

Bryoflora and vegetation of Pakri Islands (Gulf of Finland, Estonia)

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Abstract: The bryoflora of Pakri islands is very species-rich. On these islands 236 species of bryophytes (31 liverworts, 205 mosses) have been found. The most species-rich habitats are alvars, limestone shingle beach ridges and limestone cliff. On Väike-Pakri island (12.9 km²) 215 species and on Suur-Pakri island (11.7 km²) 160 species of bryophytes are found. The number of rare species on Pakri islands is remarkable. Four species have their only Estonian localities on Pakri islands (*Mannia sibirica*, *Bryum arcticum*, *Rhytidium rugosum* and *Seligeria patula*).

Kokkuvõte: Pakri saarte (Soome laht, Eesti) samblaflora.

Pakri saarte samblaflora on väga liigirikas. Siit on leitud 236 liiki sammaltaimi (31 liiki helviksamblaid ja 205 lehtsamblaid). Kõige liigirikkamad kasvukohad on alvarid, paeklibuga rannavallid ja klint. Väike-Pakri saarelt (12,9 km²) on leitud 215 sambllaliiki, Suur-Pakri saarelt (11,7 km²) 160 liiki. Tähelepanuväärne on haruldaste liikide rohkus. Neljal liigil (*Mannia sibirica*, *Bryum arcticum*, *Rhytidium rugosum* ja *Seligeria patula*) on leiukohad Pakritel ainsad tänaseni teadaolevad Eestis.

INTRODUCTION

The islands of Väike-Pakri (Lilla or Östra Rågö, 12.9 km²) and Suur-Pakri (Stora or Västra Rågö, 11.7 km²) are situated in the Gulf of Finland, 2–3 km west of the Paldiski town (Fig. 1). Six smaller islands are located between the islands of Suur-Pakri and Väike-Pakri, Longrund (0.1 km²) and Kappa (0.04 km²) being the largest. Along the northern coast of Väike-Pakri and Suur-Pakri runs a steep limestone cliff, which reaches the height of 13 m a.s.l. on Väike-Pakri. Beach ridges and shallow depressions with several lakelets are the main relief forms on the islands. Numerous erratic boulders can be found here and there. Many different plant communities have been described on Pakri islands: alvar meadows (alvars), fresh boreo-nemoral and paludified grasslands, coastal meadows, spring fens, swampy forests, alvar forests and shrublands, fresh boreo-nemoral forests (Truus & Kannukene, 1998). Two thirds of the area of the Väike-Pakri and three fourths of the area of the Suur-Pakri are covered with meadows, mostly alvar meadows. About one third of Väike-Pakri island and one fourth of Suur-Pakri island are covered with forests. Forests cover also former wooded meadows, courtyards and lanes of former villages. Most of the forests are swampy deciduous forests. Swampy, fresh boreo-nemoral and alvar forests are less

frequent. The northern parts of Pakri islands, southern part of Väike-Pakri island and Kappa island belong to the Pakri Landscape Reserve since 1998.

The first data about bryophytes of Pakri islands date back to the beginning of the 20th century. In 1907 Latvian bryologist Joh. Mikutowicz visited Väike-Pakri island, where he collected exsiccata specimens for 12 species of mosses (most of them from an old limestone quarry)

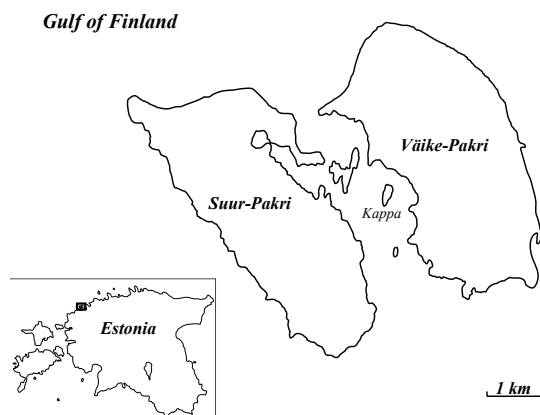


Fig. 1. Location of Pakri islands

(Mikutowicz, 1908-1913). Another Latvian bryologist, A. Apinis visited Väike-Pakri island in the 1920s. N. Malta (1930) refers to four species found by Apinis – *Pterigynandrum filiforme*, *Thuidium philibertii*, *Tortella inclinata* and *Ulota curvifolia*. The last is rare in Estonia and has not been found on the island later.

