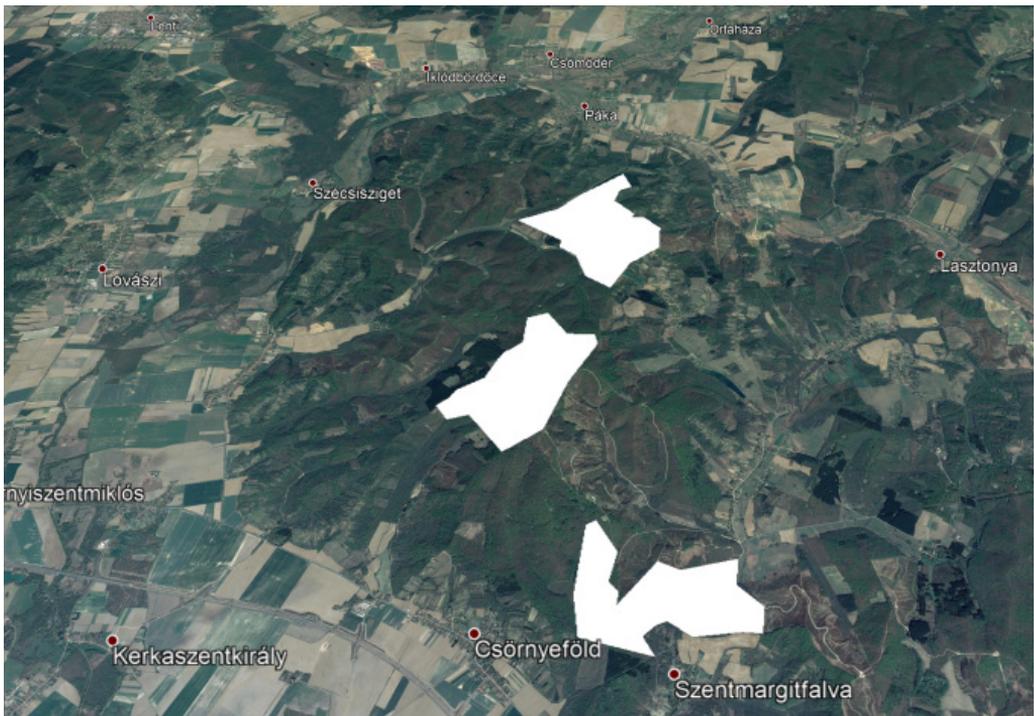


Fig. 3. Location of the studied forests in Vétým Protected Area.

RESULTS AND DISCUSSION

Altogether 102 bryophyte taxa (13 liverworts and 89 mosses) were collected. The list of the bryophyte taxa collected can be found in the Appendix.

Bryophyte vegetation

The epiphyte flora of the studied forests has high bryophyte diversity. In many places the bryophyte cover is very dense on the trees up to 1–1.5 m height. *Hypnum cupressiforme* and *Platygyrium repens* are the most frequent species, but on the lower part of the trees *Anomodon attenuatus*, *Brachythecium rutabulum*, *B. salebrosum*, *Isothecium alopecuroides*, and *Homalia trichomanoides* are also frequent and abundant, while *Amblystegium subtile* and *Leucodon sciuroides* are also characteristic species in some sites. The upper part of trees is covered by many liverworts like *Frullania dilatata*, *Metzgeria furcata* and *Radula complanata*, and species of Orthotrichaceae moss family (*Orthotrichum affine*, *O. lyellii*, *O. patens*, *O. speciosum* and *Ulota crispula*) are also abundant.

On decaying wood *Herzogiella seligeri*, *Hypnum cupressiforme* and *Lophocolea heterophylla* are the most important members of the bryophyte assemblage. In humid places and on the trunks of more advanced rotting stage *Dicranum montanum* is frequent.

