Memoranda Soc. Fauna Flora Fennica 90: 33–54. 2014

Vascular plant and moss species across successional mire basins on the land uplift coast of Northern Ostrobothnia, Finland

Sakari Rehell & Jarmo Laitinen

Rehell, S., Metsähallitus, Parks & Wildlife Finland. E-mail: sakari.rehell@metsa.fi
Laitinen, J., University of Oulu, Dept. of Biology, PO Box 3000. E-mail: jarmo.laitinen@oulu.fi

Succession of mire vegetation was studied in mire basins providing uniform chronosequences on the land uplift coast of the Bothnian Bay. The research was performed from transects crossing mire basins with similar hydrology in order to highlight the occurrence on different mire species in catchment areas. Material from vegetation sample plots was used, central species for each altitude belt were presented. Also the differences between the mire basins on moraine and sand were handled. On the mires under 5 m asl, the vegetation is dominated by species typical for swamps and seashores. Most *Sphagnum* species spread to the mire basins very quickly after the disappearance of the brackish sea-water effect. Along with the *Sphagna* are spreading most species typical for the mature hummock, lawn and carpet levels. The occurring of rich fen species seems to be closely connected with the groundwater discharge pattern. The study areas are situated on the coast of northern Bothnian Bay, where the developed mire systems are dominated by aapa mires. The results are compared with those from the more southern zone of bogs. The main difference seems to be the larger coverage of *Sphagnum* mosses even on the wetter sites on the development of bogs.

Introduction

The land uplift rate on the Finnish side of the Bothnian Bay is about 8 mm/year in relation to the mean sea-level (Niskanen 1939, Kääriäinen 1966, Kakkuri 1985). The eustatic uplift of sea-level is clearly smaller (approximately 1 mm yr^{-1}, but probably increasing (Johansson et al. 2004). According to regression lines of areas near northern Bothnian Bay (e.g. Taipale & Saarnisto 1991) the regression of the seashore during the last 4000 years has been quite stable and about the same magnitude or a little faster than nowadays. The succession of vegetation on emerging coasts is affected both by temporary sea-level fluctuations and by gradual shore line regression. The temporary fluctuations of sea-level in Bothnian Bay are for the most part due to changes in the air-pressure and the direction and strength of winds, the effect of tides is very little (e.g. Ericsson & Wallentinus 1979, Siira 1999). The seawater on coasts of the northern Bothnian Bay can reach the maximum level of about 2 m above mean level at times of exeptional southern storms, while the absolute minimum levels are about 1 m below the mean level. The littoral belt (e.g. Siira 1970, Elveland 1976) is situated between these levels. Sea-water levels up to 1,5 m asl can be considered so usual, that this point can be considered as the approximate upper level of littoral belt. The regression of the shoreline causes a very interesting situation: land of different age forms distinct belts so that the age after emergence from the sea can be concluded from the elevation above sea level. On geologically older land one can see mire complexes, watercourses and forests which have already reached the stable state. On the land uplift coast on the contrary it is possible to see a full series of habitats of different age and development stage and one can study the development of the older stages by studying the contemporary condition of the younger stages. The use of chronosequence like this to reconstruct successional patterns is based on the assumption that there have been no ecologically significant differences except the age and stage of development among the studied sites (Klinger & Short 1996).

In a strict sense, this is of course impossible, but by placing the research lines to a landscape of homogenous bedrock and topography and proving that the hydrology of studied sites along the chronosequence resemble each other as closely as possible, the assumption can be considered valid. The succession of mires goes side by side with the succession of forests and watercourses; on the land-uplift coast the primary mire formation has been assessed to be about the same as magnitude as the secondary paludification of forests (Huikari 1956, Huttunen & Tolonen 2006).

The studies in succession of vegetation on the land uplift coast of the Bothnian Bay have largely concentrated on the young belts near the coast. The vegetation studies on seashore meadows (Havas 1961, Siira 1971) restrict naturally to the littoral belt, but also studies on forests concentrate to the primary succession of a few hundred years. (Havas 1967, Lindroos 1990, Svensson & Jeglum 2003). Studies on mires on the aapamire zone of the Bothnian Bay coastland have concentrated in the question of primary mire formation and paludification of forest land (Huikari 1956) with study areas 0–20 m asl) and to the difference between littoral belt and areas above it (Elveland (1976). The works with long successional series from seashores to old mire complexes are from areas, where succession to ombrotrophic bogs prevail: Southern Ostrobothnia (Aario 1932, Brandt 1948), the Hudson Bay area (Klinger & Short 1996) and White Sea coast (Kouznetsova 1999). On the land-uplift coasts that belongs to the aapamire zone the succession of vegetation has been studied on the mires between the sandy ridges of Siikajoki area (Timonen 2005). Chosen parts of the mire chronosequence in Siikajoki has been used to compare the observed succession in vegetation and peat increment with those predicted by a mathematical model (Tuittila et al. 2013). This work emphasizes the val-

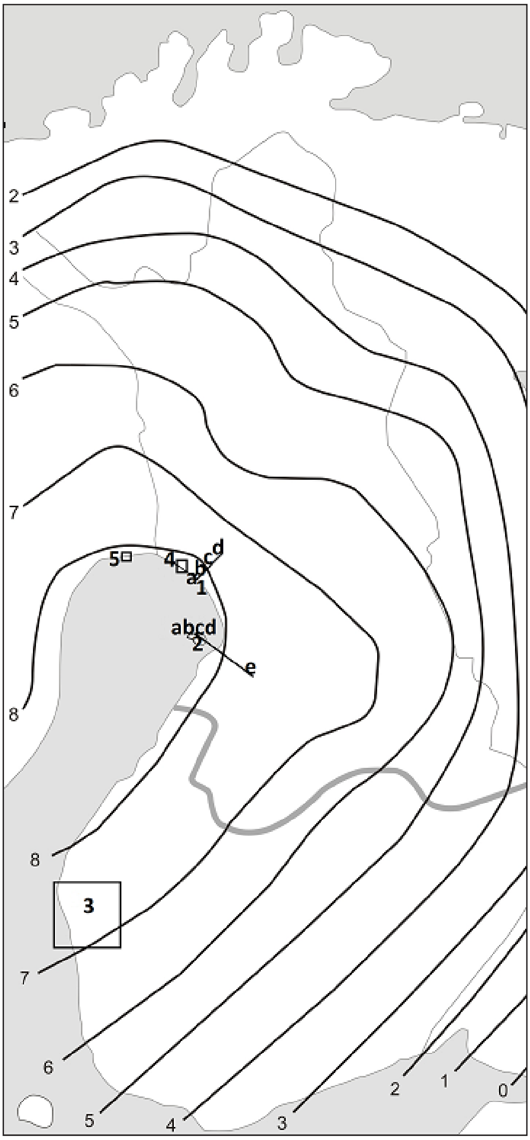


Fig 1. The research areas (1 and 2) and the sites of comparable researches on the land uplift coast (3. Brandt 1948, 4. Huikari 1956, 5. Elveland 1976)

Table 1. Studied areas along the transect chain. The elevations refer to the main sites of primary mire formation. Areas 1–5 on moraine topography, areas 6a–7 on sandy topography. Their ages are expressed as calibrated years before present (AD 1950, Weninger & al. 2005).

Site name	**Elevation of mire nuclei** m a.s.l.	**Age of primary mire nuclei** cal yr	**Total length of lines** m
1.a Ryöskäri	0–6	0–700	980
1.b. Sahkari	6–7	700–800	710
1.c Ihanalampi	18–19	1900–2000	2050
1.d Nikkilänaapa	34–37	3900–4200	2500
1.e Kairavaara	67–69	6000–6200	2250
2.a Hailuoto, Keskiniemi	1,0–1,5	100–150	750
2.b Hailuoto, Satajärvi	4,0–4,5	300–400	600
2.c Hailuoto, Pitkäjärvi	6,0–7,0	700–800	850
2.d Hailuoto, Valkjärvi	8,5–9,0	1000–1100	450
2.e Ressunaro	43–47	4000–4200	2900

ue of chronosequences of this kind, but has the presumption that these mires are developing into ombrotrophic bogs.

This article is a part of a larger plan to study the development of aapamires by the chronosequence method (Rehell & Heikkilä 2009, Rehell et al. 2012 a,b). The aim of the present article is to show the altitude distribution of the dominant vascular plant and moss species across altitude belts and to suggest reasons for the distribution of those species. It contains the results of studies from sample plots on different belts, both on moraine and sandy topography. One part of this study is to compare the data of present study areas with other areas along the coast of the Bothnian Bay. The comparison of the aapa-mire zone to the more southern zone of bogs (e.g. Brandt 1948) makes it possible to assess of the effect of climatic changes on the vegetation.

Material and methods

The research has been done on land uplift coast of Bothnian Bay in areas, where the bedrock, soil and topography continue homogenous from the seashore to the inland area. The age of the primary mire formation of the basins has been calculated from the elevation of the bottoms of the mire basins (meters above sealine) using the published regression diagrams for the region (Taipale & Saarnisto 1991). The ages refer to calibrated C-14 years. The research areas were situated along two main transects, the other situated on moraine topography and the other on sandy topography. (Table 1, Fig.1)

The studied mire basins on moraine topography are situated near the border between communes Simo and Kuivaniemi (study area 1). The bedrock is composed mainly of quite acidic granitoid gneiss and migmatite with small diabase joints and other more basic veins in the whole area (GTK 1997). It is overlain by a layer of bottom moraine, which forms small drumlins in places. Along the transect the research areas are placed on paludified basins bordered by mineral soil on different elevations above sealine. Each basin includes a full catchment area with mire on the central part. The studied lines were placed across the whole basin so that they give a picture of the whole paludified area including hydrologically different parts of it (Laitinen et al. 2007).

The studied mire basins on sandy topography (study area 2) are situated on a large esker formation, which stretches from the island of Hailuoto towards southeast. This esker chain is composed mainly of fine sand with little amount of gravel and boulders, so the waves and wind have moved the sand to beach ridges and dunes stretching kilometres on both sides of the original core of the esker. The mires are situated on narrow basins between these ridges. The bedrock consists mainly of sedimentary siltstone (GTK 1997), which is covered by thick layers of sand, till and other loose sediments (Gibbard 1985). The study lines were situated according to same principles as on the moraine topography.

The difference in hydrology between moraine and sandy areas is notable. On the former, the amount of surface flow is quite remarkable and the ground water discharge takes place in the paludified depressions between forest heaths. On the latter rainwater infiltrates more totally to the ground. The water in the paludified depressions concentrates in the lowest parts, where it can percolate through the damming beach ridges giving rise to unstable aro-wetlands (Laitinen et al. 2007) with little or no peat layer. The discharge of the groundwater can take place far away, in the case of the research area in Hailuoto on the seashore and under the sea (Rehell & Heikkilä 2009).

Vegetation sample plots (10 × 10 meters) were studied on the lines with the distance of 100 meters. Each plot was placed so that some corner of it was on the measured point of the line. When the line crossed an island of mineral soil, plots were made on both sides of the island. On each line on one or a few sites the area of the plot was largened by adding one or even more 10 × 10 m sample plots to the original. This was done, because the material has been used also in a study of the microtopograhical patterning of the mires (Rehell et al. 2012b) and at some places one plot was not enough to cover all patterns relevant on the site. On the central part of the aapamire complex on area 4 only every other plot was studied, because the mire at that place was very wet flark fen with little variation between the plots. When summing up the mean coverages of species, this was taken account by multiplying the values of these plots by two. Smaller quadrats (1 × 1 metres) were studied on each large plot, they were situated so that they represent all water level categories (Eurola et al. 1984) (hummock-level, intermediate-level, flark level, and sub-levels of them). From those quadrats the coverage (per cent) of plant species was studied. The field work was done in late summer (July – September), on morainic topography in the years 2001 and 2002, on sandy topography in the year 2003.

