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NEW DATA ON BRYOPHYTE DISTRIBUTION IN THE PENEDA-GERÊS NATIONAL PARK (NW PORTUGAL): THE USE OF GIS FOR CONSERVATION REMARKS

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Abstract: Peneda-Gerês National Park is a nature reserve in North-western Portugal. This is an important protected area due to the diversity of habitats, within which the bryophyte flora is particularly rich. Recent field work provided an updated distribution of bryophytes, including those with conservation status, and added new species to this area. Additionally, we provide potential areas of occurrence for threatened/rare bryophyte species using Geographical Information Systems (GIS) and present the possible relationships between environmental variables and bryophyte distribution data.

INTRODUCTION

Peneda-Gerês National Park (PNPG) is a nature reserve located in North-western Portugal (figure 1). This territory belongs to two different provinces –Minho (Mi) and Trás-os-Montes e Alto Douro (TM)– and has an area of approximately 70.000 hectares. Due to its location, PNPG is close to the transition between the Mediterranean and Eurosiberian Regions, and therefore it has a remarkable climatic diversity, with annual average temperatures ranging from 10º C to 16º C and an annual rainfall of 1.600-3.000 mm. Consisting of a mountainous complex, this area shows a high altitude variation, between 50 and 1.545 m. As most of the North-western territories of Portugal, it is dominated by granitic rocks (Honrado, 2003). In addition, this Park is an important floristic and phytogeographic area. Climactic vegetation of the area consists of *Quercus robur* L. and *Q. pyrenaica* L. oaklands and their presence in the form of well preserved pure and mixed woodlands is important to bryophytic vegetation growth and development. Bogs, mires, streams and rocky outcrops are also relevant habitats for bryophytes present in this area.

Until 1950 this Park was the object of some botanical and bryological investigations (Sá Nogueira, 1950; Tavares & Tavares, 1950), but its total area was only sufficiently explored afterwards. Further work (Sérgio & Schumacker, 1992) increased the number of taxa recorded to 285 species, about half of the Portuguese bryophyte taxa known. Information from recent field work (2000-2003) was used to present an updated list of the bryophyte distribution. This effort also provided a better knowledge of the ecology and general present status of the bryoflora.

Figure 1. Peneda-Gerês National Park. Geographic situation.

Additionally, environmental parameters related to the presence of bryophytes were selected in order to model potential distribution areas of selected species, in particular those of threatened/rare bryophytes. Discussion of the importance of GIS systems and the use of the Overlap Analysis technique in understanding the distribution patterns of species is presented, as well as their importance to determine potential areas of occurrence for conservation purposes. Furthermore, new data on the distribution of threatened/ rare bryophytes and the distribution of ten species which are recorded for the PNPG area for the first time is included.

Figure 2. Peneda-Gerês National Park. Surveyed squares representation.

METHODS

The species data

The species data was obtained from herbarium, literature references and field work performed during 2000-2003. Species occurrence was recorded in a UTM grid (1x1 km) and stored in a GIS system (ArView-ArcMap 8.1®). 130 UTM squares were sampled during last field work (figure 2).

This data was used to produce species distribution maps, with a special emphasis on threatened/rare taxa. Two of these species, *Hylocomium splendens* and *Trichocolea tomentella*, were selected to perform Overlap Analysis technique, as examples of its use for conservation remarks.

The nomenclature is according to Sérgio & Carvalho (2003) and the authors of species names as proposed by Brummit & Powell (1992).

Environmental Data

Five environmental variables –temperature, precipitation, insolation, humidity and frost– were selected for analysis. Digital information on the climate parameters was available on-line in the page www.iambiente.pt/atlasdoambiente. A digital cartography of natural habitats (unpublished data), particularly information regarding natural woodlands distribution, was also used.

Overlap Analysis

The nature of the data largely determined the use of the Overlap Analysis technique as only species presence was available. This technique does not require species absence data and combines environmental variables with species presence points, eliminating the variables that do not explain the presence of species (Brito *et al.*, 1999). Selected climate information was integrated into a Geographical Information System (GIS) and overlaid with species presence points. After that, classes of variables where reclassified using Spatial Analyst (Spatial Analyst extension for ArcView-ArcMAP 8.1® ESRI): presence was scored as 1 and absence as 0, resulting in presence/ absence areas. Subsequently, all the selected climatic variables were multiplied in order to produce potential distribution maps. To perform a more accurate discussion and analysis of the potential distribution areas, the final maps were overlapped with the layer of natural woodlands, as these seem important habitats for the distribution of the selected taxa.

RESULTS

The bryophyte flora of the PNPG

Recent field work (2000-2003) provided an updated distribution of bryophytes, confirmed old records and added 10 new species to this area. Localities for these new species in the Park are presented in Appendix I and the new localities for the threatened/rare bryophytes are listed in Appendix II.

From the 316 taxa recorded for this area, 77 species are listed as threatened in Portugal (Sérgio *et al.*, 1994) and 11 are considered threatened in Europe (ECCB, 1995) (table 1). Of the 77 threatened taxa, 11 are endemic to Europe and one –*Racomitrium lusitanicum* Ochyra & Sérgio– is endemic to Iberian Peninsula (Sérgio *et al.*, 1994). From the non-threatened species in Portugal only *Racomitrium lamprocarpum* (Müll. Hal.) A. Jaeger is included in the Red List of Europe (ECCB, 1995).

Table 1. Threatened bryophytes in PNPG. * Endemic to Europe including Macaronesia; ** Iberian endemics. Status in Portugal (**P**) and Iberian Peninsula (**IP**), after Sérgio *et al*. (1994); Status in Europe (**E**), after ECCB (1995). **B**: Bibliographic references; **H**: Herbarium specimens (Herbarium specimens in column "*Records > 1950*" were collected during the period 2000-2003). **HABITAT**: **A**, Freshwater habitats; **B**, Bogs; **C**, Rocky Habitats; **D**, Wet heaths; **E**, Forests; **F**, Anthropogenic environments. **SUBSTRATE**: **a**, on soil; **b**, on peat; **c**, on rock; **d**, on bark.

