

Original research

Bryophyte diversity as an indication of habitat quality in two special areas of conservation on the outskirts of Vilnius (Verkiai Regional Park)

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Abstract

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The research results on bryophyte diversity in two special areas of conservation (Environs of Lakes Žalieji and Ežerėliai Complex) included into the Natura 2000 network and occurring on the outskirts of Vilnius are presented. The study aimed to ascertain bryophyte diversity at the studied sites. In addition, the conservation status of habitats protected under the European Union Habitats Directive in terms of bryophyte species they contain was evaluated. The research was carried out in 2019–2020 and 2022 and covered all habitat types and substrata in the territories. A total of 110 bryophyte species (11 liverworts and 99 mosses) were recorded in both studied areas. About 70% of bryophytes were recorded in one of the areas. Among 13 habitats protected under the Habitats Directive, bryophyte diversity in three of them confirmed their favourable status. Habitats with dominant deciduous trees (9020 Fennoscandian hemiboreal natural old broad-leaved deciduous forests rich in epiphytes and 9180 *Tilio-Acerion* forests of slopes, scree and ravines) distributed in the area Environs of Lakes Žalieji were characterised by a large number of epiphytes, among which there were also indicators of favourable habitat conservation status. In both habitats, *Dicranum viride* was recorded. Our research did not reveal bryophyte species indicating the favourable status of 9010 Western taiga habitats. In contrast, small areas of wetland habitats are of favourable conservation status. Three typical bryophyte species (*Hamatocaulis vernicosus*, *Sphagnum warnstorffii* and *Tomentypnum nitens*) were recorded in 7140 Transition mires and quaking bogs (the area Ežerėliai Complex). The results of our study confirm that some habitats of Vilnius outskirts, despite increased pressure of urbanisation, are still able to maintain favourable status.

Keywords: *Dicranum viride*, Habitats Directive, *Hamatocaulis vernicosus*, Natura 2000 network, woodland key habitats.

INTRODUCTION

Wild flora reflects the interaction between human impact and natural development and can therefore be used as a general indicator of the conditions of the urban environment (Sukopp & Werner, 1983). In addition, vegetation composition, structure, and cover-

age have been recognised as prime determinants of habitat quality, impacting the levels of biodiversity recorded in cities (Beninde et al., 2015).

Verkiai Regional Park is situated on the north-eastern edge of Vilnius city on the right bank of the Neris River. It occupies a 2673 ha area, which includes territories of both Vilnius city and Vilnius

district. The park was established in 1992 to protect the Lakes Žaliejai landscape and the valuable cultural complexes of Verkiiai, Kalvarijos and Trinapolis. Forests cover 76% of the park area. The forest-covered hilly area with five glacial lakes, called Lakes Žaliejai (Lith. *Žaliejai ežerai*; Eng. *Green Lakes*), is particularly valuable due to water with high content of carbonates. In addition, calcareous soils, beneficial microclimate and hilly relief ensure exceptionally rich plant diversity (Kirstukas, 2004). The park's natural values are protected within five special areas of conservation (Biomon, 2022). They are part of the Natura 2000 network of sites established throughout the European Union under the Habitats Directive. The necessary conservation measures are applied to maintain the favourable conservation status of the natural habitats and (or) the species for which the area was designated (European Commission, 2022). Two of these special areas of conservation were the focus of our research.

The special areas of conservation, i.e. Environs of Lakes Žaliejai (Lith. *Žaliųjų Ežerų apylinkės*) and Ežerėliai Complex (Lith. *Ežerėlių kompleksas*) are close to each other. They both are under intense pressure from recreational activities and urban development (Fig. 1). In the area Environs of Lakes Žaliejai (130 ha), nine habitat types and plant species *Cypripedium calceolus* L. protected under the Habitats Directive (EUNIS, 2019a) are targeted for protection. Nearly a third of the territory is covered by 3140 Hard oligo-mesotrophic waters with benthic of *Chara* spp. The inland habitats include forests, among which 9020 Fennoscandian hemiboreal natural old broad-leaved deciduous forests rich in epiphytes dominate. A large area is occupied by 9050 Fennoscandian herb-rich forests with *Picea abies*. 9010 Western taiga and 9180 *Tilio-Acerion* forests of slopes, screes and ravines are rarely distributed (Table 1). The area Ežerėliai Complex (190.8 ha) is designated for the protection of the following species: *Dytiscus latissimus* Linnaeus, 1758 (beetle), *Graphoderus bilineatus* (de Geer, 1774) (water beetle), *Leucorrhinina pectoralis* (Charpenter, 1825) (libellulid), *Triturus cristatus* (Laurenti, 1768) (reptile), plant *Thesium ebracteatum* Hayne and six habitat types protected under the Habitats Directive (EUNIS, 2019b). The prevailing habitat type is 9010 Western taiga. The area contains wetland habitats, albeit in small areas (Table 1).

