Daniel Spitale

The bryophytes of the spruce forests of South Tyrol: species list, distribution and ecology

Abstract

The knowledge about the bryophytes of forest habitats in the Alps, and more particularly in South Tyrol, is still inadequate. Most works are floristic, and scarce are quantitative studies examining spruce forests. Therefore, aims of this work are: 1) to increase the knowledge of bryophyte distribution in the spruce forests of South Tyrol; 2) to discuss the ecology and distribution of the most significant species or species groups. A total of 48 plots were surveyed in South Tyrol along the elevational gradient and covering the province in 8 main areas. Bryophyte species were examined on three different types of substrates, tree trunks of spruce (*Picea abies*), deadwood and on the forest floor. This work allowed to record 120 species (91 mosses and 29 liverworts), 27 considered rare or threatened. One interesting discovery was *Sciuro-hypnum curtum*, a pleurocarpous moss firstly recorded in Italy. The ecology of the most significant groups of species were outlined. Elevation, canopy closure, rainfall and amount of necromass were the main factors determining the species distribution. The role of the environment and the responsibility of forest managers for the biodiversity conservation was discussed.

Keywords: bryophytes, environmental gradients, liverworts, mosses, South Tyrol

Introduction

The concept of "sustainable forest management" considers the maintenance of biodiversity a crucial point, and it is a target of many governments, scientific and economic initiatives (Lindenmayer et al. 2000). The sustainable forest management is included in the more encompassing ecological target of "forest integrity". Forest integrity is the capacity to support and maintain a balanced, integrated, adaptive community of organisms having a species composition, diversity and functional organization comparable to that of similar undisturbed forest ecosystem (e.g. Tierney et al. 2009). However, defining criteria for forest integrity is challenging.

Bryophytes are important components of forest integrity. Their contribute to species richness is at least as high as that of the vascular plants in many forest types (e.g. Grytnes et al. 2006). Although the live biomass of bryophytes comprises a small fraction of the total ecosystem carbon content, they greatly influences the function of the ecosystem (Oechel & Van Cleve 1986, Kolari et al. 2006). Bryophytes are involved in the processes regulating soil thermal regimes, hydrology and nutrient availability (Sveinbjornsson & Oechel 1992).

The relationship between bryophyte species occurrence and habitats in the spruce forests is well studied. Some investigations focussed on the occurrence of species on selected microhabitats (Söderström 1988, Márialigeti et al. 2009, Király & Ódor 2010), others examined the variation in bryophyte community along environmental gradients and scales (Mills & MacDonald 2005, Tinya et al. 2009). However, even though studies

Author's address

Daniel Spitale
Museo di Scienze Naturali dell'Alto Adige,
via Bottai 1
39100 Bolzano
spitale.daniel@gmail.com

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dealing with the relationships between bryophytes and environmental and management factors are not rare, more patchy are the regional distribution of such works. This is an important shortcoming, as bioindicators often are specific of a particular pool of species in a biogeographic area.

The knowledge about the bryophytes of spruce forests in the Alps, and more particularly in South Tyrol, is scarce. Most works are floristic and considered the spruce forests only among other habitats (e.g. Aleffi & Cortini Pedrotti 1996). In South Tyrol bryological studies date back to the 19th century, the most important work represented by Dalla Torre & Sarnthein (1904). Later, almost all the knowledge about the bryophyte distribution in the province has been collected by Ruprecht Düll, and summarized in the check-list of South Tyrol (Düll 2006). However, even though the province seems to be well studied from the floristic point of view (in contrast to other Italian provinces), still lacking are quantitative studies examining spruce forests. Therefore, the aims of this work are: 1) increasing the knowledge of bryophyte distribution in the spruce forests of South Tyrol; 2) discuss the ecology and distribution of the most significant species or species groups. This contribution will enhance our comprehension of the bryodiversity and will elucidate the peculiarities of this taxonomic group in South Tyrol.

Methods

Field sampling was preceded by an accurate examination of available data in collaboration with the Department of Forest Planning of Bolzano. Spruce-forests are the most common type of wood in the province covering a total of 3330 km^2 (AA. VV. 2010). They represent the 88% of the total forested area. The first localization of the potential survey areas was accomplished balancing the number of plots according to the distribution in the province. Eight continuous gradients from 900 m to 1900 m a.s.l. were selected (Figure 1). The gradient was distinguished into three elevational steps (900-1200 m a.s.l. = sub-montane, 1400-1600 m = montane and 1800-1900 m = sub-alpine). At each elevational steps, two circular plots (13 m radius) were allocated randomly once the following conditions were fulfilled: (i): the property of the forest had to be public; (ii) the spruce trees had to be adult and ready to be harvested; (iii) the plots had to be distant hundreds of meters (mean distance between plots within elevational steps: 574 m). In each plot, bryophytes were sampled on three types of substrates: tree trunks of living spruces (*Picea abies*), deadwood and forest floor. We used standard grids of 10 x 50 cm to sample bryophytes. A "sample" consisted of 4 grids within which the presence of the species was recorded. This kind of grid is commonly used also by lichenologists (Nascimbene 2014). On tree trunks, the grids were placed at North and South both on the trunk base and at 1 m height (4 grids = 200 cm^2). Deadwood (stumps and fallen logs), were selected only if the surface area exceeded 4 grids (50 cm^2 x 4 = 200 cm^2). Because most of the deadwood consisted of stumps, two grids were placed on the vertical side and two on the top. Ground substrate was similarly sampled arranging 4 grids side by side and recording the presence of the species. A total of 5 samples for each substrate were surveyed on each plot. Sampling work was completed in the 2013.

