

THE STATE OF BRYOPHYTE CONSERVATION IN ESTONIA

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Bryophyte conservation started in Estonia in 1994; currently 46 bryophyte species are listed in the three protection categories. The updated red list of Estonian bryophytes was compiled in 2008. Of the EU Habitat Directive species, 10 species are listed in Annex II, and one species and one genus in Annex V. Of these, 6 species are in a recently established monitoring program: *Buxbaumia viridis*, *Dichelyma capillaceum*, *Dicranum viride*, *Encalypta mutica*, *Hamatocaulis vernicosus* and *Tortella rigens*. The preliminary results show that three species (*B. viridis*, *D. viride* and *H. vernicosus*) have stable populations, but populations of three other species are slowly declining.

Key words: bryophytes, Estonian red list, EU Habitat Directive species, monitoring methods

INTRODUCTION

The history of bryological investigations in Estonia dates back to the 18th century and at present 583 species are recorded in the country (VELLAK *et al.* 2011). The number of species rises permanently, as within last 18 years 73 new species have been added to the bryoflora of Estonia (VELLAK and INGERPUU 2011). On the other hand, several species documented by old herbarium specimens, have not been seen and/or collected in the last 50–60 years.

The first steps of nature conservation were made in Estonia, when, back in the 13th century, rules were adopted to regulate forest harvesting. The first nature reserve in the entire Baltic Region was established in 1910 to protect nesting birds on Vaika Islands in West-Estonia. In 1936, 26 vascular plant species were declared as protected. Bryophyte conservation started in 1994 when 3 liverworts and 21 mosses were taken under state protection. Since 2004, 46 bryophyte species are recorded as protected in Estonia. In 2007 there were 407 nature conservation areas of various kinds, incl. 5 national parks, and 570 protected species in Estonia (KLEIN 2008).

Legal protection is not applicable for red-listed species in Estonia. Red lists provide information about taxa that are threatened and might (or should) be included in the lists of protected species. In 1979, the first red data book was compiled for rare and threatened species of Estonia, but bryophytes were not yet included. This book, published in 1982, was supplied with illustrations (KUMARI

1982). The first list of threatened bryophytes was compiled in 1988. This list contained 50 species in five categories of rarity and threat status. Unfortunately, this draft was never published although the lists of vascular plants and vertebrates were taken up in the red data book of the Baltic Region (INGELÖG *et al.* 1993). The first red data book also containing bryophytes (199 species) was published in 1998 (LILLELEHT 1998), an updated version was compiled in 2008 (elurikkus.ut.ee.). In 2004 Estonia became a member of the European Union and since then we have a greater level of responsibility for the preservation of species important for the whole of Europe.

The aim of the present paper is to provide an overview of the current state of bryophyte protection and bryophyte monitoring methods in Estonia with a special attention to the EU Habitat Directive species.

The nomenclature follows HILL *et al.* (2006) and SÖDERSTRÖM *et al.* (2007). Distribution maps of EU Habitat Directive (HD) species are based on data from all Estonian herbaria: University of Life Sciences (TAA), Tallinn Botanical Garden (TALL), Estonian Natural History Museum (TAM) and University of Tartu (TU).

Protected species

In 1994 a law for protection of natural objects was adopted in Estonia. Protected species lists, divided into three categories, were compiled in 1994 and 1995. These lists included 23 bryophyte species in categories II and III. An amended list of legally protected species of plants, animal and fungi was published in 2004 according to the newly adopted law of nature conservation (LOODUSKAITSESEADUS 2004). This law establishes three species protection categories as follows:

Category I: species that are rare, have restricted distribution area or isolated populations in Estonia, and species that are extremely endangered due to human activity, and their survival in nature is questionable if the threats will not be eliminated;

Category II: species that are vulnerable due to low or declining abundance since their native habitats have been destroyed or the species is overused by humans, and species that may disappear if the unfavourable conditions persist;

Category III: species that require special care and attention due to declining abundance and may be included in the endangered species list if the influence of threat factors will continue, or species that have been included in the two previous categories but are not explicitly endangered any more.

