Supplementary Material

The Kulbäcksliden Research Infrastructure: a unique setting for northern peatland studies

Koffi Dodji Noumonvi*, Anneli M. Ågren, Joshua L. Ratcliffe, Mats G. Öquist, Lars Ericson, Cheuk Hei Marcus Tong, Järvi Järveoja, Wei Zhu, Stefan Osterwalder, Haijun Peng, Charlotta Erefur, Kevin Bishop, Hjalmar Laudon, Mats B. Nilsson, Matthias Peichl

*** Correspondence:** Corresponding Author: koffi.noumonvi@slu.se

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1. APPENDIX A: Areal cover of different combinations of quaternary deposits and land use

In the main article, percentage shares of the different quaternary deposits and land use are presented separately. Here in Table S1, different combinations of the 2 themes are presented separately.

Table S1: Areal cover (in ha) of different combinations of quaternary deposits and land use.

Sites	Quaternary deposit \ Landuse	Forests	Open lands	Water
Degerö Stormyr	Peat	82.68	112.32	
	Rock outcrops	0.13		
	Till	76.15	0.71	
	Water			0.50
Stortjärn	Peat	5.44	8.11	
	Till	15.83	0.16	
	Water			0.03
Hålmyran	Peat	9.28	15.89	
	Rock outcrops	0.31	0.00	
	Till	6.49	0.21	
	Water			0.88
Hälsingfors-mire	Peat	10.17	32.03	
	Rock outcrops	5.67		
	Till	14.80	0.47	
	Water			1.67
Hälsingfors-forest dense section	Peat	7.85		
	Rock outcrops	2.26		
	Till	3.54		
Hälsingfors-forest open section	Peat	2.63		
	Rock outcrops	3.64		
	Till	5.60		

2. APPENDIX B: Catchment delineation details

In order to illustrate the groundwater movements, the 0.5 m DEM was aggregated to 2 m and 6 m resolution DEMs to smooth out the micro-topography. In fact, in high resolution DEMs hummocks and hollows might act as “dams” and route the water in the wrong direction in the model, while the water actually drains perpendicularly to these features and underneath the surface of the mire. The DEMs were pre-processed using the optimal method for the Swedish landscape (Lidberg et al., 2017), using the Breach function in WhiteboxTools 2.0 and the modelled stream lines indicate where the flow accumulation is larger than 1 ha. Two different watershed delineations were calculated for each catchment based on the different resolution DEMs. The delineation was overall similar for the two DEM resolutions, and at locations where the delineation depended on the DEM resolution, additional field survey was conducted to verify the flow direction and correct the delineated catchment borders.

3. APPENDIX C: Climate stations

Several climate stations exist in the vicinity of the study area. In a radius of 30 km from the common centroid of all catchments, this includes nine climate stations of the Swedish Meteorological and Hydrological Institute (SMHI, 2021) and two reference climate stations of the Swedish University of Agricultural Sciences (SLU, 2021) (Table S2).

Table S2: Air temperature and precipitation data availability in a radius of 30 km from the peatland complex. The data is provided by the Swedish University of Agricultural Sciences (SLU) and the Swedish Meteorological and Hydrological Institute (SMHI)

Station name	Data provider	Distance to study area (km)	Time span	Air temperature	Precipitation
Kulbäcksliden	SLU	1.84	1990 - Ongoing	Yes	Yes
Vindeln-Sunnansjönäs	SMHI	10.99	1989 - Ongoing	Yes	Yes
Hällnäs-Lund	SMHI	11.3	1961 - 1989	Yes	Yes
Svartberget	SLU	13.1	1990 - Ongoing	Yes	Yes
Granö D	SMHI	14.48	2008 - Ongoing	No	Yes
Harrsele	SMHI	17.2	1961 - 1998	No	Yes
Malkälen D	SMHI	25.28	1989 - Ongoing	No	Yes
Pengfors	SMHI	27.37	1961 - 1975	No	Yes
Örträsk	SMHI	27.67	1973 - 2012	No	Yes
Vännäs	SMHI	29.3	1961-1976	Yes	No
Tavelsjö D	SMHI	29.59	1989 - Ongoing	No	Yes

4. APPENDIX D: Mire vegetation classification workflow

4.1. Introduction

The present classification of mire vegetation is mainly based on the Finnish mire system (Eurola et al., 1984, 1995, 2015) with some additions. The Finnish system also has some similarities with the system utilized in the Swedish Wetland Survey for northern Sweden (Forslund et al., 1993), which in large is based on a system finally published in Vegetationstyper i Norden (Påhlsson, 1994). The latter however covers all Nordic countries and as a result the marked regional differences in the mire vegetation and its response on various directions of variation have been difficult to grasp. One advantage with the Finnish system is that it is easily applicable for mires in boreal Sweden. In order to enable comparisons, naming utilized in other classification systems are sometimes given.

Classification of forest vegetation also follows the Finnish system as outlined by (Kalela, 1961) which shows great similarities with the forest site types described by (Ebeling, 1978) for northern Sweden. In accordance with the Finnish system forests on moist and wet sites (“swamp forests”) are here included in the mire vegetation. As a consequence also thin-peated forest types are included among the mire sites, and the border of the mire massif is set by the mineral soil. Where to draw the limit depends upon focus. In vegetational-ecological studies mire is often preferred, while peatland sets the limit at a peat depth of 30 cm thus including drained peatland (Joosten and Clarke, 2002).

Mire terminology follows Eurola et al. (1984, 1995, 2015), Laitinen et al. (2005, 2007), Rydin et al. (1999), and Rydin and Jeglum (2013).

4.2. Mire types

KRI is located in the middle boreal zone, an area where the gradual, latitudinal, transition from southern to northern mire types has received much attention in Finland (Laitinen et al., 2007; Ruuhijärvi, 1983) while until recently less so in Sweden due to its more complicated topography (Gunnarsson and Löfroth, 2009; Rydin et al., 1999). The extensive interest for zonal, climatic, vegetation systems in Finland, has demonstrated a zonal, climatic mire system continuum from ordinary raised bog systems (in temperate and south boreal areas), to a northward gradually increasing proportion of fens compared to bogs within the aapa mire zone (Laitinen et al., 2007; Ruuhijärvi, 1983). Thus aapa mires are mixed peatland complexes where the central fen areas, with patterned and unpatterned fens, are surrounded by marginal areas also including bogs close to the divides (Laitinen et al., 2007; Ruuhijärvi, 1983). A bog is a convex to flat structure under ombrotrophic influence while an aapa mire is a concave structure under minerotrophic influence. An aapa mire is a mire system (complex) where the central parts are characterized by minerotrophy, and that these parts (as well as the marginal areas) may receive supplementary nutrients also from snow-melt water; the definition is vegetational-ecological (Eurola et al., 1995). Aapa mires (according to the present broad concept) are morphologically variable and three main types have been described (Laitinen et al., 2007; Ruuhijärvi, 1983): (1) a lawn aapa mire where lawns dominate but the flark level often occurs in form of longitudinal soaks (e.g. the westernmost part of Stortjärn); (2) a lawn-flark aapa mire where peripheral lobes and different flark fens (string flark fens, stringless flark fens, flark outlets) dominate (e.g. Hålmyran); (3) a flark aapa mire where the mire massif is dominated by the flark level (e.g. Hälsingfors-mire). However, there are at least two intermediate massif types (Laitinen et al., 2007). First, an aapa mire–raised bog intermediate with the morphology of a hummock ridged raised bog but with minerotrophic hollows/flarks; a string mixed mire (Sw. strängblandmyr) often easy to identify on air photos (e.g. Hälsingfors-mire). Second, an aapa mire–raised bog intermediate with the morphology of a lawn aapa mire although with ombrotrophic vegetation (e.g. some central parts of Degerö Stormyr approach this situation; extremely poor fen (Sjörs and Gunnarsson, 2002).

A characteristic feature of KRI is the nutrient poor conditions. Most fens are oligotrophic, and the result is a remarkably species poor mire vegetation. For example, many common mire plants indicating mesotrophic conditions, e.g. *Molinia caerulea*, *Carex chordorhiza*, *C. livida*, do not occur or are very rare. This species poverty implies that the dichotomy ombrotrophic-minerotrophic may be elusive when focusing on species composition as stressed by (Ruuhijärvi, 1960, p. 35). For that reason areas that are judged to represent ombrotrophic vegetation have been specifically marked in Figure 6. Here belongs two flat bog areas of northern type (Rydin et al., 1999); unpatterned bog/*Fuscum* bog in (Eurola et al., 1995) at Degerö and Hälsingfors, one area with the structure of reticulate bog (Gunnarsson and Löfroth, 2009) at Hälsingfors, and several sloping, clearly patterned mires in the marginal areas close to the divides (northern eccentric bog in (Eurola et al., 2015)). However the species poor biota in combination with that several minerotrophic indicators tend to show a northward increasing occurrence in bog communities (Økland, 1990; Pakarinen and Ruuhijärvi, 1978; Rydin et al., 1999) should be kept in mind. The issue of how well species composition, and particularly so scattered occurrences of fen indicators, mirrors the movement of minerotrophic water was already treated by (Sjörs, 1948). The winter conditions, the duration and magnitude of snowpack and timing of snowmelt may play a role here.

The following are some major characteristics of mire vegetation at KRI:

- The area is characterized by aapa mire – raised bog complexes; central patterned and unpatterned fens + bogs in marginal areas
- The presence of different aapa mire types: lawn type (Stortjärn), lawn-flark type (Hålmyran), flark type (Hälsingfors)
- The presence of intermediate types: with the morphology of a hummock ridged raised bog with minerotrophic hollows/flarks; or morphology of a lawn aapa mire with ombrotrophic vegetation (approaching nutrient availability similar to ombrotrophic conditions)
- A very species poor flora as most fens are oligotrophic and only a few slightly mesotrophic which makes the ombrotrophic – minerotrophic dichotomy elusive
- Vegetation types indicate important differences in hydrology, from unstable to stable (in the order Stortjärn –Hålmyran –Hälsingfors –Degerö)
- A strong groundwater outflow from surrounding mineral soils resulting in dominance of minerotrophic pine and spruce mire forests

4.3. Vegetation types

The Finnish mire system distinguishes four main types (Eurola et al., 1984; Ruuhijärvi, 1983): letto (L) eutrophic fens, which does not occur in the area; neva (N) fens, remaining open wet, ombrotrophic (Om), oligotrophic (Ol) and mesotrophic (Me) mires, dominated by graminoids and Sphagna; korpi (K) spruce and birch-dominated minerotrophic (Mi) mires; and räme (R) ombrotrophic pine mires and hummocks characterized by dwarf shrubs and Sphagna. However, due to extensive groundwater influence from the mineral soil in the area, most pine-dominated mires have a clear minerotrophic influence. It should be noted that the open treeless neva mire has no sharp border between ombrotrophy and minerotrophy; thus the transition may be gradual. Another important feature of the system is the identification of a large number of combination site types. For occurrence of ombrotrophic vegetation and wet combination types see Figure S2 and for different mire-forest and forest types see Figure S3.

