

Comparison of Finnish and Russian approaches for large-scale vegetation mapping: a case study at Härkösuo Mire, eastern Finland

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SUMMARY

The purpose of this study was to compare Russian and Finnish mire vegetation classifications and large-scale vegetation mapping methods. Härkösuo Mire in Kuhmo, eastern Finland covers about 20 hectares and includes a small area of aapamire, together with spring fen and pine bog types. Two vegetation maps of this site were prepared from aerial photographs and field observations by different observers using the Russian and Finnish approaches independently, and the maps were compared quantitatively using GIS techniques. Despite the different vegetation classification methods, the maps have a great deal in common. The correspondence of results obtained using the Russian ‘dominant’ approach and the Finnish ‘site type’ approach is discussed. The main differences occurred in the marginal zones of the mire. In the Finnish approach, marginal areas with dense spruce cover are regarded as mire whilst in the Russian approach they are classified as forest.

KEY WORDS: aapamire, Fennoscandia, mire site type, vegetation classification.

INTRODUCTION

Vegetation mapping is a branch of phytosociology which provides a useful tool for understanding the spatial distribution of plant communities and for revealing their diversity and patterns. There are several different schools of vegetation mapping, for example those in central Europe, Scandinavia and Russia (Küchler & Zonneveld 1988). This paper focuses on the methodologies of the Russian and Finnish schools.

Russian school of vegetation mapping

The Russian school of geobotanical cartography has a long tradition. It was established by Professor N. Kuznetsov in 1922, and the Laboratory of Geography and Vegetation Cartography at the Komarov Botanical Institute of the Russian Academy of Sciences became the Russian centre for its development into a theoretically based discipline which can be adapted for different practical applications (Yurkovskaja 2004). A long-term project initiated in the 1930s aimed to map the vegetation of the European part of the USSR. New impetus came in the 1950s and 1960s, when Academician Viktor Sochava developed the system paradigm for phytocological mapping and established the annual *Vegetation Mapping* (Геоботаническое картографирование). Under the leadership of Academician Evgeny Lavrenko (1967–1979) the Laboratory became an international

authority in the field, publishing remarkable maps including the *Geobotanical Map of the Non-chernozem Zone of the RSFSR* (Isachenko *et al.* 1976) and the *Vegetation Map of the European Part of the USSR* (Isachenko & Lavrenko 1979).

The large area of Russian territory meant that small-scale vegetation mapping was often the most appropriate and cost-effective approach. The maps usually cover large areas and show the general features and patterns of regional vegetation, or they have been compiled according to vegetation zones. The mapping process begins with a preliminary interpretation of morphological and vegetation structures visible in aerial photographs or satellite images, and the patterns identified are verified in the field using vegetation relevés placed on transects. The legends to the maps usually present interpretations of the data that reflect the authors' point of view. Actual and potential vegetation, vegetation dynamics and anthropic transformation sequences are common themes. Much attention has been paid to theoretical aspects, such as the correlation between the vegetation classification and the legend; developing ecological, floristic and geographical criteria for use in mapping; and establishing principles for the phytogeographical differentiation of territories.

In general, the mires of the boreal zone do not occur as isolated mesotopes; rather they form interconnected systems or complexes. The “mire massif” is defined as “a part of the earth’s surface

occupied by a mire whose boundaries form in plan a closed outline or figure” (Ivanov 1981). Mire vegetation in Russia has been studied and mapped by Tatiana Yurkovskaya, who adopted the mire massif as the unit for vegetation mapping at small and medium scales (Yurkovskaya 1995). She developed the original mire massif type classification, based on the ideas of Tsinzerling (1938), Bogdanovskaja-Gienef (1949) and Kats (1928, 1948, 1971), and applied this in mapping mire vegetation (Yurkovskaja 1992). She also attempted to characterise the most widespread mire massif types in European Russia according to their latitudinal and longitudinal zonation. A recently published vegetation map of mires in north-eastern Karelia at scale 1:600,000 (Yurkovskaja & Elina 2005) was compiled according to the traditions of the Russian cartographic school.

Finnish school of vegetation mapping

Vegetation mapping is not an established theoretical discipline in Finland. Very few scientific maps have been made, and there are no vegetation maps covering the whole country apart from a very general contribution to the *Map of the Natural Vegetation of Europe* (Bohn *et al.* 2004). Nonetheless, the history of vegetation mapping in Finland is only *ca.* a decade shorter than in Russia. Paasio (1933) was the first to produce a detailed vegetation map of a mire using aerial photographs, at scale 1:15,000. Seppälä & Rastas (1980) made the first small-scale vegetation map based on satellite images; this was for an area in the northernmost part of Finnish Lapland, and vegetation classes were defined mainly on the basis of tree cover and moisture. Ruuhijärvi (1988) prepared a small-scale map (1:1,000,000) of the mire complexes (massifs) of Finland, using six mire complex types as mapping units.

In Finland, vegetation maps are required mainly for practical applications in nature conservation or environmental impact assessment. Routine vegetation mapping to reveal the biotope diversity of national parks and some other nature reserves began in the early 1980s. The scale of the maps is usually 1:10,000 or 1:20,000 and the mapping units are botanical ‘site types’ based on a national vegetation classification (see below). These are identified using checklists, and delimited on the basis of aerial photograph interpretation and field observations. The minimum size of a mire site is generally 100 m², but smaller units containing e.g. springs and other key habitats may also be mapped. The site type determinations are not usually verified with relevés, but floristic lists are compiled either for vegetation patches or for quadrats of one square

kilometre defined by map co-ordinates (e.g. Heikkilä 1986, Heikkinen & Kalliola 1989, Heikkilä *et al.* 2001).

Classification of mire vegetation

The neighbouring countries of the northern Baltic adopt different approaches to the classification of vegetation. Paal (1997) compiled a list of vegetation site types for Estonia based on physiognomic features which were then combined with ecological classes; the physiognomic-ecological classes were then divided into site types floristically. In the Nordic countries, especially Sweden, a topological-ecological system has been developed. However, Pålsson (1994) compared the classification systems employed by Estonia, the Nordic countries and Finland, and found rather close correspondence between them.

In Finland, approximately 80 mire site types have been defined on the basis of botanical criteria (Ruuhijärvi 1983, Eurola *et al.* 1984, 1994) whilst for practical applications such as forestry, 30–35 site types are distinguished (Laine & Vasander 2005). The site type indices are clearly-distinguished synthetic physiognomic-botanical characteristics which are accepted by Finnish scientists as the national standard. The site types are organised into six groups – namely spruce mire, pine mire, open bog and fen, rich fen, spring mire and flooded swamp – which can be identified more or less reliably from aerial photographs. The site types can also be classified according to a pH gradient as bog, poor fen and rich fen (Tahvanainen *et al.* 2002).