Since the mid-1950s up to the summer of 1992, Pakri islands were used as a practice bombing area by Soviet military air forces and the islands were closed for visitors, including any researchers. Studying the bryoflora of islands was possible again since 1993. The bryoflora of Pakri islands was studied by L. Kannukene in 1993-1995, and as a result 143 bryophyte species were recorded (Kannukene, 1995). During the period of 1993-2004 several botanists (L. Truus, T. Ploompuu, T. Kukkk) and bryologists (N. Ingerpuu, M. Tobias) visited Pakri islands and collected the bryophytes. As a result 8 new for Estonia bryophytes were found (Kannukene, 1998; Kannukene et al., 1997; Vellak et al., 2001, 2006).

The aim of this paper is to compile a common list of bryophytes of the three alongside located islands: Väike-Pakri, Suur-Pakri and Kappa and give an overview of the bryophyte vegetation of main habitats there.

MATERIAL AND METHODS

The most recent investigation of bryophytes on Pakri islands was accomplished during four days in 2007 by M. Leis. She visited Väike-Pakri, Suur-Pakri and Kappa islands. The route was chosen to include all the different ecotypes, especially in the protected area. To compile a complete list of bryophytes of Pakri islands, also data from literature, different project reports (monitoring of alvar meadows and monitoring of coastal landscapes), and herbaria (TAA, TAM, TU) were included.

The samples of bryophytes collected by M. Leis (ca 160 specimens) and T. Kukkk (67 specimens) are located in the Herbarium of the Estonian University of Life Sciences (TAA). The moss specimens collected by L. Kannukene (ca 1100 specimens) are kept in the Herbarium of Estonian Museum of Natural History (TAM). The liverworts collected by L. Kannukene and ca 20 specimens collected by N. Ingerpuu are held in the Herbarium of the Museum of Natural History of Tartu University (TU).

The names of bryophytes are according to Ingerpuu et al. (1998) and Hill et al. (2006).

RESULTS AND DISCUSSION

An short description of the bryophyte vegetation

Alvars occupy large territory on the islands. They are unique landscape form that unite the characteristic features of South European meadow steppe, arctic or alpine stone heath and Central European rocky landscapes (Sterner, 1938). Alvars are regarded as valuable habitats in Europe because of their uniqueness and high diversity of plant species (Paal, 2004). One of Estonian largest alvars (5 km²) is situated in the northern part of Suur-Pakri, which is in contrast quite poor of bryophyte species. This is probably a consequence of being a military polygon area for a long time. The alvar is without bushes and covered with numerous bomb craters. On the bottoms of the craters where plate limestone is denudated, *Scorpidium scorpioides* is often the only moss species. Most of the other alvars on Pakri islands are wet. In the field layer, the species-rich *Carici flaccae-Seslerietum* community is common. In the moss layer, *Ctenidium molluscum* is frequent and *Scorpidium turgescens* occurs pretty often. The last species grows in Estonia and in Sweden mostly on wet alvars and is one of the fewest postglacial relics (Albertson, 1940). Some other bryophyte taxa, common to these alvars (*Dicranum brevifolium*, *Encalypta raptocarpa*, *Myurella julacea* and *Aulacomnium palustre* var. *imbricatum*) exhibit also an arctic-alpine distribution in Europe. The representatives of continental or steppe species *Homalothecium lutescens* and *Thuidium abietinum* are widely distributed on dry alvars. On Pakri alvars one can find the following rare for Estonia species: *Mannia pilosa*, *M. sibirica*, *Bryum bicolor*, *Tortella rigens*, *Trichostomum crispulum* and *Weissia squarrosa*.

On limestone beach ridges, all bryophyte species common for alvars can be met. On ancient beach ridges *Hypnum cupressiforme* forms a continuous cover under the shrubs. *Dicranum scoparium* and *Hylocomium splendens* are very common. The only localities for *Rhytidium rugosum* in Estonia are the southeastern beach ridges on Väike-Pakri.

Coastal meadows are located in the southern parts of the islands. The rare in Estonia *Bryum subapiculatum* grows on a coastal meadow of Suur-Pakri.

Shallow depressions with several lakelets are quite common on Pakri islands. The moss

species composition of the lakelets with high pH value (8.4–8.8) in northern part of Suur-Pakri is especially interesting. *Bryum neodamense*, which is quite rare in Estonia, grows abundantly on the bottom of such lakelets together with a common species *Scorpidium scorpioides*. The paludified shores of the lakelets are covered with carpets of *Drepanocladus cossonii*, *D. lycopodioides*, *Campylium stellatum* and *Calliergonella cuspidata*, whereby near the lakelets on the northern part of Suur-Pakri mostly only *Scorpidium scorpioides* is growing.