The information in the below text has the following structure:

Numbering and acronyms refer to unpublished field notes.

E 84/95: Naming mainly following Eurola et al. (1984, 1995, 2015), if not otherwise stated. Acronyms refer to the Finnish names

ViN 1994: Naming in Vegetationstyper i Norden (Påhlsson, 1994)

E 1978: Naming (in Swedish) in (Ebeling 1978) for forest site types

F 1993: Naming (in Swedish) in (Forslund et al., 1993)

M 1923: Naming in (Malmström, 1923). Note that “mosse” (bog) at that time was used for *Sphagnum*-dominated vegetation types.

Short information on species composition and environmental conditions

The four mires are referred to as follows: De Degerö Stormyr, Hå Hålmyran, Hä Hälsingfors-mire, St Stortjärn.

Minerotrohic communities

Flark level types have been split up into several smaller units as it is assumed that these are likely to be particularly sensitive to global change (Granlund et al., 2022; Sallinen et al., 2022). Also note that *Trichophorum cespitosum* dominated fens with *Sphagnum compactum* (*i.e.* n° 2, 4, and 8) are indicative of an unstable hydrology (Laitinen et al., 2007) – in contrast to the different *Sphagnum papillosum* fens. These two types are distinguished in (Eurola et al., 1995) while treated more collectively in (Eurola et al., 2015). As they differ in hydrology they are separated here.

1b EvCpSa

E 84/95: oligotrophic true short-sedge fen, OlVLkN; oligotrophic ordinary low-sedge fen, OlLkN (Eurola et al., 1995, 2015)

ViN 1994: *Carex pauciflora-Eriophorum vaginatum-Sphagnum angustifolium*-var., 3.2.3.1.a

F 1993: taggstarr-*S. angustifolium*-var. av fastmattekärr av tuvull-vitmosstyp

An oligotrophic lawn of peripheral lobes characterized by *Carex pauciflora* and *Eriophorum vaginatum* and the rich occurrence of *Sphagnum angustifolium* and a regular occurrence of *S. fuscum, S. medium* and *S. rubellum,* Often only as a narrow border towards the surrounding mire forest; important type in sparsely treed pine fens or in combination with pine hummocks. Often mapped as a combination type, oligotrophic short-sedge pine fen (n° 40, see further below).

1 EvCp

E 84/95: true *Sphagnum papillosum* short-sedge fen, OlKaN; oligotrophic *Papillosum* low-sedge fen, OlKaN (Eurola et al., 2015)

ViN 1994: *Eriophorum vaginatum-Sphagnum papillosum*-type, 3.2.3.1

F1993: fastmattekärr av tuvull-vitmosstyp

M 1923: *Eriophorum vaginatum-Sphagnum balticum*-mosse (Sw. tuvdunmosse)

An oligotrophic lawn of peripheral lobes characterized by *Eriophorum vaginatum*, *Carex pauciflora* and *Trichophorum cespitosum* and a closed *Sphagnum* layer with *S. balticum* and *S. papillosum* as most important species. Dwarf shrubs, *Andromeda polifolia* and *Oxycoccus palustris*, of limited importance.

2 TcEv

E 84/95: oligotrophic true *Sphagnum papillosum-S. compactum* short-sedge fen, OlKaN (Eurola et al., 1995); poor *Sphagnum compactum* fen (Laitinen et al., 2005). The *Compactum* fens are included among the *Papillosum* fens in (Eurola et al., 2015) although I prefer to keep them separated.

ViN 1994: *Eriophorum vaginatum-Sphagnum papillosum-S. compactum*-var., 3.2.3.1.b

F 1993: tuvsäv-*S. papillosum-S. compactum*-variant av fastmattekärr av tuvull-vitmosstyp

M 1923: *Scirpus austriacus-Sphagnum balticum*-mosse (Sw. “jämn” tuvsävmosse). Malmström differs between “jämn” (“smooth”) and “tuvig” (“tussocky”) *Scirpus austriacus*-mosse (see further n° 4 below).

An oligotrophic lawn, characterized by the dominance of *Trichophorum cespitosum*. *Eriophorum vaginatum* of regular although variable occurrence. Replaces the preceding type on sites with a stronger water flow from surrounding mire forests (fen type). Key indicator in the bottom layer *Sphagnum compactum*, otherwise similar species composition as in n° 1. Characterized by unstable hydrology (as n° 4, 8 and 9; cf. (Laitinen et al., 2005; Ruuhijärvi, 1960)). A dominant community of peripheral lobes in the western half of St; also important at Hå and Hä.

At St, northern side, also “short-sedge pine fens dominated by *S. compactum*”, LkNR (Laitinen et al., 2005) in the transition to surrounding mire forest. This combination type is also mentioned by Malmström (1923) as: trädbevuxen *Sphagnum fuscum*-rismosse-*Scirpus austriacus*-mosse.

3 EvS

E 84/95: oligotrophic true *Sphagnum papillosum* short-sedge fen (with small flarks), OlKaN; oligotrophic *Papillosum* low-sedge fen, OlKaN (Eurola et al., 2015)

ViN 1994: included in *Eriophorum vaginatum-Sphagnum papillosum*-type, 3.2.3.1

F 1993: Mjukmattekärr av starr-vitmosstyp starr-*S. papillosum*-variant

M 1923: included in *Eriophorum vaginatum-Sphagnum balticum*-mosse (Sw. tuvdunmosse)

Eriophorum vaginatum lawns and carpets, often with *Carex pauciflora*, and a closed *Sphagnum* carpet (*S. papillosum* and *S.* subgenus *Cuspidata*). Characteristic in gently sloping peripheral lobes, in stringless central flark fens with a stable hydrology (De, Hä) or in string flark fens as mosaic with n° 5.

4 Tc(Ev)Sb(p+co)

E 84/95: oligotrophic true *Sphagnum papillosum-S. compactum* short-sedge fen with larger flarks (>1/5 of the area), OlRiKaN (Eurola et al., 1995); oligotrophic *Papillosum* fen with flarks (around ½ the area), RiKaN (Eurola et al., 2015). *Sphagnum compactum* Weissmoor ((Ruuhijärvi, 1960), Tab. 9).

ViN 1994: included in *Eriophorum vaginatum-Sphagnum papillosum-S. compactum*-var., 3.2.3.1.b

F 1993: included in “tuvsäv-*S. papillosum-S. compactum*-variant av fastmattekärr av tuvull-vitmosstyp” (see n° 2 above).

M 1923: *Scirpus austriacus-Sphagnum compactum-S. balticum*-mosse (Sw. “tuvig” tuvsävmosse).

An oligotrophic lawn-carpet community dominated by *Trichophorum cespitosum* and linked to an unstable water regime (cf. (Laitinen et al., 2005, 2007; Ruuhijärvi, 1960) indicated by the presence of *Sphagnum compactum* in the bottom layer. A more “smooth” type often occurs in the transition between hummock strings and loose-bottom flarks, or dominates flark carpets on slightly sloping mires; it is characterized by a continuous cover of *S.* subgenus

Cuspidata and fits the description of ORiKaN (Hä). On more sloping mires forming narrow strings (with *S. balticum*, *S. compactum*, *S. rubellum*, *S. papillosum*) alternating with narrow flarks (with different *S.* subgenus *Cuspidata*) (Hå) which corresponds more to OlKaN. At stronger slopes (particularly at St north of the small lake) clear string-flark fen structure characterized by a mixture of liverworts (*Cladopodiella fluitans*), Sphagna and lichens (e.g. *Cetrariella delisei*, *Cladonia mitis*, and *C. squamosa* (the mire ecotype)) with features similar to moist heath vegetation (e.g. *Empetrum nigrum*; see also n° 15), indicating regular occurrence of longer drought periods.

5 SchS

E 84/95: oligotrophic *Sphagnum* flark fen, OlSphRiN; oligotrophic *Sphagnum* flark fen, OlRsRiN (Eurola et al., 2015)

ViN 1994: *Carex* spp.-*Scheuchzeria palustris*-*Sphagnum* spp.-var., 3.2.4.1c

F 1993: kallgräs-vitmoss-varianten av mjukmattekärr av starr-vitmosstyp

An oligotrophic carpet community characterized by *Scheuchzeria palustris* and a closed layer of *Sphagnum* subgenus *Cuspidata* (*S. balticum*, *S. majus*, *S. lindbergii*, and some *S. jensenii*); scanty occurrence of *Eriophorum vaginatum* and *Trichophorum cespitosum*. Forms extensive flarks in central string flark fens (De, Hå, Hä, St). Also a frequent component forming small carpets in soaks (in combination with n° 3 and 12).

6 (Sch)S

E 84/95: ~*Sphagnum dusenii* (=*S. majus*) flark fen, OlSphRiN (Eurola et al., 1984); oligotrophic *Sphagnum* flark fen, OlRsRiN (Eurola et al., 2015).

ViN 1994: included in *Carex* spp.-*Scheuchzeria palustris*-*Sphagnum* spp.-var. (see n° 5 above).

F 1993: Mjukmattekärr av starr-vitmosstyp, 3.6.2.1; similar to alpin starr-*S lindbergii*-variant.

M 1923: included in *Scheuchzeria*-*Sphagna Cuspidata*-mosse (Sw. kallgräs-mosse)

The name is here used for very wet areas (loose bottoms) in stringless central flark fens with a stable hydrology and a covering *Sphagnum* subgenus *Cuspidata* carpet with *S. majus* as dominant, and with scanty occurrence of vegetative *Scheuchzeria palustris* (large areas at De, Hå, Hä).

7 ClS

E 84/95: oligotrophic *Sphagnum* flark fen, OlSphRiN, Rimpiartiges Weissmoor in (Eurola et al., 1984), Oligotrophes moos-armes Rimpiweissmor in (Ruuhijärvi, 1960)

ViN 1994: included in *Carex* spp.-*Scheuchzeria palustris*-*Sphagnum* spp.-var. (see n° 5 above).