SPECIES	STATUS			RECORDS <1950		RECORDS > 1950		HABITAT	SUBSTRATE
	P	IP	E	B	H	B	H		
BRYOPHYTA									
Amphidium mougeotii (Bruch & Schimp.) Schimp.	R	N	NT	3	1	4	3	A	c
Andreaea heinemannii Hampe & Müll. Hal. subsp. *crassifolia* (Luisier) Sérgio)	R	N	R			1	2	C	c
Andreaea megistospora B. M. Murray	R	R	R	1		9	7	C	c
Andreaea rupestris Hedw.	R	N	NT	1	1	2	1	C	c
Anomobryum julaceum (P. Gaertn., B. Mey. & Scherb.) Schimp.	R	R	NT	3		1	4	F	a, c
Bartramia ithyphylla Brid.	R	N	NT	1				F	a, c
Brachythecium campestre (Müll. Hal.) Schimp.	R	R	NT	1		1		F	a, c
Brachythecium glareosum (Spruce) Schimp.	R	N	NT			1		E	a, c
Brachythecium mildeanum (Schimp.) Milde	R	R	NT			1		E	a
Bryum muehlenbeckii Bruch & Schimp.	V	R	NT			1		A	a, c
**Bryum platyloma* Schwägr.	R	N	T	1				E	c
Buckiella undulata (Hedw.) Ireland	R	N	NT	1		4	2	E	a
Campylostelium strictum Solms	R	R	V			1		C	c
Cyclodictyon laetevirens (Hook. & Taylor) Mitt.	Ex	V	R		1			A	c
Cynodontium polycarpon (Hedw.) Schimp.	Ex	R	NT	1				C	c
Dicranum tauricum Sapjegin	V	N	NT			1		E	d
Entosthodon obtusus (Hedw.) Lindb.	R	R	NT	1				D	a
Fissidens rivularis Bruch & Schimp.	R	R	NT	1			1	A	c
Grimmia hartmanii Schimp.	R	N	NT	1				C	c
**Grimmia lisae* De Not.	R	R	R		1		1	A	c
Habrodon perpusillus (De Not.) Lindb.	R	N	NT			1	1	E	d
Hylocomium brevirostre (Brid.) Schimp.	Ex	N	NT		1			E	a,c
Hylocomium splendens (Hedw.) Schimp.	R	N	NT	3			2	E	a
Hypnum imponens Hedw.	R	R	NT		1			D	a
Mnium stellare Hedw.	V	N	NT				1	F	a
Philonotis caespitosa Jur.	R	N	NT	1	1		2	A	c
Plagiothecium succulentum (Wilson) Lindb.	R	N	NT		1	1	14	A	c
Pogonatum urnigerum (Hedw.) P. Beauv.	Ex	N	NT		2			C	c
Pohlia bulbifera (Warnst.) Warnst.	R	R	NT			1		D	a
Pohlia longicollis (Hedw.) Lindb.	E	E	NT	1				F	a

Pohlia nutans (Hedw.) Lindb.	R	N	NT	1				C	a
Polytrichum alpinum Hedw.	R	N	NT	2				C	c
**_Racomitrium lusitanicum_ Ochyra & Sérgio	R	R	R			7	1	A	c
Racomitrium sudeticum (Funck) Bruch & Schimp.	R	N	NT	3				C	c
Rhizomnium magnifolium (Horik.) T. J. Kop.	V	E	NT	1				A	a
Schistidium apocarpum (Hedw.) Bruch & Schimp.	R	N	NT				2	F	c
Schistostega pennata (Hedw.) F. Web. & D. Mohr	R	V	NT			1	2	C	c
Sphagnum capillifolium (Ehrh.) Hedw.	R	N	NT	3	1	4	3	B	b
Sphagnum cuspidatum Hoffm.	V	R	NT			2	1	B	b
Sphagnum palustre L.	R	N	NT	2		3		B	b
Syntrichia latifolia (Bruch ex Hartm.) Huebener	R	N	NT			1		E	d
Syntrichia papillosa (Wilson) Jur.	R	N	NT	1				E	d
*_Ulota bruchii_ Brid.	R	N	NT	3	3	1	2	E	d
Ulota hutchinsiae (Sm.) Hammar	V	N	NT	2	1			C	c
Zygodon conoideus (Dicks.) Hook. & Taylor	E	E	NT			1		E	d
MARCHANTIOPHYTA									
Barbilophozia hatcheri (A. Evans) Loeske	R	N	NT			1		D	a, c
Calypogeia muelleriana (Schiffn.) Müll. Frib.	V	N	NT	4				D	a, c
Cephalozia connivens (Dicks.) Lindb.	V	V	NT	1				B	b
Cephaloziella rubella (Nees) Warnst.	R	R	NT			3		D	a
Chiloscyphus pallescens (Ehrh. ex Hoffm.) Dumort.	R	R	NT		1	1		A	a,c
Douinia ovata (Dicks.) H. Buch	R	N	NT	3	2	4	2	E	d
Dumortiera hirsuta (Sw.) Nees	E	N	R	2		2	3	A	c
Frullania oakesiana Austin	V	V	E			1		E	d
Gymnocolea inflata (Huds.) Dumort.	R	R	NT			1		C	a
*_Gymnomitrion crenulatum_ Gottsche ex Carrington	V	R	NT	6		2		C	c
Gymnomitrion obtusum Lindb.	V	N	NT	7		2	1	C	c
Harpalejeunea molleri (Steph.) Grolle	R	N	NT	1	2	3		E	d
Jungermannia hyalina Lyell	R	N	NT	2		3	3	A	c
Jungermannia pumila With.	V	N	NT	1	2	2		A	c
Jungermannia sphaerocarpa Hook.	R	N	NT			1		A	a,c
Kurzia pauciflora (Dicks.) Grolle	R	R	NT			1	1	B	b
*_Lejeunea lamacerina_ (Steph.) Schiffn.	R	R	NT			3	4	E	c,d
Lejeunea patens Lindb.	R	N	NT	4		2		E	c,d
Lepidozia reptans (L.) Dumort.	V	N	NT	1		1		E	c
Lophozia longiflora (Nees) Schiffn.	E	N	NT			1		E	d
*_Marsupella profunda_ Lindb.	R	R	V			1		C	c
Nardia compressa (Hook.) Gray	R	N	NT	2	1	5	13	A	c
Pellia endiviifolia (Dicks.) Dumort.	V	N	NT	1			2	A	c