Canopy closure (the proportion of sky hemisphere obscured by vegetation), influences the forest floor microclimate and light conditions (Korhonen et al. 2006). To estimate canopy closure we used a spherical densiometer (it is a convex mirror, engraved with 24 squares). The densiometer was used by holding it at breast height and counting the number of squares occupied by the canopy reflected in the convex mirror (Korhonen et al. 2006). Canopy closure was measured above each bryophyte sample for a total of 15 points per plot. The average of them represented the canopy closure of the plot.

The mean age of the trees on the plot was quantified by extracting cores using a Pressler-type increment borer at a vertical height of 1.30 m (Nascimbene et al. 2014). The procedure was repeated on the 5 trees where corticolous species were surveyed.

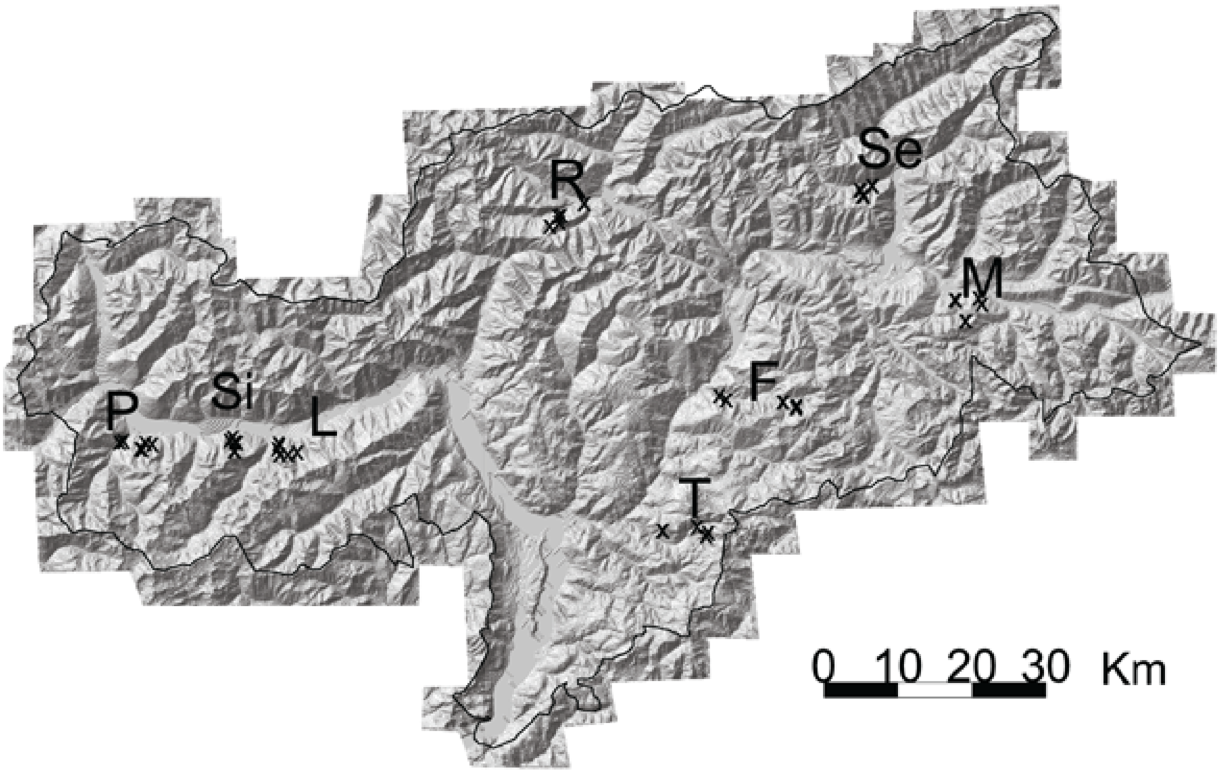

Figure 1. Distribution of plots surveyed between 2013-2014 in South Tyrol, Italy. The eight areas are identified with the following letters: P = Prato allo Stelvio / Prad am Stilfserjoch, Si = Silandro / Schlanders, L = Laces / Latsch; T = Tires / Tiers, F = Funes / Villnöß, M = Monguelfo / Welsberg; Se = Selva dei Molini / Mühlwald; R = Racines / Ratschings. Symbols represent plots.