F 1993: kallgräs-vitmoss-varianten av mjukmattekärr av starr-vitmosstyp

M 1923: *Carex limosa*-*Sphagna Cuspidata*-mosse (Sw. *Carex limosa*-mosse), A loose-bottom community characterized by *Carex limosa* (and vegetative *Scheuchzeria palustris*) and *Sphagnum* subgenus *Cuspidata* (particularly *S. majus*, *S. lindbergii* and *S. jensenii*) of variable cover. Regular occurrence of *Drosera longifolia*. Best developed in central stringless flark fens with a stable water regime (De); may form small flarks in soaks (together with n° 12). Often seen with suffering, loose-lying Sphagna, transitional to n° 9 (see below).

8 Tctuss

E 84/95: poor mud-bottom flark fen (Rimpiartiges Weissmoor), OlRuRiN (Eurola et al., 1984); Oligotrophes moos-armes Rimpiweissmoor in (Ruuhijärvi, 1960)

ViN 1994: included in *Carex* spp.-*Gymnocolea inflata*-*Sphagnum* spp.-type, 3.2.4.2 (Sw. fattig mossfattig torvslamtyp)

F 1993: most likely included in “lösbottenkärr av oligotrof typ” (oligotrophic loose-bottom fen)

M 1923: may be included in his *Carex limosa*-dykärr

Characterized by the occurrence of scattered *Trichophorum cespitosum* tussocks (sometimes also *Eriophorum vaginatum* tussocks), suffering loose-lying Sphagna, often replaced by the liverwort *Cladopodiella fluitans*. The occurrence of Sphagna and liverworts varies between years depending on precipitation (and growth of green algae). Tussock dieback affected by frost heave and formation of needle ice during severe cold spells during dry autumns. Unstable hydrology. Important community at St and Hä. Forms the transition between n° 4 and n° 9.

A few larger flarks with *Rhynchospora alba* tussocks in a string mixed mire occur at St and are included in this type.

9 Clad

E 84/95: poor mud-bottom flark fen, OlRuRiN

ViN 1994: included in *Carex* spp.-*Gymnocolea inflata*-*Sphagnum* spp.-type, 3.2.4.2 (Sw. fattig mossfattig torvslamtyp)

F 1993: lösbottenkärr av oligotrof typ

M 1923: referred to as “vegetationslösa flarkar” (flarks without any vegetation)

Mud-bottom flarks (St, Hå, Hä, less so at De) with a more or less covering dark brown liverwort carpet (that is *Cladopodiella fluitans*), which typically show large between-year variations in cover due to variation in precipitation with marked declines in rainy years.

10 (mud)

E 84/95: poor mud-bottom flark fen

Here used for flark pools with more or less permanent water.

11 CrSf

E 84/95: oligotrophic true tall-sedge fen, OlVSN; oligotrophic ordinary tall-sedge fen, OlSN (Eurola et al., 2015); mesotrophic true tall-sedge fen, MeVSN; mesotrophic ordinary tall-sedge fen, MeSN (Eurola et al., 2015).

ViN 1994: *Carex* spp.-*Sphagnum fallax*-var., 3.2.4.1a

F 1993: Starr-*S. fallax*-variant av mjukmattekärr av starr-vitmosstyp

M 1923: *Carex rostrata*-mosse

Forms extensive carpet/loose bottom stands, in the wettest parts of central, stringless flark fens (De in northeast, Hä in northwest), characterized by vigorous *Carex rostrata* and a bottom layer with *Sphagnum fallax* (dominant), *S. angustifolium*, and sometimes *S. lindbergii* and *S. majus*. In the wettest areas (at De, Hä) with increasing occurrence of *Drepanocladus fluitans* (*Warnstorfia f.*), indicating more mesotrophic conditions. Also important in various combination types (see n° 45-47 below), as well as in old ditches (see n° 62 below) at the mire margin (De, Hä).

12 (Cr)S

E 84/95: oligotrophic *Sphagnum papillosum* tall-sedge fen, OlKaSN; also with some weak mesotrophic influence, MeKaSN; oligotrophic *Papillosum* tall-sedge fen, OlKaSN, and mesotrophic *Papillosum* tall-sedge fen, MeKaSN, respectively in (Eurola et al., 2015)

ViN 1994: *Carex* spp.-*Sphagnum papillosum*-var., 3.2.4.1b

F 1993: Starr-*S papillosum*-variant of “mjukmattekärr av starr-vitmosstyp” (Eng. fen carpet of *Carex*-*Sphagnum*-type)

M 1923: *Carex rostrata*-*Sphagnum papillosum*-*Sphagna Cuspidata*-mosse

A tall sedge community (*Carex rostrata*, often with scattered, in the area vegetative, *Eriophorum angustifolium*, *Carex lasiocarpa*) and a closed *Sphagnum* carpet (*S. papillosum* + *S.* subgenus *Cuspidata*). Inhabits somewhat drier sites compared with n° 11, often bordering ponds in stringless flark fens, in longitudinal soaks in lawn aapa mires, in soaks or areas of strong groundwater influence (Hä eastern part) in marginal lobes (in combination with n° 5 and 7), or in bogs. Similar communities around small lakes and ponds are classified as n° 14 (see below).

13 MeT = *Menyanthes* type

E 84/95: *Sphagnum* flark fen (Eurola et al., 1984), poor oroarctic flark fen (Eurola and Virtanen, 1991), oligotrophic mud-bottom flark fen, OlRuRiN (Eurola et al., 2015)

ViN 1994: *Menyanthes trifoliata*-*Sphagnum* spp.-var., 3.2.4.1d (Sw. vattenklöver-vitmoss-variant)

F 1993: -

M 1923: *Menyanthes*-*Sphagna Cuspidata*-mosse (vattenklövermosse)

Forms a characteristic border around small pools both in central stringless flark fens (De, St) and where groundwater discharges from the surrounding mineral forest (Hä, the eastern side). Covering Sphagna (*S. balticum*, *S. lindbergii*, *S. majus*) and *Menyanthes trifoliata* together with *Carex rostrata*, *C. magellanica*, *C. lasiocarpa*, and *Eriophorum angustifolium*, indicative of slight mesotrophic influence. Stable hydrology in contrast to n° 9.

14 Cr

This classification was used for the *Carex rostrata* stands that frequently border small ponds and water- covered flarks in stringless central flark fens. In the area often together with the *Menyanthes* type (n° 13) and the two may be united. See also the comment on quagmires under n° 15 below.

M 1923: *Carex limosa-C. rostrata* dykärr

15 SSquag

A short-sedge quagmire with a mosaic of carpets (*Carex limosa*) and lawns (*Trichophorum cespitosum*) with dying Sphagna (*S. compactum, S. lindbergii*, *S. medium*, *S. papillosum*, *S. rubellum*) colonized by liverworts (*Cladopodiella fluitans*), lichens (*Cetrariella delisei, Cladonia squamosa*, the mire ecotype) and dwarf shrubs (*Empetrum nigrum, Calluna vulgaris*). As quagmire only seen around the small lake at St. Similar vegetation types in lawns in the outlet area at Hä. Here interpreted as a drought effect due to unstable hydrology. Eurola et al. (1984 p. 80) suggests that the floating moss carpets overgrowing the water surface of pond and lakes, with a mixture of swampy and tall-sedge fens, flark fens, and short-sedge lawns (that is n° 13, 14, 15), can be united under the name “poor fen marginal to a pool”. This pragmatic view is suitable for vegetation mapping.

Malmström (1923, Tab 3:1-5): describes the quagmire vegetation around ponds as a zonation from a *Menyanthes-Sphagna Cuspidata*-mosse, over a *Carex limosa-Sphagna Cuspidata*-mosse, to a *Scheuchzeria-Sphagna Cuspidata*-mosse.

Ombrotrophic communities

Hollow communities

16 EvSb

E 84/95: ombrotrophic short-sedge flark-level bog, KuN; ombrotrophic low-sedge bog, OmLkN (Eurola et al., 2015)

ViN 1994: *Eriophorum vaginatum-Sphagnum balticum*-type, 3.1.3.5

F 1993: included in ”mjukmattemosse av vitag-kallgräs-*S.balticum*typ” (ombrotrophic carpet of *Rhynchospora alba-Scheuchzeria palustris-Sphagnum balticum*-type)

M 1923: *Eriophorum vaginatum-Sphagnum balticum*-mosse

Carpet community characterized by *Eriophorum vaginatum* and *Trichophorum cespitosum* and covering Sphagna with *S. balticum* (dominant), *S. tenellum* and *S. rubellum*. Characteristic for the driest bog hollows. Differs from n° 3 due to the absence of *S. papillosum*.

17 SchScu

E 84/95: ombrotrophic flark-level bog, SphKuN; *Scheuchzeria-Sphagnum balticum*-Weissmoor (Eurola, 1962). Schlenken Weissmoor (Ruuhijärvi, 1960); ombrotrophic hollow bog, KuN (Eurola et al., 2015)

ViN 1994: *Rhynchospora alba-Scheuchzeria palustris-Sphagnum balticum*-type, 3.1.4.1

F 1993: Mjukmattemosse av vitag-kallgräs-*S.balticum*typ

M 1923: *Scheuchzeria-Sphagna Cuspidata*-mosse

Very characteristic for flarks (hollows) in bogs or transitional mires. Carpet community characterized by *Eriophorum vaginatum*, *Scheuchzeria palustris*, *Trichophorum cespitosum*, *Carex limosa* and covering *Sphagnum balticum*, *S. lindbergii*, and *S. tenellum*. The absence of *S. papillosum* (and *S. majus*) is diagnostic towards oligotrophic flark communities. In the area, *Rhynchospora alba* does not occur in this type (however see the comment under n° 8 above).

18 SchSm

E 84/95: *S. dusenii* (=*majus*) flark-level bog (Eurola 1962), SphKuN

ViN 1994: *Rhynchospora alba-Scheuchzeria palustris-Sphagnum majus*-type, 3.1.4.4

F 1993: mjukmattemosse av vitag-kallgräs-*S.majus*typ

A carpet/loose-bottom community with scattered *Scheuchzeria palustris* and *Carex limosa* and covering Sphagna (*S. balticum*, *S. lindbergii*, *S. tenellum* and *S. majus*) that is very close to n° 17. Confined to the lowest flarks of bogs/transitional mires in the transition to unpatterned central flark fens. Most likely transitional between ombrotrophic and minerotrophic and maybe best united with n° 5. As to *Rhynchospora alba* see the comment under n° 17.