In Russia, regional reviews of mire vegetation have been compiled e.g. for Leningrad region (Botch & Smagin 1993), Kaliningrad region (Napreenko 2002) and the Karelian Republic (Kuznetsov 2003, 2005). Three vegetation classification systems are commonly used, namely the dominant (ecological-phytocoenotic), floristic (central European) and topological-ecological (Scandinavian) approaches. The one that is used most often in vegetation mapping is the dominant approach. However, the vegetation classes that are defined are not used directly as mapping units; the latter are derived individually for each map according to the authors’ focus. Isachenko & Lavrenko (1979) distinguished five principal mire types (*Sphagnum*; herb-lichen-moss; herb-*Sphagnum-Hypnum*; herb and herb-*Hypnum*; forest) on the basis of predominant vegetation categories. More traditionally, three mire types – raised bogs (verhovyie), transitional mires (perehodnye) and fens (nizinnye) – are recognised (e.g. Ogureeva *et al.* 1996). Trophic status (oligotrophic, mesotrophic and eutrophic categories) has also been used as a

basis for map legends.

The first attempt to compare classifications of mire vegetation according to the Finnish and Russian schools was published by Antipin *et al.* (1997), who mapped a large (2,000 ha) mire complex at medium scale (1:50,000). The Russian scientists used vegetation formations (*Herbo-Sphagneta*, *Cariceta* etc.) as mapping units, whilst the Finnish scientists used mire site indices. The authors concluded that, in general, Finnish mire sites are slightly ‘narrower’ ecologically than Russian mapping units; but at the same time the boundaries between some of the units fall at different points so that one site type in the Finnish classification can correspond to two types in the Russian system and *vice versa*.

Aim of this study

The work reported here was carried out within a collaboration that was established to bring together the experience of the Finnish and Russian schools of vegetation mapping, to compare the results of mapping according to their respective traditions, and to gain familiarity with the natural habitats of the Finnish-Russian border area. The immediate aim was to prepare two vegetation maps of Härkösuo Mire independently, using Russian methodology for one and the Finnish approach for the other; to verify them by analysis of vegetation relevés; and to compare them quantitatively using GIS techniques.

MATERIALS AND METHODS

Study site

Härkösuo Mire (64°12'N, 30°26'E, 235 m a.s.l.) is located within the Elimyssalo Nature Reserve in Kuhmo, eastern Finland (Figure 1). It lies in the middle boreal climatic-phytogeographical zone (Ahti *et al.* 1968, Tuhkanen 1984) and in the Archaean Karelian province of the Fennoscandian bedrock shield. The mean annual rainfall is 600 mm, the mean annual temperature is 1.2°C (Alalammi 1987), and the bedrock consists of granite and gneiss (Luukkonen 1992, Gorkovets & Rayevskaya 2003).

Kats (1971) places the study area within the Karelo-Finnish province ‘middle taiga and Karelian mires of mixed type’, and we subscribe to this view. However, opinions vary both within Russia and between Finland and Russia; according to the Finnish system of mire regions it belongs to the southern aapamire zone (Ruuhijärvi 1988), whilst Russian literature sources place it in the northern taiga (Aleksandrova *et al.* 1989, Yurkovskaja & Pajanskaja-Gvozdeva 1993, Safronova *et al.* 1999).



Figure 1. Location of Härkösuo Mire within Finland.

The area of Härkösuo Mire is 20 hectares. It extends for 1,000 m in an east–west direction, and its mean north–south width is 200 m (Figure 2). It occupies a tectonic depression. The calibrated radiocarbon age for the basal peat is 10,240 years (Markku Mäkilä unpublished data 2006) and the peat layer is very thick, with maximum depth 805 cm. The mire slopes gently and is mostly soligenous. Groundwater influence is clearly apparent at the south-western margin of the mire, and weaker in its south-eastern part (Tahvanainen *et al.* 2002). As a result of the highly variable ecological conditions, the vegetation is very diverse. Tahvanainen *et al.* (2002) divide the mire into five vegetation zones, namely four fen types ranging from rich to extremely poor categories, and marginal pine bog which exhibits high internal variability. There is central string-flark patterning with strings that are elevated by only 10–20 cm above the flark level, as is typical for southern aapamires (Ruuhijärvi 1960).



Figure 2. Oblique aerial photograph of Härkösuomire from the west (Suomen Ilmakuva Oy, September 1997).

Vegetation mapping

The vegetation of Härkösuo Mire was mapped separately and independently by the Russian author and the Finnish author, both following similar procedures but each applying his/her own national approach.

The vegetation was first mapped in detail from a 1995 false colour infrared aerial photograph at scale 1:5,000 (Rafstedt & Andersson 1981, Aaviksoo *et al.* 1997); the scale of the negative was 1:20,000. In addition, low-altitude oblique aerial colour photographs from 1997 (e.g. Figure 2) were used to clarify patterns. All visible elements of vegetation pattern (patches) were delimited on the aerial photographs. They were verified in the field between 5th and 8th August 2002 by recording vegetation relevés to determine vegetation structure and species composition for each of the patches identified. In total, 163 relevés were made; a larger number of relevés would have been needed to undertake a quantitative classification of the vegetation. For areas of uniform ground, a single 1m² sample plot was placed randomly near the centre of each patch, and percentage cover of species was recorded for both the field layer and the ground layer. In cases where there was a mosaic of hummocks, lawns and/or flarks (microforms) within the patch, a separate relevé was made for each microform type. The vegetation types were initially named botanically rather than using traditional physiognomic terms. Nomenclature followed Hämet-Ahti *et al.* (1998) for vascular plants and Ulvinen *et al.* (2002) for bryophytes and hepatics.

The Finnish author then assigned each patch to a site type, according to the classification of Ruuhijärvi (1983) and Eurola *et al.* (1984, 1994). A more detailed classification using subtypes was also made. The site types were used directly to compile the legend for the 'Finnish' map.

The Russian author, following the traditional ecological-phytocoenotic (i.e. dominant) approach, also recorded species abundance data (Drude scale) for each plot. During the data analysis phase, the relevés were grouped according to the trophic status of their vegetation, organised into tables and rearranged on the basis of the dominant species in the different vegetation layers. This procedure yielded diagnostic tables of similar plant communities which summarised the vegetation and were used to prepare the legend for the 'Russian' map.

The vegetation patterns portrayed by the Finnish and Russian maps were compared quantitatively using ArcGIS9 (ESRI) software with Spatial Analyst extension, in order to reveal the correspondence of the vegetation units and their degree of overlap. The aim was to determine which

Finnish mire site types corresponded to each Russian community, and in which cases more than one Finnish site type belonged to a single Russian community and *vice versa*. For each vegetation community identified in the legend of the Russian map, the Finnish site types mapped for the same areas were identified and the percentage of the total area covered by each site type (the area of overlap) was calculated. Overlaps smaller than 10% were omitted because they were probably due to subjectivity in drawing the lines between vegetation patches identified from the aerial photographs.

RESULTS

The two vegetation maps and their legends are shown in Figures 3 and 4. Most of the mire area is occupied by open *Trichophorum* communities, and there are aapa complexes in the deepest (central) part of the mire. Farther from springs, aapa complexes are replaced by poor *Scheuchzeria-Sphagnum majus* communities as the groundwater influence becomes weaker, and a homogeneous *Carex pauciflora* – *Sphagnum angustifolium* community has developed in the shallow eastern basin. Pine bog communities are present along the mire margins except in places where groundwater comes to the surface.