The updated list contains 46 species of bryophytes encompassing the three above categories (Table 1). The law prescribes that all known localities of the species included in Category I must be protected and a management plan should

Table 1. The list of bryophytes under State protection in Estonia in 2004 (LOODUSKAITSESEADUS 2004); HD – species that belong to the list of EU Habitat Directive (EU Habitats Directive 1992).

Category I (4)	Category II (26)	Category III (16)
<i>Buxbaumia viridis</i> HD	<i>Andreaea rupestris</i>	<i>Anastrophyllum hellerianum</i>
<i>Fissidens arnoldii</i>	<i>Anomodon rugelii</i>	<i>Antitrichia curtipendula</i>
<i>Metzgeria conjugata</i>	<i>Bartramia pomiformis</i>	<i>Bryum neodamense</i>
<i>Seligeria patula</i>	<i>Bazzania trilobata</i>	<i>Hamatocaulis vernicosus</i> HD
	<i>Brachythecium turgidum</i>	<i>Leucobryum glaucum</i> HD
	<i>Bryum marratii</i>	<i>Neckera pennata</i>
	<i>Calliergon megalophyllum</i>	<i>Rhynchostegium murale</i>
	<i>Catosciopium nigratum</i>	<i>Scapania apiculata</i>
	<i>Dichelyma capillaceum</i> HD	<i>Sphagnum lindbergii</i> HD
	<i>Dichelyma falcatum</i>	<i>Sphagnum inundatum</i> HD
	<i>Dicranum viride</i> HD	<i>Sphagnum quinquefarium</i> HD
	<i>Encalypta mutica</i> HD	<i>Sphagnum wulfianum</i> HD
	<i>Frullania tamarisci</i>	<i>Thamnobryum alopecurum</i>
	<i>Lophozia perssonii</i>	<i>Timmia megapolitana</i>
	<i>Neckera crispa</i>	<i>Tortula lingulata</i>
	<i>Octodiceras fontanum</i>	<i>Warnstorfia tundrae</i>
	<i>Palustriella decipiens</i>	
	<i>Plagiopus oederi</i>	
	<i>Plagiothecium undulatum</i>	
	<i>Porella cordaeana</i>	
	<i>Porella platyphyllum</i>	
	<i>Pterogonium gracile</i>	
	<i>Rhytidium rugosum</i>	
	<i>Saelania glaucescens</i>	
	<i>Tortella rigens</i> HD	
	<i>Tritomaria quinquedentata</i>	

be compiled for each taxon. To preserve the species in Category II and III, 50% and 10%, respectively, of the known localities must be protected. Special Species' Protection Sites can be established if new localities will be found outside of otherwise protected areas. Up to 2010, there were 1594 Species' Protection Sites established for different organisms, seven of them for bryophytes. Such sites were assigned for *Anomodon rugelii*, *Buxbaumia viridis*, *Bryum marratii*, *Encalypta*

mutica, *Hamatocaulis vernicosus* and *Tortella rigens*. The list of protected species is planned to be checked and corrected periodically. New proposals to amend and re-evaluate the species categories have been forwarded to the Ministry of the Environment in 2010.

Monitoring

The efficiency of species conservation can be evaluated only by monitoring. The monitoring of rare and endangered species started in Estonia in 1994 with the first period devoted to searching for the precise localities of rare species and checking old data of occurrence.

During this period we also developed the methodology for bryophyte monitoring and made a selection of species to focus on. The preliminary methodology was published in 2000 (KLEIN 2000) and has been updated in recent years. Twenty-six species have been selected for monitoring, 17 of these are habitat specialists, five belong to the EU Habitat Directive list, and four to the first category of legally protected species.