Lawn communities

20 EvSb

E 84/95: short-sedge intermediate-level bog, OmLkN; *Sphagnum balticum*-Weissmoor (Eurola, 1962); ombrotrophic low-sedge bog, OmLkN (Eurola et al., 2015)

ViN 1994: *Eriophorum vaginatum-Sphagnum balticum*-type, 3.1.3.5

F 1993: Fastmattemosse av tuvull-*S.balticum*typ; Fastmattemosse av tuvull-*S.angustifolium*typ

M 1923: *Eriophorum vaginatum-Sphagnum balticum*-mosse

A species poor lawn community characterized by *Eriophorum vaginatum*, the occurrence of *Andromeda polifolia*, *Oxycoccus palustris*, *Rubus chamaemorus*, and a closed *Sphagnum* carpet (*S. balticum, S. angustifolium*, *S. rubellum*, and some *S. fuscum*). Often in mosaic with n° 24 (see below).

Comment: occurs often together with the close "short-sedge intermediate-level bog", OmLkN; *Sphagnum parvifolium*-Weissmoor (Eurola, 1962); ViN 1994: *Eriophorum vaginatum-Sphagnum angustifolium*-type, 3.1.3.4. This type differs through the dominance of *S. angustifolium*. The two types have been treated collectively.

Hummock communities

21 Anfu

E 84/95: A*ndromeda-Sphagnum fuscum* bog, OmLkNR (Eurola, 1962).

ViN 1994: *Eriophorum vaginatum-Sphagnum fuscum*-type 3.1.3.1

F 1993: Fastmattemosse av tuvull-*S.fuscum*-typ; Fastmattemosse av tuvull-*S.angustifolium*-typ.

M 1923: shows similarities with his "*Andromeda*-rik trädbevuxen *Fuscum*-mosse" except for the absence of a tree canopy.

The driest lawn/hummock community dominated by *Eriophorum vaginatum* and dominant *S. fuscum* in the bottom layer; often with some *S. medium* and *S. rubellum*. Other regular species in this species poor community are *Andromeda polifolia*, *Drosera rotundifolia*, *Oxycoccus* spp. Often as mosaic and particularly so together with n° 1. May be difficult to separate from n° 20 and n° 24.

22 Empfu = *Empetrum nigrum-Sphagnum fuscum* bog

E 84/95: Empetrum-Sphagnum fuscum bog *pro parte,* VmRaR; *Empetrum-Fuscum* bog *pro parte*, VaRaR (Eurola et al., 2015); Eigentliches *Empetrum-Sphagnum fuscum* Reisermoor (Eurola, 1962)

The two *Empetrum* species differ in their ecology. *E. nigrum* is a species of vitally growing *Sphagnum fuscum*, while *E. hermaphroditum* is a species of stagnant *Sphagnum* growth (Eurola, 1962), mirroring their differences in shoot growth.The above name is here used for the *Sphagnum fuscum* hummocks with *Empetrum nigrum* that form a characteristic feature in island mixed mires. Frequently co-occurring species are *Andromeda polifolia*, *Oxycoccus microcarpus, Rubus chamaemorus,* and *Eriophorum vaginatum*. The circumscription accords with the true *Empetrum–Sphagnum fuscum* bog (Eurola, 1962) and with the comment by (Ruuhijärvi, 1960), p. 151, concerning his *Empetrum – Sphagnum fuscum* – Reisermoor, namely that *E. nigrum* is light demanding ("Lichtplanze") and thus a species of the mire expanse. These *E. nigrum-Sphagnum fuscum* hummocks of island mixed mires form a characteristic feature in the area (and throughout the boreal forest land). Here, they are not included in the broader *Empetrum-Sphagnum fuscum* bog in Eurola et al. (1984, 1995, 2015) which also includes hummocks at the mire margin (and on open concentric bogs) with stagnant *Sphagnum* growth where *Empetrum hermaphroditum* prevails. *E. nigrum* is also a characteristic species in hummock communities of raised bogs in temperate and south boreal areas (Eurola, 1962; Sjörs, 1948) with vitally growing Sphagna. The hybrid can be found on hummocks at the mire edge. For *E. hermaphroditum* see also n° 23-25 further below.

23 Ulfu

E 84/95: *Empetrum-Sphagnum fuscum* bog, VmRaR; *Empetrum-Fuscum* bog, VaRaR (Eurola et al., 2015)

ViN 1994: *Calluna vulgaris-Empetrum* spp.-*Sphagnum fuscum*-type, 3.1.2.2

F 1993: Rismosse av *Sphagnum fuscum*-typ

M 1923: included in his "rismossesträngar" (hummock strings)

In the field notes referred to Ulfu, *Uliginosum-Sphagnum fuscum*-type, in order to avoid confusion with n° 22.

A characteristic community for open bogs and higher strings and higher hummock islands in mixed mires. Dwarf-shrubs dominate (*Andromeda polifolia*, *Empetrum hermaphroditum*, *Ledum palustre*, *Vaccinium uliginosum*, *V. vitis-idaea*) together with *Rubus chamaemorus*, and *Betula nana*; regular occurrence of low pines. *Sphagnum fuscum* gradually replaced by *S. angustifolium*, lichens (*Cladonia mitis*, *C. stygia*, and various cup lichens) and forest mosses (*Pleurozium schreberi*).

24 Cvfu

E 84/95: *Calluna-Sphagnum fuscum* bog, KrRaR (Eurola et al. 1984); *Calluna-Fuscum* bog, KaRaR (Eurola et al., 2015)

ViN 1994: *Calluna vulgaris-Empetrum* spp.-*Sphagnum fuscum*-type, 3.1.2.2

F 1993: included under n° 23

M 1923: included in his "*Calluna*-rik trädbevuxen *Fuscum*-mosse" (see n° 26 below) forming the transition between his *Andromeda*- and *Ledum*-types

The most important bog community in the area, both fringing the open mire areas and on lower hummock strings and islands. Differs from n° 23 through the dominance of *Calluna vulgaris* (and co-dominant *E. hermaphroditum*). Sphagna (*S. fuscum*, *S. angustifolium*) dominate the bottom layer together with *Pleurozium schreberi*. Whether the striking dominance of *Calluna* in the area may mirror an unstable hydrology (Laitinen et al., 2005) or a more local continental climate, or both, resulting in a reduced peat growth remains to be understood.

The type merges gradually over to n° 26 – the most important pine bog community fringing the open mire in the area.

25 Lifu = Lichen-*Sphagnum fuscum* bog

E 84/95: Similar to the following descriptions: *Calluna - Sphagnum fuscum - Cladonia* Reisermoor (Eurola, 1962); *Dicranum-Sphagnum fuscum* bog, KsRaR (Eurola et al., 1984); Oroarctic dwarf-shrub bog vegetation (Eurola and Virtanen, 1991)

ViN 1994: *Empetrum hermaphroditum-Vaccinium microcarpum-Sphagnum fuscum*-type, 3.1.2.1

F 1993: –

The driest hummock community on treeless bogs, characterized by declining dwarf-shrubs (most important *Empetrum hermaphroditum*) and Sphagna (*S. fuscum*, *S. angustifolium*, *S. medium*, *S. rubellum*) overgrown by liverworts (e.g. *Mylia anomala*), crustaceous (e.g. *Ochrolechia frigida*) and mat-forming lichens (e.g. *Cladonia mitis*, *Cetraria nivalis* (syn. *Flavocetralia n*)), and mosses (*Dicranum undulatum*, *Polytrichum strictum*, *Pleurozium schreberi*). Confined to the driest hummocks on open treeless, wind-exposed bogs typically with thin snow cover; only present at Hä.

Dwarf-shrub pine bogs

26 PCv

E 84/95: Pine-*Calluna* bog; Dwarf-shrub pine bog, *Calluna* variant, RaIR, OmIR; Dwarf-shrub pine mire, VIR (Eurola et al., 2015)

ViN 1994: *Pinus sylvestris-Vaccinium uliginosum*-type, *Calluna* var., 3.1.1.3

F 1993: included in "tallmosse av ristyp" (Eng. Pine bog, dwarf-shrub-type)

M 1923: *Calluna*-rik trädbevuxen *Fuscum*-mosse (trädbevuxen ljung-mosse)

A sparsely treed pine bog community forming the transition between the open mire and the surrounding mire forest. Due to the marked minerotrophic influence from surrounding mineral soils, the bog community inhabits smaller areas only, while it is frequently present as a combination type: low sedge pine fen (see n° 40 further below).

27 PLe

E 84/95: Pine-*Ledum* bog; Dwarf-shrub pine bog, *Ledum* variant, RaIR, OmIR; Dwarf-shrub pine mire, VIR (Eurola et al., 2015)

ViN 1994: *Pinus sylvestris-Ledum palustre*-type, 3.1.1.2

F 1993: Tallmosse av skvattramtyp (Eng. Pine bog, *Ledum*-type)

M 1923: *Ledum*-rik trädbevuxen *Fuscum*-mosse (trädbevuxen skvattram-mosse)

Similar to n° 28 (see below) but *Ledum palustre*, *Vaccinium uliginosum*, *Betula nana* dominate the forest floor. Sphagna of decreasing and *Pleurozium schreberi* (and lichens) of increasing importance.

Pine bog communities, with a rather closed tree canopy, approaching this type have a limited occurrence in the area. A few smaller patches close to small lakes (Hå at the western side of the small lake, St north of the small lake), not in the mire forest fringing the open mire, approach this vegetation type. However, *Ledum* does not reach that dominance characteristic for areas closer to the Bothnian coast. In the area *Ledum* is a characteristic species on higher strings in mixed mires (see n° 23 above), in the true spruce pine mire (see n° 34 below), in Pine-*Uliginosum* bogs (see n° 28 below) and in many heath forest types (see n° 51-52 below).

28 PUl

E 84/95: Pine-*Uliginosum* bog; Dwarf-shrub pine bog, *Uliginosum* variant, RaIR, OmIR; Dwarf-shrub pine mire, VIR (Eurola et al., 2015)

ViN 1994: *Pinus sylvestris-Vaccinium uliginosum*-type, *Vaccinium uliginosum*-var., 3.1.1.3

F 1993: Tallmosse ristyp

M 1923: included in his *Ledum*-rik trädbevuxen *Fuscum*-mosse (trädbevuxen skvattram-mosse); se n° 27 above

Characterized by the dominance of *Empetrum hermaphroditum*, *Vaccinium uliginosum*, *V. vitis-idaea*, and rich occurrence of *Calluna vulgaris*, *Ledum palustre*, and *Betula nana*. Well-developed bottom layer with dominant Sphagna (*S. fuscum*, *S. angustifolium, S. divinum, S. russowii*) and *Pleurozium schreberi*.