The legend of a Russian vegetation map usually looks like a hierarchical text (Figure 3). It indicates the physiognomic features of the vegetation by subtitles (in this case: pine mire communities; mire communities with sparse pine which is partly dead; open mire communities, among them complex vegetation; sloping fen communities with spring influence). The diversity of Härkösuo Mire, which arises from the complex hydrological regime, is reflected by the 21 different vegetation categories distinguished in the legend. Following the dominant approach, each category is characterised by listing the dominant plants in each of the vegetation layers. For example, in "*Carex rostrata*+*Scheuchzeria palustris*-*Sphagnum papillosum*", "+" means that the first two species are present in the same layer and have more or less equal phytosociological value, and "-" indicates that the third species is the dominant species in another vegetation layer.

The map compiled by the Finnish author distinguishes 26 different vegetation units which are characterised by indices of the Finnish mire type classification. They are arranged in subclasses and in the order prescribed by Eurola *et al.* (1994) (Figure 4). Very small patches of spruce mire occur around the margins of the site, mostly as narrow strips which cannot be shown on the map, although

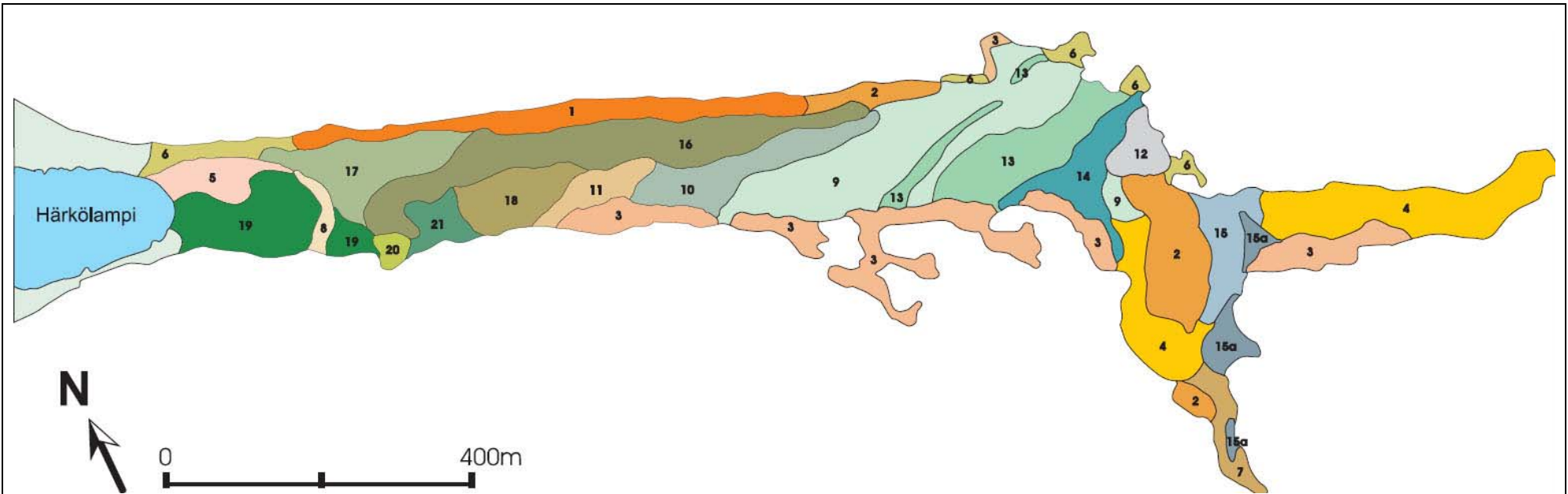


Figure 3. Vegetation map of Härkösuomire according to the Russian classification.

LEGEND:

Pine mire communities

1. *Pinus sylvestris*-*Rubus chamaemorus*+*Empetrum hermaphroditum*-*Sphagnum fuscum*
2. *Pinus sylvestris*-*Vaccinium uliginosum*-*Carex pauciflora*-*Sphagnum angustifolium*
3. *Pinus sylvestris*-*Chamaedaphne calyculata*+*Ledum palustre*+*Vaccinium uliginosum*-*Carex globularis*+*C. pauciflora*-*Sphagnum russowii*+*Pleurozium schreberi*

Mire communities with sparse pine

4. *Betula nana*+*Eriophorum vaginatum*-*Carex pauciflora*-*Sphagnum angustifolium*
5. *Eriophorum vaginatum*+*Empetrum hermaphroditum*-*Sphagnum fuscum*
6. *Carex lasiocarpa*-*Sphagnum angustifolium*

continued.....

Figure 3 continuation

Open mire communities

7. *Carex rostrata*-*Sphagnum fallax*
8. *Menyanthes trifoliata*+*Trichophorum alpinum*-*Carex lasiocarpa*-*Sphagnum angustifolium*+*S. warnstorffii*
9. *Scheuchzeria palustris*-*Sphagnum balticum*
10. *Carex rostrata* + *Scheuchzeria palustris*-*Sphagnum papillosum*
11. *Trichophorum cespitosum*-*Sphagnum papillosum*
12. Complex
hummocks: *Betula nana*+*Chamaedaphne calyculata*-*Sphagnum fuscum*
hollows: *Scheuchzeria palustris*-*Sphagnum balticum*
13. Complex
hummocks: *Empetrum nigrum*+*Rubus chamaemorus*-*Sphagnum fuscum*
carpet: *Carex rostrata*+*Scheuchzeria palustris*+*Carex pauciflora*-*Sphagnum balticum*+*S. papillosum*
14. *Menyanthes trifoliata*+*Scheuchzeria palustris*-*Sphagnum majus* +*Warnstorffia exannulata*
15. Aapa complex
hummocks: *Carex lasiocarpa*-*Sphagnum angustifolium*
flarks: *Scheuchzeria palustris*-*Sphagnum majus*
- 15a flarks: *Scheuchzeria palustris*+*Menyanthes trifoliata*-*Utricularia intermedia*
16. Aapa complex
strings: *Betula nana*-*Trichophorum alpinum*-*Sphagnum angustifolium*
flarks: *Carex rostrata*-*Rhynchospora alba*-*Sphagnum platyphyllum*+*Scorpidium scorpioides*
17. Aapa complex
carpet: *Trichophorum alpinum*-*Sphagnum subfulvum*
small depressions: *Rhynchospora alba*+*Carex limosa*
18. Aapa complex
hummocks: *Molinia caerulea*-*Sphagnum fuscum*
flarks: *Carex lasiocarpa* +*Trichophorum alpinum*-*Scorpidium revolvens*+*Campylium stellatum*