Each selected species is monitored at 3–5 locations, if possible. The monitoring interval for species living in stable habitats (*e.g. Leucobryum glaucum*) is 10 years, for species of unstable habitats (*e.g. Buxbaumia viridis*) 5 years. Species that are sensitive to weather fluctuation (*e.g. B. viridis*, *Dichelyma capillaceum*) and those not recorded during the regular monitoring year will be additionally monitored in the following year. Since 2007 the monitoring interval for all Habitat Directive species is 6 years. If possible, the monitoring is always carried out at the same time, when diaspores are expected to be formed. In localities with highly restricted populations, all patches are counted, measured and photographed. In localities with sparse populations but with numerous patches, a 50 m × 50 m square or round plot is established, the species are searched for a period of 2 hours and all recorded patches are measured. Suitable substrate pieces (except soil) for species growth are counted inside the plot or around the locality in case of species with restricted populations. In patches where the species are growing intermingled, the cover percentage of the target species is estimated and all co-occurring species are listed. The full area covered by the population is calculated by summing the areas of all patches. The change of the occupied area is followed up at every monitoring event. All changes in the environment (*e.g.* forest cutting, wind throw etc.) are also noted and an overall estimation of these factors is given.

EU Habitat Directive species in Estonia and their monitoring

Since the early 1990s many new localities for EU Habitat Directive species, some new species for Estonia among them, have been reported in numerous

plant inventories. Currently ten species in Annex II, *Leucobryum glaucum* and the whole genus of *Sphagnum* (38 species in Estonia) in Annex V of Habitat Directive are reported from Estonia, which is quite a large number for such a small country (45,000 sq km). Unfortunately, not all specimens are supplied with coordinates and we were unable to re-define exact localities of four Habitat Directive species (*Hamatocaulis lapponicus*, *Herzogiella turfacea*, *Meesia longiseta*, *Orthotrichum rogeri*). The monitoring sites for *Buxbaumia viridis*, *Dichelyma capillaceum*, *Dicranum viride*, *Encalypta mutica*, *Hamatocaulis vernicosus* and *Tortella rigens* have been established and the state of populations evaluated in recent years. Eleven Habitat Directive species (including four *Sphagnum* species) are part of the legally protected species list (Table 1). Management plans with the proposed monitoring scheme have been compiled for eight species in 2011.

Buxbaumia viridis has ten localities: it has disappeared from two localities, eight populations are still viable. These are situated on larger Estonian islands (Fig. 1), all in nature conservation areas. The species is monitored at three localities, with the first site established in 2004. Recent monitoring results are pleasing: both the number of occupied substrates and the number of counted sporophytes have increased at two localities, and only at one site the number of capsules has decreased (Table 2). Due to short monitoring period it is hard to say whether this population growth is a random event or a continuing trend. The species occurs in virgin western taiga (EU habitat 9020). Although the area of this forest type (2.7% of the whole Estonian territory) is a bit larger than that of the habitats of other HD species, the species apparently prefers only the maritime part of it, since the humidity is important for spore dispersal and establishment (WIKLUND 2002). *Buxbaumia viridis* is listed as vulnerable in the Estonian Red List due to diminished distribution area and its specific habitat requirements.

Dichelyma capillaceum was registered for Estonia in 1995, and afterwards identified from an older herbarium sample (KANNUKENE *et al.* 1997). This second site was checked and found to be destroyed by land melioration and currently the species is known from only a single locality in Estonia (Fig. 1). The locality is also inhabited by *Dichelyma falcatum*. In 1997, both species were taken under state monitoring at this locality. But in 2002 *D. capillaceum* was not found

Table 2. Monitoring results for *Buxbaumia viridis* at three sites on Hiiumaa island.

Year	2004/2005		2009	
Site no	No of occupied logs	No of capsules	No of occupied logs	No of capsules
1	3	41	5	54
2	1	7	9	197
3	1	27	2	5



Fig. 1. Current distribution of *Buxbaumia viridis* (triangles) and *Dichelyma capillaceum* (dots) in Estonia.

and monitoring was done only for *D. falcatum*, which showed a stable population there. In 2006, one patch with a couple of small shoots of *D. capillaceum* was registered again from one stone on the bank of the rivulet. In 2012, this boulder was overrun by water and the patch was washed off again. So, apparently the situation of this species is rather unstable. Although the locality lies in a protected area, the rivulet, where the species has been found, runs through a larger area, which may influence the habitat conditions. Small forest rivulets with naturally fluctuating water level are very rare in Estonia. Due to habitat and species rareness and vulnerability, *D. capillaceum* is included in the critically endangered species category according to the Estonian Red List.