The amount of deadwood in the plots was estimated inventorying all the stumps and downed logs with dbh > 7 cm. The volume of deadwood was calculated according to the Huber formula (Hush et al. 2003). The decay stage of stumps was classified according to a four-stage system adopted by Motta et al. (2006): (1) bark intact, wood hard; (2) bark almost completely intact, wood hard in the outermost part of stump, decaying in the innermost part, texture with large pieces; (3) only traces of bark, decay spread in most of the stump, texture with blocky pieces; (4) bark absent, wood soft and with powdery structure. The decay stage of logs was determined using again four classes: (1) bark intact, shape round, wood texture intact; (2) trace of bark, shape round and wood still hard; (4) bark absent, shape round to oval, texture of wood with blocky pieces; (4) no bark, shape oval, wood soft and powdery structure.

Mosses were identified mainly according to the keys of Cortini Pedrotti (2001, 2006), Smith (2004) and Nyholm (1986), while Paton (1999) and Damsholt (2002) were used for liverworts.

The data analyses performed were as follows: Species diversity was calculated both as number of species and also using Shannon Index. In order to get the habitat preference of species, weighted average and tolerance was calculated for several environmental variables. Canonical Correspondence Analysis was used to identify the main environmental factors driving the species assemblages. All the analyses were accomplished with the R statistical platform (R Development Core Team 2014).

Results and discussion

Overall, 120 species of mosses and livevorts were found in 48 plots of spruce forests. On average, there were 20 species on each plot (range 9-37), among which 6 liverworts (range 0-15 species). Shannon diversity was on average 2.6 (0.32 SD). The number of bryophytes recorded on three types of substrates (on tree trunks of spruces, on deadwood and on the forest floor) was very similar to the number of lichens recorded only on trees of the same plots (120 vs 124, Nascimbene & Marini 2015). Comparison of these values with other studies which used different sampling strategies cannot be done safely.

A total of 26 species were included in the Red List of the neighbor Province of Trento (Cortini Pedrotti & Aleffi 2011), the most significant species were: *Calypogeia neesiana* (EN), *Cynodontium gracilescens* (VU), *Cynodontium strumiferum* (VU), *Lepidozia reptans* (VU), *Lophozia ascendens* (VU), *Lophozia longiflora* (EN), *Lophozia ventricosa* (VU), *Plagiothecium denticulatum* (VU), *Plagiothecium succulentum* (VU), *Pohlia longicollis* (VU). According to Düll (2006) 17 species are considered rare, and 10 extremely rare or recorded few times in the province. An interesting discovery was *Sciuro-hypnum curtum*, a pleurocarpous moss firstly recorded in Italy (Spitale 2015a). The species has been synonymized with *S. oedipodium* but Ignatov & Milyutina (2007) showed that they are two distinct species. As currently understood, *S. curtum* is a widespread species in boreal forests of Eurasia and occurs also in the east of North America. Instead, *Sciuro-hypnum oedipodium* is mainly an American species, with few localities in Eurasia (Caucasus and in Chukotka). Another interesting finding, already known in the province but only with scanty data, was *Buxbaumia viridis*. To this species we devoted a special study to clarify its ecology and distribution (Spitale & Mair 2015, Spitale et al. 2015).

Liverworts

Among the most characteristic taxa of liverworts found in the spruce forests of South Tyrol were *Barbilophozia* (*B. barbata*, *B. hatcheri* and *B. lycopodioides*), *Lophozia* (*L. ascendens*, *L. incisa*, *L. longidens*, *L. longiflora*, *L. silvicola*, *L. ventricosa*), *Calypogeia* (*C. integristipula*, *C. muelleriana*, *C. neesiana*, *C. suecica*) and *Tritomaria* (*T. exsecta*, *T. exsectiformis*).

The species of *Barbilophozia* were quite common but they were characteristic of intermediate elevation (1300-1600 m a.s.l.). With the exception of *B. lycopodioides* which prefers the forest floor, the other two species inhabit tree trunks, deadwood and forest floor indifferently.

The genus *Lophozia* is a difficult taxon with many species with overlapped morphological characters (Damsholt 2002). Often they have abundant gemmae, green in *L. ventricosa*, *L. incisa*, *L. ascendens*, *L. silvicola* and red in *L. longidens*. *Lophozia incisa* and *L. longiflora* were found only on deadwood, *L. longidens*, *L. silvicola*, *L. ventricosa* both on tree trunks and deadwood. All the *Lophozia* species preferentially grow between 1500 and 1800 m a.s.l.

Also the genus *Calypogeia* is a difficult taxon which needs abundant and well developed specimens to be determined at species level with some confidence (Buczkowska 2004). In particular, the couple *C. integristipula- C. neesiana* (underleaves entire) and *C. muelleriana - C. suecica* (underleaves with distinct sinus) can be sometimes difficult to separate. The *Calypogeia* species occur preferentially between 1650 m and 1850 m a.s.l., and on forests with abundant deadwood on advanced stage of decay (class 3 and 4).