**Plagiochila bifaria* (Sw.) Lindbenb.	R	N	NT	1	1			A	a,c
Plagiochila porelloides (Torrey ex Nees) Lindenb.	V	N	NT		1	3		A	c
**Plagiochila punctata* (Taylor) Taylor	R	R	NT		2			A	c
Porella cordaeana (Huebener) Moore	R	N	NT			3		E	c,d
**Radula holtii* Spruce	E	V	R	1	1		3	A	c
Riccardia latifrons (Lindb.) Lindb.	E	R	NT		1			A	a
**Saccogyna viticulosa* (L.) Dumort.	R	N	NT	4	3	2	9	A	c
Telaranea nematodes (Gottsche ex Austin) M. Howe	Ex	V	NT	1				B	b
Trichocolea tomentella (Ehrh.) Dumort.	E	N	NT	5		2	3	A	c

Figure 3 shows the preferential habitats of the threatened/rare species in PNPG. About 32% are associated with freshwater habitats, 22% are epiphytes, 22% are related with rocky habitats and 10% are present in wet heaths. Bogs and anthropogenic environments have the smallest proportion, 7% each, of the bryophytes included in the Portuguese Red List (Sérgio *et al.*, 1994).

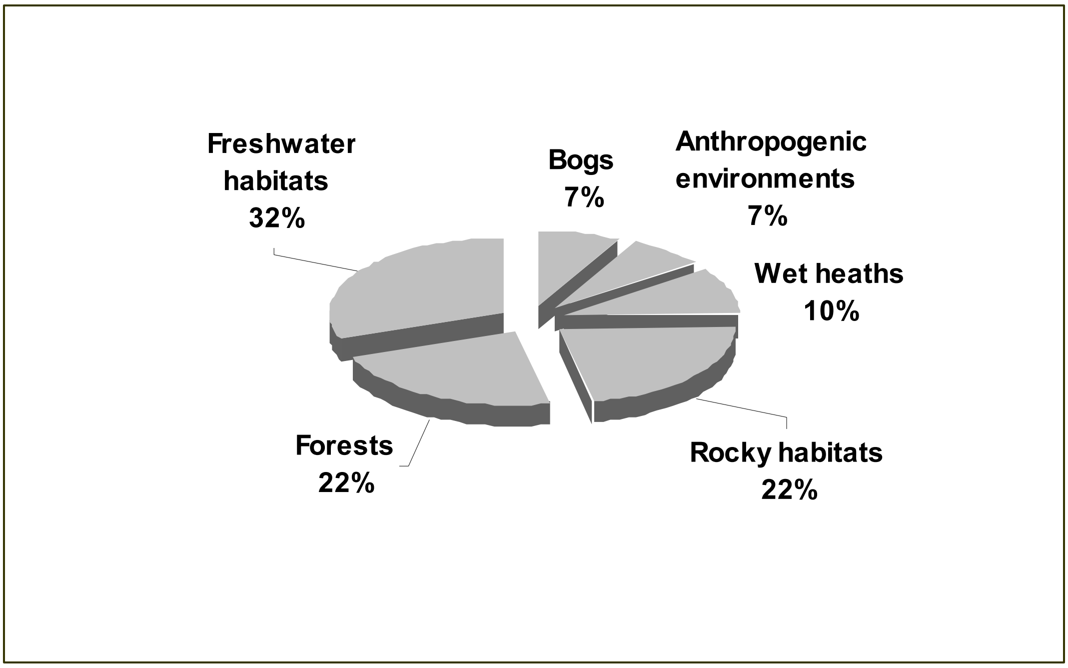

Figure 3. Percentage of threatened bryophytes to each habitat type in PNPG

Estimation of potential distribution areas

The use of GIS combined with the new data on bryophyte distribution allowed the identification of areas with high and low number of red-listed species (figure 4) that, when overlapped with natural woodlands patches present in PNPG, helped to support some previous assumptions.