The moss species of lakelets dominate also in calcareous fens. Characteristic species of spring fens are *Tomentypnum nitens* and *Helodium blandowii*. Some redlisted species like *Leiocolea heterocolpus* and *Catoscopium nigratum* have also been found in fens. In a small spring fen on the limestone shore of Väike-Pakri (former limestone quarry) grows a quite rare arcto-alpine species in Estonia *Calliergon trifarium*.

The springy limestone outcrops (coastal cliffs) are usually covered with *Cratoneuron filicinum*. On such outcrops of Väike-Pakri a very rare species *Bryum arcticum* is found. In the crevices of limestone outcrops *Didymodon rigidulus*, *Encalypta srteptocarpa*, and *Bryothyrophyllum recurvirostrum* are common. On the limestone cliffs on the shore of Väike-Pakri there are habitats of some very rare mosses like *Scapania gymnostomophila* and *Seligeria patula*.

In swampy deciduous forests the characteristic species in the moss layer are *Calliergonella cuspidata*, *Brachythecium rutabulum* and *Calliergon cordifolium*. Here one can also find *Mnium hornum* which is a species with an atlantic distribution. *Leucobryum glaucum* which forms large cushions in swampy forests on Väike-Pakri, is protected in Estonia. The epiphytic bryoflora is poor of species. Among the common species, a rather rare species in Estonia *Callicladium haldanianum* was found on some deciduous trees. Logs and rotten stumps are covered with lots of different bryophyte species: *Brachythecium rutabulum*, *D. montanum*, *Herzogiella seligeri*, *Lepidozia reptans*, and *Tetraphis pellucida* being the most common. Atlantic species *Aulacomnium androgynum*, which is common on the islands in the western part of Estonia, is quite rare on Pakri islands.

The fresh boreo-nemoral forests are spread on Kappa island and appear as little groves on the north-western part of Väike-Pakri. These

forests are remarkable because of their rich epiphytic bryoflora. *Leucodon sciuroides*, *Hypnum cupressiforme* and *Orthotrichum speciosum* appear often on trunks. Bryophyte cover on trunk basis often consists of *Amblystegium serpens*, *Anomodon longifolius* and *Homalia trichomanoides*. On the ground *Brachythecium rutabulum*, *Plagiomnium affine* and *Plagiochila asplenioides* are most frequent.

On erratic boulders in shady habitats some interesting moss species occur, e.g. *Pterigynandrum filiforme*, *Isothecium alopecurioides* and the protected *Antitrichia curtipendula*. Shady boulders and stone fences are often covered all over with bryophytes. *Hypnum cupressiforme* dominates there over other species. One can also find *Barbilophozia barbata*, *Metzgeria furcata*, *Brachythecium populeum*, and *Homalia trichomanoides*. On siliceous boulders that are open to light *Hedwigia ciliata* dominates. This species is often accompanied by *Grimmia muehlenbeckii* and *Orthotrichum rupestre*. On limestones mainly *Schistidium apocarpum* and *Tortula ruralis* occur. *Grimmia pulvinata* and *Homalothecium sericeum* are distributed on the western islands but are seldom met on Pakri islands. On Suur-Pakri the very rare species *Aloina rigida* was found growing on the basement of the ruins of a house.

Species richness, rare and threatened species

Bryoflora of Pakri islands is remarkably species-rich. Approximately 41% of the 579 species of bryophytes found in Estonia (Vellak et al., 2009) are met on Pakri islands. The list of bryophytes found on Pakri islands (Table 1) includes 236 species, 31 of them are liverworts (Marchantiophyta) and 205 mosses (Bryophyta). There are 12 infraspecific taxa.

According to species diversity and the number of rare species, the bryoflora on Pakri islands is comparable to Vormsi island which, however, has an almost four times as large area (93 km²). On Vormsi island, 229 species of bryophytes (32 liverworts and 197 mosses) have been found (Leis & Kannukene, 2001). The bryoflora of the islands on noncalcareous deposits with acidic soils remains less species-rich: on Ruhnu Island (11.4 km², situated in the Gulf of Riga) 135 species are recorded, on Naissaare Island (18.6 km²; situated in the Gulf of Finland) 149 species are found (Leis, 1993; Kannukene,

1999). The milder climate of maritime Estonia and presence of calcareous substrata are the main causes for the rich bryoflora on the Pakri islands.

The bryoflora of Väike-Pakri is more diverse than that of Suur-Pakri. 215 species of bryophytes (including 27 species of liverworts) have been found on Väike-Pakri, while 160 species of bryophytes (13 species of liverworts) have been found on Suur-Pakri. On the small island of Kappa only 16 species of mosses have been found.