No bryophyte species were targeted for protection either in the Environs of Lakes Žaliejai or in the area Ežerėliai Complex. Our survey on bryophyte diversity was the first carried out at these sites and in Verkiiai Regional Park. The urban bryophyte flora is significant not only for its floristic composition,

Table 1. Distribution and occupied area of the habitats protected under the Habitats Directive in special areas of conservation, the Environs of Lakes Žaliejai and Ežerėliai Complex

Habitat type code	Habitat type	Area (ha)		Number of bryophyte species
		Environs of Lakes Žaliejai	Ežerėliai Complex	
3140	Hard oligo-mesotrophic waters with benthic vegetation of <i>Chara</i> spp.	40.3	0	0
3150	Natural eutrophic lakes with <i>Magnopotamion</i> or <i>Hydrocharition</i> -type vegetation	14.0	0	1
6270	Fennoscandian lowland species-rich dry to mesic grasslands	0.8	0	1
6510	Lowland hay meadows (<i>Alopecurus pratensis</i> , <i>Sanguisorba officinalis</i>)	0	8.8	1
7110	Active raised bogs	0	0.3	0
7140	Transition mires and quaking bogs	0	0.6	22
9010	Western taiga	17.1	98.2	26
9020	Fennoscandian hemiboreal natural old broad-leaved deciduous forests (<i>Quercus</i> , <i>Tilia</i> , <i>Acer</i> , <i>Fraxinus</i> or <i>Ulmus</i>) rich in epiphytes	32.9	0	33
9050	Fennoscandian herb-rich forests with <i>Picea abies</i>	13.9	10.2	39
9060	Coniferous forests on, or connected to, glaciofluvial eskers	1.5	0	10
9080	Fennoscandian deciduous swamp woods	10.0	0	0
9180	<i>Tilio-Acerion</i> forests of slopes, screes and ravines	7.7	0	25
91E0	Alluvial forests with <i>Alnus glutinosa</i> and <i>Fraxinus excelsior</i> (<i>Alno-Padion</i> , <i>Alnion incanae</i> , <i>Salicion albae</i>)	0	2.5	2