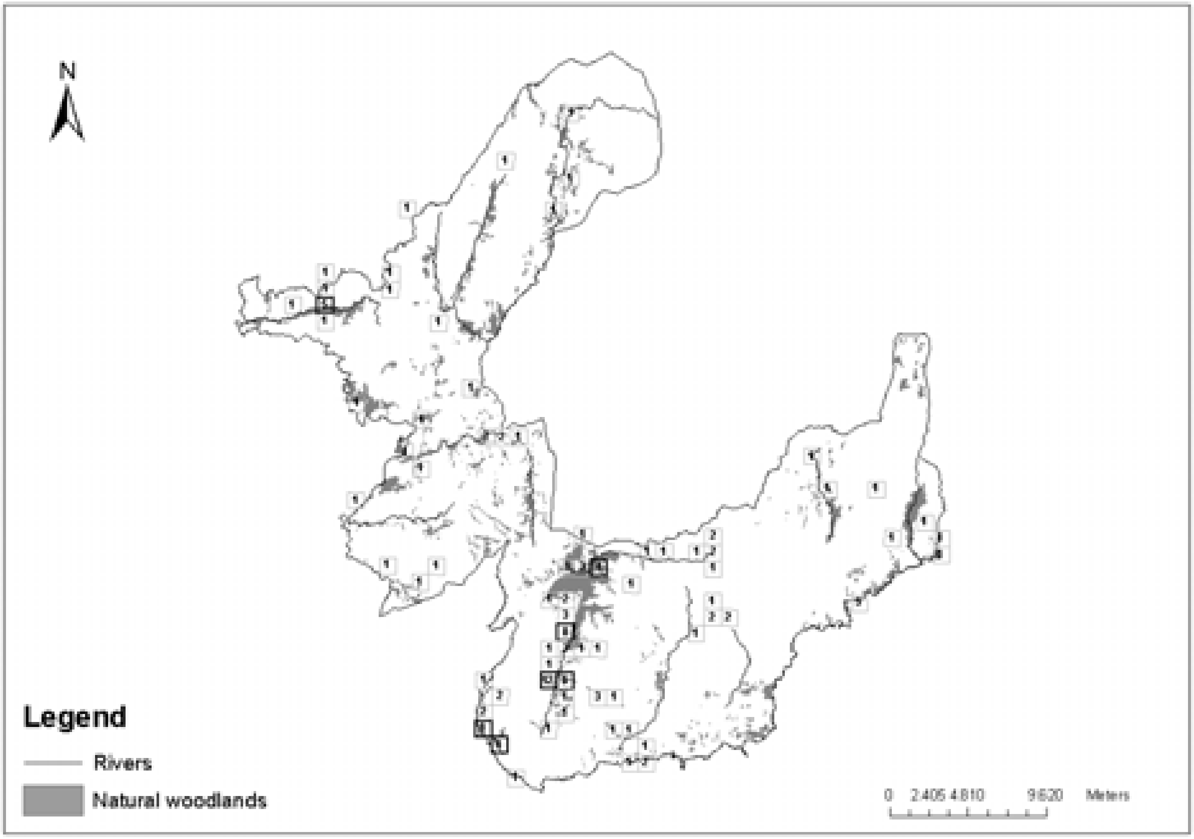

Figure 4. Hot spots of richness in threatened bryophytes in PNPG. Number of threatened bryophytes per surveyed squares between 2000-2003.

Using the methodological principles of Overlap Analysis and GIS techniques it was possible to relate the distribution of species with some environmental factors. In the case of *H. splendens*, the overlapping of temperature, precipitation, insolation, humidity and frost layers with distribution points, showed that all these environmental variables had some relation with the presence of this species and, therefore, no variable was eliminated from the analysis. When using the same method for *T. tomentella* only one variable (temperature), revealed to be uninformative, as the presence points overlapped all the classes of that variable and thus, it was eliminated from the analysis.

In figures 5 and 6 we present presence/absence areas for the two taxa in PNPG in relation to each environmental variable. The final potential areas of occurrence for these taxa are presented in figures 7 and 8, as well as their overlap with the natural woodlands patches in PNPG.