The names of vascular plant species follow the nomenclature of Hämet-Ahti et al. (1998). All *Sphagnum* species (Mossornas Vänner 1993) and leaf mosses (Ulvinen 2002, Hedenäs 1993) were defined to the species level (by using microscope when needed). From the liwerworts and lichens often only the genus was defined (compare Eurola et al. 1990). Some taxons very close to each other were combined in Appendix 1 (*Sphagnum angustifolium* + *S. fallax* + *S. flexuosum, Warnstorfia exannulata* + *W.procera, Sphagnum annulatum* + *S. jensenii, Polytrichum commune* + *P. jensenii, Warnstorfia fluitans* + *W. pseudostraminea*). Three last mentioned groups are combined also in Appendix 2. When counting the total amounts of species on different belts all *Sphagnum* mosses, leaf mosses, field layer vascular plants, trees and bushes observed on the studied sample plots were taken into account.

Studies were made on mires and paludified heaths. On the littoral zone also seashore meadows and thickets were studied. Stabile heath vegetation was not studied, nor permanent water bodies. The mires on the land uplift coast are placedoin following separate belts (meters above sealine): 0–1,5 m, 1,5–5 m, 5–15 m, 15–30 m 30–50 m and over 50 m. On the sandy topography it was possible to find comparable sites from only some of these belts. Of the used limits the elevation 1,5 m above mean sea level represents the approximate mean height of the highest sea-level on the coasts of northern Bothnian Bay (e.g. Siira 1999, Elveland 1976). The belt 5 to 15 m asl is according to Huikari (1956) the belt, where the primarily paludified basins have been filled and mires have their fastest rate of expanding to the surrounding heathlands. The sites over 50 m asl represent mires, which are old enough (over 4000 years on the primarily paludified parts) to be considered having gained their climax state according to chronosequence studies on ombrotrophic bogs (Aario 1932, Brandt 1948, Klinger & Short 1996).

The results of the study areas have been compared with the situation in different areas along the Bothnian Bay (see Appendix 2). The work of Brandt (1948) gives results from the land uplift coast on the more southern zone of bogs, south of the town Vaasa. This work contains a large vegetation data from central parts of chosen mire sites from coastal swamps on the littoral belt to old bogs about 80 m asl. The geology and topography are quite similar to the study area 1 (moraine topography). The sample plots were 5 × 5 meters in area and vegetation data includes coverage (per cent) approximations of the moss species. The species of the old genus *Drepanocladus* have not been separated. The occurrence of vascular plant species was recorded without using percentage approximations. The data of Huikari (1956) is collected from a transect line on the belt 0–20 m asl on the border between communes of Simo and Kemi. The area is hence quite close to the study area 1 of this article although it is situated nearer the area of calcareous bedrock. The study of Elveland (1976) has data collected by detailed mapping of areas on the littoral belt and just above it on Kalix Storö in Sweden. The area is in the middle of the area with calcareous bedrock and the mires are largely composed of quite small rich fens.

Results

The mean cover of the most important mire species on belts of different altitude above sea line along the studied lines are shown as figures in Appendix 1. Typical littoral species and swamp species were frequent near the seashore but appear on more developed mires only on most favourable sites (e.g. *Sphagnum squarrosum, S. fimbriatum, Calliergon cordifolium, Drepanocladus aduncus, Potentilla palustris, Lysimachia thyrsiflora* and *Calla palustris* in swamp sites with much water flow or *Carex nigra, Agrostis canina, Calamagrostis stricta* and *Juncus filiformis* in thin peated depressions). *Phragmites australis* was a typical seashore species having sporadical occurrences on the mires above the littoral belt. Some species typical for seashore thickets (eg. *Equisetum arvense, Filipendula ulmaria, Vicia cracca*) appeared also on the herb-rich spruce mires above the littoral belt mainly under 5 m asl. Species typical for paludifying forests on the moraine topography (*Sphagnum girgensohnii, Equisetum sylvaticum* and *Carex globularis*) were lacking from the littoral belt and concentrated to the belt 5 to 15 m asl. On the sandy topography they were rarer and concentrated on belts near the seashore.

Most *Sphagnum* species seemed to be practically lacking from the littoral belt but were quite common on the belt just above it. The lowest occurrences are situated mainly on the margins of the mire basins. Even those *Sphagnum* species, which concentrate on the belts near the coast (*Sphagnum squarrosun, S. fimbriatum*) did not grow on the lowest parts of the littoral belt. Many species of other groups were closely connected with *Sphagnum*-surfaces; eg. *Straminergon stramineum, Scheuchzeria palustris, Drosera rotundifolia, Carex limosa* and *C. chordorrhiza* on the wetter levels and *Polytrichum strictum, Eriophorum vaginatum, Rubus chamaemorus, Empetrum nigrum, Ledum palustre* and *Vaccinium uliginosum* on the hummocks. All these had their lowest situated occurrences on the belt 1,5 to 5 m asl or just above it although they occurred there only on small patches among other vegetation.

A group of mud bottom species (*Rhynchospora alba, Drosera anglica, Sphagnum compactum, S. tenellum, S. pulchrum*) were lacking from the belts under 15 m asl on the morainic topography. On the sandy topography they however had some occurrences also on lower levels. *Rhynchospora fusca*, which can be considered as ecologically similar, was very rare on the moraine topography (found only on the belt 30–50 m asl) but it was common on the upper studied basins on sandy topography.

Of the tree and shrub species accounted on the mires *Alnus incana, Salix phylicifolia* and *Myrica gale* were very clearly connected with the littoral belt and *Salix pentandra* with the belt just above it. *Betula pubescens* and *Picea abies* had their maximums about 1,5–5 m asl, above that they occurred on special sites e.g. on the margins of the mire basins. *Picea* was not accounted on sandy topography at any level. The occurrence of *Pinus silvestris* on the mires seemed to be connected with the formation of hummocks. It was scarce near the seashore and lacking from the youngest belts on morainic topography. Above that it clearly became the most common tree species of the mires.

The species indicating eutrophic (rich fen) or meso-eutrophic (here synonymous with intermediate fen) conditions were very common in young mires on morainic topography. Typically, they indicate ground water influence (*Carex diandra, Bryum pseudotriquetrum, Calliergonella cuspidata, Calliergon giganteum, C. richardso-*

nii, Hamatocaulis vernicosus, Helodium blandowii, Sphagnum contortum, Tomentypnum nitens, Warnstorfia tundrae). These species seemed to be common on the morainic topography, where they concentrated to belts 1,5 to 15 m asl. At the belt 30 to 50 m asl some indicators of moderately rich fens (*Scorpidium revolvens, S. scorpioides* and *Campylium stellatum*) were present in small amounts and *Loeskypnum badium*, a typical species of intermediate fens, had its maximum. On the uppermost studied lines (above 50 m asl) the indicators of rich fen were lacking. On mires on sandy topography all species indicating rich or intermediate fens were restricted to the vicinity of some springs near the seashore. Oligotrophic (extremely poor) fens are the most widespread at the uppermost belts. True ombrotrophic bogs were accounted only on the belt above 30 m as but even there they covered only very small fragments of the mire areas.

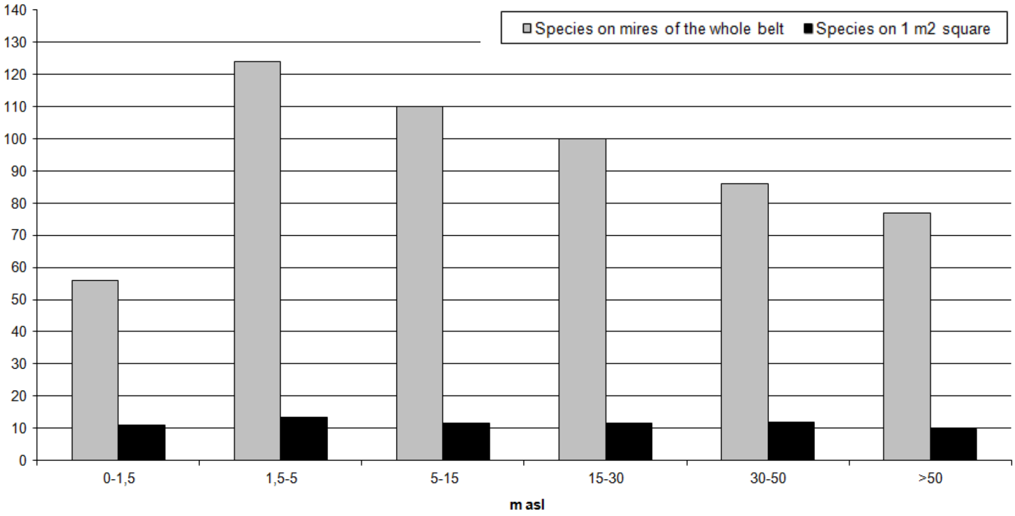
The species diversity on different belts can be seen in Fig. 2. The amount of species on whole mire basins reflects the amount of different habitats in that area. The amount of species in a small sample plot reflects how many species can grow together in the same habitat.

The occurrence of the main species of mire vegetation on different are given in table (Appendix 2). The table contains the results from the study areas of this article but also from other parts of Bothnian Bay based on literature (Brandt 1948, Huikari 1956, Elveland 1976). For the comparison of the succession of aapa mires and bogs, the data of Brandt (1948) is especially interesting because it is comparable to the data collected from the succession series on moraine topography on the zone of aapa mires. Because of the different methods used, only quite rough comparisons can be made. The total coverage of *Sphagnum* mosses is a very crucial variable, which is observed by the same methods in both studies. The coverages of *Sphagnum* on different elevations above sealine are shown in Fig. 3. On the hummock and lawn level vegetation the coverage of *Sphagnum* seems to reach near 100 % already on the belts just above the littoral belt on both succession series. On the wet surfaces the situation on the succession on aapa mires and bogs seems to follow different courses. On the succession series of bogs, the wet surfaces are mainly covered by uniform *Sphagnum* carpets from the belts just above the littoral belt. On the succession series of aapa mires, on the contrary, the coverages of *Sphagnum* mosses on wet levels are smaller.

Discussion

The species diversity on different belts on sandy topography (Fig. 2) shows how the diversity on large scale increases during the succession. This result is very similar to the results from the mires situated between the sandy beach ridges near the river Siikajoki (Timonen 2005). This increase in the diversity during the succession can best be explained by the larger size of mires on the upper belts (Rosenzweig 1995) and by the divergent succession (Sjörs 1990). On the studied basins on the moraine topography, the amount of species is, however, clearly the biggest on the belt just above the littoral belt (1,5–5 m asl). This tendency is very pronounced in the data for whole mire basins, but also on small sample plots. This is clearly due to the centralizing of rich and intermediate fens on that belt. On this bel,t the rich fen species have their maximum, most sea shore species are still growing and besides the species typical for older mires (e.g. *Sphagnum* mosses and species growing with them) have their lowest occurrences on the margins of the same basins. On the belts above it, the diversity of the vascular plant and mosses decreases, while the species of herb-rich spruce mires are lacking from the belts above 5 m asl and the species of rich fens with groundwater influence from the belts above 30 m asl. The especially high species diversity of intermediate and moderately rich fens is observed to be typical for Finnish mires (Tahvanainen 2004).