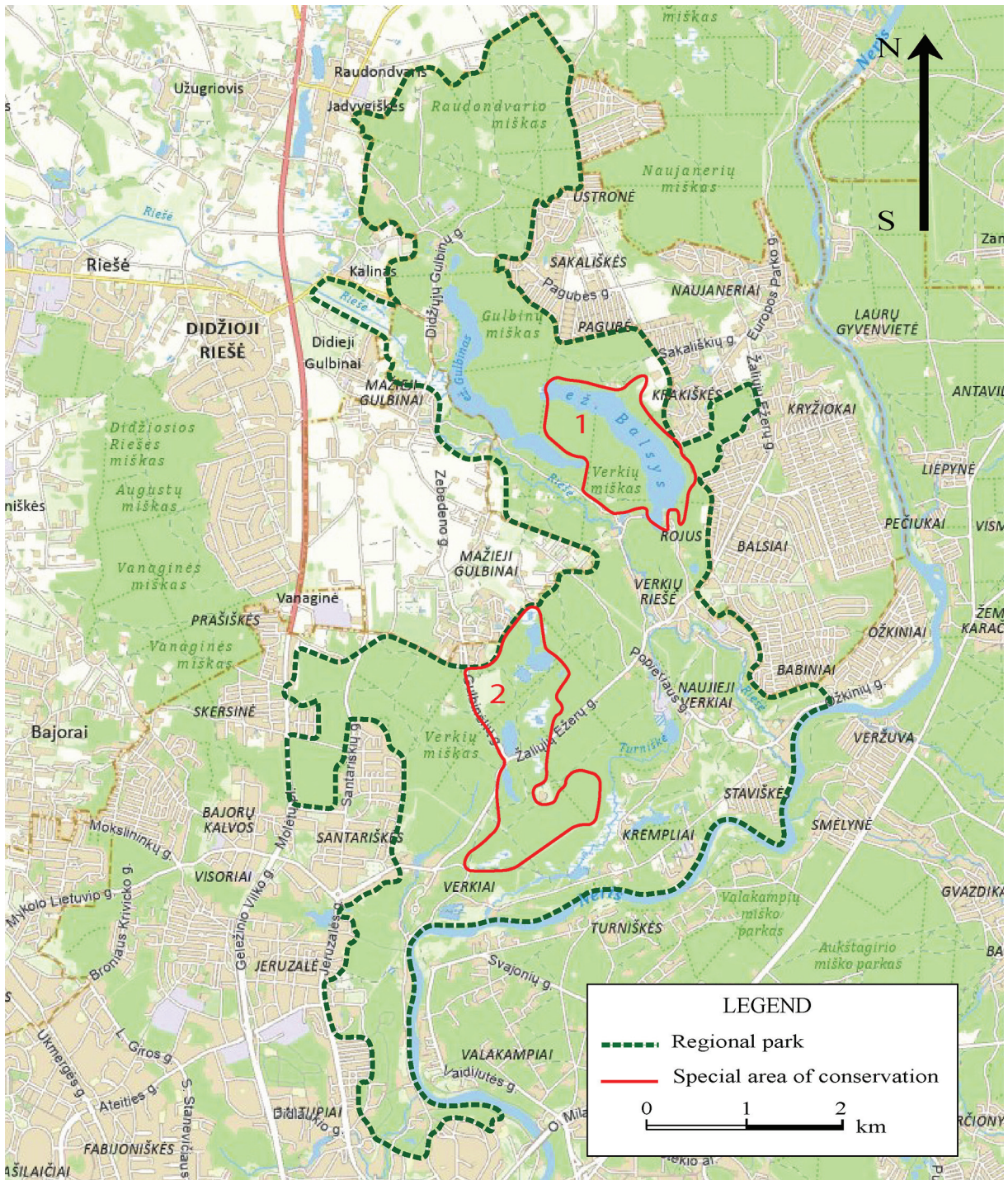


Fig. 1. Special areas of conservation in Verkių Regional Park (1 – Environs of Lakes Žaliejai, 2 – Ežerėliai Complex)

but also for the presence of rare and important taxa (Saboljėvić & Grdović, 2009).

The present study aimed to ascertain bryophyte diversity and conservation value at the studied sites.

In addition to the main goal, it was also essential to determine the status of the habitats protected under the Habitats Directive regarding the bryophyte species they contain.

MATERIALS AND METHODS

The research was carried out in 2019–2020 and 2022. It was provided in 30 randomly selected study points (30 m radius) that covered all habitat types of the territories and all substrata within them. Additionally, bryophyte species were registered in specific bryophyte habitats and substrata not covered by the main research: solitary deciduous trees, lakeshores, concrete constructions, exposed soil near forest roads, etc. Substrata were placed into the following categories: trees, decaying wood, stones, concrete constructions and soil (exposed or with grass cover).

Distribution of the data on habitats protected under the Habitats Directive, registered at the sites, was obtained from maps in the Spatial Information Portal of Lithuania (Geoportal, 2022), in which the information on the results of the nationwide inventory of natural habitats is provided. Typical species that represent favourable conservation status of the habitats were followed by Čiuplys et al. (2012) and Matulevičiūtė et al. (2012).

Unidentified in the field species were collected for identification in the laboratory. Approximately 250 specimens of bryophytes were collected in both areas. Voucher specimens were deposited at the Herbarium of the Institute of Botany of the Nature Research Centre (BILAS).

Special attention was paid to the population status of species protected according to the Habitats Directive (Council of the European Communities, 1992). When *Dicranum viride* was recorded, in the plot of a 30 m radius, host trees with the species and potential host trees were counted. The population size was evaluated on 1–3 host trees. We measured the highest and the lowest tree trunk height at which *Dicranum viride* was found. Additionally, the distribution area (the area of the trunk with the cushions of *Dicranum viride* (cm²) and summarised coverage of the species (cm²) was estimated.

Vegetation description based on the Braun-Blanquet (1964) scale was performed in the total area of species distribution to ascertain the population status of *Hamatocaulis vernicosus*. Total coverage (%) of *Hamatocaulis vernicosus* was estimated.

The species were identified after Damsholt (2002), Hallingbäck et al. (2006, 2008), Hedenäs et al. (2014), Ignatov & Ignatova (2003, 2004),

Jukonienė (2003), Lüth (2019a, b, c), Naujalis et al. (1995), Paton (1999), Smith (1978, 1990). Bryophyte species names followed Hodgetts et al. (2020), while those of vascular plants – World checklist of vascular plants (2021).

RESULTS

Characteristics of bryophyte diversity

A total of 110 bryophyte species (11 liverworts and 99 mosses) were recorded in both studied areas (Table 2).

The number of species in each territory was as follows: 61 species (5 liverworts and 56 mosses) were recorded in the area Environs of Lakes Žalieji, and 79 species (6 liverworts and 72 mosses) in the area Ežerėliai Complex (Table 1). The territories shared 31 (28%) bryophyte species. These species occurred mostly in pine or spruce forest habitats (*Dicranum polysetum*, *Dicranum scoparium*, *Plagiochila asplenoides*, *Plagiomnium affine*, *Pleurozium schreberi*) or they were usual epixylic (*Lophocolea heterophylla*, *Lepidozia reptans*, *Tetraphis pellucida*) or epiphytic (*Dicranum montanum*, *Hypnum cupressiforme*, *Radula complanata*) species.