Bryoflora of Pakri islands is remarkably rich in rare and conservationally important species. Noteworthy is the finding of *Bryum subapiculatum* on Suur-Pakri in 2007. It was earlier found in Estonia only once in 1853 by G. K. Girgensohn near Tartu (specimen in TAA). During the investigations in 2007 several new localities for rare Estonian species were discovered (*Lophozia heterocolpos*, *Bryum elegans*, *Hedwigia stellata*,

Schistidium confusum, *S. rivulare*, *Ulota drummondii* and *Weissia squarrosa*). The bryoflora of Pakri islands include altogether ten species that are very rare in Estonia (1-3 localities), and fourteen species that are rare (4-7 localities, Table 1).

According to the new Estonian Red Data List that was compiled in 2008 (<http://unite.ut.ee/temp/plutof2/prmt.php?lang=eng>) two species are critically endangered (category CR), sixteen are vulnerable (VU) and fifteen species belong to the category of Near Threatened (NT) species. Four rare species are not evaluated yet (NE) (Table 1).

The European Red Data Book of Bryophytes includes 36 species of Estonian bryophytes (ECCB, 1995). Fourteen of them have been found on the Pakri islands (Table 1).

47 species of bryophytes are protected by law in Estonia (Rügi Teataja, 2004). Nine of them are found on Pakri (Table 1).

Table 1. Rare and threatened bryophyte species on Pakri islands. Bold - rare in Estonia species. VP – Väike-Pakri, SP – Suur-Pakri, K – Kappa, VU – vulnerable, NT – near threatened, CR – critically endangered, NE – not evaluated, R – rare, RT – regionally threatened, K – insufficiently known

Species name	Occurrence	Red-listed in Estonia	Red-listed in Europe	Protection category
MARCHATIOPHYTA				
<i>Aneura pinguis</i> (L.) Dumort.	VP			
<i>Barbilophozia barbata</i> (Schmidel ex Schreb.) Loeske	VP			
<i>Calypogeia integristipula</i> Steph.	VP			
<i>Calypogeia sphagnicola</i> (Arnell et J.Perss.) Warnst. et Loeske	VP			
<i>Cephalozia connivens</i> (Dicks.) Lindb.	VP			
<i>Cephalozia lunulifolia</i> (Dumort.) Dumort.	VP			
<i>Cephaloziella rubella</i> (Nees) Warnst.	SP			
<i>Chiloscyphus pallescens</i> (Ehrh. ex Hoffm.) Dumort.	VP, SP			
<i>Chiloscyphus polyanthos</i> (L.) Corda	SP			
<i>Conocephalum conicum</i> (L.) Dumort.	VP			
<i>Lepidozia reptans</i> (L.) Dumort.	VP			
<i>Lophocolea bidentata</i> (L.) Dumort.	VP			
<i>Lophocolea heterophylla</i> (Schrad.) Dumort.	VP, SP			
<i>Lophocolea minor</i> Nees	SP			
<i>Lophozia badensis</i> (Gottsche) Schiffn.	VP			
<i>Lophozia heterocolpos</i> Thed. ex O.Hartm.) M.Howe	VP	VU		
<i>Mannia pilosa</i> (Hornem.) Frye & L.Clark	VP	VU		
<i>Mannia sibirica</i> (Müll.Frib.) Freye & L.Clark	SP	VU		
<i>Marchantia polymorpha</i> L.	VP, SP			
subsp. <i>montivagans</i> Bischl. & Boisselier	VP			
<i>Metzgeria furcata</i> (L.) Dumort.	VP			
<i>Pellia endiviifolia</i> (Dicks.) Dumort.	VP			
<i>Plagiochila asplenoides</i> (L. emend. Taylor) Dumort.	VP, SP			
<i>Plagiochila porelloides</i> (Torrey ex Nees) Lindenb.	VP			
<i>Preissia quadrata</i> (Scop.) Nees	VP, SP			
<i>Prilidium ciliare</i> (L.) Hampe	VP, SP			
<i>Prilidium pulcherrimum</i> (Weber) Vain.	VP, SP			
<i>Radula complanata</i> (L.) Dumort.	VP, SP			

Table 1 (continued)