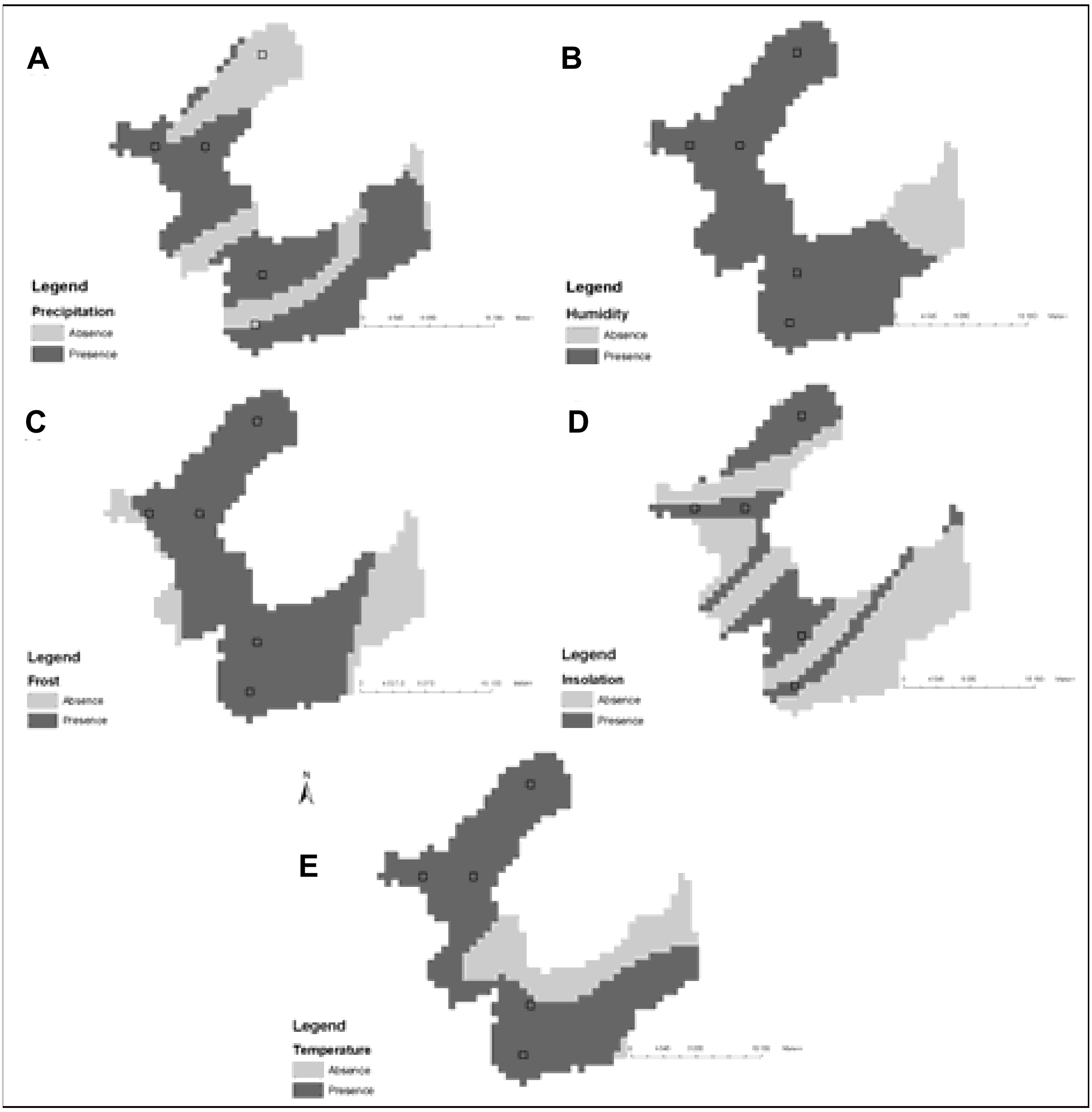

Figure 5. Distribution of *Hylocomium splendens* and its presence/absence areas in PNPG in relation to each environmental variable.

DISCUSSION

The bryophyte flora of the PNPG

The current conservation status of bryophyte species in PNPG is still difficult to establish, as it would require the assessment of generally used population biology parameters that are essential to classify bryophyte taxa, according to widely used conservation criteria (Hallingbäck *et al*., 1998). This approach was not possible due the lack of detailed information about species locations in early collections, preventing a possible evaluation of conservation status within a time frame. Nevertheless, the information obtained by this study can be used as a starting point for future evaluations of the bryoflora status in PNPG.

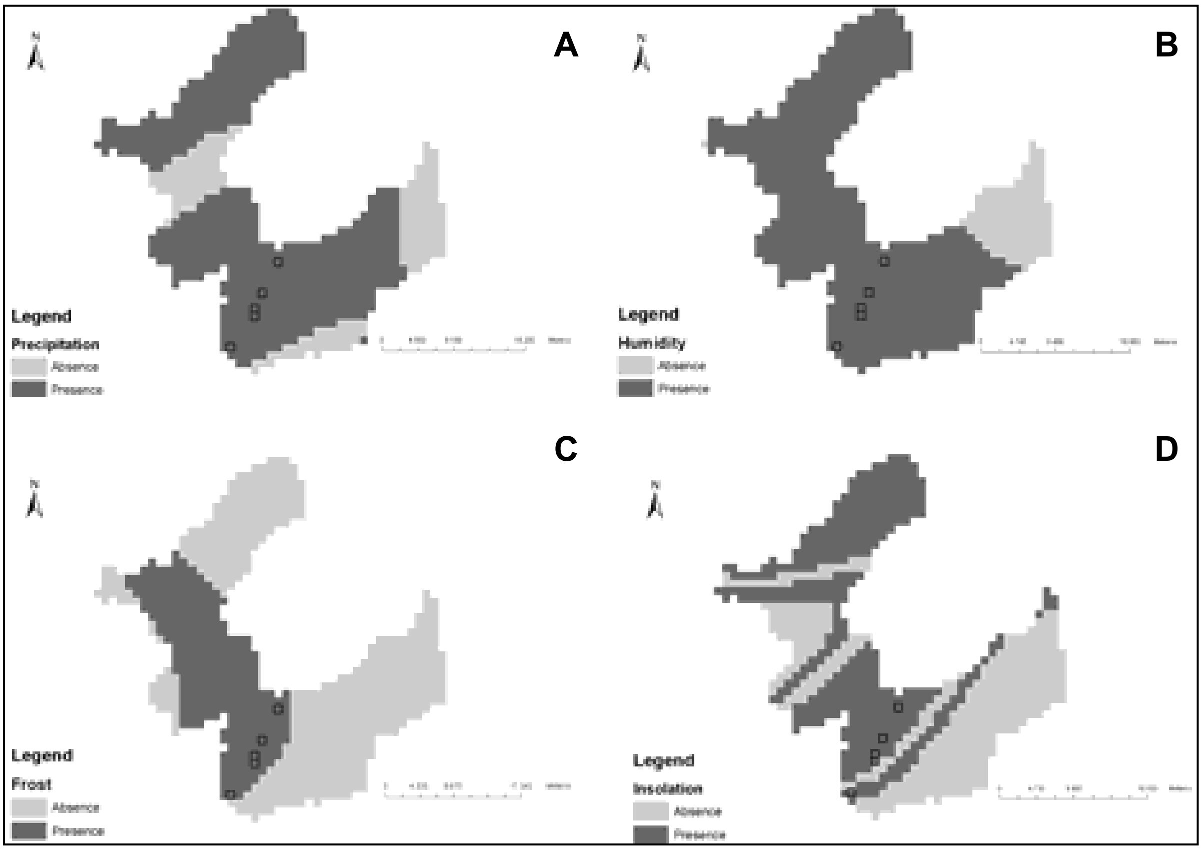

Figure 6. Distribution of *Trichocolea tomentella* and its presence/absence areas in PNPG in relation to each environmental variable.

This recent field work expanded significantly the PNPG sampled area, when comparing with the surveyed area before 2000. As a result, new species were added, the number of species occurrences increased and some species considered extinct in PNPG such as *Radula holtii* Spuce and *Cinclidotus fontinaloides* (Hedw.) P. Beauv. were found again (Vieira *et al*., 2004). However, a considerable number of threatened bryophytes could not be registered or collected. Therefore, new efforts are needed to continue exploring this area, as new sites suitable for these bryophytes may still be discovered. Moreover, some of the considered threatened/rare taxa may be more frequent than evaluated presently.