A more densely treed pine bog replacing n° 26, although with limited areal extension in the area, mirroring the minerotrophic influence from surrounding mineral forests.

The following three pine bog communities (Eurola et al., 2015) (mentioned in Forslund et al., 1993) do not occur in any of the four study areas: Pine-*Betula nana* bog, OmVkR (for a close type see n° 37), Pine-*Vaginatum* bog, OmTR (for a close type see n° 38), Pine-*Carex globularis* bog, OmPsR (for a close type see n° 36). However, they may occur within KRI, although all close vegetation types observed were minerotrophic.

Forest vegetation included in the mire series

In Finnish classification, these communities are included in the mire vegetation, while in Swedish classification (Ebeling, 1978) they are generally included in forest vegetation as "swamp forests". The paludified types (n° 30 and 31) are transitional between heath (moor) and mire (peat) forests; the remaining with peat formation. In classification of mire forest types the occurrence of, and relative proportion of, heath-forest and hummock-level species play an important role. The forest types are mapped in Figure S3.

30 moistP

E 84/95: Paludified pine forest

ViN 1994: *Picea abies-Vaccinium* spp.–*Sphagnum* spp.-type, 2.1.2.3

E 1978: fuktig ristyp (moist dwarf-shrub type)

F 1993: included in sumptallsskog av ristyp

M 1923: risbevuxna *Sphagnum acutifolium*-tuvor (syn. *S. capillifolium*)

Heath forest species (*Calluna vulgaris*, *Empetrum hermaphroditum*, *Vaccinium myrtillus*, *V. vitis-idaea*) dominate over hummock level species. However, Sphagna (*S. capillifolium, S. angustifolium*, *S. russowii*) of regular occurrence. Of fragmentary occurrence in the area due to rather steep forest slopes.

31 moistS

E 84/95: Paludified spruce forest

ViN 1994: *Picea abies-Vaccinium* spp.–*Sphagnum* spp.-type, 2.1.2.3

E 1978: fuktig ristyp (moist dwarf-shrub type)

F 1993: granskog av lågörtstyp sumpvariant, 2.1.2.3

M 1923: blåbärs-rik gransumpskog (see also n° 33 below)

Similar to n° 30, heath forest species dominate over hummock level species. A closed bottom layer of forest mosses *Dicranum majus*, *Hylocomium splendens*, *Barbilophozia lycopodioides*, and in slight depressions Sphagna (*S. girgensohnii*, *S. angustifolium* and *S. russowii*). Scattered occurrence of deciduous shrubs (*Alnus incana*). Of limited occurrence in the four areas although common within KRI.

32 wetP

E 84/95: Thin-peated pine mire, KgR; the type is close to dwarf-shrub pine bogs, IR, n° 26-28, and transitional types can be named minerotrophic dwarf-shrub pine bog, MiIR.

ViN 1994: *Pinus sylvestris-Vaccinium uliginosum*-type, 2.1.1.3 (Sw. sumptallskog av ristyp); cf. *Pinus sylvestris-Vaccinium uliginosum*-type, 3.1.1.3 (Sw. tallmosse av ristyp, Eng. dwarf shrub pine bog) close to n° 28 (see above).

E 1978: våt ristyp (wet dwarf-shrub type)

F 1993: included in sumptallskog av ristyp

M 1923: -

A mosaic type where hummock level species dominate over heath forest species. Important species in the bottom layer besides ordinary heath forest mosses are *Polytrichum commune*, *Sphagnum angustifolium*, *S. fuscum*, *S. capillifolium* (syn. *S. nemoreum*), *S. russowii*. Scattered *Carex globularis* tussocks are characteristic. Very limited occurrence in the area, often only as a narrow border of a few m.

33 wetS

E 84/95: Thin-peated spruce mire, KR (if including pine spruce forest, KgKR); divided in two types: thin-peated *Myrtillus* spruce mires, MKgK; thin-peated *Vitis-idaea* spruce mires, PKgK.

Note: The thin-peated spruce mires are close to true spruce mires which are diveded in the following four types: *Myrtillus* spruce mire, MK; *Vitis-idaea* spruce mire, PK; *Rubus chamaemorus* spruce mire, MrK; *Equisetum sylvaticum* spruce mire, MkK. Due to their fragmentary occurrence in the four areas they are here treated collectively, in spite of the quantitative differences in species composition.

ViN 1994: *Picea abies-Vaccinium* spp.–*Sphagnum* spp.-type, 2.1.2.3; *Picea abies-Equisetum sylvaticum*-var., 2.1.2.3b

E 1978: våt ristyp (wet dwarf-shrub type)

F 1993: Sumpgranskog av ristyp, hjortronvariant + skogsfräkenvariant.

M 1923: describes the following types: hjortron-rik (*Rubus chamaemorus*) gransumpskog; *Equisetum silvaticum*-rik gransumpskog; blåbärs-rik gransumpskog (which also seems to include n° 31 above)

In common with n° 32 is that hummock level species dominate over heath forest species. In the field layer *Rubus chamaemorus*, *Equisetum sylvaticum* and *Carex globularis* together with *Vaccinium* spp., particularly *V. myrtillus*. A closed bottom layer with rich occurrence of *Sphagnum giergensohnii*, *S. russowii* and *S. angustifolium* together with *Dicranum majus*, *Hylocomium splendens*, *Ptilium crista-castrensis*, *Polytrichum commune* and *Barbiolophozia lycopodioides*. The true spruce mire types differ through the marked dominance of Sphagna (also with the rare *S. wulfianum*) and *Polytrichum commune*. The remaining two variants, with *Rubus chamaemorus*, often with covering *Polytrichum commune*, and *Equisetum sylvaticum*, both have a more marked mosaic where the intermediate and flark level dominate. In the latter case often with scattered *Alnus incana* and *Salix lapponum*, *S. phylicifolia*, *S. myrsinifolia*. Small fragments of the *Chamaemorus* type, with abundant *Eriophorum vaginatum* at the flark level, are found close to discharging brooks (Hå). Otherwise, all types only occur as fragments in the four areas, while they are important vegetation types in more gently sloping terrains within KRI.

34 wetDws

E 84/95: Ordinary spruce pine mire, VKR;

ViN 1994: Lists the following swamp forest types: *Pinus sylvestris-Vaccinium uliginosum*-type, 2.1.1.3 (KgR, IR), *Pinus sylvestris-Ledum palustre*-type, 3.1.1.2 (OmIR), and *Pinus sylvestris-Vaccinium uliginosum*-type, 3.1.1.3 (RaIR); *Picea abies-Vaccinium* spp.-*Sphagnum* spp.-type, 2.1.2.3

E 1978: våt ristyp (wet dwarf-shrub type).

F 1993: Sumptallskog av ristyp

M 1923: Trädbevuxen *Sphagnum russowii*-rismosse may include this type, although the rich occurrence of *Carex globolaris* points towards n° 35 (see below).

Tall dwarf shrubs (*Ledum palustre, Vaccinium uliginosum*) of about equal importance as *Vaccinium myrtillus* and *V. vitis-idaea*; tall-growing *Betula nana* and regular occurrence of *Carex globularis* present. A closed bottom layer as in n° 33 although with particularly rich occurrence of Sphagna (*S. angustifolium* often most important, *S. giergensohnii, S. divinum, S. russowii*) and *Polytrichum commune*. A very characteristic type in marginal pine and spruce mires.

Comment: The type is close to ombrotrotrophic pine bog communities but the minerotrophic influence is shown by the occurrence of minerotrophic species such as *Carex globularis, Dicranum majus, Sphagnum giergensohnii* and *Polytrichum commne*. An alternative name would be: minerotrophic dwarf-shrub spruce-pine mire, MiIR.

35 wetCglS

E 84/95: *Carex globularis* spruce-pine mire, PsKR

ViN 1994: seems to be included under *Picea abies—Vaccinium* ssp.—*Sphagnum* spp.-type, 2.1.2.3; (Sw. sumpgranskog av ristyp)

E 1978: våt ristyp (wet dwarf-shrub type); included in n° 34 (above)

F 1993: Sumptallskog av ristyp, klotstarrvariant

M 1923: trädbevuxen *Sphagnum russowii*-rismosse (klotstarr-rik gransumpskog); the placement here based on the rich occurrence of dwarf shrubs.

Similar to n° 34 (see above) but differs in the following respects: Tall dwarf shrubs (*Ledum palustre, Vaccinium uliginosum*) dominate over *Vaccinium myrtillus* and *V. vitis-idaea*. *Carex globularis* of increasing importance. Increasing role of *S. angustifolium, S. divinum*, *S. russowii*, and *Polytrichum commune* in the bottom layer. A transitional type approaching n° 36.

36 wetCglP

E 84/95: *Carex globularis* pine mire, PsR

ViN 1994: *Pinus sylvestris-Carex globularis*-type, 3.2.1.1

F 1993: tallkärr av klotstarrtyp

M 1923: trädbevuxen *Sphagnum russowii*-rismosse (trädbevuxen klotstarrismosse)

Tall dwarf shrubs of limited importance, *Carex globularis* dominant together with *Eriophorum vaginatum* and *Carex pauciflora* in the depressions. *Sphagnum angustifolium* and *S. fuscum* dominant in the bottom layer. Of limited occurrence in the four studied areas except for the southern part of St.

37 wetBn

E 84/95: close to *Betula nana* pine bog, OmVkR; in the area best characterized as ”*Betula nana* pine mire”, MiVkR, VkR (Eurola et al., 2015)

ViN 1994: listed as a transitional type towards sumptallskog ristyp, 2.1.1.3; våt ristyp (wet dwarf-shrub type)

E 1978: våt ristyp (wet dwarf-shrub type)

In the area this type is best characterized as ”*Betula nana* pine mire”; a sparsely treed type, fringing the open mire, characterized by a rich occurrence of *Betula nana*; under strong mineroptrophic influence from surrounding mire forest. Also a characteristic type of strings and hummocks and particularly so in the mire cross area in the wet central parts of Hä.