Species name	Occurrence	Red-listed in Estonia	Red-listed in Europe	Protection category
<i>Reboulia hemisphaerica</i> (L.) Raddi	VP	VU		
<i>Riccardia latifrons</i> (Lindb.) Lindb.	VP			
<i>Scapania calcicola</i> (Arnell & J.Perss.) Ingham	VP			
<i>Scapania gymnostomophila</i> Kaal.	VP	VU		
BRYOPHYTA				
<i>Aloina rigida</i> (Hedw.) Limpr.	SP	VU		
<i>Amblystegium riparium</i> (Hedw.) Schimp.	VP, SP			
<i>Amblystegium serpens</i> (Hedw.) Schimp. var. <i>juratzkanum</i> (Schimp.) Rau & Herv.	VP,SP,K VP,SP			
<i>Amblystegium subtile</i> (Hedw.) Schimp.	VP, K			
<i>Amblystegium varium</i> (Hedw.) Lindb.	SP			
<i>Anomodon longifolius</i> (Schleich. ex Brid.) Hartm.	VP			
<i>Antitrichia curtipendula</i> (Hedw.) Brid.	VP, SP	NT		III
<i>Atrichum undulatum</i> (Hedw.) P.Beauv.	VP			
<i>Aulacomnium androgynum</i> (Hedw.) Schwäger.	VP, SP			
<i>Aulacomnium palustre</i> (Hedw.) Schwäger. var. <i>imbricatum</i> B., S. & G.	VP, SP VP, SP			
<i>Barbula convoluta</i> Hedw.	VP, SP			
<i>Barbula unguiculata</i> Hedw.	VP, SP			
<i>Brachythecium albicans</i> (Hedw.) Schimp.	VP,SP			
<i>Brachythecium glareosum</i> (Bruch ex Spruce) Schimp.	VP,SP			
<i>Brachythecium mildeanum</i> (Schimp.) Schimp.	VP			
<i>Brachythecium oedipodium</i> (Mitt.) A.Jaeger	SP			
<i>Brachythecium populeum</i> (Hedw.) Schimp.	VP,SP,K			
<i>Brachythecium reflexum</i> (Starke) Schimp.	VP,SP			
<i>Brachythecium rivulare</i> Schimp.	VP,SP			
<i>Brachythecium rutabulum</i> (Hedw.) Schimp.	VP,SP,K			
<i>Brachythecium salebrosum</i> (Hoffm. ex F.Weber & D.Mohr.) Schimp., nom.cons.	VP,SP,K			
<i>Brachythecium turgidum</i> (Hartm.) Kindb.	SP	NT		II
<i>Brachythecium velutinum</i> (Hedw.) Schimp.	VP,SP,K			
<i>Bryoerythrophyllum recurvirostrum</i> (Hedw.) P.C.Chen	VP, SP			
<i>Bryum algovicum</i> Sendtn. ex Müll.Hal.	VP,SP			
<i>Bryum arcticum</i> (R.Br.) Bruch & Schimp.	VP,SP	VU		
<i>Bryum argenteum</i> Hedw.	VP,SP			
<i>Bryum bicolor</i> Dicks.	SP	VU		
<i>Bryum caespiticium</i> Hedw.	VP,SP			
<i>Bryum capillare</i> Hedw.	VP,SP			
<i>Bryum elegans</i> Nees	VP			
<i>Bryum flaccidum</i> auct. non Brid.	VP,SP			
<i>Bryum imbricatum</i> auct. non (Schwäger.) Bruch & Schimp.	VP,SP			
<i>Bryum intermedium</i> (Brid.) Blandow	VP,SP			
<i>Bryum mamillatum</i> Lindb.	VP	CR	R	
<i>Bryum neodamense</i> Itzigs.	VP,SP	NT	R	III
<i>Bryum pallens</i> Sw. ex anon.	VP,SP			
<i>Bryum pallescens</i> Schleich. & Schwäger.	VP,SP			
<i>Bryum pseudotriquetrum</i> (Hedw.) P.Gaertn. et al. var. <i>bimum</i> (Schreb.) Lilj.	VP,SP VP,SP			
<i>Bryum subapiculatum</i> Hampe	SP	CR		
<i>Bryum subelegans</i> auct. non Kindb.	VP	NE	RT	
<i>Bryum uliginosum</i> (Brid.) Bruch & Schimp.	VP		RT	
<i>Bryum warneum</i> (Röhl.) Brid.	SP	VU	R	
<i>Callicladium baldanianum</i> (Grev.) H.A.Crum	VP,SP		RT	
<i>Calliergon cordifolium</i> (Hedw.) Kindb.	VP,SP			
<i>Calliergon giganteum</i> (Schimp.) Kindb.	VP			

Table 1 (continued)