On the littoral belt few mire mosses and other typical mire plant species can be found. This is probably due to the unstable water regime on this belt (Elveland 1976). Above the littoral belt, the variation in the water quality and quantity on the basins diminishes. On the developing mires the water table stabilizes to the horizons in surface peat, giving rise to the typical water table of hummock-level, lawn level and carpet or mud-bottom level (Sjörs 1950, Eurola et al. 1995) with the plant species typical for these. Many typical mire species can grow on the littoral belt only on spe-



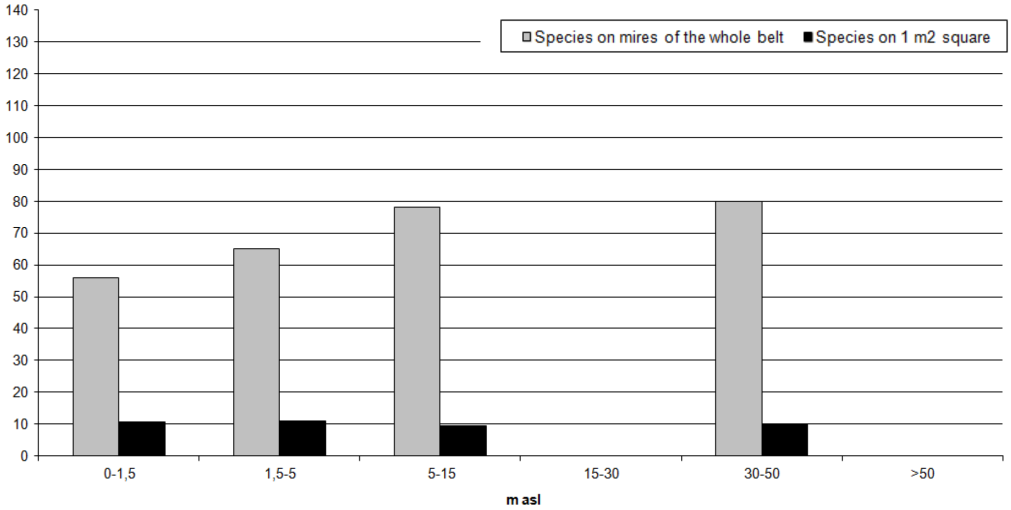


Fig. 2. The species diversity on different belts above sea line. The mires on moraine topography (above) and sandy topography (below).

cial sites, which get steadily terrestrial water and where the water level and water quality remains quite stable comparing the situation in other parts of the seashore (Elveland 1976). Typical examples are *Menyanthes trifoliata, Equisetum fluviatile, Carex chordorrhiza, Scorpidium scorpioides, Calliergon giganteum* and *C. richardsonii*.

The expansion of *Sphagnum* species on the basins emerging from the sea is a very interesting process. Few *Sphagnum* species were found on the seashore littoral belt within the study transects, whilst almost all of them, quickly appeared just above the littoral belt, occurring as small patches mainly in the margins of young mire basins. Quick appearance and succession of *Sphagnum* species (Sundberg et al. 2002) on the land uplift coast thus happens on the belt which has very luxuriant vegetation but which is no more affected by seawater. It is probable that most *Sphagna* disperse into such sites by spores. The significance of spores is emphasized by the fact that *Sphagnum* species can readily colonise sites, where dispersal by other means is improbable; for instance islands emerging from the sea (Sundberg et al. 2002). *Sphagnum* species colonizing the littoral belt most quickly (*S. squarrosum, S.*

fimbriatum) are known to be autoicous, and commonly form spores (Ulvinen et al. 2002), but the dispersion seems to be efficient also for many dioicous species. The germination of spores is considered the most probable on sites, where the amount of nutrients, especially that of phosphorus is high, and the moss layer has gaps (Sundberg & Rydin 2002). Some species like *S. tenellum* and *S. compactum* seem to behave in a different manner: they emerge only on the quite late stage of succession on the aapamires, on developed surface topography with poor mud-bottom level flarks.

The comparison of the study area 1 of this study and the areas of Huikari and Elveland shows that the beginning of the mire succession is very similar in all these areas. These are the mire basins on moraine topography in the area on the northern belt of aapamires. The young mires on the more southern zone of bogs (Brandt 1948) differs by having only a very few species of rich fens and in very small amounts. The area on sandy topography is hydrologically very different and this explains the differences in species composition.

Establishment of *Sphagnum* moss vegetation is considered a key factor in the process of transition from fens to bogs (Hughes 2000, Hughes & Barber 2003). The impact of climatic and hydrological factors on autogenic succession can wary. Shifts to ombrotrophy have been linked with greater peat-growth rates and increased the growth of *Sphagnum* mosses. These are found during wet and warm periods (eg. Hughes 2000, Granath et al. 2010). The role of hydrological changes (diminishing water flow) as a central factor in the expansion of *Sphagnum* mosses was emphasized by Tahvanainen (2011). The role of vascular plants growing together with *Sphagna*, especially *Eriophorum vaginatum* tussocks, can be very important (Hughes 2000). The rise in the amount of *Sphagnum* together with *Eriophorum vaginatum* marks the phase of shifting from minerotrophy to ombrotrophy in the southern raised bogs (Aartolahti 1965, Tolonen 1987) and also on the peripheral parts of aapa mire systems (Rehell & Heikkilä 2009, Rehell 2012b). The results from the land uplift coasts of the Bothnian Bay (see Fig. 3) show, that the coverage of *Sphagnum* mosses on the young mire basins on the zone of bogs is large on all hydrotopographical levels also in the wet parts. On the zone of aapa mires, the central parts of basins with large amount of water flow are characterized by leaf mosses and mud-bottom (Rehell et al. 2012 a) and only small amounts of wet-level *Sphagnum* mosses. This difference between the young mires in southern and northern parts of the land uplift coast can be seen also on the aerial photographs (Rehell 2006). On the zone of bogs, the *Sphagnum* mosses can also cover the central parts of the mire basins. Only some special sites e.g. narrow joints with very strong water flow remain without *Sphagnum* carpet leading to swampy lags. The hummocks of the old bogs at about 30–80 m asl (Fig. 3) have clearly less *Sphagnum* than the younger bogs. That can be explained by the common occurrence of lichens and forest mosses on the old bogs (Brandt 1948, Eurola 1962). The decrease in *Sphagnum* mosses on the hummocks of old bogs can be linked with locally diminishing peat growth rate on those bogs (Tolonen 1971).

The climate change can affect the vegetation succession on the land uplift coastlands. If the temperatures are rising, the conditions on the aapa-mire zone can in the future resemble those now found on the zone of bogs. Hence in the future the *Sphagnum* mosses can be expected to cover larger parts of the mire basins even in the northern part of the land uplift coast. Some examples of that kind of increased *Sphagnum* invasion were described from southern Ostrobothnia by Brandt (1948). The increased growth of *Sphagnum* mosses attributed to the recent climate warming has been observed also on the northern part of the land uplift coast in Siikajoki (Tuittila et al. 2012).

Acknowledgements. Antti Huttunen (†2011) and Raimo Heikkilä have made valuable comments on the manuscript. Antti Reinikainen sent the original field data of Huikari study. Societas pro Fauna et Flora Fenniae gave financial support for the field works.

References

Aario, L 1932: Pflanzentopographische und paläogeographische Mooruntersuchungen in N-Satakunta. — Fennia 55 (1):1–189

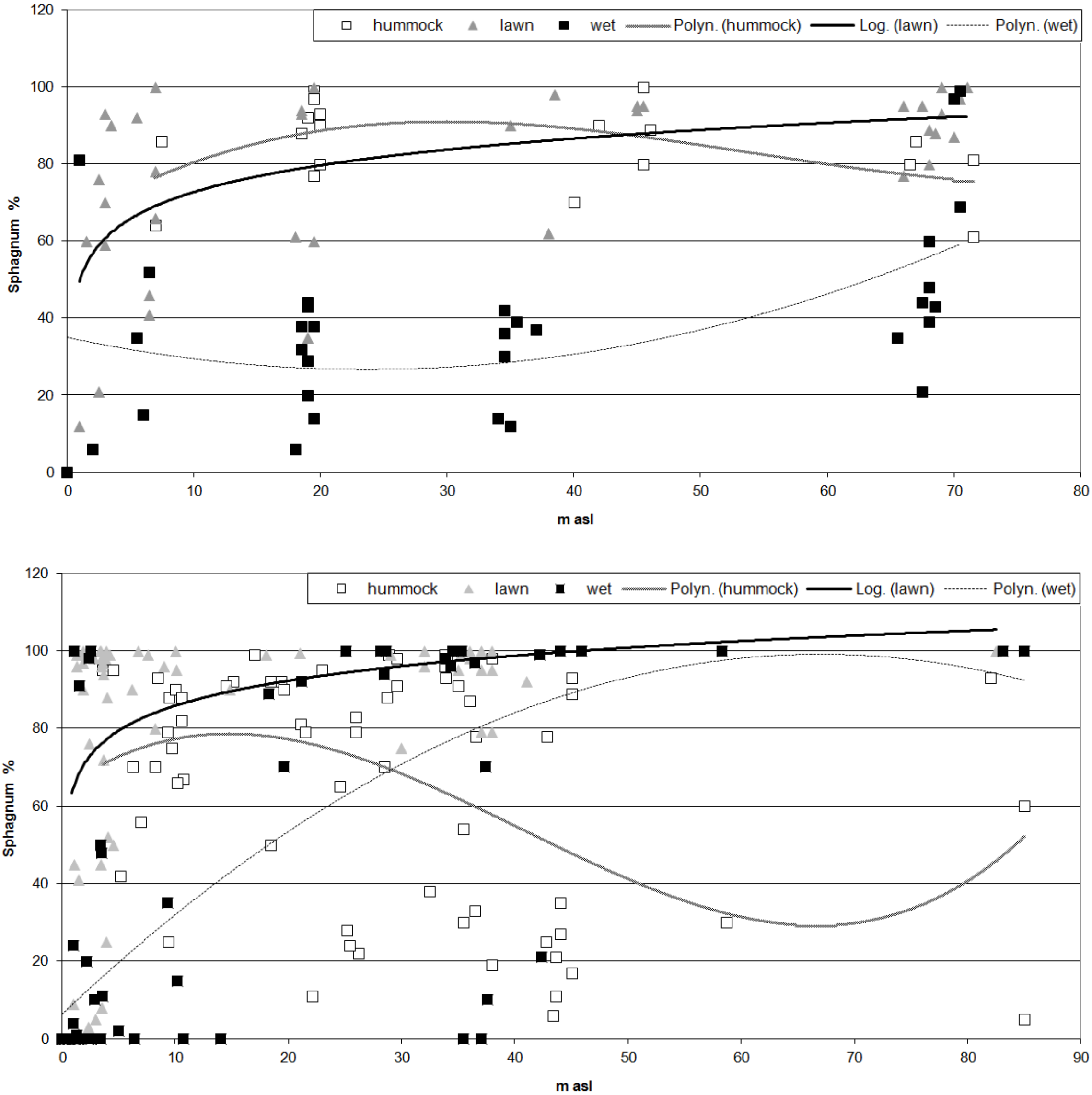


Fig. 3. The total coverage of *Sphagnum* mosses on the sample plots on different elevations above the sea line. Above the results from the study area 1 on aapa more zone (moraine topography) of this study, below the results from the zone of bogs (Brandt 1948).

Brandt, A. 1948: Über die Entwicklung der Moore im Küstengebiet von Süd-Pohjanmaa am Bottnischen Meerbuse. — Annales Botanici Societatis Zoologicae-Botanicae Fennicae ”Vanamo” 23(4): 1–134.

Clymo, R.S. & Hayward, P.M. 1982: The ecology of Sphagnum. — In: Smith, A. J. E. (eds.), Bryophyte ecology: 30–78. Chapman & Hall. London

Elveland, J. 1976: Myrar på Storön vid Norrbottenkusten. — Wahlenbergia 3: 1–274

Ericsson, L. & Wallentinus, H.G. 1979: Seashore vegetation around the Gulf of Bothnia. Guide for the International Society for vegetation science. July-august 1977. — Wahlenbergia 3: 1–274.

Eurola, S. 1962: Über die regionale Einteilung der Südfinnischen Moore. — Annales Botanici Societatis Zoologici Botanici Fennicae ”Vanamo” 33 (2): 1–243.

Eurola, S., Huttunen, A. & Kukko-oja, K. 1994: Suokasvillisuusopas. — Oulanka Reports 13: 1–81.

Eurola, S., Rönkä, A. & Bendiksen, K. 1990: Suokasviopas. — Oulanka Reports 14: 1–216.

Geologian tutkimuskeskus 1997: Suomen kallioperä. 1:1000000. Geologian tutkimuskeskus. Helsinki.

Gibbard, P. I. 1979: Late Pleistocene stratigraphy of the area around Muhos, North Finland. — Annales Academia Scientiarum Fenniae Ser A 129: 1–138.