The genus *Tritomaria*, with abundant and red gemmae occurring at the top of the shoots, is readily recognizable in the field. However, in order to separate the two species, gemmae should be checked under the microscope to inspect their shape. *Tritomaria exsectiformis* was found only two times, whereas *T. exsecta* was found in 6 plots. They prefer elevation between 1500 and 1700 m a.s.l. and they grow on deadwood.

Mosses

The taxon *Hypnum cupressiforme* probably is among the few, most emblematic species of forests (Fig. 2). It is a polymorphic species, often treated as a species complex. It can grow anywhere in the spruce forests, and often it was the only species able to colonize the acid bark of spruces. It occupied a well-defined range of altitude with an optimum at 1274 m a.s.l (tolerance 254 m). *Hypnum andoi* shared the same habitat condition of *H. cupressiforme* and it is not so rare as previously retained (Düll 2006). *Hypnum pallescens* is a rare species (also according to Düll 2006), and in fact it was found only once.

The genus *Plagiothecium* was well represented with five species but only two were common (*P. denticulatum* and *P. laetum*). *Plagiothecium nemorale*, *P. platyphyllum* and *P. succulentum* are rare species (one record each) even though Düll (2006) stated that they are sporadic. Probably, the optimal habitat is not the spruce forest in South Tyrol. Concerning the altitudinal gradient occupied by the two more common species, *P. denticulatum* has an optimum at 1521 m (tolerance 384 m), whereas *P. laetum* stays upward (optimum at 1707 m, tolerance 212 m). *Plagiothecium denticulatum* grows both on the forest floor and on deadwood, more rarely on tree trunks; *P. laetum* occurs indifferently on all the substrates.

The genus *Polytrichum* s.l. (including also *Polytrichastrum*), is another widespread taxon but with several species differentiation. For example, *P. formosum* and *P. alpinum* were the most common, but occupied different altitudinal ranges (lower the former, upper the latter). Both the species have been never found on tree trunks. *Polytrichum longisetum* was retained extremely rare by Düll (2006), and in fact it has been found only in 3 plots.

The genus *Dicranum* was dominated by two species (*D. montanum* and *D. scoparium*) which occupy indifferently all the substrates and altitudes. The other two species, *D. brevifolium* and *D. muehlenbeckii* were singletons and are not typical for forest habitats. Identification of *D. brevifolium* and *D. muelenbeckii* should be considered tentative, as intermediate forms exists (Hedenäs & Bisang 2004).

Figure 2. The moss Hypnum cupressiforme, a common species colonyzing all the substrates in forests with an optimum growth and diffusion around the 1300 m s.l.m.

General patterns

In order to obtain a general overview of the main environmental variables driving the bryophyte distribution in the spruce forests, a Canonical Correspondence Analysis (CCA) was performed (Fig. 3). The analysis suggested that the most important factors were elevation, age, canopy closure, rainfall and the amount of necromass in advanced stage of decay (class 3 and 4). The model was highly significant ($F = 2.53$, $P < 0.001$). Elevation and age (average of spruce trees in the surveyed plot) had similar sign and importance in determining species distribution, and both factors were opposite to canopy closure. These three environmental variables explained the turnover of species along the altitudinal gradient. Tree age co-varied with elevation as a result of different tree growth rates along the elevation gradient. That is, trees with similar diameter were on average older at high elevation. Canopy closure was negatively correlated with elevation and age, because mature forests and upland forests tend to have more gaps. Thus, the primary factors determining the bryophyte species composition were elevation (and co-related factors like temperature), and light (Spitale 2015b). These both factors gain importance as the elevation gradient extends. These fundamental environmental variables are directly related to the physiology of bryophytes. In lowland forests, which have higher temperatures, the tallus of bryophytes desiccate more rapidly than upland (they are poikylohydric organisms, Proctor 2000). This environmental setting probably is too stressful for many species, and species diversity decreases in lowland forests. Only species more tolerant and with large colony like *Hypnum cupressiforme*, *Isothecium alopecuroides*, *Dicranum scoparium*, are able to dominate at low elevation. A comparable pattern was observed also on lichens for the same study sites (Nascimbene & Marini 2015). Rainfall was the third most important environmental factor according to the CCA analysis (Fig. 3). It was orthogonal to elevation, so it accounted for another fraction of the total variance. In ecological terms, this suggested some spatial differences in the assemblage composition related to the different rainfall observed in South Tyrol (563-1182 mm/yr). Even rainfall was related to fundamental physiological processes of bryophytes. Finally, the amount of necromass was able to explain a significant amount of variance. Necromass constitute a special habitat, crucial for many organisms in the forests other than bryophytes (Jonsson et al. 2005). A number of liverworts and saproxylic species like *Buxbaumia viridis* (Spitale & Mair 2015) were directly dependent from the amount of deadwood in forests. This result alone suggested the fundamental role that forest managers play in determining the sustainable use of the forests. Unfortunately, based on the data we collected, it seems that on average the amount of deadwood was largely insufficient to sustain the forest integrity (Spitale et al. 2015). On average, 15 m^3/ha (range 1-53 m^3/ha) of deadwood was present in the spruce forests of South Tyrol. As suggested also by Müller & Bütler (2010), this amount is below the threshold suggested to be effective in maintaining the integrity of spruce forests (20-30 m^3/ha).