Species name	Occurrence	Red-listed in Estonia	Red-listed in Europe	Protection category
<i>Calliergon trifarium</i> (F.Weber & D.Mohr) Kindb.	VP,SP	NT		
<i>Calliergonella cuspidata</i> (Hedw.) Loeske	VP,SP			
<i>Campylium calcareum</i> Crundw. & Nyholm	VP			
<i>Campylium chrysophyllum</i> (Brid.) Lange	VP,SP			
<i>Campylium elodes</i> (Lindb.) Kindb.	VP,SP		RT	
<i>Campylium polygamum</i> (Schimp.) Lange & C.E.O.Jensen	VP,SP			
<i>Campylium sommerfeldtii</i> (Myrin) Lange	VP,SP			
<i>Campylium stellatum</i> (Hedw.) Lange & C.E.O.Jensen	VP,SP			
var. <i>protensum</i> (Brid.) Bryhn ex Grout	VP,SP			
<i>Catocopium nigratum</i> (Hedw.) Brid.	VP	NT		II
<i>Ceratodon conicus</i> (Hampe) Lindb.	VP	VU		
<i>Ceratodon purpureus</i> (Hedw.) Brid.	VP,SP,K			
<i>Cinclidium stygium</i> Sw.	VP			
<i>Cirriphyllum piliferum</i> (Hedw.) Grout	VP, K			
<i>Climacium dendroides</i> (Hedw.) F.Weber & D.Mohr	VP,SP			
<i>Cratoneuron filicinum</i> (Hedw.) Spruce	VP,SP			
<i>Crenidium molluscum</i> (Hedw.) Mitt.	VP,SP			
<i>Cynodontium strumiferum</i> (Hedw.) Lindb.	SP			
<i>Desmatodon heimii</i> (Hedw.) Mitt.	VP,SP			
<i>Dicranella varia</i> (Hedw.) Schimp.	SP			
<i>Dicranum bergeri</i> Blandow	VP			
<i>Dicranum bonjeanii</i> De Not.	VP,SP			
<i>Dicranum brevifolium</i> (Lindb.) Lindb.	VP,SP			
<i>Dicranum drummondii</i> Müll.Hal.	VP			
<i>Dicranum flexicaule</i> Brid.	VP	NT		
<i>Dicranum leioneuron</i> Kindb.	VP,SP			
<i>Dicranum majus</i> Sm.	VP,SP			
<i>Dicranum montanum</i> Hedw.	VP			
var. <i>truncicolum</i> (De Not) Podp.	VP			
<i>Dicranum polysetum</i> Sw. ex anon.	VP,SP			
<i>Dicranum scoparium</i> Hedw.	VP,SP			
<i>Didymodon fallax</i> (Hedw.) R.H.Zander	VP,SP			
<i>Didymodon ferrugineus</i> (Schimp. ex Besch.) M.O.Hill	VP,SP			
<i>Didymodon rigidulus</i> Hedw.	VP,SP			
<i>Didymodon tophaceus</i> (Brid.) Lisa	VP,SP	NT		
<i>Distichium capillaceum</i> (Hedw.) Bruch & Schimp.	VP,SP			
<i>Distichium inclinatum</i> (Hedw.) Bruch & Schimp.	VP	NT		
<i>Ditrichum flexicaule</i> (Schwägr.) Hampe	VP,SP			
<i>Drepanocladus aduncus</i> (Hedw.) Warnst.	VP,SP			
var. <i>kneiffii</i> (B., S. & G.) Mönkem.	VP			
<i>Drepanocladus cossonii</i> (Schimp.) Loeske	VP,SP			
<i>Drepanocladus lycopodioides</i> (Brid.) Warnst.	VP,SP		RT	
<i>Drepanocladus sendtneri</i> (Schimp. ex H.Müll.) Warnst.	VP,SP		RT	
<i>Encalypta rhaptocarpa</i> Schwägr.	VP,SP			
<i>Encalypta streptocarpa</i> Hedw.	VP,SP			
<i>Encalypta vulgaris</i> Hedw.	SP			
<i>Eurhynchium angustirete</i> (Broth.) T.J.Kop.	VP,SP			
<i>Eurhynchium bians</i> (Hedw.) Sande Lac.	VP,SP			
<i>Eurhynchium pulchellum</i> (Hedw.) Jenn.	VP,SP			
<i>Fissidens adiantoides</i> Hedw.	VP,SP			
<i>Fissidens dubius</i> P.Beauv.	VP,SP			
var. <i>mucronatus</i> (Limpr.) Waldh.	VP			
<i>Fissidens exilis</i> Hedw.	VP	NT		
<i>Fissidens osmundoides</i> Hedw.	VP			
<i>Fissidens taxifolius</i> Hedw.	VP			
<i>Fontinalis antipyretica</i> Hedw.	VP			

Table 1 (continued)