About 70% of bryophytes were recorded in only one of the sites. The dominant habitats determined the difference. The area Environs of Lakes Žalieji was distinguished by a large number of epiphytes: 14 bryophyte species that occurred on trunks of broad-leaved trees are specific to the site. On the other hand, species occupying the shrinking shores of small lakes (*Riccia cavernosa* and *Riccia fluitans*) and transitional mires (*Hamatocaulis vernicosus*, *Tomentypnum nitens*, *Straminergon stramineum*, *Sphagnum teres*, *Sphagnum warnstorffii*) give exclusivity for bryophyte diversity of the area Ežerėliai Complex.

Bryophyte diversity in protected habitats

Among 13 habitats protected under the Habitats Directive, typical bryophyte species were ascertained in five of them. Although at both sites, a similar number of bryophyte species were established for 9010 Western taiga habitats, none of these typical bryophyte species of the habitat were recorded.

Rhodobryum roseum and *Cirriphyllum piliferum*,

Table 2. List of bryophyte species recorded in the Environs of Lakes Žaliejai (1) and Ežerėliai Complex (2). Abbreviations: cc – concrete constructions, dw – dead wood, es – exposed soil, s – soil overgrown with grasses, st – stones, tr – trunks of trees

Species	Area	Habitat type	Substrata
Liverworts			
<i>Blepharostoma trichophyllum</i> (L.) Dumort.	2	9050	dw
<i>Cephaloziella hampeana</i> (Nees) Schiffn. ex Loeske	2	9010	es
<i>Lepidozia reptans</i> (L.) Dumort.	1	9050	dw
<i>Lophocolea heterophylla</i> (Schrad.) Dumort.	1	9010, 9050	dw, es
	2	9010, 9050	dw, es
<i>Metzgeria furcata</i> (L.) Corda	1	9020, 9050, 9180	tr
<i>Nowellia curvifolia</i> (Dicks.) Mitt.	2	9010	dw
<i>Plagiochila asplenioides</i> (L.) Dumort.	1	9050	s
	2	9050	s
<i>Ptilidium ciliare</i> (L.) Hampe	2	9010	es
<i>Radula complanata</i> (L.) Dumort.	1	9020, 9050, 9180	tr
	2	9050	tr
<i>Riccia fluitans</i> L.	2		s
<i>Riccia cavernosa</i> Hoffm.	2		s
Mosses			
<i>Abietinella abietina</i> (Hedw.) M. Fleisch.	1		es
	2		es
<i>Alleniella complanata</i> (Hedw.) S.Olsson, Enroth & D.Quandt	1	9020	tr
<i>Amblystegium serpens</i> (Hedw.) Schimp.	1		es
<i>Anomodon longifolius</i> (Schleich. ex Brid.) Hartm.	1	9020, 9050, 9180	tr
<i>Anomodon viticulosus</i> (Hedw.) Hook. & Taylor	1	9020, 9180	tr
<i>Atrichum tenellum</i> (Röhl.) Bruch & Schimp.	2	9050	es
<i>Atrichum undulatum</i> (Hedw.) P.Beauv.	1	9050	es
	2	9050	es
<i>Aulacomnium palustre</i> (Hedw.) Schwägr.	2	7140	s
<i>Barbula unguiculata</i> Hedw.	1	9050	es
	2	9010	es
<i>Brachytheciastrum velutinum</i> (Hedw.) Ignatov & Huttunen	1	9020	
<i>Brachythecium albicans</i> (Hedw.) Schimp.	1		es
	2		es
<i>Brachythecium rivulare</i> Schimp.	1		dw
	2	7140, 9010	cc, s
<i>Brachythecium rutabulum</i> (Hedw.) Schimp.	2	9050	dw, tr
<i>Brachythecium salebrosum</i> (Hoffm. ex F.Weber et D.Mohr) Schimp.	1	6270, 9020, 9050, 9180	dw, s, tr
	2	6510	s
<i>Bryum argenteum</i> Hedw.	2		cc
<i>Calliergon cordifolium</i> (Hedw.) Kindb.	2	7140, 91E0	s
<i>Calliergon giganteum</i> (Schimp.) Kindb.	2	7140	s
<i>Calliergonella cuspidata</i> (Hedw.) Loeske	2	7140	s
<i>Campylophyllopsis sommerfeltii</i> (Myrin) Ochyra	1	9020	es, tr
<i>Ceratodon purpureus</i> (Hedw.) Brid.	1	9010, 9060	es
	2	9010	es
<i>Cirriphyllum piliferum</i> (Hedw.) Grout	2	9050	s
<i>Climacium dendroides</i> (Hedw.) F.Weber & D.Mohr	2	7140, 9010, 91E0	cc, dw, s
<i>Dicranella heteromalla</i> (Hedw.) Schimp.	2	9010	es
<i>Dicranum montanum</i> Hedw.	1	9010, 9020, 9050, 9060, 9180	dw, tr
	2	9010, 9050	dw, tr