The terricolous bryophyte flora appears mainly on the road sides, bank of ditches and steep slopes of 10–20 m deep mini-valleys, which are a characteristic feature of the relief. The most abundant species are as follows: *Atrichum undulatum*, *Brachythecium rutabulum*, *B. velutinum*, *Dicranella heteromalla*, *Eurhynchium hians*, *Fissidens taxifolius*, *Plagiomnium cuspidatum*, *Plagiothecium cavifolium* and *Polytrichum formosum*. In some sites *Eurhynchium angustirete*, *E. schleicheri*, *Fissidens bryoides* and *Plagiomnium rostratum* are also frequent. On the wet muddy walls of car wheel traces *Pohlia melanodon* is the most characteristic species. On the bank of ditches with watercourses and along streams *Conocephalum conicum*, a thalloid liverwort, appears and the occurrence of Mniaceae species (*Mnium marginatum*, *M. stellare*, *Plagiomnium undulatum*, *Rhizomnium punctatum*) are characteristic.

Species of conservation interest

Two species found are protected in Hungary and included in the Red data book of European bryophytes (ECCB 1995). Several other species are red-listed in Hungary (PAPP *et al.* 2010); one is in the data deficient (DD) category (without any recent records for almost 50 years), two are vulnerable (VU). Further 14 species are near threatened (NT), 14 are in the least concern-need attention (LC-att)

category, and 20 species are regarded as indicators, which by their mere presence represents a greater level of conservation value of the habitat.

Dicranum viride

Dicranum viride is a species of the temperate zone of Europe (DÜLL 1984). It occurs on the bark of trees in humid forests and occasionally on decaying wood. It is included in the Annex II of EU Habitat Directive, and in the Bern Convention; it is vulnerable (VU) according to the Red data book of European bryophytes (ECCB 1995). It is protected in Hungary and also included in the Hungarian Red List of Bryophytes as vulnerable (VU) (PAPP *et al.* 2010).

The field identification of the species is very difficult and doubtful due to the resemblance to another relative in the genus, *D. tauricum*, which lives in the same habitat and sometimes even on the same tree (PAPP *et al.* 2002).

In Hungary 14 extant populations are known mainly in the Northern Hungarian Mountain Range, e.g. Bükk Mts (5 populations), Zemplén Mts (3), Börzsöny Mts (1), Pilis Mts (1); a few in Eastern Hungary as Bátorliget (1) and Bereg region (1); two in Western Hungary in Órség region and Vétyem (Tormafölde) (PAPP *et al.* 2003, P. Erzberger, B. Papp unpublished). The population size is usually small; mostly it occurs with 1–2 patches on 1 tree. Larger populations can be found in the Bükk Mts (Hór-völgy, Óserdő) and in the swamp forest at Bátorliget, but the population size is less than 50 everywhere, maximum 50 trees are inhabited.

Earlier data from Zala were collected from decaying wood in 1955 by Ádám Boros in Szurkosárok valley at Vétyem (Tormafölde). This population is probably existing as in 2001 the authors found the species in a stream valley at the edge of the Vétyem Forest Reserve area. Only one large decaying beech trunk was covered by a 57 cm² patch of the species (PAPP *et al.* 2003).

During the recent investigation it was found in Hosszú-hegyhát forest at Kiscsehi. The area belongs to the Vétyem Protected Area. A small patch (1 cm²) occurred accompanied by *Dicranum montanum* on a decaying log in a humid, shady valley bottom in a beech forest, where temporary rivulet flows. The species is very threatened and hardly survives in the site, as the supply of large decaying logs is uninsured. Forest cutting and thinning in the surroundings cause drier microclimate which cannot be compensated by the temporary watercourses having unpredictable and small water yield.

Neckera pennata

Neckera pennata is a subboreal species (DÜLL 1985) being vulnerable (VU) according to the Red data book of European bryophytes (ECCB 1995). It is pro-

tected in Hungary and included in the Hungarian red list of bryophytes as endangered (EN) species (PAPP *et al.* 2010).

In Hungary 4 extant populations are known; 2 in Bereg region (PAPP 2008, P. Szűcs unpubl.), 1 from the Őrség region (SZŰCS 2009) and 1 from Zala County (Z. Purger unpubl.). The populations are very small occurring only on 1–2 trees each.