Combination types

38 wetEv

E 84/95: *Eriophorum vaginatum* birch fen, TK ; Sometimes approaching minerotrophic *Eriophorum vaginatum* bog, MiTR

ViN 1994: *Pinus sylvestris –Eriophorum vaginatum*-type, 3.1.1.4

F 1993: Tallmosse av tuvulltyp (with minerotrophic features) often in mosaic with tallrismosse

M 1923: Trädbevuxen *Eriophorum vaginatum*-mosse (trädbevuxen tuvdunmosse),

Characterized by dominant, tall *Eriophorum vaginatum* tussocks, often together with *Carex pauciflora*, and the low importance of dwarf shrubs (mostly only *Andromeda polifolia* and *Oxycoccus palustris*). Insignificant role of forest and hummock level species, except close to discharging brooks. Strong minerotrophic influence from surrounding mineral soil. In the area mostly in birch/pine mires (Hå, St), more fragmentary in spruce mires.

40 EvCvP

E 84/95: oligotrophic short-sedge pine fen, OlLkNR

F 1993: Tallkärr av fattig vitmosstyp

M 1923: trädbevuxen *Sphagnum fuscum*-rismosse–*Eriophorum vaginatum*-mosse

In the field notes named *Eriophorum vaginatum-Calluna* pine mire (EvCvP).

The most important transition type between the open mire and surrounding mire forest. A combination type between true short-sedge fen (n° 1b and 1) and dwarf-shrub pine bog (n° 26). The hummocks may either form islands or strings; in the latter case resulting in a pronounced patterning parallel to the slope (Hå in the south; Hä in the north). The fen (lawn) and hummock areas easily separated on aerial photos.

45 CrB

E 84/95: oligotrophic tall-sedge birch fen, OlSK; sometimes slightly mesotrophic MeSK

M 1923: Trädbevuxen *Carex rostrata*-mosse

A combination type with low hummocks (abundant *Betula nana*) and tall-sedge communities (*Carex rostrata*). *Sphagnum angustifolium* and *S. fallax* in general most important Sphagna. Confined to ground water discharge in small forest islands on the open mire (De in the north; Hä in north-west). Also with slight mesotrophic influence (*Potentilla palustris, Salix lapponum, S. myrtilloides*). Occurrences marked with asterisk on Figure S2.

46 Crmes

E 84/95: poor birch fen NK; around some discharging brooks swampy birch fen, LuNK

ViN 1994: Gran-björkkärr av fattig vitmoss-type, 3.2.1.3; *Picea abies-Betula pubescens-Sphagnum* spp.-type

F 1993: Gran-björkkärr av fattig vitmosstyp

M 1923: Trädbevuxen *Carex rostrata*-mosse, trädbevuxen *Eriophorum vaginatum*-mosse

A combination type with tall hummocks, lawns and carpets (*Eriophorum vaginatum*) and wet depressions (loose-bottoms) with tall sedges (*Carex rostrata* and covering *Sphagnum angustifolium*, *S. fallax*, *S. flexuosum*, *S. riparium*). Mesotrophic indicators: *Dactylorhiza maculata*, *Potentilla palustris*, *Calamagrostis phragmitoides*, *Carex echinata*, *C. nigra* and low willows (*Salix phylicifolia*, *S. lapponum*, *S. myrtilloides*). Ground water discharge from the mineral soil, brooks at mire margin (Hå in north-east, although outside catchment; St in the south). Occurrences marked (hatched) on Figure S2.

47 Cr3

E 84/95: Oligotrophic tall-sedge pine fen OlSR, (incl. oligotrophic short-sedge pine fen OlLkNR)

M 1923: seems to be included in "trädbevuxen *Carex rostrata*-mosse"

A combination type, mostly 3-level type, with large wet flarks of tall sedges (*Carex rostrata*) with covering *Sphagnum riparium*, *S. angustifolium*, *S. fallax*, *S. flexuosum*). Characteristic for brook outlets and groundwater discharge close to mineral soil (Hå in south-east;) and in outlet areas (Hä in south-west). Occurrences marked (hatched) on Figure S2.

48CnJf

E 84/95: *Carex nigra* birch fen, NigNK

Was not observed in the four areas but occurs within KRI. Confined to small depressions under strong ground water influence.

Forest vegetation on mineral soil

Naming follows (Kalela, 1961) and (Ebeling, 1978). Ebeling stresses the danger of judging moisture and nutrient status only on forest site type as the moor layer may have disappeared due to past intense fire history resulting in a lichen-dominated vegetation, supposed to mirror dry, as well as nutrient poor, site conditions. To accurately judge hydrological conditions one also need to know the thickness of the E-horizon (which was ignored during the field survey). That means that moisture conditions for lichen-dominated ClT (n° 50) may in fact vary from very dry to mesic. The regular occurrence of *Vaccinium uliginosum* (and also *Ledum palustre*) in heath forests is a northern zonal feature due to increasing humidity (Kalela, 1961). In the area Norway spruce normally dominates in VMT and Scots pine dominates in the other types. The forest types are mapped in Figure S3.

50 ClT

(Kalela, 1961): *Cladina* type, ClT

(Ebeling, 1978): lavtyp (lichen type), skarp-frisk lavtyp (very dry-mesic lichen type), skarp lav-ristyp (very dry/very poor lichen – dwarf-shrub type)

ViN 1994: *Pinus sylvestris-Cladonia* spp.-typ, 2.1.1.1, tallskog av lav-ristyp

Calluna vulgaris (scattered) is the most important species in the field layer, while the bottom layer is dominated by lichens (*Cladonia* spp.) and small acrocarpous mosses. Scattered *Salix starkeana* shrubs are relicts from past forest fires; also in n° 51 and 52 below.

51 ECT

(Kalela, 1961): *Empetrum-Calluna* type, ECT

(Ebeling, 1978): Kråkris-ljungtyp (*Empetrum-Calluna*-type; mesic *Empetrum-Calluna*-type), Lavristyp (ljungtyp and kråkristyp (dry and mesic lichen–dwarf-shrub-type; both *Calluna* and *Empetrum* type)

ViN 1994: *Pinus sylvestris-Calluna vulgaris-Empetrum* spp.-type, 2.1.1.2 (tallskog av ljung-kråkris-typ)

Field layer dominated by *Empetrum hermaphroditum* and *Calluna vulgaris*. Bottom layer dominated by lichens (*Cladonia* spp.), acrocarpous mosses (*Dicranum* spp., *Polytrichum* spp.) while pleurocarpous mosses are of low importance.

52 EVT

(Kalela, 1961): *Empetrum-Vaccinium* type, EVT

(Ebeling, 1978): lingon-ristyp (*Vitis-idaea*-type; mesic *Vitis-idaea*–dwarf-shrub-type); torr lavristyp (dry lichen–*Vitis-idaea*-type), torr-frisk ristyp (semi dry dwarf-shrub type).

ViN 1994: *Pinus sylvestris-Vaccinium vitis-idaea*-type, 2.1.1.4; tallskog av lingonris-typ

Field layer dominated by *Empetrum hermaphroditum* and *Vaccinium vitis-idaea*. *Pleurozium schreberi* and acrocarpous mosses (*Dicranum polysetum*, *D. scoparium*, *Polytrichum juniperinum*) dominate the bottom layer and some *Cladonia* lichens. The first herbs may appear.

53 VMT

(Kalela, 1961): *Vaccinium-Myrtillus* type, VMT

(Ebeling, 1978): frisk blåbärsristyp (mesic dwarf-shrub type, mesic *Myrtillus*-type), frisk ristyp.

ViN 1994: *Picea abies-Vaccinium myrtillus*-type, 2.1.2.1; granskog av blåbärsristyp

Vaccinium myrtillus and *V. vitis-idaea* dominate together with a closed bottom layer of forest mosses (*Dicranum* spp., *Hylocomium splendens*, *Pleurozium schreberi*, *Ptilium crista-castrensis*) and liverworts (*Barbilophozia lycopodioides*). More frequent herbs: *Luzula pilosa, Maianthemum bifolium, Melampyrum pratense*, *Trientalis (Lysimachia) europaea.*

Others

60 flark pools with open water

61 Phragmites swamp (RuRl in Eurola et al., 2015), loose-bottom, mesotrophic, surrounded by n° 46 (only at Hå, in north-east, although outside the catchment area; see Figure S3).

62 Ditches

Carex rostrata tall-sedge fen. Loose bottoms with *Sphagnum fallax* dominant, *S. angustifolium*, *S. flexuosum*, *S. riparium* (De, Hä).

4.4. Vegetation classification workflow

The vegetation classification involved microtopography identification/classification, ground truth handling and model training to finally achieve the actual classification (Figure S1)

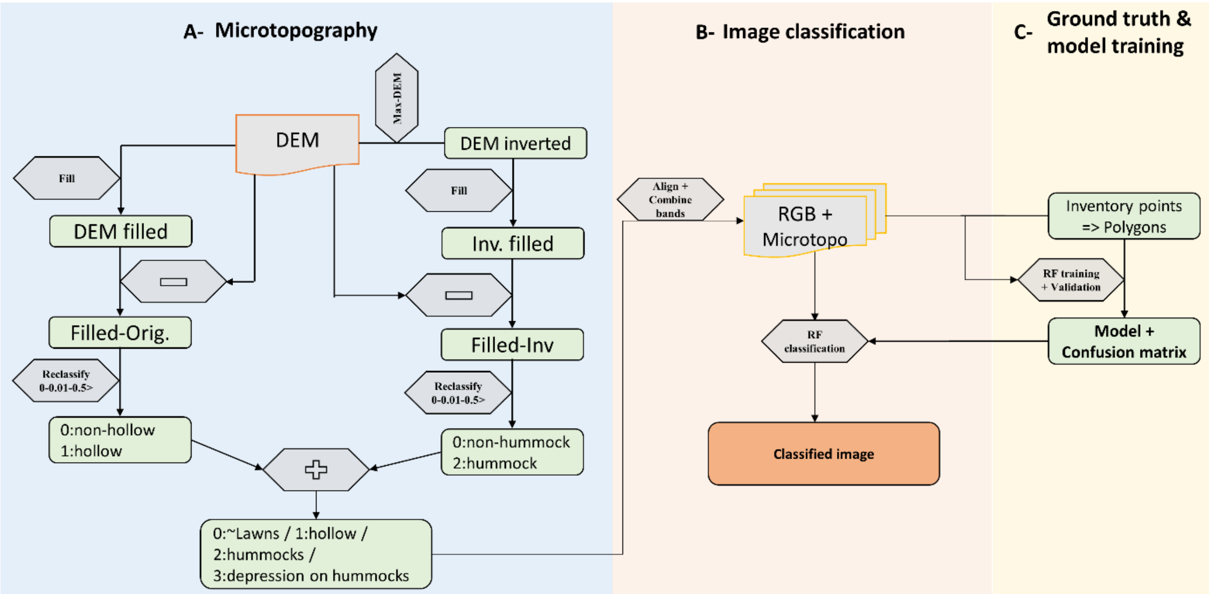

Figure S1. Mire vegetation classification workflow. The classification includes microtopography identification/classification (A), ground truth and model training (C) and image classification (B).