Species	Area	Habitat type	Substrata
<i>Dicranum polysetum</i> Sw.	1	9010, 9060	s
	2	9010	s
<i>Dicranum scoparium</i> Hedw.	1	9010, 9020, 9050, 9060	dw, s, tr
	2	9010, 9050	dw, s, tr
<i>Dicranum viride</i> (Sull. & Lesq.) Lindb.	1	9020, 9180	tr
<i>Encalypta streptocarpa</i> Hedw.	1		es
<i>Eurhynchium angustirete</i> (Broth.) T.J.Kop.	1	9010, 9020, 9050, 9180	s
	2	9050	s
<i>Fontinalis antipyretica</i> Hedw.	2	3150	s
<i>Funaria hygrometrica</i> Hedw.	2		es
<i>Hamatocaulis vernicosus</i> (Mitt.) Hedenäs	2	7140	
<i>Herzogiella seligeri</i> (Brid.) Z.Iwats.	2	9050	dw
<i>Homalia trichomanoides</i> (Hedw.) Brid.	1	9020, 9050, 9180	s, tr
<i>Homalothecium sericeum</i> (Hedw.) Schimp.	1	9020, 9180	tr
<i>Hygroamblystegium varium</i> (Hedw.) Mönk	1		s
<i>Hylocomiadelphus triquetrus</i> (Hedw.) Ochyra & Stebel	1	9050	s
	2	9050	s
<i>Hylocomium splendens</i> (Hedw.) Schimp.	1	9010, 9020, 9050, 9060	dw, s, tr
	2	9010, 9050	dw, s, tr
<i>Hypnum cupressiforme</i> Hedw.	1	9010, 9020, 9050, 9180	dw, s, st, tr
	2	9010, 9050	cc, dw, s, tr
<i>Isothecium alopecuroides</i> (Lam. ex Dubois.) Isov.	1	9020	tr
<i>Jochenia pallescens</i> (Hedw.) Hedenäs, Schlesak & D.Quandt	1	9020, 9180	dw, tr
	2	9050	dw
<i>Leptodictyum riparium</i> (Hedw.) Warnst.	2		dw, s
<i>Leucodon sciuroides</i> (Hedw.) Schwägr.	1	9020, 9180	tr
<i>Lewinskya affinis</i> (Schr. ex Brid.) F.Lara, Garilleti & Goffinet	2		st
<i>Lewinskya speciosa</i> (Nees) F.Lara, Garilleti & Goffinet	1	9020, 9050, 9180	tr
	2		tr
<i>Neckera pennata</i> Hedw.	1	9020	tr
<i>Oxyrhynchium hians</i> (Hedw.) Loeske	1	9020	es
	2	9050	s
<i>Oxyrhynchium schleicheri</i> (R. Hedw.) Röhl	1	9180	tr
<i>Plagiomnium affine</i> (Blandow) T.J.Kop.	1	9010, 9050	s
	2	9050	s
<i>Plagiomnium cuspidatum</i> (Hedw.) T.J.Kop.	1	9010, 9020, 9050, 9180	dw, s, tr
	2	9050	cc, dw, s, tr
<i>Plagiomnium ellipticum</i> (Brid.) T.J.Kop.	2	7140	s
<i>Plagiomnium rostratum</i> (Schr.) T.J.Kop.	1	9020, 9050	dw, s
<i>Plagiomnium undulatum</i> (Hedw.) T.J. Kop.	2		cc
<i>Plagiothecium cavifolium</i> (Brid.) Z.Iwats.	1	9180	tr
<i>Plagiothecium curvifolium</i> Schlieph. ex Limpr.	1	9010, 9180	s
<i>Plagiothecium laetum</i> Schimp.	1	9010, 9050	tr
	2	9050	tr
<i>Platygyrium repens</i> (Brid.) Schimp.	2		st
<i>Pleuridium subulatum</i> (Hedw.) Rabenh.	2		es
<i>Pleurozium schreberi</i> (Willd. ex Brid.) Mitt.	1	7140, 9010, 9020, 9050, 9060, 9180	dw, s, tr
	2	9010, 9050	dw, s