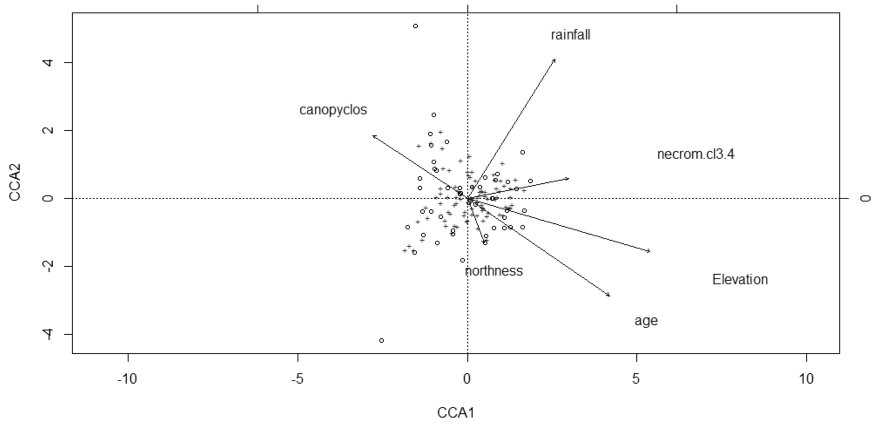

Figure 3. Canonical Correlation Analysis on the bryophytes of spruce forests of South Tyrol. Canopyclos = canopy closure, necrom.cl3.4 = necromass in decay class 3 and 4.

Table 1. List of the species recorded in the 48 spruce forests in South Tyrol in 2013. Rec = number of records; s, w, t, are the relative frequency of the species respectively on the soil, deadwood and tree trunks. RL = Red List species compiled according to Cortini Pedrotti & Aleffi (2011) concerning the neighbor province of Trento; distr = species distribution according to Düll (2006): v = verbreitet = common; h = häufig = frequent; zv = ziemlich verbreitet = fairly widespread z-v = meint stellenweise = sporadic but locally common; z = zerstreut = sporadic; r-z = selten bis zerstreut = from sporadic to rare; r = selten = rare; rr = nur an einem oder sehr wenigen Orten nachgewiesen = recorded only once or in few places. Areas were referred to the location of surveyed plots: P = Prato allo Stelvio; Si = Silandro; L = Laces, T = Tires, F = Funes, M = Monguelfo, Se = Selva del Molini; R = Racines. Altitude was the weighted average. Nomenclature was according to Ros et al. (2007, 2013).