Freshwater habitats, as well as forests and rocky habitats, have the largest proportion of red listed species (Sérgio *et al*., 1994), when compared to other habitat types in the studied area. The best explanation for this is that PNPG is an area where natural woodlands in sheltered and humid valleys occur, working as privileged areas for bryophyte diversity. Furthermore, this area presents a large extension of rock formations and a well preserved and extensive network of streams and rivers. Wet heaths, bogs and anthropogenic environments have the lowest proportion of threatened bryophytes. Bogs and wet heaths do not occupy a vast extension and, on the other hand, these habitats are more similar to those in other European areas. Consequently, the number of endemics and red listed species (Sérgio *et al.*, 1994) is not as high as for other habitat types. In contrast to these habitats, anthropogenic environments occupy a vast extension and the high disturbance in these environments only allows the establishment of common taxa.

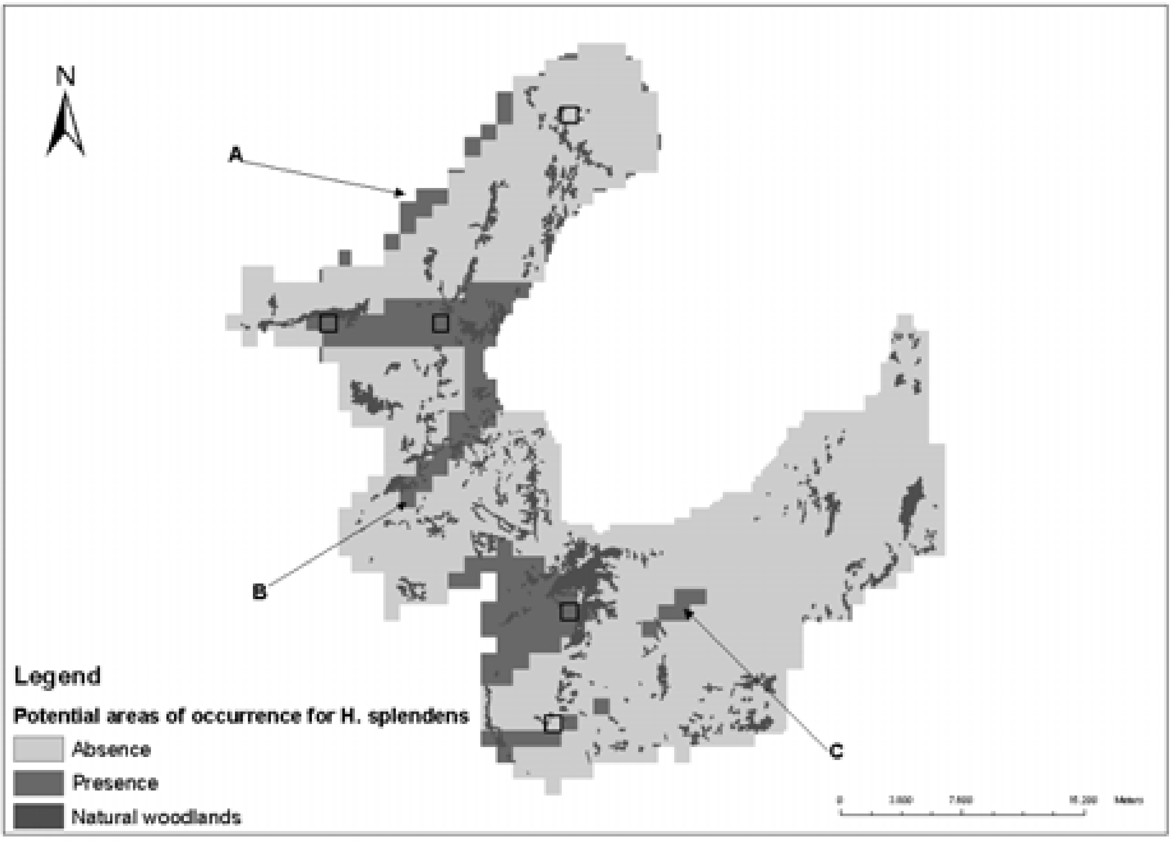

Figure 7. Representation of the potential areas of occurrence for H*ylocomium splendens* and the natural woodlands patches in PNPG - the marked areas (A, B, C) are the new potential areas (see text for discussion).

Estimation of potential distribution areas

The calculation of the bryological richness of threatened bryophytes per each surveyed square was a very useful tool to identify potential sites of high interest of conservation. In fact, it was possible to define hot spots of richness in threatened bryophytes that mostly were located in natural woodlands and surrounded by intermediate richness areas (Figure 4).

From the maps showing the presence points of species overlapped with the environmental layers (figures 5 and 6) it was possible to infer some remarks about the relation between environmental variables and presence of a species. If, in these maps, all but the lower classes of a variable have presence points this should be interpreted as a positive relation of a species with that variable; on the contrary, presence points absent from the higher classes of a variable should mean that a species has a negative relation with that variable (Brito *et al.*, 1999). Taking these observations into consideration, both the bryophytes *H. splendens* and *T. tomentella* reveal a positive relation with precipitation and humidity and a negative relation with insolation and frost. Moreover, *H. splendens* has a positive relation with temperature.