Species	Area	Habitat type	Substrata
<i>Pohlia nutans</i> (Hedw.) Lindb.	1	9010, 9020, 9050, 9060, 9180	dw, es, s, tr
	2	9010, 9050	dw, es, s
<i>Polytrichum commune</i> Hedw.	2	9010	s
<i>Polytrichum formosum</i> Hedw.	2	9050	s
<i>Polytrichum juniperinum</i> Hedw.	1	9010, 9060	s
	2	9010	es
<i>Polytrichum piliferum</i> Hedw.	1		es
	2		es
<i>Polytrichum strictum</i> Menzies ex Brid.	2	7140	s
<i>Pseudanomodon attenuatus</i> (Hedw.) Ignatov & Fedosov	1	9020	tr
<i>Pseudoamblystegium subtile</i> (Hedw.) Vanderp. & Hedenäs	1	9020, 9180	tr
<i>Pseudoleskeella nervosa</i> (Brid.) Nyholm	1	9020, 9050, 9180	tr
	2		tr
<i>Ptilium crista-castrensis</i> (Hedw.) De Not.	1	9010	s
	2	9010	s
<i>Ptychostomum capillare</i> (Hedw.) Holyoak & N.Pedersen	1	9180	s
<i>Ptychostomum moravicum</i> (Podp.) Ros & Mazimpaka	1	9180	es, dw
<i>Ptychostomum pseudotriquetrum</i> (Hedw.) J.R.Spence & H.P.Ramsay ex Holyoak & N.Pedersen	1	7140	s
<i>Pylaisia polyantha</i> (Hedw.) Schimp.	1	9020	tr
	2		tr
<i>Racomitrium canescens</i> (Hedw.) Brid.	1		es
	2		es
<i>Rhizomnium punctatum</i> (Hedw.) T.J.Kop.	1	9050	dw
<i>Rhodobryum roseum</i> (Hedw.) Limpr.	2	9050	s
<i>Rhytidiadelphus squarrosus</i> (Hedw.) Warnst.	2	9050	s
<i>Sarmentypnum exannulatum</i> (Schimp.) Hedenäs	2		s
<i>Schistidium apocarpum</i> (Hedw.) Bruch & Schimp.	2	9010	cc, st
<i>Sciuro-hypnum oedipodium</i> (Mitt.) Ignatov et Huttunen	2	9050, 9060	s, tr
<i>Sciuro-hypnum populeum</i> (Hedw.) Ignatov & Huttunen	2		cc
<i>Sciuro-hypnum reflexum</i> (Starke) Ignatov et Huttunen	2	9050	dw
<i>Sphagnum divinum</i> Flatberg & Hassel	2	7140	s
<i>Sphagnum angustifolium</i> (C.E.O.Jensen ex Russow) C.E.O.Jensen	2	7140	s
<i>Sphagnum fallax</i> (H.Klinggr.) H.Klinggr.	2	7140	s
<i>Sphagnum fuscum</i> (Schimp.) H.Klinggr.	2	7140	s
<i>Sphagnum palustre</i> L.	2	7140	s
<i>Sphagnum papillosum</i> Lindb.	2	7140	s
<i>Sphagnum rubellum</i> Wilson	2	7140	s
<i>Sphagnum russowii</i> Warnst.	2	7140	s
<i>Sphagnum teres</i> (Schimp.) Ångstr.	2	7140	s
<i>Sphagnum warnstorffii</i> Russow	2	7140	s
<i>Straminergon stramineum</i> (Dicks. et Brid.) Hedenäs	2	7140	s
<i>Tetraphis pellucida</i> Hedw.	1	9010, 9050, 9060	dw
	2	9050	dw
<i>Thuidium assimile</i> (Mitt.) A.Jaeger	1	9020, 9050, 9180	s, tr
<i>Thuidium delicatulum</i> (Hedw.) Schimp.	1		es
<i>Thuidium recognitum</i> (Hedw.) Lindb.	1	9020	tr
<i>Tortella tortuosa</i> (Hedw.) Limpr.	1		es
<i>Ulota crispa</i> (Hedw.) Brid.	1	9020	tr

typical species of the habitat 9050 Fennoscandian herb-rich forests with *Picea abies*, were found not abundantly growing in the area Ežerėliai Complex. Especially rich in bryophyte species, including typical, were 9020 Fennoscandian hemiboreal natural old broad-leaved deciduous forests rich in epiphytes and 9180 *Tilio-Acerion* forests of slopes, screes and ravines in the area Environs of Lakes Žalieji. All typical for the habitats, five bryophyte species (*Alleniella complanata*, *Anomodon viticulosus*, *Metzgeria furcata*, *Neckera pennata* and *Pseudanomodon attenuatus*) were epiphytes.

Among ten bryophyte species recorded in 7140 Transition mires and quaking bogs in the area Ežerėliai Complex, three species (*Hamatocaulis vernicosus*, *Sphagnum warnstorffii* and *Tomentypnum nitens*) were typical to the habitat. Eleven bryophyte species were recorded in the area, in which 7110 Active raised bog habitats were mapped. Meanwhile, in addition to characteristic bryophyte species of this habitat *Sphagnum divinum*, *Sphagnum fallax*, *Sphagnum fuscum* and *Sphagnum rubellum*, species characteristic of 7140 Transition mires and quaking bogs (*Calliergon cordifolium*, *Calliergonella cuspidata* and *Sphagnum teres*) were recorded in the area.