Sloping fen communities with spring influence

19. *Pinus sylvestris*+*Picea abies*-*Salix* spp.-*Betula nana*+*Empetrum hermaphroditum*-*Equisetum fluviatile*-*Sphagnum angustifolium*+*S. warnstorffii*+*Pleurozium schreberi*
20. *Angelica sylvestris*+*Molinia caerulea*-*Menyanthes trifoliata*-*Sphagnum angustifolium*+*S. warnstorffii*
21. *Carex lasiocarpa*+*Trichophorum alpinum*+*Molinia caerulea*-*Sphagnum angustifolium*+*S. warnstorffii* (with sparse pine trees)

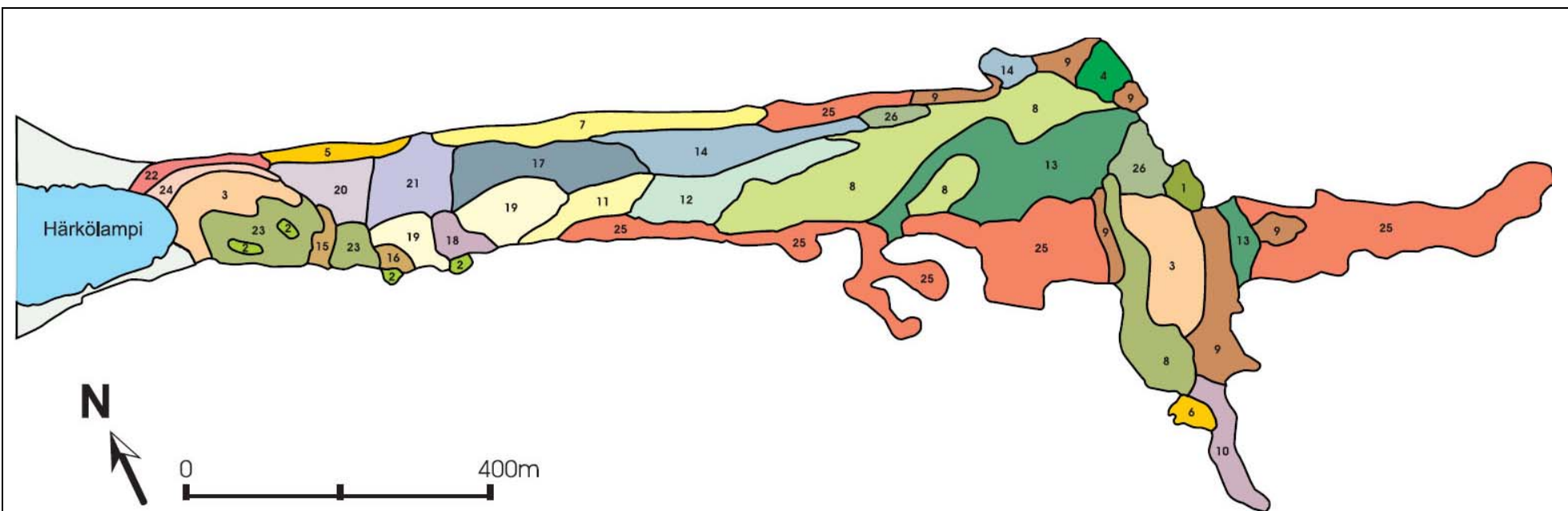


Figure 4. Vegetation map of Härkösuomire according to the Finnish classification. Site type indices follow Eurola *et al.* (1994) and the names of the site types are modified from Ruuhijärvi (1983) and Eurola *et al.* (1994).

LEGEND:

Spruce mire

1. MK *Vaccinium myrtillus-Sphagnum girgensohnii* spruce mire

Spring vegetation

2. MeLä Poor spring vegetation with *Warnstorfia exannulata* and *Straminergon stramineum*

continued....

Figure 4 continuation

Pine mire

3. RaTR *Eriophorum vaginatum* pine bog with *Sphagnum fuscum* hummocks
4. KR Pine-spruce-birch-dwarf shrub–*Sphagnum angustifolium* mire
5. IR *Ledum–Chamaedaphne–Sphagnum angustifolium* pine mire
6. RaIR *Ledum–Chamaedaphne–Sphagnum fuscum* pine bog
7. RaR *Sphagnum fuscum–Empetrum* pine bog

Fen

8. LkN *Eriophorum vaginatum–Carex pauciflora–Sphagnum angustifolium* fen
9. VSN *Carex rostrata–Sphagnum fallax* fen
10. LuRiSSN *Carex rostrata–Potentilla palustris–Sphagnum riparium* fen
11. LkKaN *Trichophorum cespitosum–Carex pauciflora–Sphagnum papillosum* fen
12. SsKaN *Carex rostrata–Sphagnum papillosum* fen
13. RaSphRiN *Sphagnum majus–Scheuchzeria palustris* fen with *Sphagnum fuscum* hummocks
14. RhRiN *Trichophorum alpinum–Sphagnum platyphyllum* flark fen
15. LN *Sphagnum subfulvum–Loeskympnum badium–Trichophorum alpinum* fen

Rich fen

16. Läl *Tomentypnum nitens–Sphagnum angustifolium* rich fen
17. RiL *Scorpidium scorpioides* rich flark fen

Combination site types

18. LR *Sphagnum warnstorffii–Eriophorum latifolium* rich pine fen
19. RL *Scorpidium revolvens–Campylium stellatum* rich pine fen with *Sphagnum fuscum* hummocks
20. LNR *Sphagnum subfulvum–Trichophorum alpinum* pine fen
21. RiRLN *Sphagnum subsecundum–Loeskympnum badium–Juncus stygius* flark pine fen with *Sphagnum fuscum* hummocks
22. VNR *Carex rostrata–Sphagnum fallax* pine fen
23. RaNR *Carex rostrata–Sphagnum fallax* pine fen with *Sphagnum fuscum* hummocks
24. RhNR *Carex lasiocarpa–Sphagnum subsecundum* pine fen
25. LkR *Carex pauciflora–Sphagnum angustifolium* pine fen
26. KeR Hummock-hollow complex with *Eriophorum vaginatum*, *Sphagnum fuscum* and *S. balticum*

Table 1. Analysis of correspondence and degree of overlap of vegetation patches between the Russian and Finnish maps of Härkösuo Mire. The last column (labelled “%”) shows the percentage of the total area of each vegetation type identified in the Russian legend that is covered by each of the Finnish mire site types indicated. Areas of overlap smaller than 10% are omitted. See text for further explanation.