	REC	S	W	T	RL	DISTR	AREAS	ALTITUDE
Abietinella abietina (Hedw.) M.Fleisch.	3	0.9	0.1	0.0		z-v	Si, L	1004
Alleniella complanata (Hedw.) S. Olsson, Enroth & D. Quandt	1	1.0	0.0	0.0		z-v	P	1110
Antitrichia curtipendula (Hedw.) Brid.	3	1.0	0.0	0.0		z	Si, L	1057
Atrichum undulatum (Hedw.) P.Beauv.	1	1.0	0.0	0.0		v	M	1880
Barbilophozia barbata (Schmidel ex Schreb.) Loeske	8	0.5	0.3	0.2	NT	z	P, L, T, Se, F	1334
Barbilophozia hatcheri (A. Evans) Loeske	15	0.4	0.3	0.3		r	P, Si, L, M, Se, R, F	1556
Barbilophozia lycopodioides (Wallr.) Loeske	11	0.8	0.1	0.1	NT	z	P, M, Se, R, F	1637
Bartramia ithyphylla Brid.	2	1.0	0.0	0.0		z	Si, M	1540
Bazzania trilobata (L.) Gray	1	0.0	1.0	0.0		z	R	1470
Blepharostoma trichophyllum (L.) Dumort.	25	0.3	0.6	0.1	NT	z	P, Si, L, T, M, Se, R, F	1630
Brachytheciastrum velutinum (Hedw.) Ignatov & Huttunen	34	0.5	0.3	0.2		v	P, Si, L, T, M, Se, R, F	1458
Brachythecium rutabulum (Hedw.) Schimp.	2	0.4	0.6	0.0		v	P, F	1120
Brachythecium salebrosum (Hoffm. ex F.Weber & D.Mohr) Schimp.	11	0.6	0.4	0.0		z	Si, L, M, Se, R, F	1752
Bryoerythrophyllum recurvirostrum (Hedw.) P.C.Chen	1	0.0	1.0	0.0		z-v	T	1803
Bryum elegans Nees	3	0.5	0.0	0.5		z	M, F	1679
Buxbaumia viridis (Moug. ex Lam. & DC.) Brid. ex Moug. & Nestl.	3	0.3	0.7	0.0		z	M, Se, F	1422
Calypogeia integristipula Steph.	10	0.2	0.8	0.0		r	P, L, M, Se, R, F	1800
Calypogeia muelleriana (Schiffn.) Müll. Frib.	1	0.0	1.0	0.0		z	R	1800
Calypogeia neesiana (C. Massal. & Carestia) Müll. Frib.	9	0.3	0.7	0.0	EN	r	L, M, Se, R, F	1673
Calypogeia suecica (Arnell & J. Perss.) Müll. Frib.	3	0.8	0.2	0.0		rr	M, Se, F	1847
Campylium protensum (Brid.) Kindb.	2	1.0	0.0	0.0		z	M, F	1853
Campylophyllum halleri (Hedw.) M.Fleisch.	2	1.0	0.0	0.0		z	F	1853
Campylopus pyriformis (Schultz) Brid.	1	1.0	0.0	0.0	VU	rr	T	1188
Cephalozia bicuspidata (L.) Dumort.	3	0.5	0.5	0.0		z	Se, R, F	1736
Ceratodon purpureus Brid.	4	0.3	0.5	0.3		h	P, Si, L	1459
Cirriphyllum piliferum (Hedw.) Grout	2	1.0	0.0	0.0		z	M, F	1410
Ctenidium molluscum (Hedw.) Mitt.	2	1.0	0.0	0.0		v	T, F	1630
Cynodontium gracilescens (F.Weber & D.Mohr) Schimp.	5	0.2	0.6	0.2	VU	r	Si, L, M, Se	1602
Cynodontium polycarpon (Hedw.) Schimp.	5	0.4	0.4	0.2		z	P, Si, L	1532
Cynodontium strumiferum (Hedw.) Lindb.	4	0.1	0.7	0.1	VU	z	P, Se	1549
Dicranodontium denudatum (Brid.) E.Britton	2	0.3	0.7	0.0	NT	z	T, R	1627
Dicranum brevifolium (Lindb.) Lindb.	1	0.0	1.0	0.0		rr	L	1900
Dicranum montanum Hedw.	40	0.1	0.5	0.4	NT	z	P, Si, L, T, M, Se, R, F	1582
Dicranum muehlenbeckii Bruch & Schimp.	1	0.0	1.0	0.0		z-v	L	1820
Dicranum scoparium Hedw.	48	0.3	0.4	0.2		z-v	P, Si, L, T, M, Se, R, F	1586
Encalypta ciliata Hedw.	1	1.0	0.0	0.0		sz	Si	1200
Eurhynchium angustirete T.J.Kop.	8	0.8	0.2	0.1	EN	v	T, M, R, F	1147
Eurhynchium pulchellum praecox (Hedw.) Ochyra & Żarnowiec	1	1.0	0.0	0.0		z	Si	1200
Eurhynchium striatum (Hedw.) Schimp.	1	1.0	0.0	0.0		r	T	1188
Exsertotheca crispa (Hedw.) S. Olsson, Enroth & D. Quandt	1	1.0	0.0	0.0		z	T	1188