Bryophyte species protected under the Habitats Directive and the status of their populations

Two bryophyte species protected under the Habitats Directive (Council of the European Communities, 1992) were recorded: *Dicranum viride* (the area Environs of Lakes Žalieji) and *Hamatocaulis vernicosus* (the area Ežerėliai Complex).

Dicranum viride was recorded in two study plots (Fig. 2), which covered two habitat types: 9020 Fennoscandian hemiboreal natural old broad-leaved deciduous forests rich in epiphytes and 9180 *Tilio-Acerion* forests of slopes, screes and ravines. *Dicranum viride* grew on oak trunks (1 tree) and lime (5 trees). However, only a solitary, small cushion of *Dicranum viride* was recorded on oak, while on lime trees, it was quite abundantly distributed (Table 3).

Hamatocaulis vernicosus was recorded at the southern part of the area Ežerėliai Complex in the transitional mire of the lakeshore (Fig. 3). The species was dominant in moss cover in an area of 6 m². The accompanying species were *Sphagnum teres*, *Sphagnum warnstorffii*, *Straminergon stramineum* and *Tomentypnum nitens*. The main area of *Hamatocaulis vernicosus* distribution was surrounded by the

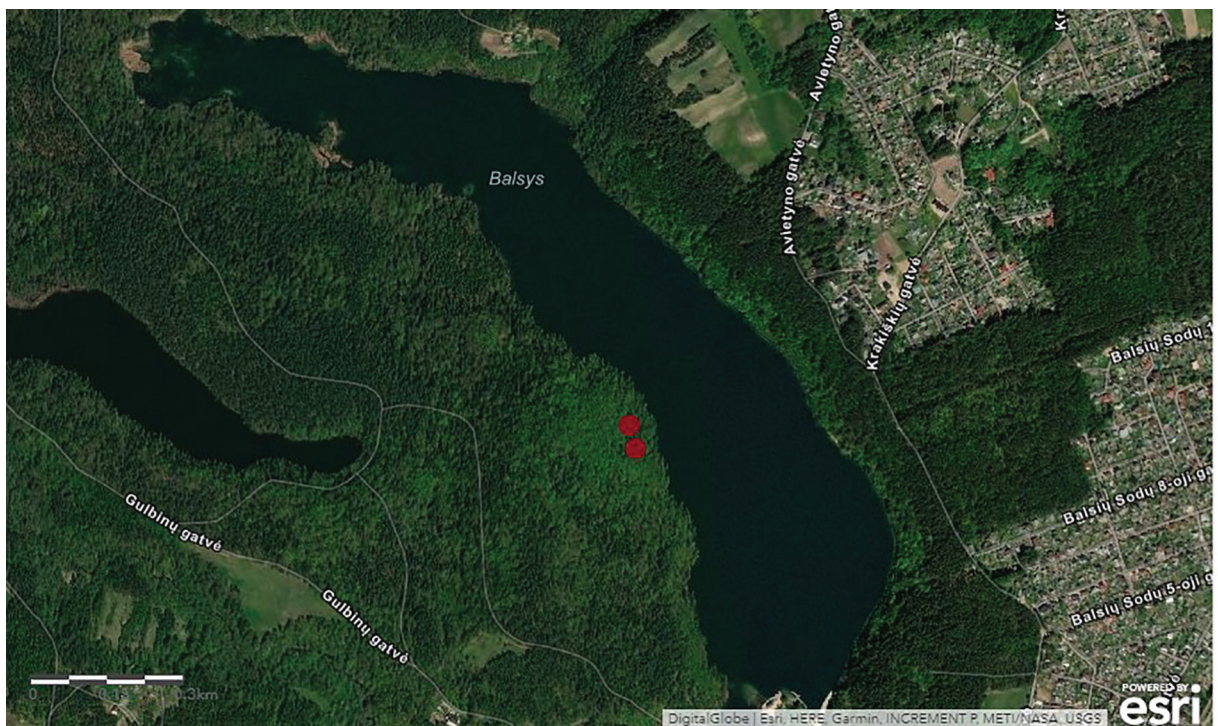


Fig. 2. Distribution of *Dicranum viride* in the area Environs of Lakes Žalieji (Verkių Regional Park)

Table 3. Characteristics of *Dicranum viride* population in the area Environs of Lakes Žalieji (Verkiai Regional Park)