Granath, G., Strengbom, J. & Rydin, H. 2010: Rapid ecosystem shifts in peatlands linking plant physiology and succession. — Ecology 91: 3047–3056.

Hedenäs, L. 1993: Field and microscopic keys of the Calliergon-Scorpidium-Drepanocladus complex (including some related or similar species). — 79 p. Biodetektor, Märsta.

Havas, P. 1961: Vegetation und Flora der nördlichen Küste des Bottnisches Meerbusens. — Archivum Societatis Zoologicae Botanicae Fennicae ”Vanamo” 16: 84–91

Havas, P. 1967: Zur Ökologie der Laubwälder, insbesondere der Grauerlenwälder an der Küste der Bottenwiek. — Aquilo Serie Botanica 6: 314–346.

Hughes, P. D. M. 2000: A reappraisal of the mechanisms leading to ombrotrophy in British raised mires. — Ecology Letters (2000) 3: 7–9.

Hughes, P. D. M. & Barber, K. E 2003: Mire development across the fen-bog transition on the Teifi floodplain at Tregaron Bog, Ceredigion, Wales, and a comparison with 13 other raised bogs. — Journal of Ecology 91: 253–264.

Huikari, O. 1956: Primäärisen soistumisen osuudesta Suomen soiden synnyssä. — Communicationes Insituti Forestalis Fenniae 46(6): 1–79.

Huttunen, A., Tolonen, K. 2006: Mire development history in Finland. — In: Lindholm, T., Heikkilä, R. (eds.) Finland – Land of Mires: 79–88. The Finnish Environment 23 / 2006.

Hämet-Ahti, L., Suominen, J., Ulvinen, T. & Uotila, P. (eds.) 1998: Retkeilykasvio. — 598 p. Luonnontieteellinen keskusmuseo, Kasvimuseo. Helsinki.

Johansson, M., Kahma, K., Boman, H. & Launiainen, J. 2004: Scenarios for sea-level on the Finnish coast. — Boreal Environmental Research 9: 150–166

Kakkuri, J. 1985: Die Landhebung in Fennoskandien im Lichte der heutigen Wissenschaft. — Zeitschrift für Vermessungswesen. 110 (2): 51–58.

Klinger, L. E. & Short, S. K. 1996: Succession in the Hudson Bay lowland, Northern Ontario, Canada. — Arctic and Alpine Research 28: 172–183.

Korpela, L., Reinikainen, A. 1996: Patterns of diversity in boreal mire margin vegetation. — Suo 47 (1), 17–26.

Kouznetsova, A. 1999: Holocene succession: from marsh to peatland. — In: Halko, L. & Myllys, M. (eds.), Chemical, physical and biological processes in peat soils. IPS-Symposium. Abstracts: 28–30. Jokioinen, Finland.

Kääriäinen, E. 1966: The second levelling of Finland in 1933–1955. — Publications of the Finnish Geodetical Institute 61: 1–314.

Laitinen, J., Rehell, S., Huttunen, A., Tahvanainen, T., Heikkilä, R. & Lindholm, T. 2007: Mire systems of Finland with special reference to aapa-mires and their water-flow pattern. — Suo (58) 1: 1–26.

Lindroos, H. 1990: Nuoren maan maannoskehityksestä Keski-Pohjanmaalla. — GTK. Tutkimusraportti 105: 65–74.

Mossornas Vänner 1993: Vitmossor i Norden. — 125 p. Vasastadens bokbinderi AB, Göteborg.

Niskanen, E. 1939: On the upheaval of land in Fennoscandia. — Annales Akadademia Scientiarum Fenniae. Ser. A.53 (10):1–34.

Rehell, S. 2006: Aapamire development in a land uplift coast. — In. Lindholm, T., Heikkilä, R. & Tahvanainen, T. (eds.), Mires of Finland – Daughters of the Baltic Sea: 31–39. The Finnish Environment 28 / 2006.

Rehell, S. & Heikkilä, R. 2009: Aapasoiden nuoret sukkessiovaiheet Pohjois-Pohjanmaan maankohoammisrannikolla. — Suo 60(1–2): 1–22.

Rehell, S., Huttunen, A., Kondelin, H. & Laitinen, J. 2012a: Development of large-scale aapa mire hydrotopography on land-uplift coastland in northern Finland. — In: Lindholm, T. & Heikkilä, R (eds.), Mires from pole to pole: 39–50. The Finnish Environment 38.

Rehell, S., Huttunen, A. & Kondelin, H. 2012b: The development of patterning on a succession series of aapamire systems on the land-uplift coast of northern Ostrobothnia, Finland. — In: Lindholm, T. & Heikkil,ä R. (eds.), Mires from pole to pole: 51–64. The Finnish Environment 38.

Rosenzweig, M.L. 1995: Species diversity in space and time. — 436 p. Cambridge Univ. Press, Cambridge.

Siira, J. 1970: Studies in the ecology of the seashore meadows of the Bothnian Bay with special reference to the Liminka area. — Aquilo Serie Botanica. 9: 1–109.

Siira, J. 1999: Kasvillisuuden kehitys Perämeren rannikolla (The development of vegetation on the coastalands of Bothnian Bay). — In: Karlsson, K. (ed.), Metsät Pohjanmaan rannikolla. Metsäntutkimuslaitoksen tiedonantoja 723: 33–42.

Sjörs, H. 1950: On the relation between vegetation and electrolytes in north-Swedish mire waters. — Oikos 2: 24–256.

Sjörs, H. 1990: Divergent successions in mires. A comparative study. — Aquilo Serie Botanica 28: 67–77.

Sundberg, S. & Rydin, H. 2002: Habitat requirements for establishment of Sphagnum from spores. — Journal of Ecology 90: 268–278.

Svensson, J. & Jeglum, J. K. 2003: Spatio-temporal properties of tree-species belts during primary succession on rising Gulf of Bothnia coastlines. — Annales Botanici Fennici 40: 265–282.

Tahvanainen, T. 2004: Water chemistry of mires in relation to the poor-rich vegetation gradient and contrasting geochemical zones of northeastern Fennoscandian shield. — Folia Geobotanica 39:353–359.

Tahvanainen, T. 2011: Abrupt ombrotrophication of a boreal aapa mire triggered by hydrological disturbance in the catchment. — Journal of Ecology 99: 404–415.

Taipale, K. & Saarnisto, M. 1991: Tulivuorista jääkausiin. Suomen maankamaran kehitys. — 414 p. WSOY, Porvoo.

Timonen, M.-L. 2005: Suokasvillisuuden sukkessio Pohjois-Pohjanmaan maankohoamisrannikolla. Kasviyhteisöjen ja kasvupaikkatekijöiden tarkastelu. — 59 p. Pro-gradu -työ. Oulun yliopisto. Biologian laitos.

Tolonen, K. 1971: On the regeneration of north European bogs. 1. Klaukkalan Isosuo in S-Finland. — Acta Agralia Fennica 123: 143–166.

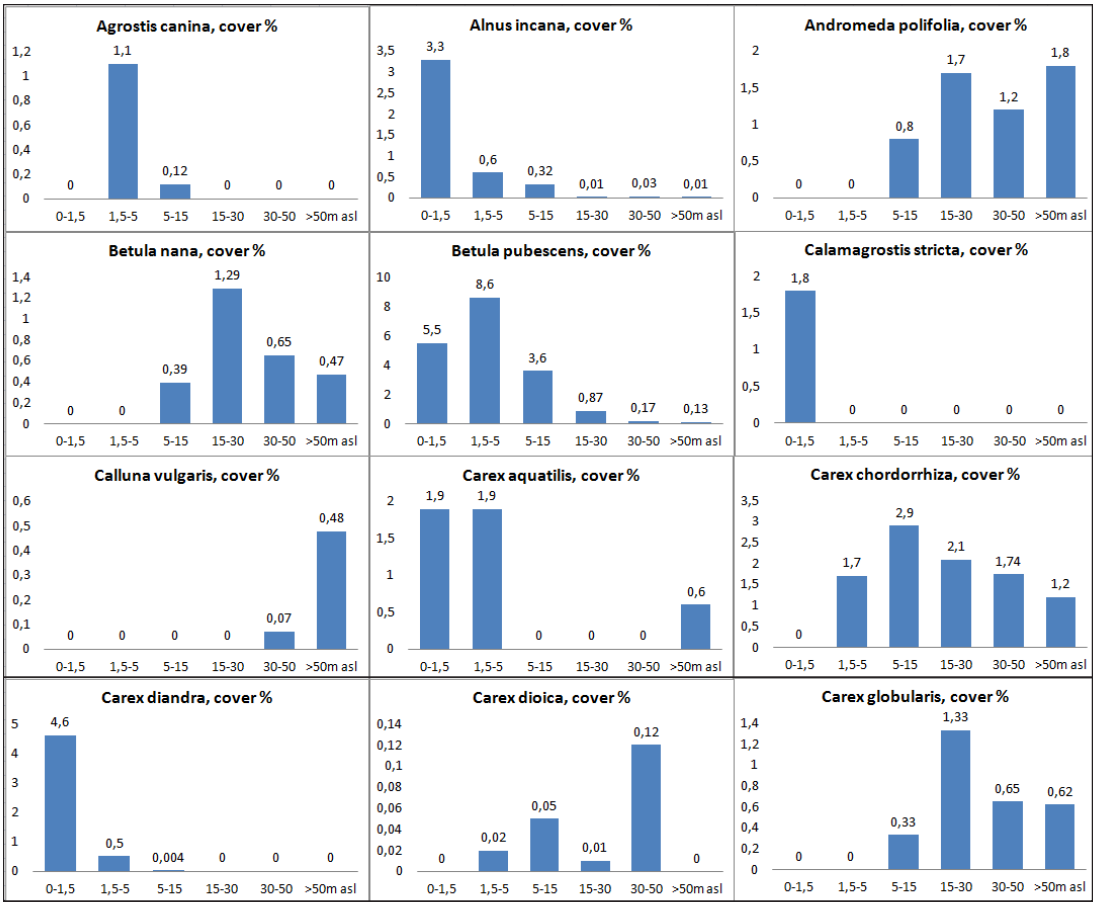
Tolonen, K. 1987: Natural history of raised bogs and forest vegetation in Lammi area, southern Finland, studied by stratigraphical methods. — Annales Akademiae Scientiarum Fenniae Ser A III. Geologica-Geographica 144: 1–46.

Tuittila, E.-S., Juutinen, S., Frolking, S., Väliranta, M., Laine, A., Miettinen, A., Seväkivi, M.-L., Quillet, A. & Merilä, P. 2012: Wetland chronosequence as a model of peatland development: Vegetation succession, peat and carbon accumulation. — The Holocene 23(1): 25–35.