In Zala County in the vicinity of our investigated areas Zoltán Purger collected two specimens in 2008 in Kozári forest at Bázakerettye.

During the recent survey the species was found in ‘Pál-völgy’ valley in ‘Hot-tói-erdő’ forest at Maróc. The site belongs to the Vétyem Protected Area. Two palm-size patches were discovered on one *Fraxinus excelsior* tree at 0.5 and 1 m height. The tree stands in a valley bottom. The survival of the species here is very doubtful as there are only few large *Fraxinus* trees which seem to be the target of forest activity. Forest cutting and thinning are very intense in the surroundings, which affect the microclimate as well causing drier conditions.

Plagiothecium platyphyllum

Plagiothecium platyphyllum is a subatlantic species with montane character (DÜLL 1985). It occurs on acidic soil in forests, on roadsides, at the bottom of trees (ORBÁN and VAJDA 1983), in rock crevices at waterfalls, and streams in mountain habitats (SMITH 2004). It is in the data deficient (DD) category in the Hungarian Red List of Bryophytes (PAPP *et al.* 2010), which means that it has not been collected in the last 50 years. After the publication of the red list some data arose; at Szóce wetland in Őrség, in the Jeli Arboretum at Kám and in the Mecsek Mts at Cserkút (B. Papp unpublished). In the Hungarian localities it was found at the base of trees and on wet soil at streams or ponds. During our recent investigation it was collected in the Vétyem protected area near Vétyempusztá at an artificial lake at the base of an *Alnus* tree.

Nowellia curvifolia

Nowellia curvifolia is a subatlantic tiny leafy liverwort with montane character (DÜLL 1983), living on decaying wood. It is vulnerable (VU) according to the Hungarian red list of bryophytes (PAPP *et al.* 2010). It has several data from the western part of Hungary mainly from Vas County, but rare and sporadic elsewhere; some small extant populations in Bükk Mts, Börzsöny Mts, Mátra Mts and Pilis Mts. On the base of our recent knowledge it seems that its Hungarian threat status was overestimated in 2010. In Zala County Árpád Károlyi collected it in 1949 and Ádám Boros in 1955 at Várfölde. During the recent study it was collected in Oltárc Protected Area, in ‘Haraszti-erdő’ forest at Borsfa. A palm-size patch was found on a large decaying trunk in a ditch with temporary watercourse.

Orthotrichum patens

Orthotrichum patens is an Atlantic, Mediterranean epiphyte moss (DÜLL 1985). It is vulnerable (VU) according to the Hungarian red list of bryophytes (PAPP *et al.* 2010). Last years several data of this species have arisen, hence its Hungarian threat status is overestimated and should be updated. In the subsequent national red list it can be placed in the least concern-need attention (LC-att) category. In the studied forests it was very frequent and abundant, occurring on various tree species.

Near threatened species

Several species of near threatened (NT) category in Hungary (PAPP *et al.* 2010) were found during our survey. Most of these species have been collected in many Hungarian localities in the last years due to the intensive and thorough bryological investigations, therefore they are much more frequent than we have thought before. In the next national red list they will be placed in the least concern-need attention (LC-att) category. These are *Cirriphyllum piliferum*, *Eurhynchium pulchellum*, *E. schleicheri* and *E. striatum*, all occur on bare soil in forests or roadsides. They are very similar to other frequent *Eurhynchium* or *Brachythecium* species; hence they are under-collected. *Diphyscium foliosum* and *Pseudotaxiphyllum elegans* are characteristic species of acidic soil in forests. *Aneura pinguis*, a thalloid liverwort is not rare on wet places. *Mnium lycopodioides* also lives on moist soil on the bank of ditches or streams. *Anomodon longifolius* grows on shaded rocks and on bark of the lower parts of trees. It is rarer than its relatives (*A. attenuatus* and *A. viticulosus*) living in similar habitats, but it is widespread throughout the country. The same can be stated about the small epiphyte *Orthotrichum* species, like *Orthotrichum obtusifolium* and *O. pumilum*.