	REC	S	W	T	RL	DISTR	AREAS	ALTITUDE
Fissidens adianthoides Hedw.	4	0.6	0.4	0.0		r	T, F	1347
Fissidens taxifolius Hedw.	1	1.0	0.0	0.0		z	M	1880
Fissidens viridulus (Sw. ex anon.) Wahlenb.	1	1.0	0.0	0.0		rr	Si	1180
Frullania dilatata (L.) Dumort.	11	0.1	0.2	0.8		v	P, Si, L, T, R	1235
Hedwigia ciliata (Hedw.) P.Beauv.	3	0.4	0.4	0.2		v	L	1088
Herzogiella seligeri (Brid.) Z.Iwats.	21	0.1	0.7	0.1		z	P, Si, L, T, M, Se, R, F	1445
Heterocladium dimorphum (Brid.) Schimp.	3	0.5	0.3	0.2		r-z	M, R, F	1646
Homalothecium lutescens (Hedw.) H.Rob.	1	0.0	1.0	0.0		z-v	T	1540
Hylocomium splendens (Hedw.) Schimp.	48	0.7	0.3	0.0		z-v	P, Si, L, T, M, Se, R, F	1449
Hymenoloma crispulum (Hedw.) Ochyra	2	1.0	0.0	0.0		z-v	P, Se	1818
Hypnum andoi A.J.E.Sm.	13	0.0	0.4	0.6		rr	Si, L, T, M, Se, F	1275
Hypnum cupressiforme Hedw.	37	0.2	0.4	0.4		v-h	P, Si, L, T, M, Se, R, F	1279
Hypnum pallescens (Hedw.) P.Beauv.	1	0.0	0.0	1.0		rr	P	1820
Isothecium alopecuroides (Lam. ex Dubois) Isov.	12	0.5	0.2	0.3		z-v	P, Si, L, T, Se, F	1316
Lejeunea cavifolia (Ehrh.) Lindb.	1	1.0	0.0	0.0		z	Se	1200
Lepidozia reptans (L.) Dumort.	22	0.2	0.7	0.1		z	P, Si, T, M, Se, R, F	1596
Lophocolea heterophylla (Schrad.) Dumort.	32	0.3	0.3	0.4		z	P, Si, L, T, M, Se, R, F	1622
Lophozia ascendens (Warnst.) R. M. Schust.	1	0.0	1.0	0.0	VU	rr	Se	1550
Lophozia incisa (Schrad.) Dumort.	8	0.0	1.0	0.0	NT	z	M, Se, F,	1734
Lophozia longidens (Lindb.) Macoun	13	0.0	0.4	0.6		r	P, Si, L, M, Se, F	1639
Lophozia longiflora (Nees) Schiffn.	7	0.2	0.8	0.0	EN	r	M, Se, R, F	1811
Lophozia silvicola H. Buch	5	0.3	0.5	0.2		z	P, M, Se, F	1588
Lophozia ventricosa (Dicks.) Dumort.	6	0.2	0.4	0.4	VU	r	P, Si, L, M, Se	1631
Metzgeria furcata (L.) Dumort.	3	0.8	0.0	0.2		v	P, Se, R	1145
Mnium lycopodioides Schwägr.	1	1.0	0.0	0.0		r	M	1880
Mnium spinosum (Voit) Schwägr.	24	0.8	0.2	0.1		z-v	P, Si, L, T, M, Se, R, F	1495
Mnium stellare Hedw.	2	1.0	0.0	0.0		z	L, M	1524
Mnium thomsonii Schimp.	2	0.5	0.0	0.5		z	Si, F	1695
Orthotrichum pallens Bruch ex Brid.	1	0.0	0.0	1.0		z	P	1110
Orthotrichum scanicum Gronvall	1	0.0	1.0	0.0	VU	rr	Si	1490
Orthotrichum speciosum Nees	2	0.0	0.5	0.5		z	P, Si	1460
Orthotrichum striatum Hedw.	2	0.0	1.0	0.0		z-v	Si L	1213
Oxystegus tenuirostre (Hook. & Taylor) A.J.E.Sm.	1	1.0	0.0	0.0	VU	z	M	1880
Paraleucobryum longifolium (Hedw.) Loeske	3	0.7	0.0	0.3	VU	z-v	L, Se	1214
Pellia neesiana (Gottsche) Limpr.	2	1.0	0.0	0.0	VU	r	M	1877
Plagiochila asplenoides (L. emend. Taylor) Dumort.	9	0.5	0.2	0.2		z	M, Se, F	1377
Plagiochila porelloides (Torrey ex Nees) Lindenb.	19	0.6	0.3	0.1		v	P, Si, T, M, R, F	1483
Plagiomnium affine (Blandow ex Funck) T.J.Kop.	8	0.6	0.3	0.1		z	T, M, Se, F	1196
Plagiomnium ellipticum (Brid.) T.J.Kop.	1	1.0	0.0	0.0	VU	r	M	1880
Plagiomnium undulatum (Hedw.) T.J.Kop.	5	0.7	0.2	0.1		v	P, M, F	1072
Plagiothecium denticulatum (Hedw.) Schimp.	10	0.6	0.3	0.1	VU	z	L, T, M, Se, R, F	1521
Plagiothecium laetum Schimp.	25	0.2	0.3	0.5		z	P, Si, L, T, M, Se, R, F	1707
Plagiothecium nemorale (Mitt.) A.Jaeger	1	1.0	0.0	0.0		z	M	1880
Plagiothecium platyphyllum Mönk.	1	0.0	1.0	0.0			F	950
Plagiothecium succulentum (Wilson) Lindb.	1	0.0	1.0	0.0	VU	z	F	950