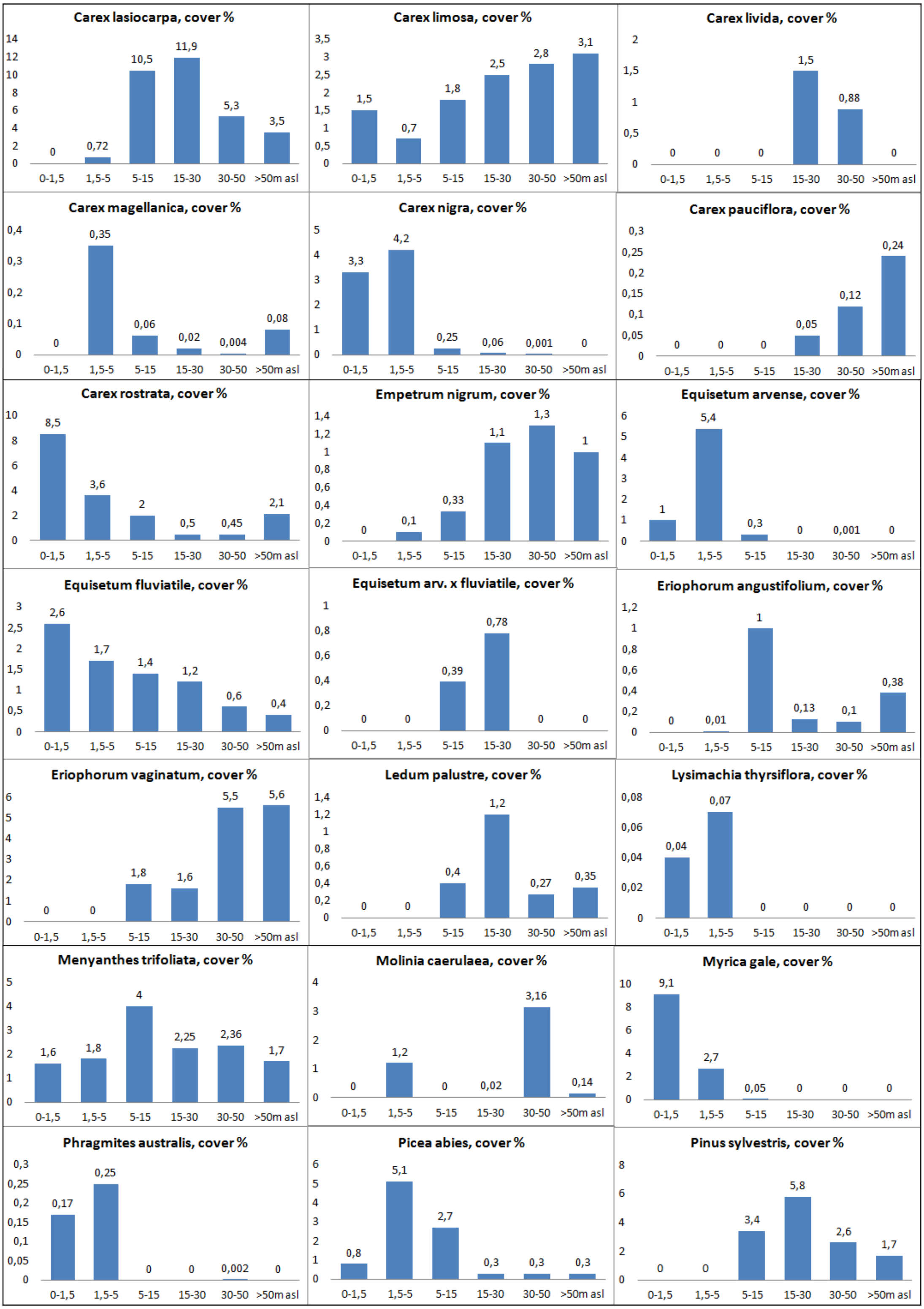
Ulvinen, T., Syrjänen, K. & Anttila, S. (ed.) 2002: Suomen sammalet – levinneisyys, ekologia, uhanalaisuus. — 354 p. Suomen Ympäristö 560. Suomen ympäristökeskus.

Weninger, B., Jöris, O., Danzeglocke, U. 2005: CalPal 2005.SFCP. Radiocarbon calibrating program package. — University of Cologne.

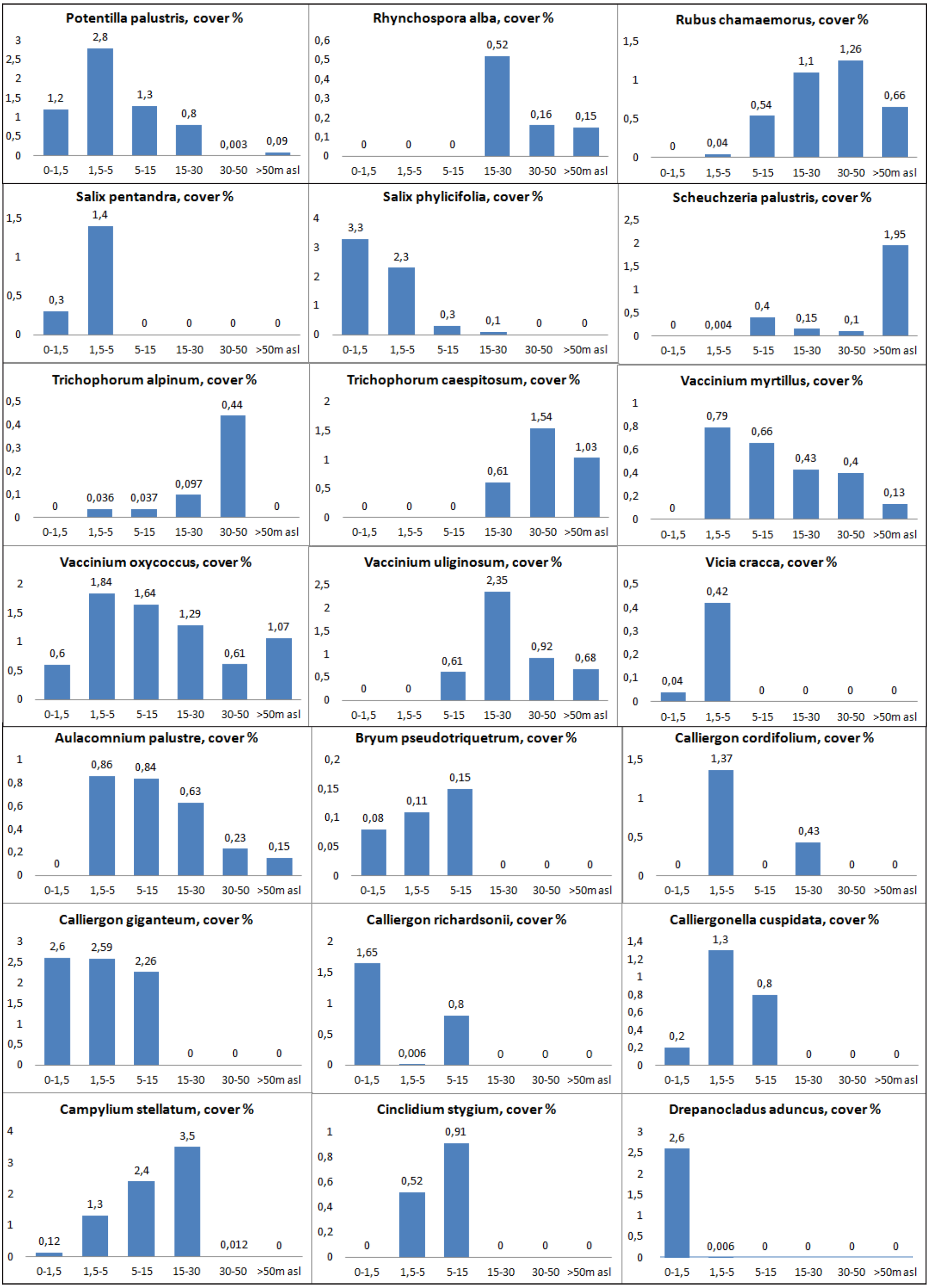
Appendix 1. The mires on moraine topography.



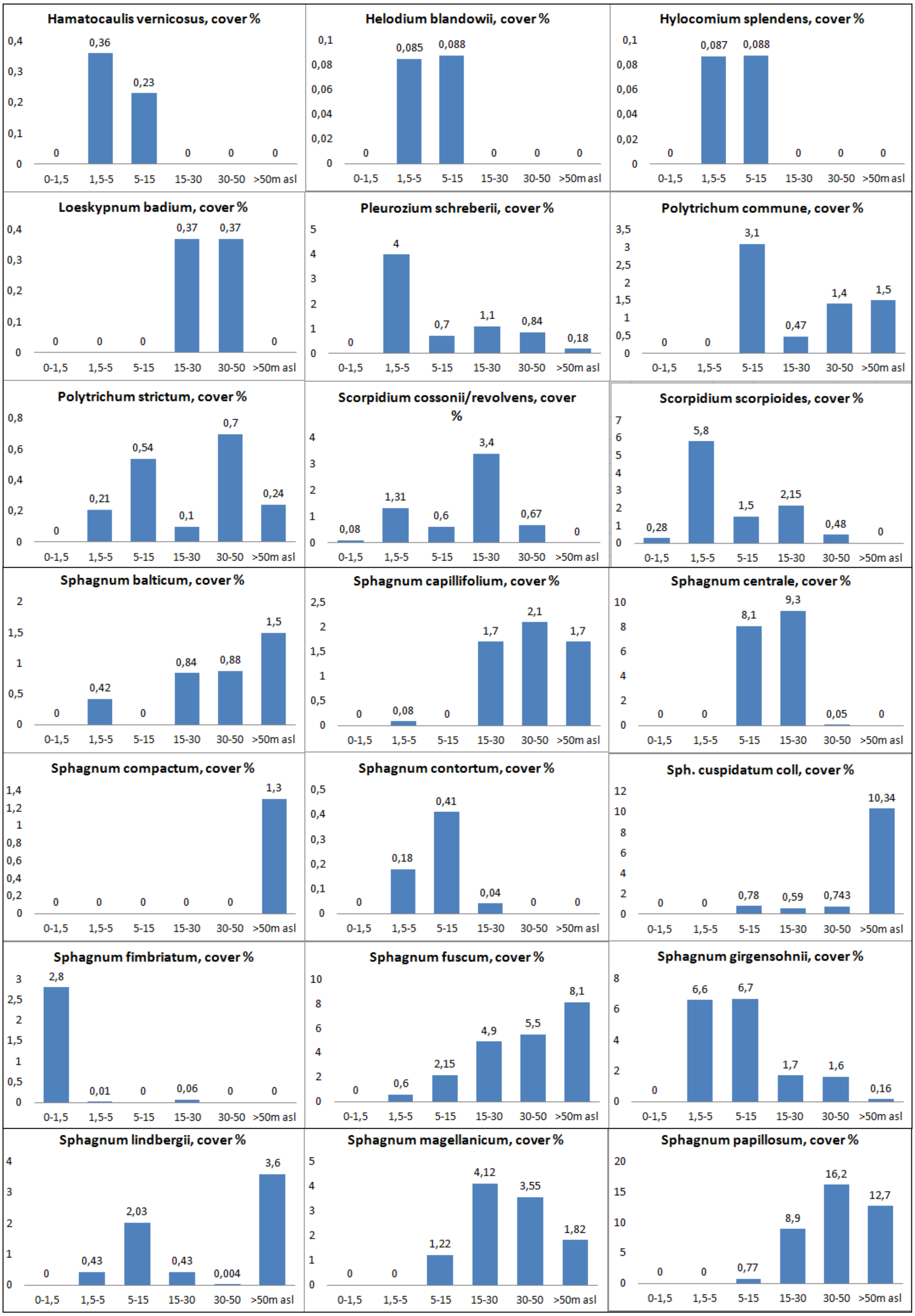
Appendix 1 continued. The mires on moraine topography.