There are some really rare, near threatened species in the study area. *Tortula latifolia* is an epiphyte moss of the temperate zone of Europe (DÜLL 1985). Its recent records have been found mainly along the riparian forests of the Danube River and its tributaries. Apart from these, it has few data e.g. from the Cserhát Mts, the Bakony Mts and from a *Populus* tree at Mikládi wetland at the foothill of the Bakony Mts (P. Erzberger, B. Papp unpublished). Hence its occurrence on a *Fagus* tree in the forest between Söjtör and Hahót is an interesting data.

Calypogeia fissa, a subatlantic, Mediterranean small leafy liverwort (DÜLL 1983) has only a few records. In the western part of Hungary, in Órség region it is not rare, but elsewhere it has only sporadic occurrences; some populations in the Bakony, the Vértes Mts and the Mecsek Mts (Cs. Németh, B. Papp, P. Erzberger unpublished). During the recent survey it was found on steep roadsides in 'Haraszti-erdő' forest at Borsfa and in the forest between Söjtör and Hahót.

Another species or species complex has to be mentioned. *Ulotia crispa* (Hedw.) Brid. is near threatened (NT) in Hungary (PAPP *et al.* 2010). During our recent study, for the identification of *Ulotia* specimens the paper of CAPARRÓS *et al.* (2016) was used, which divides the *Ulotia crispa* complex into three species; *U. crispa* s.s., *U. crispula* Bruch, *U. intermedia* Schimp. On the basis of this most of our specimens were *Ulotia crispula*. *U. crispa* s.s. was not rare either but *U. intermedia* was collected only in one locality. Usually many *Ulotia* were found in the studied forests in all tree species, but the three *Ulotia* species co-occurred only in 'Bikacsa' forest at Kiscsehi.

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Összefoglaló: A Balaton-felvidéki Nemzeti Parkhoz tartozó olyan területeken végeztünk mohafióra-feltárást 2017-ben, ahonnan korábbról csak kevés adat volt. Ilyenek a Natura 2000-es Vétyem és Oltárc területek Zala megyében, ahol többnyire bükkösök és gyertyános-tölgyesek fordulnak elő agyagos, homokos talajon. Jelen cikkben a vizsgált erdők mohavegetációjára vonatkozó ismereteinket és a mohafiórájuk természetvédelmi értékelését foglaltuk össze. Összesen 102 mohafajt (13 májmohát és 89 lombosmohát) mutattunk ki a vizsgált területről. Két, hazánkban védett Európai Vörös Könyves (*Dicranum viride*, *Neckera pennata*); egy Magyarországon adathiányos (DD), azaz az utóbbi 50 évben nem gyűjtött (*Plagiothecium platyphyllum*); két Magyarországon sérülékeny (VU) (*Nowellia curvifolia*, *Orthotrichum patens*); 14 veszélyeztetettséghez közeli (NT), 14 nem veszélyeztetett, de figyelmet érdemlő (LC-att) és 20 élőhelyének jó természetvédelmi állapotára utaló, ún. indikátor mohafaj került elő a vizsgálataink során. Az erdők többségének az epifiton mohafiórája igen fajgazdag, helyenként a fák törzsét akár 1–1,5 m-ig is sűrű mohaborítás fedi. A fák felsőbb részén pedig nagy mennyiségben fordulnak elő májmohák, mint pl. *Frullania dilatata*, *Metzgeria furcata*, *Radula complanata* és az Orthotrichaceae lombosmohacsalád tagjai (*Orthotrichum* és *Ulotia* fajok). Természetvédelmi szempontból a legértékesebb élőhelyek azok a nedves, hűvös völgyaljak, amelyeket érintetlenebb erdő vesz körül.

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Appendix

Enumeration of the bryophyte taxa found in Vétyem and Oltárc protected areas. After the name the Hungarian red list status and indicator character of the species (PAPP *et al.* 2010) are given in brackets, which are followed by the number of collecting sites and substrates.