	REC	S	W	T	RL	DISTR	AREAS	ALTITUDE
Pleurozium schreberi (Willd. ex Brid.) Mitt.	31	0.7	0.3	0.0		z-v	P, Si, L, T, M, Se, R, F	1612
Pogonatum urnigerum (Hedw.) P.Beauv.	2	0.5	0.5	0.0		z-v	M, F	1385
Pohlia cruda (Hedw.) Lindb.	4	1.0	0.0	0.0		z	P, Si, M	1482
Pohlia longicolla (Hedw.) Lindb.	2	0.5	0.5	0.0	VU	r	T, R	1811
Pohlia nutans (Hedw.) Lindb.	16	0.3	0.7	0.0		z-v	P, Si, L, T, M, Se, F	1656
Polytrichastrum alpinum (Hedw.) G.L.Sm.	11	0.6	0.4	0.0		z-v	P, Si, L, M, Se, R	1851
Polytrichum commune Hedw.	1	0.7	0.3	0.0		z	Se	1815
Polytrichum formosum Hedw.	12	0.3	0.3	0.3		z-v	T, M, Se, R, F	1424
Polytrichum juniperum Hedw.	6	1.0	0.0	0.0		z-v	L, M, Se, R	1672
Polytrichum longisetum Sw. ex Brid.	3	0.6	0.4	0.0		rr	M, R, F	1742
Polytrichum piliferum Hedw.	2	0.5	0.5	0.0		v	P, M	1650
Pseudoscleropodium purum (Hedw.) M.Fleisch.	1	1.0	0.0	0.0		z-v	T	1188
Pterigynandrum filiforme Hedw.	14	0.3	0.2	0.5		z-v	P, Si, L, M, Se, R	1407
Ptilidium pulcherrimum (Weber) Vain.	17	0.0	0.4	0.5		z	P, T, M, Se, R, F	1541
Ptilium crista-castrensis (Hedw.) De Not.	2	0.5	0.5	0.0		z-v	Se, F	1213
Ptychostomum pallens (Sw.) J.R. Spence	12	0.5	0.3	0.2		z	P, Si, L, T, M, F	1470
Racomitrium microcarpon (Hedw.) Brid.	1	1.0	0.0	0.0	NT	r	Se	1870
Radula complanata (L.) Dumort.	12	0.3	0.2	0.5		v	P, Si, L, T, M, Se, R, F	1227
Rhizomnium magnifolium (Horik.) T.J.Kop.	1	1.0	0.0	0.0	CR	r	Se	1815
Rhizomnium punctatum (Hedw.) T.J.Kop.	9	0.4	0.5	0.1		z-v	M, Se, R, F	1501
Rhytidiadelphus squarrosus (Hedw.) Warnst.	2	1.0	0.0	0.0		sz	M, F	1070
Rhytidiadelphus triquetrus (Hedw.) Warnst.	44	0.8	0.2	0.0		v	P, Si, L, T, M, Se, R, F	1425
Sanionia uncinata (Hedw.) Loeske	18	0.2	0.7	0.1		z-v	P, Si, L, T, M, Se, R, F	1689
Scapania aequiloba (Schwägr.) Dumort.	2	1.0	0.0	0.0		r	F	1853
Schistidium robustum (Nees & Hornsch.) H.H.Blom	1	1.0	0.0	0.0		rr	F	1860
Sciuro-hypnum curtum (Lindb.) Ignatov	1	1.0	0.0	0.0		*new*	L	1820
Sciuro-hypnum reflexum (Starke) Ignatov & Huttunen	4	0.3	0.4	0.3		z	M, Se, R	1821
Sciuro-hypnum starkei (Brid.) Ignatov & Huttunen	10	0.5	0.3	0.1		z	Si, L, M, Se, R, F	1824
Syntrichia ruralis ruralis (Hedw.) F.Weber & D.Mohr	1	1.0	0.0	0.0		v	L	936
Tetraphis pellucida Hedw.	38	0.1	0.9	0.0		z	P, Si, L, T, M, Se, R, F	1575
Thuidium assimile (Mitt.) A. Jaeger	1	1.0	0.0	0.0		z-v	Si	1180
Tortella tortuosa (Hedw.) Limpr.	5	1.0	0.0	0.0		z-v	P, T, F	1647
Tortula subulata Hedw.	2	1.0	0.0	0.0		z	Si	1190
Tritomaria exsecta (Schmidel ex Schrad.) Loeske	6	0.4	0.5	0.1	NT	r	P, L, T, M, R	1572
Tritomaria exsectiformis (Breidl.) Loeske	2	0.7	0.3	0.0	NT	z	P, Si	1677

Riassunto

Le conoscenze sulle briofite degli ambienti forestali sulle Alpi, e in particolare in Trentino-Alto Adige, sono ancora limitate. La maggior parte dei lavori sono floristici, e sono ancora assenti studi quantitativi che esaminano l'ambiente di pecceta. Gli obiettivi del presente lavoro sono: 1) accrescere le conoscenze sulla distribuzione delle briofite nelle peccete della provincia di Bolzano; 2) discutere l'ecologia e la distribuzione delle specie, o gruppi di specie, più significativi. In totale sono stati esaminati 48 plots lungo un gradiente altitudinale e in 8 aree della provincia. Le briofite sono state esaminate su tre diversi substrati, tronchi di abete rosso, legno morto e suolo. Il lavoro ha permesso di identificare 120 specie (91 di muschi e 29 di epatiche), 27 delle quali appartenenti alla Lista Rossa. Una interessante scoperta è stata la specie *Sciuro-hypnum curtum*, un muschio pleurocarpo segnalato per la prima volta in Italia. I principali fattori che determinano la distribuzione delle briofite in questi ambienti sono l'altitudine, la copertura forestale, la piovosità e la quantità di necromassa. Viene discusso il ruolo dell'ambiente e la responsabilità della gestione forestale per la conservazione della biodiversità.

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