RUSSIAN LEGEND		FINNISH LEGEND		%
Community		Mire site type		
Pine mire communities				
1.	<i>Pinus sylvestris</i> - <i>Rubus chamaemorus</i> + <i>Empetrum hermaphroditum</i> - <i>Sphagnum fuscum</i>	7.	<i>Sphagnum fuscum</i> – <i>Empetrum</i> pine bog (RaR)	64
2.	<i>Pinus sylvestris</i> - <i>Vaccinium uliginosum</i> - <i>Carex pauciflora</i> - <i>Sphagnum angustifolium</i>	3.	<i>Eriophorum vaginatum</i> pine bog with <i>Sphagnum fuscum</i> hummocks (RaTR)	61
3.	<i>Pinus sylvestris</i> - <i>Chamaedaphne calyculata</i> + <i>Ledum palustre</i> + <i>Vaccinium uliginosum</i> - <i>Carex globularis</i> + <i>C. pauciflora</i> - <i>Sphagnum russowii</i> + <i>Pleurozium schreberi</i>	25.	<i>Carex pauciflora</i> – <i>Sphagnum angustifolium</i> pine fen (LkR)	81
Mire communities with sparse pine				
4.	<i>Betula nana</i> + <i>Eriophorum vaginatum</i> - <i>Carex pauciflora</i> - <i>Sphagnum angustifolium</i>	25.	<i>Carex pauciflora</i> – <i>Sphagnum angustifolium</i> pine fen (LkR)	60
		8.	<i>Eriophorum vaginatum</i> – <i>Carex pauciflora</i> – <i>Sphagnum angustifolium</i> fen (LkN)	29
5.	<i>Eriophorum vaginatum</i> + <i>Empetrum hermaphroditum</i> - <i>Sphagnum fuscum</i>	3.	<i>Eriophorum vaginatum</i> pine bog with <i>Sphagnum fuscum</i> hummocks (RaTR)	76
6.	<i>Carex lasiocarpa</i> - <i>Sphagnum angustifolium</i>	9.	<i>Carex rostrata</i> – <i>Sphagnum fallax</i> fen (VSN)	30
		22.	<i>Carex rostrata</i> – <i>Sphagnum fallax</i> pine fen (VNR)	26
Open mire communities				
7.	<i>Carex rostrata</i> - <i>Sphagnum fallax</i>	10.	<i>Carex rostrata</i> – <i>Comarum palustre</i> – <i>Sphagnum riparium</i> fen (LuRiSSN)	92
8.	<i>Menyanthes trifoliata</i> + <i>Trichophorum alpinum</i> + <i>Carex lasiocarpa</i> - <i>Sphagnum angustifolium</i> + <i>S. warnstorffii</i>	15.	<i>Sphagnum subfulvum</i> – <i>Loeskyppnum badium</i> – <i>Trichophorum alpinum</i> fen (LN)	58
		20.	<i>Sphagnum subfulvum</i> – <i>Trichophorum alpinum</i> pine fen (LNR)	36
9.	<i>Scheuchzeria palustris</i> - <i>Sphagnum balticum</i>	8.	<i>Eriophorum vaginatum</i> – <i>Carex pauciflora</i> – <i>Sphagnum angustifolium</i> fen (LkN)	80
10.	<i>Carex rostrata</i> + <i>Scheuchzeria palustris</i> - <i>Sphagnum papillosum</i>	12.	<i>Carex rostrata</i> – <i>Sphagnum papillosum</i> fen (SSKaN)	85
11.	<i>Trichophorum cespitosum</i> - <i>Sphagnum papillosum</i>	11.	<i>Trichophorum cespitosum</i> – <i>Carex pauciflora</i> – <i>Sphagnum papillosum</i> fen (LkKaN)	92

continued....

Table 1 continuation

RUSSIAN LEGEND		FINNISH LEGEND		%
Community		Mire site type		
Complex vegetation				
12.	Complex; hummocks: <i>Betula nana</i> + <i>Chamaedaphne calyculata</i> - <i>Sphagnum fuscum</i> ; hollows: <i>Scheuchzeria</i> - <i>Sphagnum balticum</i>	26.	Hummock-hollow complex with <i>Eriophorum vaginatum</i> , <i>Sphagnum fuscum</i> and <i>S. balticum</i> (KeR)	91
13.	Complex; hummocks: <i>Empetrum nigrum</i> + <i>Rubus chamaemorus</i> - <i>Sphagnum fuscum</i> ; carpet: <i>Carex rostrata</i> + <i>Scheuchzeria palustris</i> + <i>Carex pauciflora</i> - <i>Sphagnum balticum</i> + <i>S. papillosum</i>	13.	<i>Sphagnum majus</i> – <i>Scheuchzeria palustris</i> fen with <i>Sphagnum fuscum</i> hummocks (RaSphRiN)	78
14.	<i>Menyanthes trifoliata</i> + <i>Scheuchzeria palustris</i> - <i>Sphagnum majus</i> + <i>Warnstorfia exannulata</i>	13.	<i>Sphagnum majus</i> – <i>Scheuchzeria palustris</i> fen with <i>Sphagnum fuscum</i> hummocks (RaSphRiN)	66
15.	Aapa complex; hummocks: <i>Carex lasiocarpa</i> - <i>Sphagnum angustifolium</i> ; flarks: <i>Scheuchzeria palustris</i> - <i>Sphagnum majus</i>	9.	<i>Carex rostrata</i> – <i>Sphagnum fallax</i> fen (VSN)	65
15a	flarks: <i>Scheuchzeria palustris</i> - <i>Menyanthes trifoliata</i> - <i>Utricularia intermedia</i>			
16.	Aapa complex; strings: <i>Betula nana</i> - <i>Trichophorum alpinum</i> - <i>Sphagnum angustifolium</i> ; flarks: <i>Carex rostrata</i> + <i>Rhynchospora alba</i> - <i>Sphagnum platyphyllum</i> + <i>Scorpidium scorpioides</i>	14.	<i>Trichophorum alpinum</i> – <i>Sphagnum platyphyllum</i> flark fen (RhRiN)	40
		17.	<i>Scorpidium scorpioides</i> rich flark fen (RiL)	38
17.	Aapa complex; carpet: <i>Trichophorum alpinum</i> - <i>Sphagnum subfulvum</i> ; small depressions: <i>Rhynchospora alba</i> + <i>Carex limosa</i>	20.	<i>Sphagnum subfulvum</i> – <i>Trichophorum alpinum</i> pine fen (LNR)	44
		21.	<i>Sphagnum subsecundum</i> – <i>Loeskyppnum badium</i> – <i>Juncus stygius</i> flark pine fen with <i>Sphagnum fuscum</i> hummocks (RiRLN)	44
18.	Aapa complex; hummocks: <i>Molinia caerulea</i> - <i>Sphagnum fuscum</i> ; flarks: <i>Carex lasiocarpa</i> + <i>Trichophorum alpinum</i> - <i>Scorpidium revolvens</i> + <i>Campylium stellatum</i>	19.	<i>Scorpidium revolvens</i> – <i>Campylium stellatum</i> rich pine fen with <i>Sphagnum fuscum</i> hummocks (RL)	82
Sloping fen communities with spring influence				
19.	<i>Pinus sylvestris</i> + <i>Picea abies</i> - <i>Salix</i> spp.- <i>Betula nana</i> + <i>Empetrum hermaphroditum</i> - <i>Equisetum fluviatile</i> - <i>Sphagnum angustifolium</i> + <i>S. warnstorffii</i> + <i>Pleurozium schreberi</i>	23.	<i>Carex rostrata</i> – <i>Sphagnum fallax</i> pine fen with <i>Sphagnum fuscum</i> hummocks (RaNR)	67
20.	<i>Angelica sylvestris</i> + <i>Molinia caerulea</i> - <i>Menyanthes trifoliata</i> - <i>Sphagnum angustifolium</i> + <i>S. warnstorffii</i>	16.	<i>Tomentypnum nitens</i> – <i>Sphagnum angustifolium</i> rich fen (LäL)	66
21.	<i>Carex lasiocarpa</i> + <i>Trichophorum alpinum</i> + <i>Molinia caerulea</i> - <i>Sphagnum angustifolium</i> + <i>S. warnstorffii</i> (with sparse pine trees)	18.	<i>Sphagnum warnstorffii</i> – <i>Eriophorum latifolium</i> rich pine fen (LR)	54
		19.	<i>Scorpidium revolvens</i> – <i>Campylium stellatum</i> rich pine fen with <i>Sphagnum fuscum</i> hummocks (RL)	40