Dicranum viride has 21 localities (Fig. 2), which are sporadically distributed in Estonia. This epiphytic species has vanished at two sites and is monitored at 4 localities. The first monitoring site was selected in 1997. Revisiting the monitored sites showed that the number of trees occupied by the species and the area of patches have increased at 3 sites and decreased at one site (Table 3). The latter was caused by natural disturbance, a tree fall, and thus the state of the species can be evaluated as good. The most characteristic habitats of *D. viride* are old broad-leaved, mainly oak forests (EU habitat 9020). In Estonia the total area of such forest cover ca 1,300 ha (ADERMANN 2009), comprising 0.03% of the state territory.



Fig. 2. Current distribution of *Dicranum viride* in Estonia.

The current occurrences of the species are all, except one, in nature conservation areas. *D. viride* is evaluated as near threatened in the Estonian Red List, due to its reduced range of distribution.

Hamatocaulis vernicosus is the most frequent species among the HD species, having 38 currently recorded localities (Fig. 3), inhabiting mainly spring fens and quagmires. It has gone extinct in 9 sites due to drainage of the habitat. The species is monitored at three localities; the first monitoring site was established in 1998. The preliminary results show that the population size is relatively stable at two localities and is declining at one site (Table 4). Although most of the present localities are, except 7, on nature conservation areas, the species is evaluated as

Table 3. Monitoring results for *Dicranum viride* at four sites in Estonia.

Year	2003		2008	
Site no	No of available trees	No of occupied trees	No of available trees	No of occupied trees
1	26	8	26	11
2	17	3	17	4
3	37	6	36	5
4	14	1	14	3

Table 4. Cover percentages for *Hamatocaulis vernicosus* (HAM) and accompanying mosses (Other) at three monitoring sites in Estonia.

Year	1998		2002		2007	
Site no	HAM	Other	HAM	Other	HAM	Other
1	35	65	30	53	5	95
2			35	78	40	65
3			20	49	15	57

near threatened in the red list of Estonia mainly due to recent loss of several localities and the vulnerability of the habitats to drainage even in a farther distance. Available habitats for the species are really limited in Estonia as shown by data of the total area of spring fens (EU habitat 7160), which is *ca* 900 ha, and of minerotrophic quagmires (EU habitat 7140), which cover *ca* 1,800 ha (PAAL and LEIBAK 2011). Altogether, these two habitat types comprise only 0.06% of the whole territory of Estonia.

Tortella rigens has 14 currently recorded localities (Fig. 4). It is monitored since 2006 at three monitoring sites. Re-monitoring data are not available yet, but preliminary observations show population decrease since it has disappeared from one locality and when collecting the species for another study, at two sites outside the monitoring plots the number of patches was fewer than before. Typical habitats of this species are alvar meadows with shallow soil (EU habitat



Fig. 3. Current distribution of *Hamatocaulis vernicosus* in Estonia.



Fig. 4. Current distribution of *Encalypta mutica* (dots) and *Tortella rigens* (triangles) in Estonia.

6280) and exposed limestones. The reason for the decline is the abandonment of the traditional land use of these meadows – grazing, which results in thickening of the sod and the land overgrowth by secondary bush vegetation. The currently recorded localities are all, except two, on nature conservation areas. The species has been evaluated as vulnerable in the Estonian red list since the total surface area of such meadows has shrunk by two third during the last 80 years (HELM *et al.* 2006) and the state of these habitats is continually getting worse.

The situation of *Encalypta mutica*, inhabiting the same habitats as *T. rigens*, is worse. It has five localities (Fig. 4), all situated on the western islands. In 2006, the species was not found at one previously known locality. Three localities were taken under monitoring. Re-monitoring data are not available yet, but it is obvious that 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 *E. mutica* at these localities. Although all localities are on nature conservation areas, *E. mutica* is evaluated as vulnerable in the Estonian red list due to its very small and declining populations.

We conclude that populations of three monitored Habitat Directive species (*B. viridis*, *D. viride*, *H. vernicosus*) are stable or even increasing, but three others are declining (*D. capillaceum*, *E. mutica*, *T. rigens*).

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