4.4.1 Mire microtopography modelling

Microtopography was included in the vegetation classification as it is an important factor in the differentiation of mire vegetation. The classification of microtopography as considered in this study is a mere simplification of its complexity. We only distinguished 4 classes: (i) lawns, (ii) hollows (i.e. flarks and carpets/loose-bottom), (iii) hummocks and strings, and (iv) small depressions on hummocks. The process for microtopography classification consisted of two steps. Hollows were identified by subtracting a digital elevation model (DEM) from a filled DEM (filled using the fill algorithm in ArcGIS Desktop). Hummocks and strings are identified by preceding a similar process as for the identification of hollows by the inversion of the DEM (by subtracting the DEM from the maximum value of the DEM). By reclassifying, encoding and finally summing up hollow-non hollow and hummock-non hummock layers, a microtopography classification is obtained (Figure S1-A).

4.4.2 Ground truth and model training

In November 2021, a vegetation inventory was conducted at over 50 points at each of the 4 mires considered in this study. Field controls were performed in September-October 2022.

The identified vegetation types follow the classification in APPENDIX B, section 3.3. Since it was not possible to discriminate between individual vegetation types with the limited spectral information available, these were further grouped as follows:

- Group I: Lawns, dominated by short sedges and Sphagna (vegetation types 1, 2, 3, 4 and 20)
- Group II: Carpets dominated by short sedges and *Sphagnum* subg. *Cuspidata* (vegetation types 5, 6, 12, 15, 16, 17, and 18)
- Group III: Mud/loose bottoms, tall-sedge fens,(vegetation types 7, 8, 9, 10, 11, 13, 14, and 15)
- Group IV: hummocks and sparsely treed mire (vegetation types 21, 22, 23, 24, 25, 26 and 40)
- Group V: Mire forests, including high hummocks (vegetation types 27-28, 30-38, 45-48)
- Group VI: Forests on mineral soils, outside of the mire system although within the catchment area. (vegetation types 50-53)

Group VI in the above grouping, i.e. forests on mineral soils was first clipped out before the image classification and appended to the final classification results. The observation points from the field survey were used to draw polygons or regions of interest (ROI) of the different groups abovementioned. The microtopography classification was stacked with the 6.5 cm resolution RGB image as an additional band. The RGB+microtography image was then trained using the random forest classifier in OrfeoToolbox v. 8.0.1 integrated into QGIS v. 3.22.6 (Figure S1-C). This training created the model that was then used for the classification. During the training, 80% of the pixels of the ROI were used for the actual training, and the remaining 20% were used for validation, i.e. computation of the confusion matrix and Cohen's kappa coefficient.

4.4.3 Image classification

In this step, the same image used during training (RGB + microtography) was classified with the random forest classifier based on the model obtained during the training stage (Figure S1-B). The resulting raster layer was then sieved and clusters with less than 100 pixels were merged with their surrounding class in order to reduce the normal fragmentation that occurs during image classification.

4.4.4 Classification results

The kappa coefficients obtained during validation were 0.76 for Degerö Stormyr and Stortjärn together, 0.82 for Hålmyran, and 0.75 for Hälsingfors, indicating a good classification performance overall. The mire vegetation classification results are presented in Figure S2. The vegetation in the area is essentially minerotrophic, but there are some areas where the vegetation has ombrotrophic characteristics. These areas are located essentially outside of the footprint of the EC towers, although small portions occur within the 90% footprint at all sites. These areas were visible on the orthomosaic and were drawn manually (Figure S2).

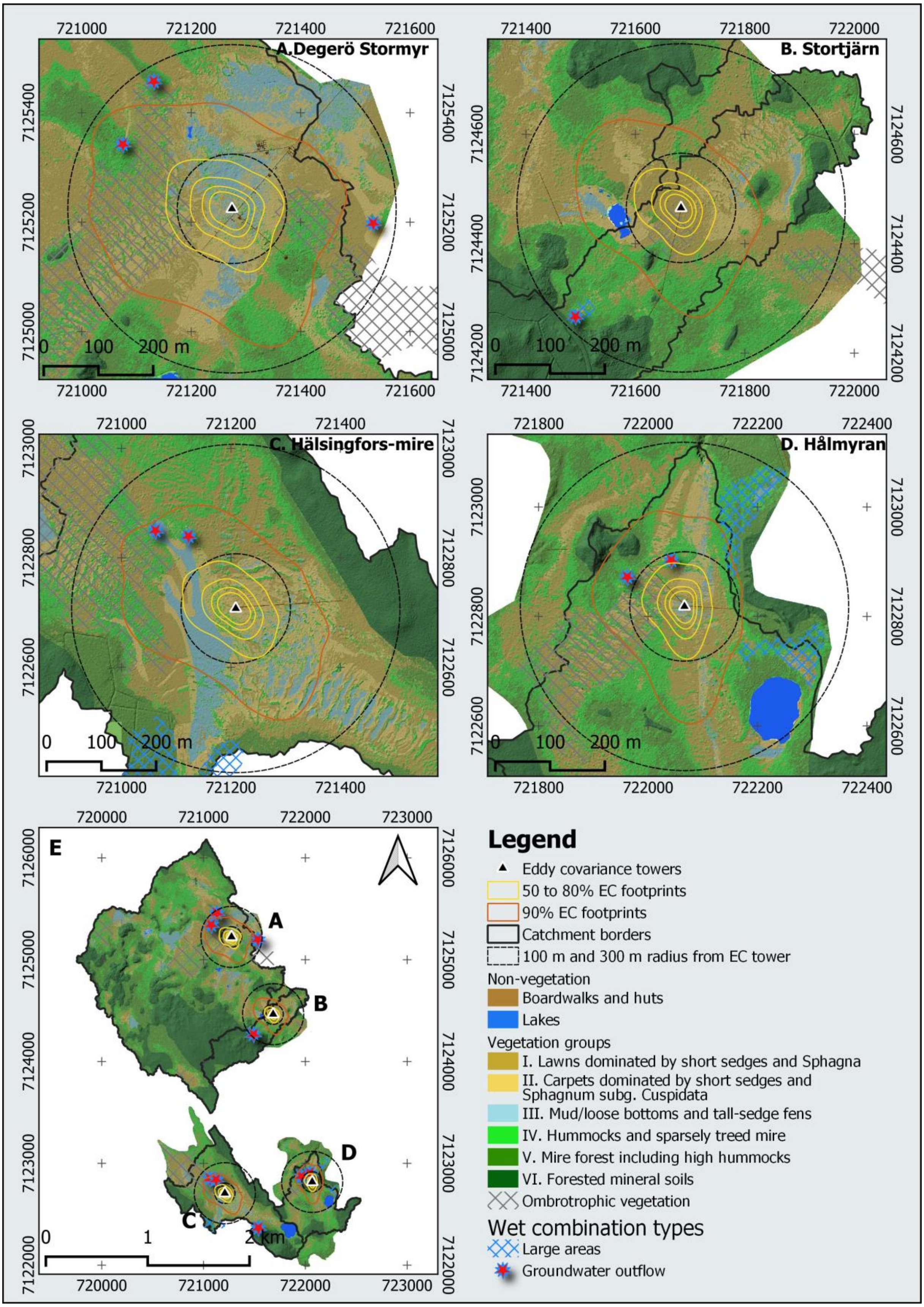

Figure S2. Vegetation classification map of the mire sites of the Kulbäcksliden peatland research infrastructure with a focus on a 300 m radius from EC towers at Degerö Stormyr (A), Stortjärn (B), Hälsingfors-mire (C), Hålmyran (D) and an overview of all four catchments (E).

The footprint climatologies were calculated from one-year data wind speed and wind direction (Mai 2020 to April 2021) based on (Kljun et al., 2015). The vegetation groups layer is blended with a hillshade derived from the 0.5 m resolution digital elevation model. Visit https://gis-slu.maps.arcgis.com/apps/View/index.html?appid=7d485f469233422aa98a5d49e031fd44 for an online version of this map.

The share of the different groups per catchment and footprint area is presented in table S3.

Table S3: Percentage share of the different groups of vegetation per catchment, 50%, 60% 70%, 80% and 90% footprint climatology area. The groups are those defined above in section 4.4.2.

Zone	Mire site	Total area (ha)	Percentage of total area							
			Group I	Group II	Group III	Group IV	Group V	Group VI	Boardwalks	Water
Catchments	Degerö Stormyr	272.93	15.5	8.1	4.4	23.0	20.6	27.9	0.2	0.2
	Stortjärn	29.64	13.9	6.6	0.6	11.4	9.8	57.5	0.1	0.1
	Hålmyran	33.11	22.7	7.0	1.6	31.0	13.8	21.2	0.1	2.6
	Hälsingfors	64.83	20.2	10.5	4.7	17.5	12.5	32.0	0.0	2.6
Footprint 50%	Degerö Stormyr	0.38	12.1	39.6	37.7	7.3	0.0	0.0	3.3	0.0
	Stortjärn	0.19	95.3	2.5	0.0	0.7	0.0	0.0	1.4	0.0
	Hålmyran	0.20	39.6	27.5	24.7	5.9	0.0	0.0	2.3	0.0
	Hälsingfors	0.25	18.1	71.6	0.3	9.0	0.0	0.0	1.0	0.0
Footprint 60%	Degerö Stormyr	0.67	11.8	40.8	38.3	7.0	0.0	0.0	2.1	0.0
	Stortjärn	0.33	92.5	5.2	0.0	1.3	0.0	0.0	1.0	0.0
	Hålmyran	0.35	46.0	30.1	16.8	5.4	0.0	0.0	1.7	0.0
	Hälsingfors	0.44	15.0	68.9	0.9	14.4	0.0	0.0	0.7	0.0
Footprint 70%	Degerö Stormyr	1.32	14.5	42.5	35.9	5.7	0.0	0.0	1.5	0.0
	Stortjärn	0.65	91.0	6.0	0.0	2.1	0.2	0.0	0.7	0.0
	Hålmyran	0.67	48.9	30.3	11.6	8.0	0.0	0.0	1.2	0.0
	Hälsingfors	0.86	12.3	65.4	5.6	16.1	0.0	0.0	0.5	0.0
Footprint 80%	Degerö Stormyr	3.29	15.9	49.1	27.2	7.0	0.0	0.0	0.9	0.0
	Stortjärn	1.65	82.9	12.5	0.0	3.3	1.0	0.0	0.4	0.0
	Hålmyran	1.61	48.6	26.5	8.1	15.8	0.3	0.0	0.7	0.0
	Hälsingfors	2.15	14.0	54.4	19.2	12.1	0.1	0.0	0.3	0.0
Footprint 90%	Degerö Stormyr	15.12	32.7	30.9	11.5	19.9	4.3	0.0	0.5	0.1
	Stortjärn	8.24	47.6	21.4	2.2	20.9	5.0	0.9	0.2	1.7
	Hålmyran	7.23	33.9	18.2	4.1	34.2	7.2	2.1	0.2	0.0
	Hälsingfors	9.97	26.7	34.9	18.7	18.8	0.7	0.0	0.1	0.0