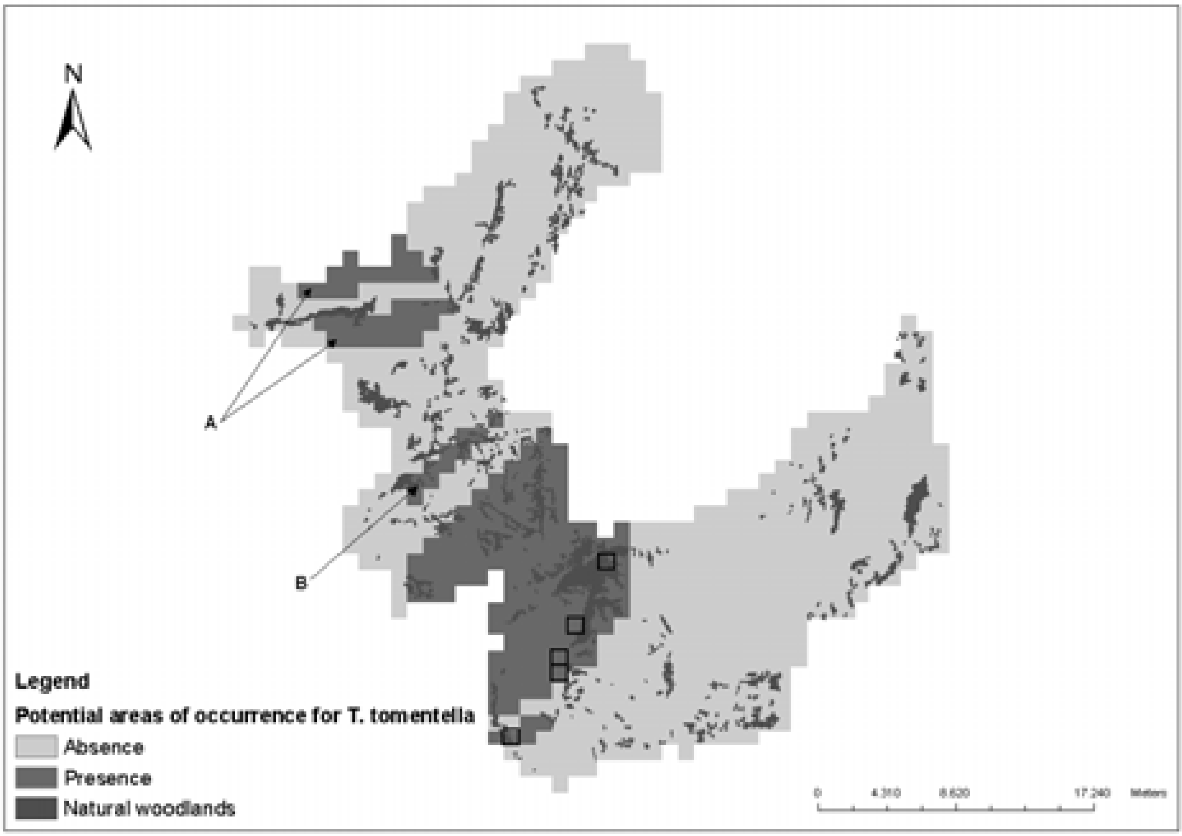

Figure 8. Representation of the potential areas of occurrence for *Trichocolea tomentella* and the natural woodlands patches in PNPG - the marked areas (A, B) are the new potential areas (see text for discussion).

When analysing the maps presenting the potential areas of occurrence for the two species some problems become obvious. The distribution model of *Hylocomium splendens* (figure 7) is not perfectly reliable, since it displays a potential absence area where this species was collected. Therefore, the model may not be suitable to estimate a potential area of occurrence in this case. Sampling error could be an explanation; however, we believe that this is not the case. Another possible interpretation is that one of the environmental variables has no influence in the distribution of this *taxon,* thus introducing "noise" to the final model. Most of the areas of potential occurrence exhibited in the model of *H. splendens* are coincident with areas with known presence points and three new potential areas (A, B and C – figure 7) are presented, that do not coincide with areas with occurrence points. In PNPG, *H. splendens* is found in humid slopes within woodlands, but the overlap of its potential areas with natural woodlands patches is not complete, as some potential areas of occurrence are in the surroundings of natural woodlands while others are far apart (figure 7). With such an analysis, we can not consider satisfactory results the potential areas that are apart from presently known natural woodlands. These results could reflect the species presence in stands of woodlands that no longer exist or in particular habitats that simulate ecological conditions found within woodlands.

Regarding the distribution model of *Trichocolea tomentella* (figure 8) a large potential area is coincident with areas with known presence points and two new areas of potential occurrence (A and B – figure 8) are presented. The map showing the overlap of the potential areas with natural woodlands patches (figure 8) indicates that all the potential areas presented are near natural woodlands formations, which reveals that this habitat type is possibly related with the presence of this *taxon*. In fact, the bryophyte *T. tomentella* grows best in dripping rocky slopes within natural woodlands. However, it may have additional ecological requirements that pre-vent its establishment in the potential areas shown by the model.

To validate these results, the potential areas presented for the two species should be subjected to further field work in order to confirm or not their presence in areas not coincident with their known presence. Additionally, this field work could also confirm the absence of these species in the potential areas, as the Overlap Analysis technique is known to overestimate these areas (Brito *et al.*, 1999).

CONCLUSIONS

The number of new records and additions of localities for a reasonable number of species provides evidence of the progress of the PNPG bryoflora knowledge. However, further investigation is needed to confirm the status of threatened/rare species at population level and also to prove the presence of species that remain to be found, as otherwise they should be considered extinct.

The use of GIS for identifying hot spots of richness in threatened bryophytes proved to be helpful in providing information on species habitat and ecological preferences and detecting sites that may require special protection.

The Overlap Analysis is a very simple technique that was used given the low number of presence points for each threatened bryophyte. After examining the results conclusions are:

1. The simple overlapping of all environmental layers with the presence points of a species is a procedure that can generate errors, like those in *H. splendens* distribution model. Before using all the variables available it is advisable to verify the influence of each variable on the species distribution by the use of statistical methods, as only the variables with significant influence on the distribution should be used. In this case, only previous knowledge about the ecological requirements that affect the distribution of bryophytes

could be used, due to the low number of records for threatened species which would cause a low fitness of the statistical methods.