there is a typical spruce mire patch (1, MK) in the north-eastern corner of the site. Poor pine mire types (7, RaR; 25, LkR,) are typical of the mire margins and occur in larger patches in the eastern part of the site. Open fen types dominate in the centre. In the west there is intermediate fen (14, RhRiN) and rich fen (17, RiL), and in the east there is poor fen (8, LkN; 13, RaSphRiN). Mosaic-like combination types occur as narrow zones between the marginal pine mire and the central fen. At the southern margin of the western part of the mire there are numerous springs and there is also groundwater seepage, reflected by small patches of spring vegetation and one patch of rich spring fen (2, MeLä; 16, Läl). Patches of rich pine fen (18, LR; 19, RL) may also be associated with the influence of spring water.

Both authors interpreted the patterning visible in the aerial photograph in more or less the same way, so that the vegetation patterns indicated by Figures 3 and 4 correspond well. The most significant difference is in the total area mapped. This arises because the Finnish spruce mire types often include tall, dense trees; such vegetation is regarded as paludified forest in Russian (as well as in central European) practice. The resulting difference in opinion of the two authors regarding the location of the mire-forest boundary meant that the area surveyed by the Finnish author was almost 10% greater than that covered by the Russian map. The authors also differed in the way that they distinguished between 'open mire' and 'mire with sparse tree cover', the Finnish author assigning patches with very sparse tree cover to the latter category in a few cases.

The GIS measurements of overlap between the different vegetation classes show that most Russian plant communities correspond to site types in the Finnish classification (Table 1). In some cases a Russian community with tree cover contains two Finnish types - an open one and a similar one with sparse tree cover (e.g. items 4, 6 and 8 in the Russian legend, Table 1). On the other hand, some Russian classes are divided into two in the Finnish classification on the basis of mire surface patterning (e.g. item 21 in the Russian legend, Table 1).

DISCUSSION

The research reported here has produced original large-scale vegetation maps showing patterns which reflect the habitat diversity, vegetation structure and spatial distribution of plant communities at Härkösuo Mire, providing a solid basis for the evaluation of biodiversity.

The plant communities distinguished by the Russian author correspond rather well to the Finnish mire site types. The greatest differences arise in defining the boundary between forest and mire because the 'spruce mire' recognised in Finland is classified as 'forest' in the Russian approach. The principles for distinguishing between open and sparsely-wooded mire types are vague in the Finnish classification (Ruuhijärvi 1983, Eurola *et al.* 1984, 1994). The position seems to be similar in the Russian approach, which does not provide quantitative criteria for recognising tree stands in terms of either crown cover or stand volume. This gives rise to differences between maps prepared by different people, but not necessarily between the Russian and Finnish classifications.

The closest correspondence between Russian and Finnish classes was achieved for open homogeneous fens and ombrotrophic hummock-hollow complexes. In minerotrophic complex communities (mixed mires *sensu* Sjörs *et al.* 1965) differences arose in interpreting the vegetation units depending on the proportions of fen carpets and hummocks. The approaches do not completely fit together in this respect, but it is nevertheless possible to achieve a mutual understanding of the classes (Antipin *et al.* 1997).

Originally, the main function envisaged for the Finnish mire site type classification system was to provide a practical tool for evaluating the potential productivity of mires for forestry and agricultural purposes (Laine & Vasander 2005). The same approach is well suited to routine mapping of habitat diversity, making it possible to compare data from maps made by different people, and to map quickly. The latter requires sufficient knowledge and extensive experience, however.

Our experience has demonstrated that there are some problems caused by subjectivity. Mapping the boundaries of vegetation patches is usually problematic, because there are gradients or transition zones between elements of pattern belonging to different vegetation classes (Mirkin 1990, Ruuhijärvi & Lindholm 2006).

The Russian author is accustomed to dealing with large mires and tended to place a minimum size limit on mapping units. This probably resulted in some of the vegetation diversity of Härkösuo mire being overlooked, especially in spring mire communities which tend to occur in small patches. Certainly, the Russian legend places less emphasis on spring influence than does the Finnish legend, and indeed it is difficult to reflect species diversity in a legend that is developed using the dominant approach. On the other hand, the patterns that are mapped should not be so detailed that they hide the

principal characteristic of the mire massif, namely its geographical type (Galkina 1962).