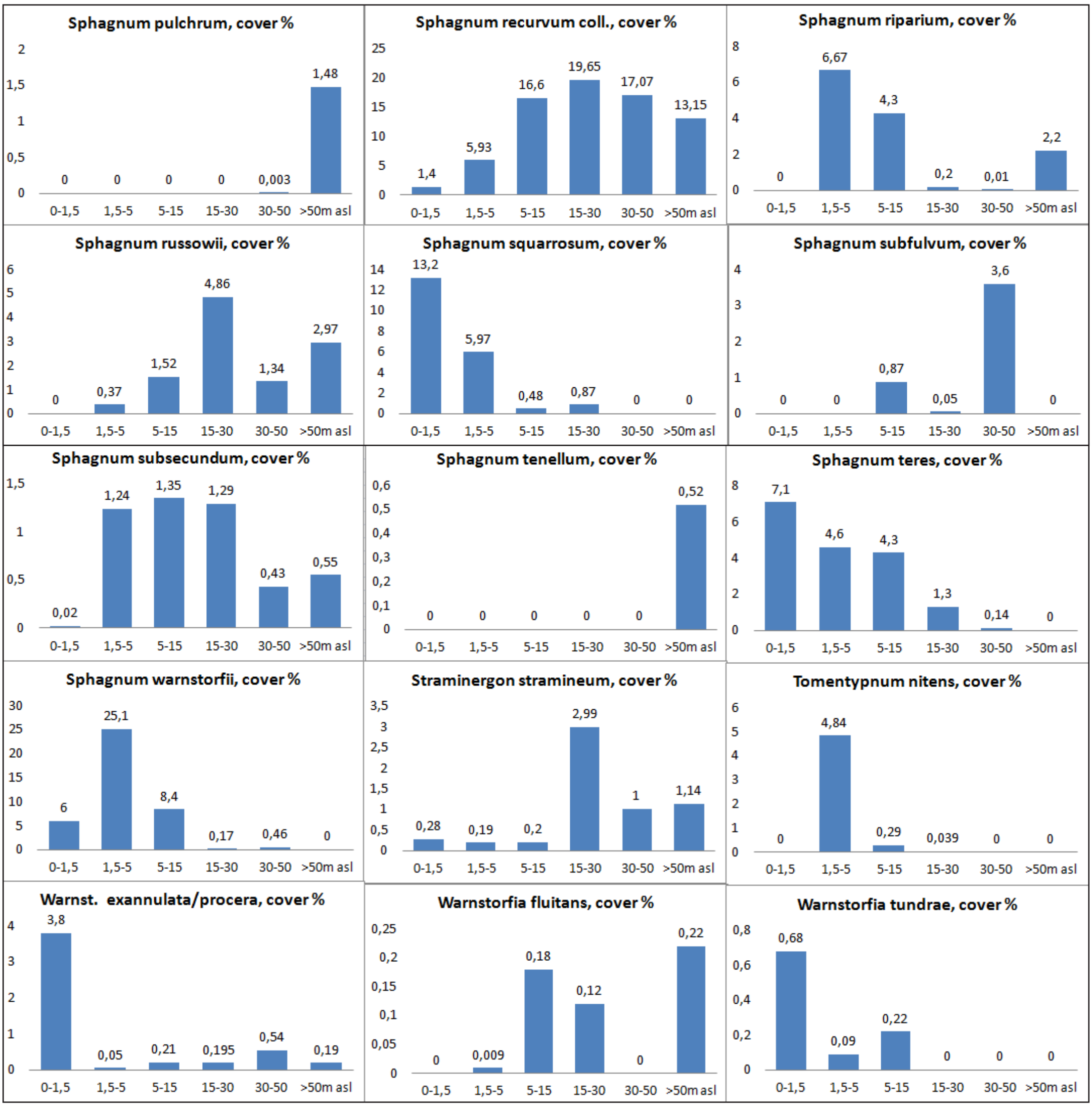
Appendix 1 continued. The mires on moraine topography.



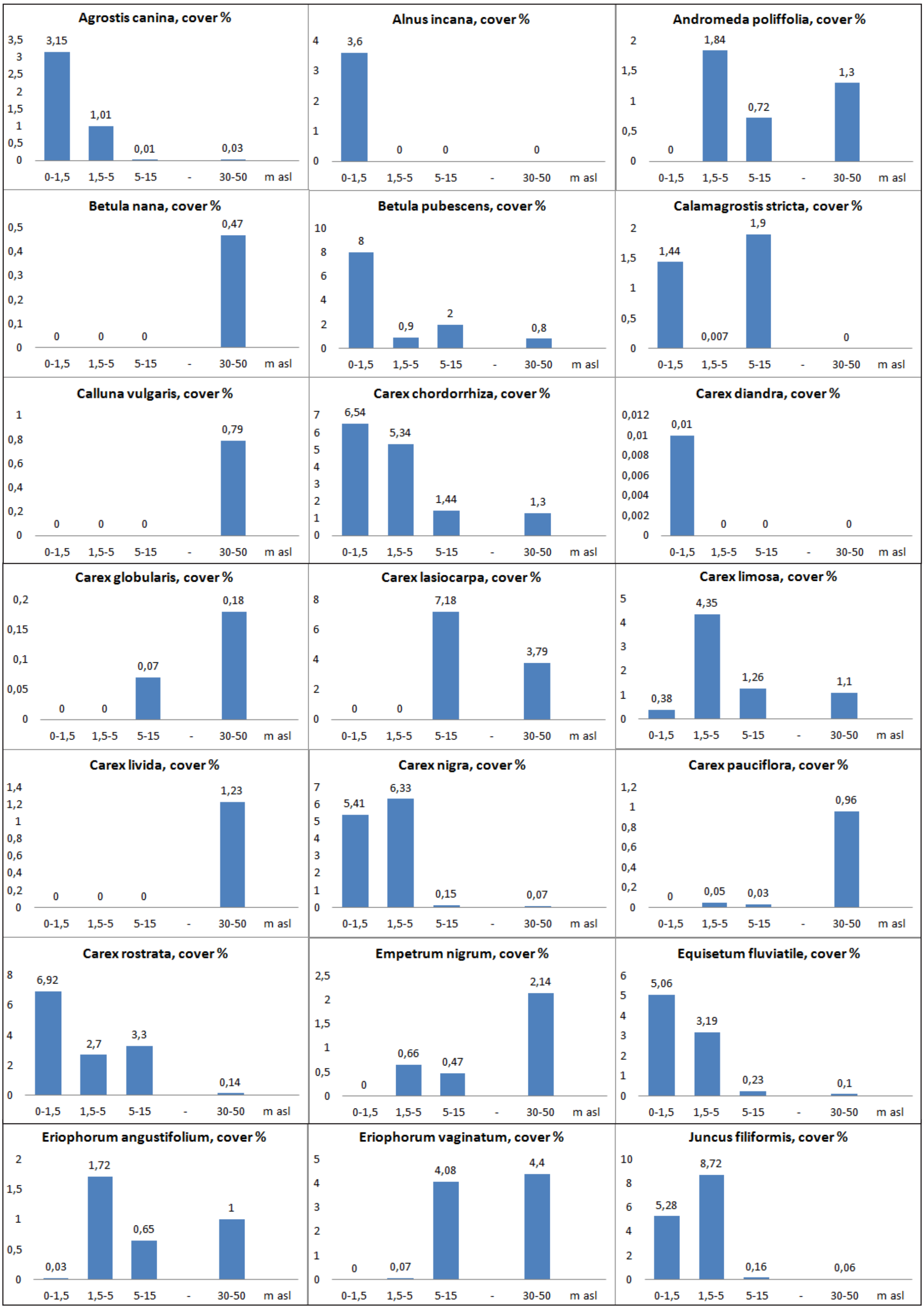
Appendix 1 continued. The mires on moraine topography.



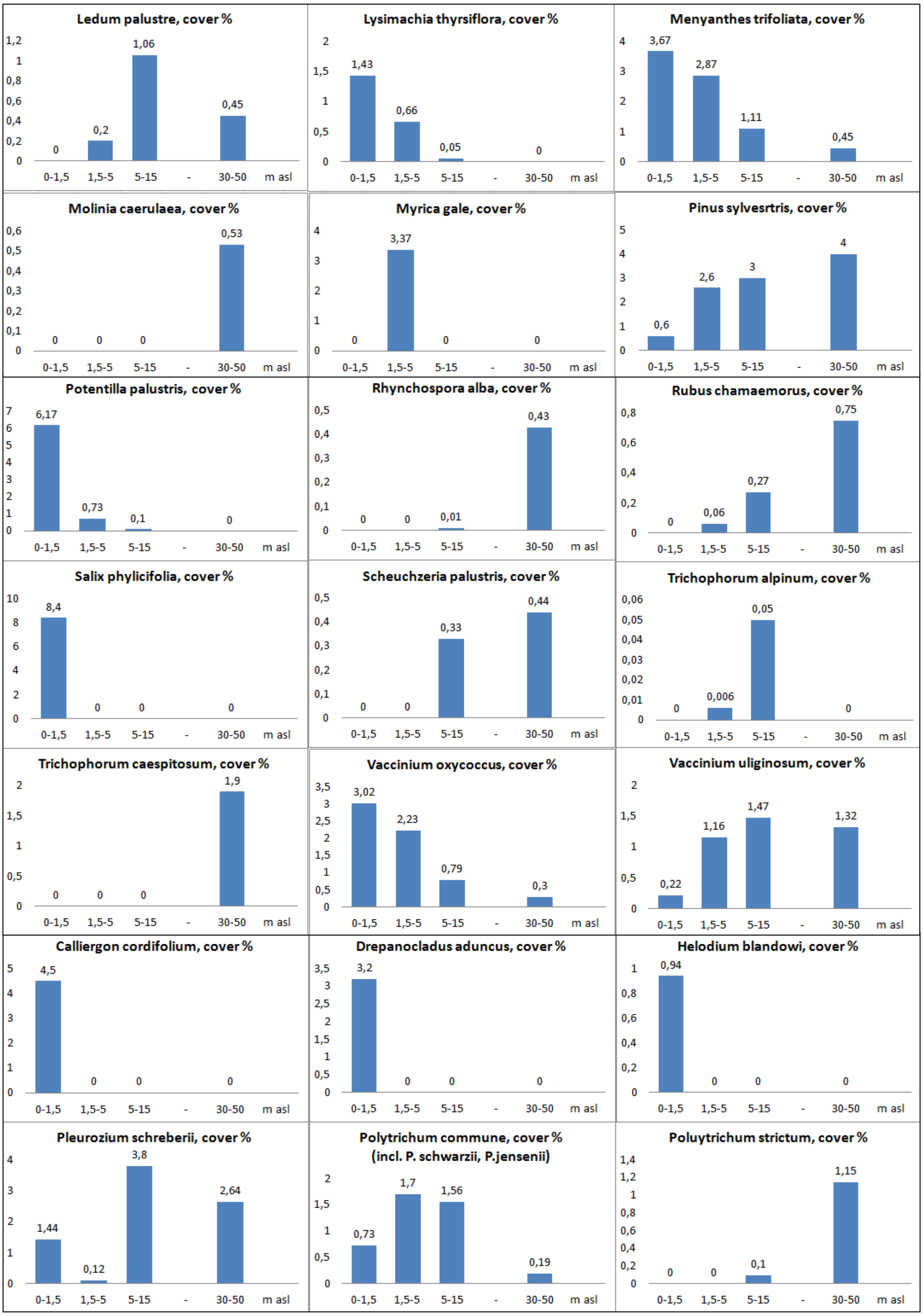
Appendix 1 continued. The mires on moraine topography.



Appendix 1 continued. The mires on sandy topography.



Appendix 1 continued. The mires on sandy topography.