Liverworts

- Aneura pinguis* (L.) Dumort., (NT, indicator) – 8: soil
- Calypogeia fissa* (L.) Raddi, (NT, indicator) – 8, 10: soil
- Cephalozia bicuspadata* (L.) Dumort., (LC-att, indicator) – 10: soil
- Conocephalum conicum* (L.) Dumort. – 3: soil on the bank of a ditch; 8: soil; 11: soil on the bank of a stream; 12: artificial rock wall; 13: soil on the bank of a lake
- Frullania dilatata* (L.) Dumort. – 1, 3, 6, 12: *Fagus* bark; 2, 14: *Quercus* bark; 4, 8: bark of *Fagus* and *Quercus*; 5: bark of *Carpinus* and *Fagus*; 9: bark of *Carpinus*, *Quercus* and *Fagus*; 10: *Salix* bark
- Lophocolea heterophylla* (Schrad.) Dumort. – 1, 3, 5, 11: decaying wood; 8: soil and decaying wood; 10: soil; 12: soil, artificial rock wall and decaying wood; 14: decaying wood in a ditch
- Marchantia polymorpha* L. subsp. *polymorpha* – 8: soil
- Metzgeria furcata* (L.) Dumort. – 1, 3, 4, 12: *Fagus* bark; 2, 9, 14: *Quercus* bark; 5: bark of *Quercus*, *Carpinus* and *Fraxinus*; 7: *Fraxinus* bark; 8: bark of *Tilia* and *Quercus*

Nowellia curvifolia (Dicks.) Mitt., (VU, indicator) – 8: decaying wood

Plagiochila porelloides (Nees) Lindenb. – 1: *Quercus* bark; 3: soil on the bank of a ditch; 10: soil; 12: artificial rock wall

Porella platyphylla (L.) Pfeiff. – 1, 4: *Quercus* bark; 3, 12: *Fagus* bark; 7: *Fraxinus* bark; 9: bark of *Fagus* and *Quercus*

Radula complanata (L.) Dumort. – 1: bark of *Fagus* and *Quercus*; 2, 9, 14: *Quercus* bark; 3, 6, 12: *Fagus* bark; 5: bark of *Quercus*, *Carpinus* and *Fraxinus*; 7: *Fraxinus* bark; 8: bark of *Tilia*, *Fagus* and *Quercus*

Riccia fluitans L., emend. Lorb., (LC-att, indicator) – 10: in the lake

Mosses

Amblystegium serpens (Hedw.) Schimp. – 2, 12: *Fagus* bark; 5: decaying wood; 8: bark of *Tilia* and *Quercus*; 10: soil on the bank of a lake; 13: rock on the bank of a lake; 14: *Quercus* bark

Amblystegium subtile (Hedw.) Schimp. – 1, 2, 4, 8: *Quercus* bark; 5: bark of *Fraxinus* and *Acer pseudo-platanus*; 7: *Fraxinus* bark; 14: bark of *Fagus* and *Quercus*

Amblystegium varium (Hedw.) Lindb., (LC-att, indicator) – 5: bottom of *Alnus*

Anomodon attenuatus (Hedw.) Huebener – 1: bark of *Fagus* and *Quercus*; 2, 8, 9: *Quercus* bark; 3: bark of *Acer campestre*; 5: bark of *Fraxinus* and *Acer pseudo-platanus*; 12: artificial rock wall; 14: *Carpinus* bark

Anomodon longifolius (Brid.) Hartm., (NT, indicator) – 1: *Quercus* bark

Anomodon viticulosus (Hedw.) Hook. et Taylor – 1, 8: *Quercus* bark; 3: bark of *Acer campestre*

Atrichum undulatum (Hedw.) P. Beauv. – 1, 2, 4, 5, 7, 8, 9, 10, 12: soil; 11: soil on the bank of a stream

Barbula convoluta Hedw. – 8: soil

Barbula unguiculata Hedw. – 4, 8: soil

Brachythecium populeum (Hedw.) Schimp. – 1, 2, 8: *Quercus* bark; 12: *Fagus* bark; 14: decaying wood in a ditch