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REFERENCES

- Aaviksoo K., Kadarik H. & Masing V. (1997) *Aerial Views and Close-up Pictures of 30 Estonian Mires*. Tallinna Raamatutrükikoda, Tallinn, 96 pp.
- Ahti, T., Hämet-Ahti, L. & Jalas, J. (1968) Vegetation zones and their sections in northwestern Europe. *Annales Botanici Fennici*, 5, 169–211.
- Alalammi, P. (ed.) (1987) *Suomen Kartasto, Vihko 131. Ilmasto. (Atlas of Finland. Folio 131. Climate)*. National Board of Survey, Finnish Geographical Society, 31 pp. (in Finnish).
- Aleksandrova V.D., Gribova S.A., Isachenko T.I., Nepomilueva N.I., Ovesnov S.A., Pajanskaja-Gvozdeva I.I., Yurkovskaja T.K. (1989) Geobotanicheskoe rajonirovanie Nechernozem'ja evropejskoj chasti RSFSR (Geobotanical zonation of the non-chernozem zone of the European part of the RSFSR). Nauka, Leningrad, 64 pp. (in Russian).
- Antipin, V., Heikkilä, R., Lindholm T. & Tokarev P. (1997) Vegetation of Lishkmokh mire in Vodlozersky National Park, eastern Karelian Republic, Russia. *Suo*, 48, 93–114.
- Bogdanovskaja-Gienuf I.D. (1949) Tipy verhovykh bolot SSSR (Raised bog types of the USSR). *Trudy 2-go Vsesojuznogo geograficheskogo s'ezda* (Proceedings of the Second Meeting of All-Soviet Union Geographers), Moscow, 3, 144–152 (in Russian).
- Bohn, U., Gollub, G., Hettwer, H., Neuhauslová, Z., Raus, T., Schlüter, H. & Weber, H. (2004) *Karte der natürlichen Vegetation Europas/Map of the Natural Vegetation of Europe* (scale 1:2,500,000). Landwirtschaftsverlag, Münster (interactive CD-ROM in German and English).
- Botch M.S. & Smagin V.A. (1993) *Flora i rastitel'nost' bolot Severo-Zapada Rossii i printsipy ikh okhrany* (Flora and vegetation of mires in north-western Russia and the principles of their conservation). Gidrometeoizdat, Saint Petersburg, 224 pp. (in Russian).
- Eurola, S., Hicks, S. & Kaakinen, E. (1984) Key to Finnish mire types. In: Moore, P.D. (ed.). *European Mires*, Academic Press, London, 11–117.
- Eurola, S., Huttunen, A. & Kukko-oja, K. (1994) *Suokasvillisuusopas (Mire Vegetation Guide)*. Oulanka Reports, 13, 81 pp. (in Finnish).
- Galkina E.A. (1962) Osobennosti kartirovaniya rastitel'nogo pokrova bolotnykh massivov (s primeneniem materialov aerofotos'emki) (Peculiarities of vegetation mapping of mire massifs (with application of aerial photos)). *Printsipy i metody geobotanicheskogo kartografirovaniya (Principles and Methods of Vegetation Mapping)*, Izdatelstvo Akademii Nauk SSSR, Moscow-Leningrad, 121–130 (in Russian).
- Gorkovets, V. & Rayevskaya, M. (2003) Crystalline basement of Nature Reserve Friendship. *The Finnish Environment*, 485, 62–65.
- Hämet-Ahti, L., Suominen, J., Ulvinen, T. & Uotila, P. (eds.) (1998) *Retkeilykasvio (Field Flora of Finland)*, 4th edition. Finnish Museum for Natural History, Botanical Museum, Helsinki, 656 pp (in Finnish).
- Heikkilä, R. (1986) Kauhanen-Pohjankankaan kansallispuiston kasvillisuus (Vegetation of Kauhanen-Pohjankangas National Park). *Metsähallitus SU*, 4(75), 52 pp. (in Finnish).
- Heikkilä, R., Kuznetsov, O., Lindholm, T., Aapala, K., Antipin, V., Djatshkova, T. & Shevelin, P. (2001) Complexes, vegetation, flora and dynamics of Kauhanen mire system, western Finland. *The Finnish Environment*, 489, 97 pp.
- Heikkinen, R.K. & Kalliola, R. (1989) Vegetation types and map of the Kevo Nature Reserve, northernmost Finland. *Kevo Notes*, 8, 1–39.
- Isachenko T.I., Karpenko A.S., Gribova S.A. & Yurkovskaya T.K. (1976) Geobotanicheskaja karta Nechernozemnoj zony RSFSR M 1:1 500 000 (Geobotanical map of the non-chernozem zone of the RSFSR at scale 1:1,500,000). Glavnoe Upravlenie Geodezii i Kartografii (GUGK), Moscow, 4 lista (in Russian).
- Isachenko, T.I. & Lavrenko, E.M. (eds.) (1979) *Karta rastitel'nosti Evropejskoj chasti SSSR M 1:2 500 000* (Vegetation map of the European

- part of the USSR at scale 1:2,500,000). Glavnoe Upravlenie Geodezii i Kartografii (GUGK), Moscow (in Russian).
- Ivanov, K.E. (1981) *Water Movement in Mirelands*. Academic Press, London, 276 pp.
- Kats, N.Ja. (1928) O tipakh oligotrofnykh sfagnovykh bolot Evropejskoj Rossii i ikh shirotnoj i meridional'noj zonal'nosti (Types of oligotrophic *Sphagnum* mires of European Russia and their latitudinal and longitudinal zonation). Trudy Bot. n.-i. instituta pri fiz.-mat. fakultete MGU (Proceedings of the Botanical Research Institute of the Physics-Mathematics Faculty of Moscow State University), Moscow, 60 pp. (in Russian).
- Kats N.Ja. (1948) Tipy bolot SSSR i Zapadnoj Evropy i ikh geograficheskoe rasprostranenie (Mire types of the USSR and western Europe and their geographical distribution). Gosudarstvennoe Izdatelstvo Geograficheskoy Literatury (OGIZ), Moscow, 320 pp. (in Russian).
- Kats N.Ja. (1971) *Bolota Zemnogo shara (Mires of the World)*. Nauka, Moscow, 295 pp. (in Russian).
- Küchler, A.W. & Zonneveld, I.S. (1988) *Vegetation Mapping*. Kluwer Publishers, Dordrecht, 623 pp.
- Kuznetsov, O. (2003) Topological-ecological classification of mire vegetation in the Republic of Karelia (Russia). *The Finnish Environment*, 485, 117–123.
- Kuznetsov O.L. (2005) Topologo-ekologicheskaja klassifikatsija rastitel'nosti bolot Karelii (ombrotrofnye i oligotrofnye soobshchestva) (Topological-ecological mire vegetation classification in Karelia (ombrotrophic and oligotrophic communities)). Bioraznoobrazie, dinamika i resursy bolotnykh ekosistem Vostochnoj Fennoskandii (Biodiversity, dynamics and resources of the mire ecosystems of Eastern Fennoscandia), Trudy KNTs RAN (Proceedings of the Karelian Research Centre, Russian Academy of Sciences), Petrozavodsk, 8, 15–46 (in Russian).
- Laine, J. & Vasander, H. 2005. *Suotyypit ja niiden tunnistaminen (Mire site types and their identification)*. With multimedia CD. Metsäkirjat, Hämeenlinna, 110 pp. (in Finnish).
- Luukkonen, E.J. (1992) Late Archaean and early Proterozoic structural evolution in the Kuhmo-Suomussalmi terrain, eastern Finland. *Annales Universitatis Turkuensis, Series A II, Biologica Geographica-Geologica*, 78, 1–37.
- Mirkin B.M. (1990) O rastitel'nykh kontinuumakh (About vegetation continuum). *Zhurnal Obshchej biologii*, 51(3), 316–326 (in Russian).
- Napreenko M.G. (2002) Flora i rastitel'nost' verkhovykh bolot Kaliningradskoj oblasti (*Flora and Vegetation of Raised Bogs in Kaliningrad Region*). Avtoreferat kandidatskoj Dissertatsii (PhD thesis), Kaliningrad, 24 pp. (in Russian).
- Ogureeva, G.N., Miklyaeva, I.M., Suslova, E.G. & Shvergunova, L.V. (1996) Rastitel'nost' Moskovskoj oblasti. [karta]. M 1:200 000. (Map of the Vegetation of Moscow Region, scale 1:200,000). Faculty of Geography, Lomonosov Moscow State University, Moscow (in Russian).
- Paal, J. (1997) *Eesti taimkatte kasvukohatüüpide klassifikatsioon (Classification of Estonian vegetation site types)*. Tartu Ülikooli Botaanika ja Ökoloogia Instituut, Tallinn, 297 pp. (in Estonian).
- Paasio, I. (1933) Über die Vegetation der Hochmoore Finnlands (On the vegetation of Finnish raised mires). *Acta Forestalia Fennica* 39: 1–190 (in German).
- Påhlsson, L. (ed.). (1994) Vegetationstyper i Norden (Vegetation types in the Nordic countries). *TemaNord*, 665, 627 pp. (in Swedish).
- Rafstedt, T. & Andersson, L. (1981) Flygbildstolkning av myrvegetation. En metodstudie för översiktlig kartering (Aerial photo interpretation of mire vegetation. A method study for small scale mapping). *SNV PM* 1433, 106 pp. (in Swedish).
- Ruuhijärvi, R. (1960) Über die regionale Einteilung der nordfinnischen Moore (On the regional zonation of northern Finnish mires). *Annales Botanici Societatis "Vanamo"*, 31(1), 360 pp. (in German).
- Ruuhijärvi, R. (1983) The Finnish mire types and their regional distribution. In: Gore, A.J.P. (ed.). *Ecosystems of the World, 4B, Mires: Swamp, Bog, Fen and Moor, Regional Studies*. Elsevier, Amsterdam, 47–67.
- Ruuhijärvi, R. (1988) Mire vegetation. *Atlas of Finland, Folio 141-143. Biogeography, Nature Conservation*, 3–4. National Board of Survey, Finnish Geographical Society.
- Ruuhijärvi, R. & Lindholm, T. (2006) Ecological gradients as the basis of Finnish mire site type system. *The Finnish Environment*, 23, 119–126.
- Safronova I.N., Yurkovskaja T.K., Miklyaeva I.M. & Ogureeva G.N. (1999) Zony i tipy pojasnosti Rossii i sopredel'nykh territorij (Map of the vegetation zones of Russia and neighbouring territories) Scale 1: 8,000,000, Moscow (in Russian).
- Seppälä, M. & Rastas, J. (1980) Vegetation map of northernmost Finland with special reference to subarctic forest limits and natural hazards.