Ledum palustre, cover %

Lysimachia thyrsiflora, cover %

Menyanthes trifoliata, cover %

Molinia caerulaea, cover %

Myrica gale, cover %

Pinus sylvesrtris, cover %

Potentilla palustris, cover %

Rhynchospora alba, cover %

Rubus chamaemorus, cover %

Salix phylicifolia, cover %

Scheuchzeria palustris, cover %

Trichophorum alpinum, cover %

Trichophorum caespitosum, cover %

Vaccinium oxycoccus, cover %

Vaccinium uliginosum, cover %

Calliergon cordifolium, cover %

Drepanocladus aduncus, cover %

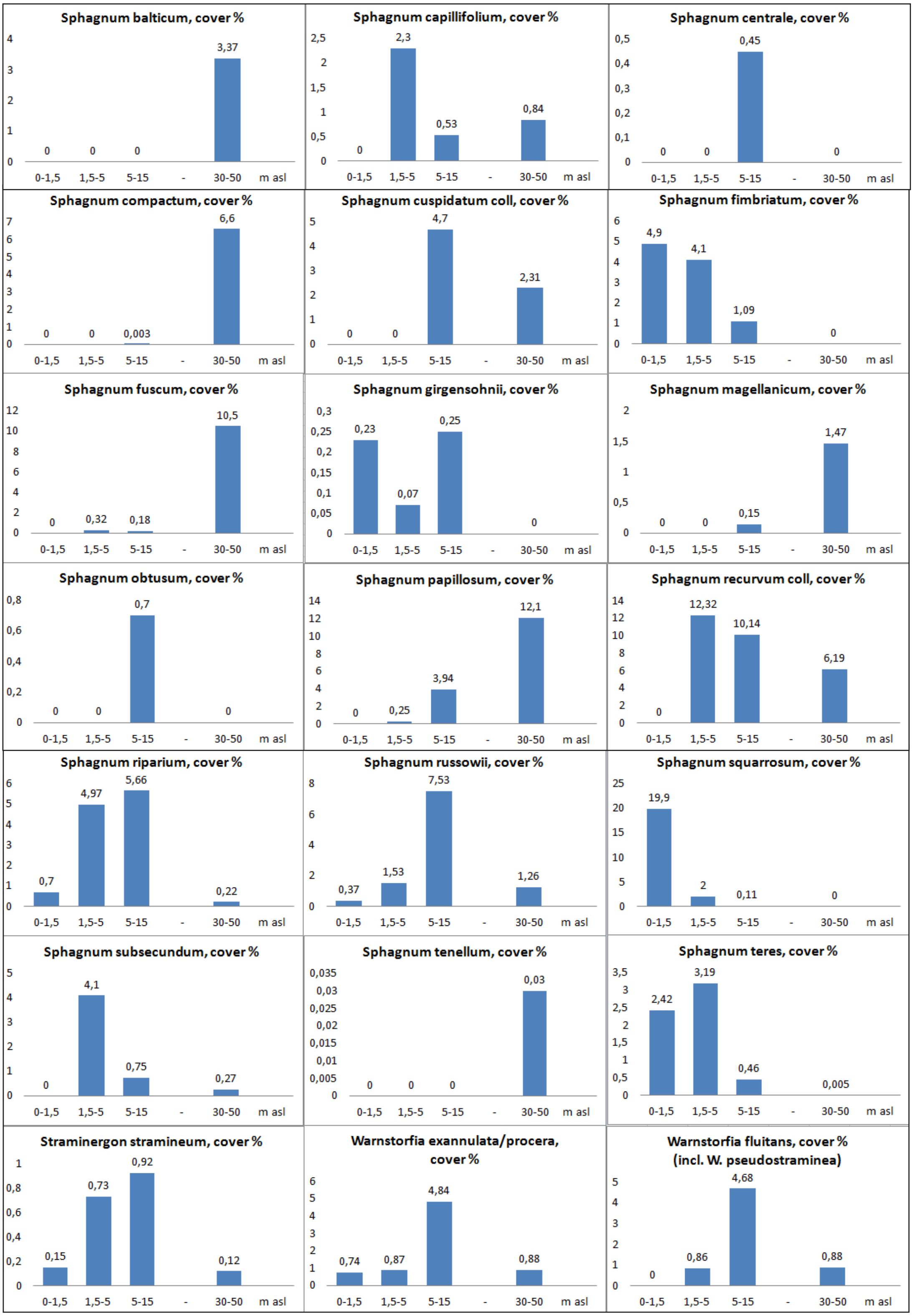
Helodium blandowi, cover %

Pleurozium schreberii, cover %

Polytrichum commune, cover %
(incl. P. schwarzii, P.jensenii)

Poluytrichum strictum, cover %

Appendix 1 continued. The mires on sandy topography.



Appendix 2. The occurrences of species on mire basins on different belts (m asl) on various sites along the land uplift coast of the Bothnian Bay (the altitudes of the belts in meters above sealine).
1. The study area 1 on moraine topography. **2.** The study area 2 on sandy topography. **3.** Data from Huikari (1956) (Simo-Kemi). **4.** Data from Elveland (1976) (Kalix, Sweden). **5.** Data from Brandt (1948) (Southern Ostrobothnia).
– not observed, + present in small amounts, **+** common , **++** dominant, ( ) found on the margins of the mire basin or other very thin peated sites. The marks with an asterisk* mean, that the species is found on the littoral belt only on sites, where there is flow of terrestrial water (Elveland 1976).

	1						**2**				**3**			**4**		**5**			
	0–1,5	1,5–5	5–15	15–30	30–50	>50	0–1,5	1,5–5	5–15	30–50	0–1,5	1,5–5	>5	0–1,5	>1,5	0–1,5	1,5–5	5–18	>18
Aulacomnium palustre	–	(+)	**+**	**+**	**+**	**+**	(+)	**+**	**+**	**+**	(+)	**+**	**+**	(+)	**+**	(+)	–	**+**	**+**
Bryum pseudotriquetrum	(+)	**+**	**+**	+	–	–	(+)	–	–	–	–	–	–	+	**+**	–	(+)	–	–
Calliergon cordifolium	**++**	**+**	+	+	–	–	**++**	**+**	+	–	–	–	–	**+**	**+**	**+**	**+**	–	–
Calliergon giganteum	**+**	**++**	**+**	+	–	–	+	–	–	–	+	+	+	+*	+	–	–	–	–
Calliergon richardsonii	–	**+**	**+**	+	–	–	+	–	–	–	–	–	+	+	+	–	–	–	–
Calliergonella cuspidata	**+**	+	+	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Campylium stellatum	**+**	**++**	**++**	**++**	+	–	–	–	–	–	+	**++**	**++**	+	**++**	–	–	–	–
Cinclidium stygium	–	**+**	**+**	+	–	–	–	–	–	–	–	–	+	–	**+**	–	–	–	–
Cladonia sp.	–	–	+	+	**+**	**+**	–	–	+	**++**	–	–	–	–	+	–	–	+	**++**
Drepanocladus aduncus	**++**	+	+	–	–	–	**++**	–	–	–	–	–	–	**+**	+	?	?	?	?
Hamatocaulis vernicosus	–	+	+	–	–	–	–	–	–	–	–	–	+	–	–	?	?	?	?
Helodium blandowii	(+)	**+**	**+**	+	+	–	(+)	+	–	–	–	–	+	–	**+**	(+)	–	–	(+)
Hylocomium spendens	–	(**+**)	(**+**)	(+)	–	–	–	–	–	–	–	–	(+)	–	(+)	–	(+)	+	+
Hypnum linbergii	–	**+**	+	–	–	–	–	–	–	–	–	–	–	+	+	–	–	–	–
Loeskypnum badium	–	–	+	**+**	**++**	–	–	–	–	–	–	–	+	–	**+**	–	–	–	–
Meesea triquetra	–	+	+	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Paludella squarrosa	–	**+**	**+**	+	+	–	–	–	–	–	–	–	+	–	+	–	–	–	–
Pleurozium schreberi	–	(**+**)	(**+**)	+	+	**+**	(+)	(+)	(**+**)	**+**	–	(+)	**+**	–	**+**	–	(+)	**++**	**++**
Polytrichum commune sl	(+)	(**+**)	**++**	**+**	**+**	**+**	(**+**)	(**+**)	(**+**)	(**++**)	–	**+**	**+**	(+)	+	–	+	**+**	**+**
Polytrichum strictum	–	+	**+**	**+**	**+**	**+**	–	–	**+**	**++**	–	–	+	–	+	–	+	**+**	**+**
Scorpidium cossonii / revolv.	**+**	**+**	**++**	**++**	**+**	–	–	–	–	–	+	**+**	**+**	+*	**++**	?	?	?	?
Scorpidium scorpioides	**+**	**++**	**++**	**++**	**+**	–	–	–	–	–	+	**+**	**+**	+*	**++**	–	+	–	–
Sphagnum angustifolium	–	**+**	**++**	**++**	**+**	**+**	–	(**+**)	(**+**)	**+**	–	**+**	**++**	–	**+**	–	**+**	**++**	**++**
Sph. annulatum/jensenii	–	+	**+**	**+**	**+**	**++**	–	**+**	**++**	**+**	–	–	–	–	+	–	–	–	+
Sph. aongstroemii	–	+	**+**	–	–	+	–	**+**	**+**	–	–	–	–	–	–	–	–	–	–
Sph. balticum	–	+	+	**+**	**+**	**++**	–	+	+	**++**	–	–	–	–	+	–	–	+	**++**
Sph. capillifolium	–	(+)	(**+**)	(**+**)	(**+**)	(**++**)	–	(**+**)	(**+**)	**+**	–	–	(**+**)	–	(**+**)	–	–	–	**+**
Sph. centrale	–	+	**++**	**+**	+	–	–	**+**	**+**	+	–	–	+	–	+	–	–	–	–
Sph. compactum	–	–	(+)	–	–	**+**	–	(+)	(**+**)	**++**	–	–	–	–	–	–	–	–	+
Sph. contortum	–	**+**	**+**	+	–	–	–	–	–	–	–	–	+	–	+	–	–	–	–
Sph. fallax	+	**+**	**+**	**+**	**+**	**+**	–	**+**	**++**	**+**	–	**+**	**+**	–	+	–	**++**	+	+
Sph. fimbriatum	(+)	**++**	**+**	+	+	–	(+)	**+**	**+**	–	+	–	+	–	–	–	+	–	–
Sph. flexuosum	–	**+**	**+**	**+**	**+**	**+**	–	**+**	**+**	**+**	–	–	+	–	?	–	**+**	+	+
Sph. fuscum	–	(+)	**+**	**++**	**++**	**++**	–	**+**	**+**	**++**	–	–	**++**	–	**++**	–	+	**++**	**++**
Sph. girgensohnii	–	(**+**)	**++**	**+**	(+)	(+)	–	(**+**)	(+)	(+)	–	**+**	**+**	–	**+**	–	**+**	–	–
Sph. lindbergii	–	+	**+**	+	+	**+**	–	**+**	**+**	+	–	+	+	–	+	–	+	+	+
Sph. magellanicum	–	**+**	**+**	**+**	**+**	**+**	–	+	**+**	**+**	–	–	+	–	+	–	**+**	**+**	**+**
Sph. majus	–	+	+	**+**	**+**	**++**	–	+	**+**	**++**	–	–	–	–	–	–	+	+	**+**
Sph. obtusum	–	**+**	**+**	+	–	–	–	**++**	**+**	–	–	–	–	–	+	–	**++**	+	+
Sph. papillosum	–	–	**++**	**++**	**++**	**++**	–	**+**	**++**	**++**	–	–	+	–	+	–	+	**+**	**++**
Sph. platyphyllum	+	**+**	**+**	+	–	**+**	–	**++**	**++**	**++**	–	+	+	–	–	–	–	–	–

Appendix 2 continued.