Brachythecium rutabulum (Hedw.) Schimp. – 1, 4: soil, bark of *Fagus* and *Quercus*; 2: soil and *Quercus* bark; 5: soil and bark of *Acer pseudo-platanus*; 7: soil and *Fraxinus* bark; 8: *Quercus* bark; 9: soil and *Carpinus* bark; 10: soil and *Salix* bark; 12: soil and artificial rock wall, *Fagus* bark and decaying wood

Brachythecium salebrosum (F. Weber et D. Mohr) Schimp. – 2: *Quercus* bark; 4: soil and *Quercus* bark; 5: soil, decaying wood and bark of *Acer pseudo-platanus*; 8: bark of *Tilia* and *Quercus*; 9: soil

Brachythecium velutinum (Hedw.) Schimp. – 1: bottom of *Quercus*; 2, 4, 7, 9: soil; 5: bark of *Fraxinus* and *Fagus*; 8, 14: *Quercus* bark; 12: soil and decaying wood

- Bryum capillare* Hedw. – 2, 3: soil
Bryum rubens Mitt. – 2, 4: soil
Campylium calcareum Crundw. et Nyholm – 3: soil on the bank of a ditch
Ceratodon purpureus (Hedw.) Brid. – 4, 8: soil
Cirriphyllum piliferum (Hedw.) Grout, (NT, indicator) – 2: soil
Ctenidium molluscum (Hedw.) Mitt. – 4: soil; 12: artificial rock wall
Ctenidium molluscum (Hedw.) Mitt. var. *condensatum* (Schimp.) Britt. – 1, 15: bottom of *Quercus*; 7: *Fraxinus* bark
Dicranella heteromalla (Hedw.) Schimp. – 2, 4, 7, 8, 9: soil
Dicranella schreberiana (Hedw.) Hilf. ex H. A. Crum et L. E. Anderson – 4: soil
Dicranella varia (Hedw.) Schimp. – 1, 5: soil
Dicranum montanum Hedw. – 1, 3, 4, 7, 8: decaying wood
Dicranum scoparium Hedw. – 4: soil and decaying wood
Dicranum tauricum Sapjegin – 4: decaying wood
Dicranum viride (Sull. et Lesq.) Lindb., (VU) – 3: decaying wood
Didymodon fallax (Hedw.) R. H. Zander – 8, 10: soil
Didymodon luridus Hornsch. ex Spreng. – 13: rock on the bank of a lake
Diphyscium foliosum (Hedw.) D. Mohr, (NT, indicator) – 4: soil
Encalypta streptocarpa Hedw. – 3: soil on the bank of a ditch
Eurhynchium angustirete (Broth.) T. J. Kop. – 1: bottom of *Quercus*; 7, 8: soil; 11: soil in *Pinetum*
Eurhynchium hians (Hedw.) Sande Lac. – 1, 2, 8, 9: soil; 5: decaying wood; 11: soil on the bank of a stream; 12: artificial rock wall
Eurhynchium pulchellum (Hedw.) Jenn., (NT, indicator) – 2: soil
Eurhynchium schleicheri (R. Hedw.) Jur., (NT) – 4, 5, 9, 12: soil
Eurhynchium striatum (Hedw.) Schimp., (NT) – 10: soil
Fissidens bryoides Hedw. – 2, 4, 8: soil
Fissidens taxifolius Hedw. – 1, 2, 3, 4, 5, 7, 8: soil; 11: soil on the bank of a stream
Funaria hygrometrica Hedw. – 8: soil
Herzogiella seligeri (Brid.) Z. Iwats. – 1, 3, 7, 8, 12: decaying wood
Homalia trichomanoides (Hedw.) Schimp., (LC-att, indicator) – 1: bark of *Fagus* and *Quercus*; 2, 4, 8: *Quercus* bark; 3: bark of *Fagus* and *Acer campestre*; 5: bark *Fraxinus* and *Acer pseudo-platanus*; 7: *Fraxinus* bark; 10: bark of *Robinia pseudo-acacia*; 14: roots of trees in a ditch, bark of *Quercus* and *Fagus*
Homalothecium sericeum (Hedw.) Schimp. – 2, 9: *Quercus* bark
Hypnum cupressiforme Hedw. – 1: bark of *Fagus* and *Quercus*; 2, 4, 12: *Quercus* bark; 3, 6: *Fagus* bark; 5: bottom of *Alnus* and *Acer pseudo-platanus*; 8: *Fagus* bark and decaying wood; 9: soil, bark of *Carpinus*, *Quercus cerris* and *Q. petraea*; 10: soil; 14: *Carpinus* bark