Study plots (number of trees with <i>Dicranum viride</i>)	1 (1,0)	2 (5,17)		
Habitat type	9020	9180		
Number of studied host trees	1	1	2	3
Host tree	Oak	Lime	Lime	Lime
Height of the occurrence of <i>Dicranum viride</i> on a tree trunk (m)	1.5	0.8–1.8	1–1.5	0.5–1.4
Distribution area (the area of the trunk with the cushions of <i>Dicranum viride</i> (cm ²))	1	1000	100	2700
Coverage (cm ²)	1	14	2	4

Fig. 3. Distribution of *Hamatocaulis vernicosus* in the area Ežerėliai Complex (Verkiai Regional Park)

areas dominated by lawns of *Sphagnum teres*, interspersed with scattered shoots of *Hamatocaulis vernicosus*. The dominant vascular plant species were *Carex rostrata* Stokes and *Menyanthes trifoliata* L.

DISCUSSION

Our research revealed that the studied areas of the Natura 2000 network harbour diverse bryoflora, reflecting the quality of the habitats the species survive. Therefore, it is irrelevant that the conservation objectives of the studied sites were directed to the protection of other groups of organisms.

As it was mentioned above, 13 habitats protected

under the Habitats Directive occurred in the studied territories.

Regarding bryophyte diversity, particularly stand-out forest habitats with dominant deciduous trees assigned to two habitat types of European importance, 9020 Fennoscandian hemiboreal natural broad-leaved deciduous forests rich in epiphytes and 9180 *Tilio-Acerion* forests of slopes, screes and ravines, were distributed in the area Environs of Lakes Žalieji. A large number of epiphytic species reflects the high quality of the habitats. This means that their structure ensures the richness of host trees (oaks, maples, limes, aspens) as substrates necessary for establishing these species and microclimate

favourable for their survival. Furthermore, the surrounding two lakes enhance the wet microclimate. It is essential to notice that *Isothecium alopecuroides* and typical for these habitats *Alleniella complanata*, *Anomodon viticulosus*, *Metzgeria furcata*, *Neckera pennata* and *Pseudoanomodon attenuatus*, are also treated as indicators of woodland key habitats (Andersson & Kriukelis, 2004). Next to all, *Dicranum viride*, protected by the Bern Convention (Council of Europe, 1979), also included in Annex II of the Habitats Directive, was recorded in both habitats. In Lithuania, where *Dicranum viride* is known in several localities (Jukonienė, 2007, 2015), it is an endangered (Įsakymas, 2020) and strictly protected species (Įsakymas, 2010). *Dicranum viride* is sciophylous species requiring a dry microclimate. The threats to its populations include both clear-cutting and excessive thinning of trees, limiting potential host tree occurrence (Jukonienė, 2015).

Historical data (Mowszowicz, 1938) show that for the first time, the species was mentioned in Lithuania from Vilnius surroundings, but in the southern part. Therefore, the rediscovery of this species confirms that in Vilnius's outskirts, this area can still maintain a high quality of biodiversity despite the increased pressure of urbanisation.

The habitats dominated by deciduous trees are distributed in the Environs of Lakes Žalieji, covering about 65% of inland territory. At the same time, most of the area of Ežerėliai Complex is occupied by 9010 Western taiga habitats. Our research did not reveal bryophyte species indicating the favourable status of this habitat in both territories. The relatively young age of the stands, absence or a small amount of deadwood, and anthropogenic activity (recreation, tree cutting) determine the low conservation value of this habitat type at both sites concerning bryophyte diversity. Neither bryophyte species diversity nor an adequate amount of deadwood was observed in the studied territories. Following these criteria, such habitats of the researched sites, at best, can be seen as potential 9010 Western taiga habitats.

Mire habitats are scarce in the studied territories. Meanwhile, a small area of one lake shore occupies 7140 transition mires and quaking bogs of high conservation value. They harbour three typical bryophyte species of the habitat, including *Hamatocaulis vernicosus*. Like *Dicranum viride*, the spe-

cies is included in the list of bryophytes protected by the Bern Convention (Council of Europe, 1979) and in Annex II of the Habitats Directive (1992). In Lithuania, *Hamatocaulis vernicosus* is quite widely distributed (Jukonienė, 2007, 2015). Meanwhile, due to the destruction of the habitats during the 20th century (Kalvaitienė & Jukonienė, 2022) and changes in their quality, *Hamatocaulis vernicosus* is attributed to vulnerable (Įsakymas, 2020) and strictly protected species (Įsakymas, 2010). So, we agree with Noreika et al. (2015) that urban mires can be considered urban biodiversity hotspots, and their protection should be secured in urban development.

Regarding bryophyte diversity, two special areas of conservation in the outskirts of Vilnius are valuable territories for their protection. To date, sliding urbanisation from nearby surroundings can lead to changes in habitats that have retained their natural structure. So, researching the biodiversity of various taxonomic groups would provide a basis for monitoring other processes.

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