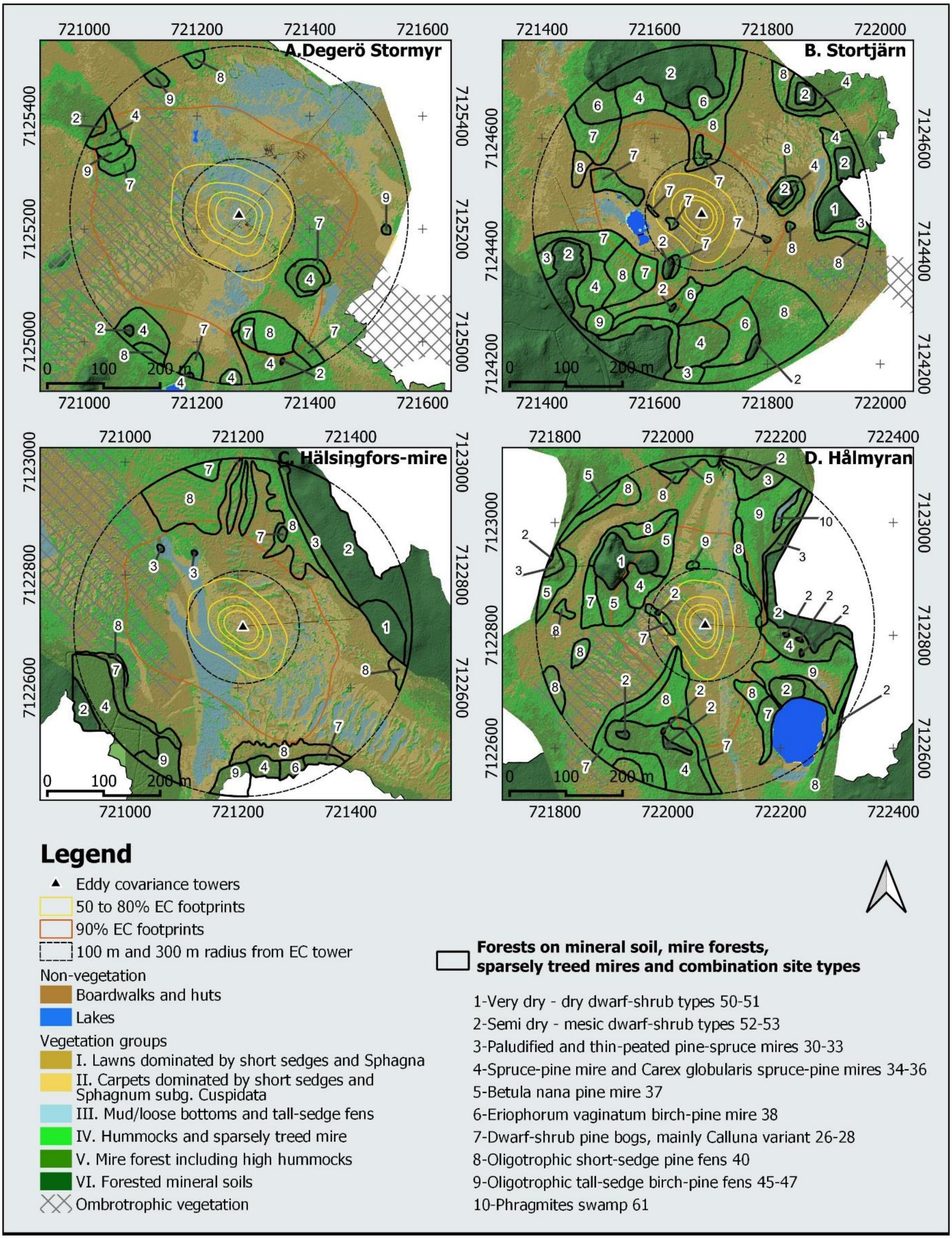

Figure S3. Simplified vegetation classification map of forests types on mineral soil, mire forests, sparsely treed mires, and various wet combination types including *Phragmites* swamps. For explanation see text. This simplified map is limited to a 300 m radius from EC towers at Degerö Stormyr (A), Stortjärn (B), Hälsingfors-mire (C), Hålmyran (D).

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5. APPENDIX E: Instrumentation at the research infrastructure

Table S4. Instrumentation at the Kulbäcksliden peatland research infrastructure up to January 2023.

System	Variable	Degerö Stormyr		Stortjärn		Hålmyran		Hälsingfors mire		Hälsingfors forest	
Eddy covariance	CO_2 & H_2O	2001 - 2014:	LI-6262	2020 - Now	Picarro G2311-f	2020 - Now:	Picarro G2311-f	2020/06 - 2020/12:	EC 155 Campbell Scientific	2020 - Now:	LGR DLT-100 FGGA 908-0010
		2014 - Now:	LI-7200					2020/12- Now:	Picarro G2311-f		
		2013 - Now:	LGR FGGA 911-0010								
	CH_4	2013 - Now:	LGR FGGA 911-0010	2020 - Now	Picarro G2311-f	2020 - Now:	Picarro G2311-f	2020/06 - 2020/12:	LI-7700	2020 - Now:	LGR DLT-100 FGGA 908-0010
								2020/12 - Now:	Picarro G2311-f		
	Hg(0)	2021 - Now:	Lumex RA-915 AM	-	-	-	-	-	-	2021 - Now:	Lumex RA-915 AM
	Wind speed & direction	2001 - 2014:	Gill R3-100	2020 - Now	Metek uSonic-3 Class A	2020 - Now:	Metek uSonic-3 Class A	2020/06 - 2020/12:	CSAT-3B	2020 - Now:	Metek uSonic-3 Class A
		2013-2017:	Metek uSonic-3 Class A					2021 - Now:	Metek uSonic-3 Class A		
		2017 - Now:	Gill HS-50								
		2021 - Now:	Metek uSonic-3 Class A (for eddy mercury)							2021 - Now:	Metek uSonic-3 Class A (for eddy mercury)

System	Variable	Degerö Stormyr		Stortjärn		Hålmyran		Hälsingfors mire		Hälsingfors forest	
Automated **Chambers**	CO2 & CH4	2014 - 2017:	LGR GGA-24EP	-	-	2021 - Now:	LGR UGGA 915-0011	-	-		
		2017 - Now:	Picarro G1101-I								
Manual **Chambers**	CH4	2004-2014	Gas chromatograph							2018	LGR UGGA model 908-0010-0002 Serial 12-0091
	CO2	2004-2014	PP IRGA Sytem							2019 - Now	GasScouter TM G4301
	CO2 & CH4	2014-2018	LGR UGGA								
Ancillary data	Air temperature and humidity	2001 - 2014:	Rotronic MP102H-331000	2020 - Now:	HC2S3 Campbell Scientific	2020 - Now:	HC2S3 Campbell Scientific	2020 - Now:	HC2S3 Campbell Scientific	2020 - Now:	HC2S3 Campbell Scientific
		2013 - Now:	Rotronic MP102H-331000								
		2018 - Now:	Rotronic MP102H-331000								
	Soil temperature	2001-2014	TO3R TOJO Skogsteknik	2020 - Now:	TO3R TOJO Skogsteknik	2020 - Now:	TO3R TOJO Skogsteknik	2020 - Now:	TO3R TOJO Skogsteknik	2020 - Now:	TO3R TOJO Skogsteknik
		2013-2019	105 type E thermocouple								
		2019-2021	Micro-step Pt100 probe								
		2021-Now:	Fischer Pt100								

System	Variable	Degerö Stormyr		Stortjärn		Hålmyran		Hälsingfors mire		Hälsingfors forest	
	Water table depth	2001 - Now:	CS450	2020 - Now:	CS451	2020 - Now:	CS451	2020 - Now:	CS451	2020 - Now:	CS451
	Precipitation	2001 - Now:	ARG100	2020 - Now:	ARG100	2020 - Now:	ARG100	2020 - Now:	ARG100		
		2013-2021	Geonor T200b								
		2022-Now	Lambrecht Rain[e]H3								
	Global radiation	2013-Now	CMP21	-	-	-	-	-	-	-	-
	SW & LW radiation	2013-Now	CNR4	2020 - Now:	NR01 Campbell Scientific	2020 - Now:	NR01 Campbell Scientific	2020 - Now:	NR01 Campbell Scientific	2020 - Now:	NR01 Campbell Scientific
	PAR	2013-2017	SQ-110	2020 - Now:	LI-190	2020 - Now:	LI-190	2020 - Now:	LI-190	2020 - Now:	LI-190
		2017-Now	LI-190								
	NDVI	2014 - now	SKYE sensors (also measure PRI and SWIR)	2020 - Now:	Decagon SRS	2020 - Now:	Decagon SRS	2020 - Now:	Decagon SRS	2020 - Now:	Decagon SRS
		2017 - now	Decagon SRS								
Phenology cameras	Images	2011 - 2014	Canon A480	2020 - Now:	Canon	2020 - Now:	Canon	2020 - Now:	Canon	2020 - 2021:	Wingscapes Timelapse
		2014 - 2022	CanonPowershot A810	2022-Now	Stardot Netcam SC	2022-Now	Stardot Netcam SC	2022-Now	Stardot Netcam SC	2022-Now	Stardot Netcam SC

System	Variable	Degerö Stormyr		Stortjärn		Hålmyran		Hälsingfors mire		Hälsingfors forest	
		2022 - now	Mobotix Mx-M26B-6D								
		2016 - now	Stardot Netcam SC(ICOS)								
		2016 - now	Mobotix Mx-M26B-6D061(SITES Spectral)								