Species name	Occurrence	Red-listed in Estonia	Red-listed in Europe	Protection category
<i>Funaria hygrometrica</i> Hedw.	VP,SP			
<i>Grimmia muehlenbeckii</i> Schimp.	VP,SP			
<i>Grimmia ovalis</i> (Hedw.) Lindb.	VP,SP			
<i>Grimmia pulvinata</i> (Hedw.) Sm.	VP			
<i>Grimmia trichophylla</i> Grev.	VP,SP			
<i>Gymnostomum aeruginosum</i> J.Sm.	VP	NT		
<i>Gymnostomum calcareum</i> Nees & Hornsch.	VP,SP			
<i>Hedwigia ciliata</i> (Hedw.) P.Beauv.	VP,SP			
<i>Hedwigia stellata</i> Hedenäs	VP	NE		
<i>Helodium blandowii</i> (F.Weber & D.Mohr.) Warnst.	VP			
<i>Herzogiella seligeri</i> (Brid.) Z.Iwats.	VP,SP			
<i>Homalia trichomanoides</i> (Hedw.) Brid.	VP,SP			
<i>Homalothecium lutescens</i> (Hedw.) H.Rob.	VP,SP,K			
<i>Homalothecium sericeum</i> (Hedw.) Schimp.	VP,SP			
<i>Hylocomium splendens</i> (Hedw.) Schimp.	VP,SP,K			
<i>Hymenostylium recurvirostrum</i> (Hedw.) Dixon	VP,SP			
<i>Hypnum cupressiforme</i> Hedw.	VP,SP,K			
var. <i>lacunosum</i> Brid.	VP,SP			
<i>Hypnum pallescens</i> (Hedw.) P.Beauv.	VP,SP			
<i>Isothecium alopecuroides</i> (Lam. ex Dubois) Isov.	VP,SP			
<i>Leptobryum pyriforme</i> (Hedw.) Wilson	VP,SP			
<i>Leucobryum glaucum</i> (Hedw.) Ångstr.	VP			III
<i>Leucodon sciurioides</i> (Hedw.) Schwägr.	VP,SP			
<i>Mnium hornum</i> Hedw.	VP,SP			
<i>Mnium stellare</i> Hedw.	VP,SP			
<i>Myurella julacea</i> (Schwägr.) Schimp.	VP,SP			
<i>Orthotrichum affine</i> Schrad. ex Brid.	SP			
<i>Orthotrichum anomalum</i> Hedw.	VP,SP			
<i>Orthotrichum pallens</i> Bruch ex Brid.	VP,SP			
<i>Orthotrichum pumilum</i> Sw. ex anon.	VP			
<i>Orthotrichum rupestre</i> Schleich. ex Schwägr.	VP,SP,K			
<i>Orthotrichum speciosum</i> Nees	VP,SP,K			
<i>Palustriella commutata</i> (Hedw.) Ochyra	VP,SP			
var. <i>falcata</i> (Brid.) Ochyra	VP			
<i>Paraleucobryum longifolium</i> (Hedw.) Loeske	VP,SP			
<i>Philonotis fontana</i> (Hedw.) Brid.	VP			
<i>Plagiomnium affine</i> (Blandow ex Funck) T.J.Kop.	VP,SP			
<i>Plagiomnium cuspidatum</i> (Hedw.) T.J.Kop.	VP,SP,K			
<i>Plagiomnium elatum</i> (Bruch & Schimp.) T.J.Kop.	VP,SP			
<i>Plagiomnium ellipticum</i> (Brid.) T.J.Kop.	VP,SP			
<i>Plagiomnium medium</i> (Bruch & Schimp.) T.J.Kop.	SP			
<i>Plagiomnium rostratum</i> (Schrad.) T.J.Kop.	VP			
<i>Plagiomnium undulatum</i> (Hedw.) T.J.Kop.	VP,SP			
<i>Plagiothecium cavifolium</i> (Brid.) Z.Iwats.	VP,SP			
<i>Plagiothecium curvifolium</i> Schlieph. ex Limpr.	VP,SP			
<i>Plagiothecium denticulatum</i> (Hedw.) Schimp.	SP			
<i>Plagiothecium laetum</i> Schimp.	VP,SP			
<i>Platygyrium repens</i> (Brid.) Schimp.	VP			
<i>Pleurozium schreberi</i> (Willd. ex Brid.) Mitt.	VP,SP			
<i>Pohlia melanodon</i> (Brid.) A.J.Shaw	VP,SP			
<i>Pohlia nutans</i> (Hedw.) Lindb.	VP,SP			
<i>Polytrichum commune</i> Hedw.	VP			
<i>Polytrichum formosum</i> Hedw.	SP			
<i>Polytrichum juniperinum</i> Hedw.	VP,SP			
<i>Polytrichum longisetum</i> Sw. ex Brid.	VP			
<i>Polytrichum strictum</i> Brid.	VP,SP			

Table 1 (continued)