- Hypnum pallescens* (Hedw.) P. Beauv. – 1: *Fagus* bark; 7: decaying wood
- Isoetecium alopecurooides* (Dubois) Isov. – 1: bottom of *Quercus*; 2, 4, 8, 9, 14: *Quercus* bark; 5: bottom of *Alnus*; 7, 10: soil; 12: *Fagus* bark
- Leptodictyum riparium* (Hedw.) Warnst. – 3: decaying wood in a ditch; 5: decaying wood; 8: decaying wood in small pond in the forest; 10: soil on the bank of a lake; 13: rock on the bank of a lake, *Salix* bark and decaying wood
- Leskea polycarpa* Ehrh. ex Hedw. – 5: decaying wood; 9, 12: *Fagus* bark; 10, 13: *Salix* bark
- Leucodon sciurooides* (Hedw.) Schwägr. – 1, 2, 4, 9, 15: *Quercus* bark; 5: bark of *Fraxinus* and *Acer pseudo-platanus*
- Mnium lycopodioides* Schwägr., (NT) – 3: soil on the bank of a ditch; 11: soil on the bank of a stream
- Mnium marginatum* (Dicks.) P. Beauv., (LC-att, indicator) – 8: soil; 11: soil on the bank of a stream; 14: decaying wood in a ditch
- Mnium stellare* Hedw., (LC-att, indicator) – 3: soil on the bank of a ditch; 7, 8: soil; 14: tree roots in a ditch
- Neckera complanata* (Hedw.) Huebener – 1: *Quercus* bark
- Neckera pennata* Hedw., (EN) – 7: *Fraxinus* bark
- Orthotrichum affine* Schrad. ex Brid. – 1, 3, 4, 6: *Fagus* bark; 2: *Quercus* bark; 7: *Fraxinus* bark; 8: *Carpinus* bark; 9: bark of *Quercus cerris* and *Fagus*; 10: *Salix* bark
- Orthotrichum lyellii* Hook. et Taylor – 1, 2: *Quercus* bark; 4: bark of *Fagus* and *Quercus*; 9: bark of *Quercus cerris* and *Q. petraea*
- Orthotrichum obtusifolium* Brid., (NT, indicator) – 10: *Salix* bark; 12: *Fagus* bark
- Orthotrichum pallens* Bruch ex Brid. – 4, 6: *Fagus* bark; 7: *Fraxinus* bark; 10: *Salix* bark
- Orthotrichum patens* Bruch ex Brid., (VU) – 1, 3, 6: *Fagus* bark, 12; 2: *Quercus* bark; 4: bark of *Fagus* and *Quercus*; 8: *Carpinus* bark; 9: bark of *Fagus*, *Quercus cerris* and *Q. petraea*; 10: *Salix* bark; 14: bark of *Carpinus* and *Quercus*
- Orthotrichum pumilum* Sw., (NT, indicator) – 4: *Fagus* bark; 10: *Salix* bark
- Orthotrichum speciosum* Nees, (LC-att, indicator) – 1: *Fagus* bark; 2: *Quercus* bark; 4: bark of *Fagus* and *Quercus*; 7: *Fraxinus* bark; 8: *Carpinus* bark; 9: bark of *Fagus*, *Quercus cerris* and *Q. petraea*; 10: *Salix* bark
- Orthotrichum stramineum* Hornsch. ex Brid. – 12: *Fagus* bark
- Orthotrichum striatum* Hedw., (LC-att, indicator) – 2: *Quercus* bark; 8: *Carpinus* bark; 9: bark of *Quercus cerris* and *Q. petraea*
- Physcomitrium pyriforme* (Hedw.) Brid. – 5: soil
- Plagiomnium affine* (Blandow) T. J. Kop. – 8: soil