2. The applied technique only presents as results potential areas of occurrence. To better interpret the final results, statistical methods should have been used to produce potential distribution maps expressing occurrence probabilities.
3. To validate the potential areas of occurrence, reliable presence/absence data should have been used. Most of the techniques used to produce potential distribution maps apply this kind of data, but the sampling was not conducted to provide such information.
4. To improve this technique or to apply other methods, more detailed environmental layers or new variables should be produced, because bryophytes are influenced by micro-conditions that are beyond the resolution of the layers available.

The use of Overlap Analysis technique and the use of GIS provided means to display and analyze layers of environmental variables with species presence and were useful in giving suggestions for identifying the location of threatened species. However, precautions must be taken while using the Overlap Analysis technique as a decisive tool in future conservation plans, given that potential areas of occurrence may be overestimated. Therefore, other techniques that can present more accurate results should be applied to predict the distribution of bryophytes (Guisan & Zimmermann, 2000).

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APPENDIX I

Localities of the new bryophyte species for PNPG. The species marked with ▲ are new to the region of Portugal presented.

BRYOPHYTA

▲***Archidium alternifolium* (Hedw.) Mitt.**, TM: NG8018.

▲***Mnium stellare* Hedw.**, Mi: NG6920.

***Orthotrichum diaphanum* Brid.**, Mi: NG7055.

***Schistidium apocarpum* (Hedw.) Bruch & Schimp.**, Mi: NG6920.

▲***Warnstorfia exannulata* (Schimp.) Loeske**, TM: NG9030, NG9230.

MARCHANTIOPHYTA

***Lophocolea heterophylla* (Schrad.) Dumort.**, Mi: NG6520.

▲***Riccia bicarinata* Lindb.**, TM: NG8018.

***Riccia macrocarpa* Levier**, TM: NG8018.

***Riccia sorocarpa* Bisch.**, Mi: NG6518.

***Tritomaria quinquedentata* (Huds.) H. Buch**, Mi: NG7023; TM: NG8825

APPENDIX II

New localities for the threatened bryophytes present in PNPG. Bryophyte species are listed by threat categories, according to Sérgio *et al*. (1994).

Endangered (E) species

MARCHANTIOPHYTA

***Dumortiera hirsuta* (Sw.) Nees**, Mi: NG6517, NG7020, NG7023.

***Radula holtii* Spruce**, Mi: NG6517, Mi: NG6616, NG6920.

***Trichocolea tomentella* (Ehrh.) Dumort.**, Mi: NG6616, NG7023, NG7227.

Rare (R) species

MARCHANTIOPHYTA

***Douinia ovata* (Dicks.) H. Buch**, Mi: NG7023, NG7122.

***Jungermannia hyalina* Lyell**, Mi: NG6949, NG7022, NG7417.

***Kurzia pauciflora* (Dicks.) Grolle**, TM: NG7924.

***Lejeunea lamacerina* (Steph.) Schiffn.**, Mi: NG6517, NG6518, NG7022, NG7023.

***Nardia compressa* (Hook.) Gray**, Mi: NG5343, NG5543, NG5544, NG5545, NG7023, NG7025, NG7219, NG7528, NG7823; TM: NG7828, NG7925, NG7928, NG8024.

***Saccogyna viticulosa* (L.) Dumort.**, Mi: NG6517, NG6616, NG6735, NG7023, NG7027, NG7127, NG7515, NG7516; TM: NG8825.

<u>BRYOPHYTA</u>

***Amphidium mougeotii* (Bruch & Schimp.) Schimp.**, Mi: NG7023, NG7227, NG7628.

***Andreaea heinemannii* Hampe & Müll. Hal. subsp. *crassifolia* (Luisier) Sérgio**, Mi: NG5945; TM: NG9230.

***Andreaea megistospora* B. M. Murray**, Mi: NG5543, NG6223, NG7020, NG7051; TM: NG7924, NG8024, NG8632.

***Andreaea rupestris* Hedw.**, Mi: NG7022.

***Anomobryum julaceum* (P. Gaertn., B. Mey. & Scherb.) Schimp.**, Mi: NG6535, NG6635, NG6714, NG6920.

***Buckiella undulata* (Hedw.) Ireland**, Mi: NG5543, NG6126.

***Fissidens rivularis* Bruch & Schimp.**, Mi: NG6517.

***Grimmia lisae* De Not.**, Mi: NG6616.

***Habrodon perpusillus* (De Not.) Lindb.**, Mi: NG6920.

***Hylocomium splendens* (Hedw.) Schimp.**, Mi: NG5542, NG6242.

***Philonotis caespitosa* Jur.**, Mi: NG5731, NG6136.

***Plagiothecium succulentum* (Wilson) Lindb.**, Mi: NG6146.

***Racomitrium lusitanicum* Ochyra & Sérgio**, Mi: NG7227; TM: NG7929.

***Schistidium apocarpum* (Hedw.) Bruch & Schimp.**, Mi: NG6535, NG6920.

***Schistostega pennata* (Hedw.) F. Web. & D. Mohr**, Mi: NG5737, NG5927.

***Sphagnum capillifolium* (Ehrh.) Hedw.**, Mi: NG7025, NG7129; TM: NG8932.

***Ulota bruchii* Brid.**, Mi: NG5543, NG5944.

Vulnerable (V) species

<u>MARCHANTIOPHYTA</u>

***Gymnomitrion obtusum* Lindb.**, Mi: NG7020.

***Pellia endiviifolia* (Dicks.) Dumort.**, Mi: NG6517, NG6536.

<u>BRYOPHYTA</u>

***Mnium stellare* Hedw.**, Mi: NG6920.

***Sphagnum cuspidatum* Hoffm.**, TM: NG9029.