Species name	Occurrence	Red-listed in Estonia	Red-listed in Europe	Protection category
<i>Pseudoleskeella nervosa</i> (Brid.) Nyholm	VP,SP,K			
<i>Pterigynandrum filiforme</i> Hedw.	VP,SP			
<i>Pylaisia polyantha</i> (Hedw.) Schimp.	VP,SP,K			
<i>Racomitrium canescens</i> (Hedw.) Brid.	VP,SP			
<i>Racomitrium heterostichum</i> (Hedw.) Brid.	VP,SP			
<i>Racomitrium lanuginosum</i> (Hedw.) Brid.	VP			
<i>Racomitrium microcarpon</i> (Hedw.) Brid.	VP,SP			
<i>Rhizomnium pseudopunctatum</i> (Bruch & Schimp.) T.J.Kop.	VP			
<i>Rhizomnium punctatum</i> (Hedw.) T.J.Kop.	VP			
<i>Rhodobryum ontariense</i> (Kindb.) Kindb.	SP			
<i>Rhodobryum roseum</i> (Hedw.) Limpr.	VP,SP,K			
<i>Rhytidiadelphus squarrosus</i> (Hedw.) Warnst.	VP,SP			
<i>Rhytidiadelphus triquetrus</i> (Hedw.) Warnst.	VP,SP			
<i>Rhytidium rugosum</i> (Hedw.) Kindb.	VP	VU		II
<i>Sanionia uncinata</i> (Hedw.) Loeske	VP,SP			
<i>Schistidium apocarpum</i> (Hedw.) Bruch & Schimp. var. <i>confertum</i> (Funck) Möll.	VP,SP VP			
<i>Schistidium confusum</i> H.H.Blom	VP,SP			
<i>Schistidium papillosum</i> Culm.	VP	NE	K	
<i>Schistidium rivulare</i> (Brid.) Podp.	VP			
<i>Schistidium trichodon</i> (Brid.) Poelt	SP		K	
<i>Scorpidium scorpioides</i> (Hedw.) Limpr.	VP,SP			
<i>Scorpidium turgescens</i> (T.Jensen) Loeske	VP,SP			
<i>Seligeria campylopada</i> Kindb.	VP	NT	K	
<i>Seligeria patula</i> (Lindb.) I.Hagen	VP	VU	K	I
<i>Seligeria pusilla</i> (Hedw.) Bruch. & Schimp.	VP	NT		
<i>Sphagnum capillifolium</i> (Ehrh.) Hedw.	VP			
<i>Sphagnum squarrosum</i> Crome	VP			
<i>Tetraphis pellucida</i> Hedw.	VP,SP			
<i>Thuidium abietinum</i> (Hedw.) Schimp.	VP,SP,K			
<i>Thuidium delicatulum</i> (Hedw.) Schimp.	VP,SP			
<i>Thuidium philibertii</i> Limpr.	VP,SP			
<i>Thuidium recognitum</i> (Hedw.) Lindb.	VP			
<i>Tomentypnum nitens</i> (Hedw.) Loeske	VP			
<i>Tortrlla fragilis</i> (Hook. & Wilson) Lindb.	VP,SP			
<i>Tortella inclinata</i> (R.Hedw.) Limpr.	SP			
<i>Tortella rigens</i> Alberts.	VP,SP	VU		II
<i>Tortella tortuosa</i> (Hedw.) Limpr.	VP,SP			
<i>Tortula muralis</i> Hedw.	VP,SP			
<i>Tortula ruraliformis</i> (Besch.) Gardot	SP			
<i>Tortula ruralis</i> (Hedw.) F.Weber & D.Mohr var. <i>calicicola</i> Barkm.	VP,SP VP,SP			
<i>Tortula subulata</i> Hedw.	VP,SP			
<i>Trichostomum crispulum</i> Bruch	VP,SP	NT		
<i>Ulotia bruchii</i> Hornsch. ex Brid.	VP			
<i>Ulotia crispa</i> (Hedw.) Brid.	VP			
<i>Ulotia curvifolia</i> (Wahlenb.) Lilj.	VP	VU		
<i>Ulotia drummondii</i> (Hook. & Grev.) Brid.	VP	VU		
<i>Warnstorfia exannulata</i> (Schimp.) Loeske	VP,SP			
<i>Warnstorfia fluitans</i> (Hedw.) Loeske	VP			
<i>Warnstorfia trichophylla</i> (Warnst.) Tuom. & T.J.Kop.	VP	NT		
<i>Warnstorfia tundrae</i> (Arnell) Loeske	VP	VU		III
<i>Weissia brachycarpa</i> (Nees & Hornsch.) Jur.	VP,SP			
<i>Weissia controversa</i> Hedw.	VP			
<i>Weissia squarrosa</i> (Nees & Hornsch.) Müll.Hal.	VP	NT	R	

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