Plagiomnium cuspidatum (Hedw.) T. J. Kop. – 1, 2, 4: soil and *Quercus* bark; 5: decaying wood; 7: soil; 8: soil, bark of *Fagus* and *Quercus*; 10: soil and bark of *Robinia pseudo-acacia*; 12: soil and decaying wood; 13: rock on the bank of a lake; 14: tree roots in a ditch

Plagiomnium rostratum (anon.) T. J. Kop. – 2: soil; 11: soil on the bank of a stream; 12: artificial rock wall; 13: soil on the bank of a lake

Plagiomnium undulatum (Hedw.) T. J. Kop. – 2, 4, 8: soil; 5: bottom of *Alnus*; 11: soil in *Pinetum* and on the bank of a stream; 13: soil on the bank of a lake

Plagiothecium cavifolium (Brid.) Z. Iwats. – 2, 4, 5, 7, 10, 12: soil; 14: tree roots in a ditch

Plagiothecium curvifolium Limpr. – 3: bottom of *Fagus*

Plagiothecium laetum Schimp., (LC-att) – 8: soil

Plagiothecium nemorale (Mitt.) A. Jaeger – 1: *Fagus* bark; 2: soil

Plagiothecium platyphyllum Mönk., (DD) – 5: bottom of *Alnus*

Platygyrium repens (Brid.) Schimp. – 1: decaying wood, bark of *Fagus* and *Quercus*; 3: decaying wood; 4, 8: bark of *Fagus* and *Quercus*; 5, 7: *Fraxinus* bark; 9: bark of *Carpinus*, *Quercus cerris* and *Q. petraea*; 10: *Salix* bark; 12: *Fagus* bark; 14: *Quercus* bark

Pohlia lutescens (Limpr.) H. Lindb., (LC-att) – 2: soil

Pohlia melanodon (Brid.) A. J. Shaw – 1, 4, 5, 7, 8, 9, 12: soil; 11: soil on the bank of a stream

Polytrichum formosum Hedw. – 1, 2, 4, 5, 8, 10, 12: soil

Pseudoleskeella nervosa (Brid.) Nyholm – 2, 9: *Quercus* bark; 12: *Fagus* bark

Pseudotaxiphyllum elegans (Brid.) Z. Iwats., (NT) – 8: soil

Pterigynandrum filiforme Hedw. – 1, 3: *Fagus* bark; 9: bark of *Fagus* and *Quercus*

Pylaisia polyantha (Hedw.) Schimp. – 1, 9: bark of *Fagus* and *Quercus*; 2, 8, 14: *Quercus* bark; 4, 6, 12: *Fagus* bark; 5, 7: *Fraxinus* bark; 10: *Salix* bark

Rhizomnium punctatum (Hedw.) T. J. Kop. – 3: decaying wood in a ditch; 8: soil and decaying wood; 11: soil on the bank of a stream

Tetraxis pellucida Hedw., (LC-att, indicator) – 7: decaying wood

Thuidium philibertii Limpr., (LC-att) – 2: soil

Thuidium recognitum (Hedw.) Lindb., (LC-att) – 1: bottom of *Quercus*

Tortula latifolia Bruch ex Hartm., (NT) – 9: *Fagus* bark

Tortula papillosa Wilson, (LC-att, indicator) – 4: *Fagus* bark; 9: bark of *Fagus*, *Quercus cerris* and *Q. petraea*; 10: *Salix* bark

Ulota crispa (Hedw.) Brid., (NT, indicator) – 1, 3: *Fagus* bark; 14: *Carpinus* bark

Ulota crispula Bruch – 1, 6: *Fagus* bark; 2, 4, 9: *Quercus* bark; 7: *Fraxinus* bark; 8: bark of *Fagus* and *Carpinus*

Ulota intermedia Schimp. – 1: *Fagus* bark