	1						**2**				**3**			**4**		**5**			
	0–1,5	1,5–5	5–15	15–30	30–50	>50	0–1,5	1,5–5	5–15	30–50	0–1,5	1,5–5	>5	0–1,5	>1,5	0–1,5	1,5–5	5–18	>18
Sph. pulchrum	–	–	–	–	+	**+**	–	–	–	–	–	–	–	–	–	–	–	–	–
Sph. riparium	(+)	**++**	**++**	**+**	+	+	(+)	**++**	**++**	+	–	**+**	+	+	**+**	–	**+**	+	+
Sph. rubellum	–	+	+	+	**+**	**+**	–	–	–	**+**	–	–	–	–	–	–	+	**+**	**+**
Sph. russowii	–	(+)	**++**	**+**	**+**	**+**	–	(**+**)	(**+**)	**+**	–	**+**	**+**	–	+	–	+	**+**	**+**
Sph. squarrosum	**++**	**++**	**+**	**+**	+	–	**++**	**++**	**+**	–	**+**	**+**	**+**	**+**	**+**	**+**	**+**	–	–
Sph. subfulvum	–	–	+	**+**	**++**	–	–	–	+	+	–	+	–	–	+	–	–	–	–
Sph. subsecundum	–	**+**	**++**	**++**	**++**	**++**	–	**+**	**++**	**++**	–	**+**	**+**	+	**+**	–	+	–	+
Sph. tenellum	–	–	–	–	–	**+**	–	–	–	**+**	–	–	–	–	–	–	–	–	**+**
Sph. teres	–	**+**	**++**	**+**	+	–	(**+**)	**+**	**+**	+	–	**+**	+	+	**+**	–	+	–	+
Sph. warnstorfii	–	(**++**)	**++**	**+**	**+**	+	–	–	–	–	–	**+**	**+**	–	**++**	–	–	–	–
Sph. wulfianum	–	–	+	+	–	–	–	–	–	(+)	–	–	–	–	–	–	–	–	–
Straminergon stramineum	+	**+**	**+**	**+**	**+**	**+**	**+**	**+**	**+**	**+**	+	**+**	**+**	+	**+**	–	**+**	+	+
Tomentypnum nitens	–	**+**	**+**	+	+	–	–	–	–	–	–	+	+	–	**+**	–	–	–	–
Warstorfia exannulata	**+**	**+**	**+**	**+**	**+**	**+**	**+**	**+**	**+**	+	**+**	+	+	**+**	**+**	?	?	?	?
Warnstorfia fluitans	–	+	+	+	+	**+**	–	+	**+**	**++**	–	+	**+**	**+**	**+**	?	?	?	?
Warnstorfia procera	–	–	–	**+**	**+**	**+**	–	**+**	**+**	+	–	+	+	–	+	?	?	?	?
Warnstorfia tundrae	+	**+**	+	–	–	–	–	–	–	–	+	–	+	+	**+**	?	?	?	?
Agrostis canina	(**+**)	(+)	(+)	(+)	–	–	(**++**)	(**+**)	(**+**)	(+)	–	–	–	+	–	**+**	+	–	–
Alnus incana	**++**	+	+	(+)	(+)	(+)	**++**	(+)	–	–	?	?	?	**+**	+	–	**+**	–	–
Andromeda polifolia	–	–	**++**	**++**	**++**	**++**	–	**+**	**++**	**++**	–	+	**++**	–	**+**	–	–	**++**	**++**
Betula nana	–	–	**+**	**+**	**+**	**+**	–	–	–	**+**	–	(+)	**+**	–	**+**	–	+	**+**	**+**
Betula pubescens	**++**	**++**	**+**	+	+	+	**++**	+	+	+	?	?	?	**+**	**+**	**+**	**++**	+	+
Calamagr. canesc / phra.	(**+**)	(**+**)	**+**	**+**	(+)	(+)	(+)	–	–	–	**+**	**+**	**+**	–	+	–	+	–	–
Calamagrostis stricta	(**++**)	+	+	–	–	–	(**++**)	(**+**)	(**+**)	–	–	–	–	(**+**)	+	+	+	–	–
Calla palustris	**++**	**++**	**+**	–	–	–	**++**	**+**	**+**	+	–	–	–	**++**	+	**++**	**++**	+	+
Calluna vulgaris	–	–	(+)	+	**+**	**+**	(**+**)	(**+**)	(**+**)	**+**	–	–	(+)	–	(+)	–	–	+	**++**
Carex aquatilis	**+**	**+**	–	–	–	(+)	**+**	–	–	(+)	–	+	–	**+**	+	**+**	**+**	–	–
Carex canescens	**+**	**+**	+	+	+	+	**++**	**+**	+	–	–	–	+	**+**	**+**	**+**	**+**	+	+
Carex chordorrhiza	–	**+**	**+**	**+**	**+**	**+**	+	**+**	**+**	**+**	+	**+**	**+**	+*	**+**	–	–	–	+
Carex diandra	**+**	**+**	+	+	–	–	**+**	–	–	–	+	–	+	**+**	**+**	–	–	–	–
Carex globularis	–	(+)	**++**	**++**	**++**	**+**	–	–	(+)	(**+**)	–	–	**++**	–	**+**	–	–	+	+
Carex lasiocarpa	–	+	**++**	**++**	**++**	**+**	–	(**+**)	**++**	**++**	–	**++**	**++**	–	**++**	–	–	–	+
Carex limosa	–	**++**	**++**	**++**	**++**	**++**	–	**++**	**++**	**++**	–	**++**	**++**	+*	**+**	–	**+**	**+**	**+**
Carex livida	–	–	**+**	**++**	**++**	+	–	–	+	**+**	–	**+**	**+**	–	**+**	–	–	–	–
Carex magellanica	–	**+**	+	+	+	**+**	(+)	+	–	+	–	+	+	–	+	–	–	–	–
Carex nigra	(**++**)	**++**	**+**	+	+	–	(**++**)	**++**	**++**	(**+**)	**+**	**+**	+	**+**	**+**	**++**	**+**	+	+
Carex pauciflora	–	–	+	**+**	**+**	**+**	–	+	+	**+**	–	–	–	–	+	–	–	+	+
Carex rostrata	**++**	**++**	**+**	**+**	**+**	**++**	**++**	**++**	**+**	**+**	**+**	**+**	**+**	+*	**+**	**++**	**++**	**+**	**+**
Chamaedaphne calyculata	–	–	**+**	+	–	–	–	**+**	**+**	**+**	–	–	+	–	–	–	–	–	–
Cicuta virosa	**+**	**+**	–	–	–	–	**+**	**+**	–	–	–	–	–	**+**	+	+	–	–	–
Drosera anglica	–	–	–	**+**	**+**	**+**	(+)	+	**+**	**+**	–	–	–	–	+	–	+	**+**	**+**
Drosera rotundifolia	–	**+**	**+**	**+**	**+**	**+**	–	**+**	**+**	**+**	–	+	+	–	**+**	–	**+**	**+**	**+**
Empetrum nigrum	–	**+**	**++**	**++**	**++**	**++**	(+)	(**+**)	**+**	**++**	–	(+)	**++**	–	**+**	–	+	**++**	**++**
Equisetum arvense	(**++**)	(**+**)	(**+**)	(**+**)	(+)	–	(**+**)	(+)	–	–	–	–	–	–	**+**	–	+	–	–
Equisetum fluviatile	**+**	**++**	**++**	**++**	**+**	**+**	**++**	**++**	**++**	**+**	**+**	**+**	**+**	+*	**+**	**+**	+	+	+
Equisetum silvaticum	–	–	(**++**	(**+**)	(+)	(+)	–	–	(+)	(+)	–	(+)	**+**	–	**+**	–	–	–	–
Epilobium palustre	**+**	**+**	+	+	–	–	**+**	**+**	–	–	+	–	–	**+**	**+**	**+**	+	+	+

Appendix 2 continued.

	1						2				3			4		5			
	0–1,5	1,5–5	5–15	15–30	30–50	>50	0–1,5	1,5–5	5–15	30–50	0–1,5	1,5–5	>5	0–1,5	>1,5	0–1,5	1,5–5	5–18	>18
Eriophorum angustifolium	**+**	**+**	**+**	**+**	**+**	**+**	**+**	**+**	**++**	**++**	+	**+**	**+**	**++**	**+**	**++**	**+**	**+**	**+**
Eriophorum gracile	–	+	**+**	+	–	+	–	+	+	–	–	–	+	–	+	–	+	–	+
Eriophorum latifolium	–	–	**+**	–	+	–	–	–	–	–	–	+	+	–	**+**	–	–	–	–
Eriophorum vaginatum	–	**+**	**++**	**++**	**++**	**++**	–	(**+**)	**++**	**++**	–	–	**++**	–	**+**	–	**++**	**++**	**++**
Filipendula ulmaria	(**+**)	**+**	+	(+)	–	–	(+)	–	–	–	**+**	**+**	+	**+**	+	–	–	–	–
Geum rivale	–	**+**	+	–	–	–	–	–	–	–	–	(+)	(+)	–	(+)	–	–	–	–
Juncus filiformis	**+**	**+**	+	+	–	–	**+**	**++**	**+**	+	–	–	–	+	+	+	+	+	–
Juncus stygius	–	–	+	**+**	**+**	+	–	–	–	**+**	–	–	–	–	+	–	–	–	–
Ledum palustre	–	–	**++**	**++**	**++**	**++**	–	(**+**)	(**+**)	**++**	–	(+)	**+**	–	**+**	–	**+**	**++**	**+**
Lysimachia thyrsiflora	**++**	**+**	**+**	+	–	–	**++**	**+**	+	–	–	–	–	+*	+	**+**	+	–	–
Menyanthes trifoliata	**+**	**++**	**++**	**++**	**++**	**+**	**+**	**++**	**++**	**+**	**+**	**++**	**++**	+*	**+**	+	**+**	+	+
Molinia caerulaea	(+)	(+)	(**+**)	**+**	**++**	**+**	–	–	–	**+**	+	+	+	(+)	**+**	–	–	–	–
Myrica gale	**++**	**+**	**+**	+	–	–	**++**	**+**	–	–	+	+	+	**+**	**+**	–	–	–	–
Peucedanum palustre	**+**	**+**	**+**	**+**	–	–	**+**	–	–	+	+	–	–	**+**	+	+	+	–	–
Phragmites australis	**++**	+	+	–	**+**	–	**++**	–	+	–	–	+	–	(+)	**+**	**++**	+	–	–
Picea abies	(**+**)	**++**	**++**	**++**	(+)	(+)	–	–	–	–	?	?	?	+	**+**	–	**+**	+	+
Pinus silvestris	–	–	+	**++**	**++**	**++**	(+)	(+)	**+**	**++**	?	?	?	–	**++**	–	+	**++**	**++**
Potentilla palustre	**++**	**+**	**+**	**+**	+	+	**++**	**+**	**+**	–	**++**	**+**	+	**+**	**+**	**++**	**+**	+	+
Rhynchospora alba	–	–	+	**+**	**+**	**+**	–	–	**+**	**+**	–	+	–	–	–	–	+	–	**+**
Rhynchospora fusca	–	–	–	–	+	–	–	–	+	(**++**)	–	+	–	–	–	–	–	–	–
Rubus arcticus	**+**	**+**	+	–	–	–	+	–	–	–	–	–	–	**+**	**+**	+	–	–	–
Rubus chamaemorus	–	+	**+**	**+**	**+**	**+**	–	+	**+**	**+**	–	(+)	**++**	–	**+**	–	+	**++**	**++**
Salix pentandra	+	**+**	+	–	–	–	–	–	–	–	?	?	?	–	–	–	–	–	–
Salix phylicifolia	**++**	**++**	+	+	–	–	**++**	–	(+)	–	?	?	?	**+**	+	**+**	+	–	–
Scheuchzeria palustris	–	+	**+**	**+**	**+**	**++**	–	+	**+**	**+**	–	–	+	–	+	–	+	**+**	**+**
Selaginella selaginoides	–	(+)	(+)	–	**+**	–	–	–	–	–	–	–	–	+*	**+**	–	–	–	–
Trichophorum alpinum	–	+	**+**	**+**	**++**	+	–	–	**+**	–	–	+	**+**	–	**+**	–	–	–	–
Trichophorum caespitosum	–	+	**+**	**+**	**++**	**+**	–	–	+	**++**	–	(+)	+	–	**++**	–	–	–	**+**
Trollius europaeus	+	**+**	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Vaccinium myrtillus	–	(+)	(**+**)	(**+**)	(+)	(+)	–	(**+**)	(+)	(+)	–	(+)	**+**	–	**+**	–	**+**	**+**	+
Vaccinium oxycoccus	–	**++**	**+**	**+**	**+**	**+**	(**++**)	**++**	**+**	**+**	+	**+**	**+**	+*	**+**	–	**++**	**+**	**+**
Vaccinium uliginosum	–	–	**++**	**++**	**++**	**++**	(+)	(**+**	**++**	**++**	(+)	**+**	**+**	–	**+**	–	–	**+**	**+**
Vaccinium vitis–idaea	–	(+)	(**+**)	(**+**)	(+)	(+)	–	(**+**)	(**+**)	**+**	–	(+)	(+)	–	(+)	–	+	**+**	+
Vicia cracca	(**+**)	**+**	+	–	–	–	(+)	–	–	–	–	–	–	–	(+)	–	–	–	–

Appendix 3. Coverages of main types of vegetation on the bottom layer on different belts. Succession on the aapa mire district (this study, moraine terrain) on the left and on the bog district (Brandt 1948) on the right.