- Fennia*, 158, 41–61 + appendix.
- Sjörs, H., Björkback, F. & Nordqvist, Y. (1965) Northern mires. *Acta Phytogeographica Suecica*, 50, 180–197.
- Tahvanainen, T., Sallantausta, T., Heikkilä, R. & Tolonen, K. (2002) Spatial variation of mire surface water chemistry and vegetation in north-eastern Finland. *Annales Botanici Fennici*, 39, 235–251.
- Tsinzerling Yu.D. (1938) Rastitel'nost' bolot / Rastitel'nost' SSSR. T.1. Moskva-Leningrad. (Vegetation of mires / Vegetation of USSR. 1. Moscow-Leningrad). Izdatelstvo Akademii Nauk SSSR, 355–428 (in Russian).
- Tuhkanen, S. (1984) A circumboreal system of climatic-phytogeographical regions. *Acta Botanica Fennica*, 127, 1–50.
- Ulvinen, T., Syrjänen, K. & Anttila, S. (2002) Suomen sammalet – levinneisyys, ekologia ja uhanalaisuus (Abstract: Bryophytes of Finland: distribution, ecology and red list status). *The Finnish Environment* 560, 354 pp. (in Finnish).
- Yurkovskaja, T.K. (1992) Geografija i kartografija rastitel'nosti bolot Evropejskoj Rossii i sopredel'nyh territorij (Geography and vegetation mapping of mires in European Russia and neighbouring territories). *Proceedings of the Komarov Botanical Institute, Russian Academy of Sciences*, Issue 4, Saint Petersburg, 256 pp. (in Russian).
- Yurkovskaja, T. (1995) Mire system typology for use in vegetation mapping. *Gunneria*, 70, 73–82.
- Yurkovskaja, T.K. (2004) Botanicheskij institut imeni V.L. Komarova RAN – tsentr stanovlenija i razvitija geobotanicheskogo kartografirovaniya v Rossii (Komarov Botanical Institute RAS – the centre of vegetation mapping development in Russia). *Botanicheskij Zhurnal*, 89(9), 1509–1513.
- Yurkovskaja T.K. & Elina G.A. (2005) Kartograficheskij analiz bolot Severo-Vostoka Karelii (Mapping analysis of mires in north-eastern Karelia). Bioraznoobrazie, dinamika i resursy bolotnykh ekosistem Vostochnoj Fennoskandii (Biodiversity, dynamics and resources of the mire ecosystems of Eastern Fennoscandia). Trudy KNTs RAN, vyp. 8. (*Proceedings of the Karelian Research Centre, Russian Academy of Sciences*), Petrozavodsk, 8, 6–14 (in Russian).
- Yurkovskaja T.K. & Pajanskaja-Gvozdeva I.I. (1993) Shirotnaja differentsiatsija rastitel'nosti vdol' rossijsko-finskoj granitsy (Latitudinal differentiation of vegetation along the Russian-Finnish border). *Botanicheskij Zhurnal*, 78(12), 72–98 (in Russian).
- Russian references** (items are cross-referenced to the main reference list by text citation)
- Aleksandrova et al. (1989): Александрова В.Д., Грибова С.А., Исаченко Т.И., Непомилуева Н.И., Овеснов С.А., Паянская-Гвоздева И.И., Юрковская Т.К. Геоботаническое районирование Нечерноземья европейской части РСФСР. Л., 1989. 64 с.
- Bogdanovskaja-Gieneuf (1949): Богдановская-Гиенэф И.Д. Типы верховых болот СССР. Труды 2-го Всесоюзного географического съезда. Москва, 1949. Т. 3. С. 144–152.
- Botch & Smagin (1993): Боч М.С., Смагин В.А. Флора и растительность болот Северо-Запада России и принципы их охраны. СПб., 1993. 224 с.
- Galkina (1962): Галкина Е.А. Особенности картирования растительного покрова болотных массивов (с применением материалов аэрофотосъемки). Принципы и методы геоботанического картографирования. М.-Л., 1962. С. 121–130.
- Isachenko et al. (1976): Исаченко Т.И., Карпенко А.С., Грибова С.А., Юрковская Т.К. и др. Геоботаническая карта Нечерноземной зоны РСФСР. 1976. М., ГУГК, М 1: 1 500 000, 4 л.
- Isachenko & Lavrenko (1979): Карта растительности Европейской части СССР м. 1:2 500 000 (Ред. Т.И. Исаченко, Е.М. Лавренко). М., 1979.
- Kats (1928): Кац Н.Я. О типах олиготрофных сфагновых болот Европейской России и их широтной и меридиональной зональности. Труды Бот. н.-и. ин-та при физ.-мат. факультете МГУ. М., 1928. 60 с.
- Kats (1948): Кац Н.Я. Типы болот СССР и Западной Европы и их географическое распространение. М., 1948. 320 с.
- Kats (1971): Кац Н.Я. Болота Земного шара. М., Наука, 1971. 295 с.
- Kuznetsov (2005): Кузнецов О. Л. Тополого-экологическая классификация растительности болот Карелии (обротрофные и олиготрофные сообщества). Биоразнообразие, динамика и ресурсы болотных экосистем Восточной Фенноскандии. Тр. КНИЦ, вып. 8. Петрозаводск, 2005. С. 15–46.
- Mirkin (1990): Миркин Б.М. О растительных континуумах. Журнал Общей биологии. Т. 51, № 3. С. 316–326.
- Napreenko (2002): Напреенко М.Г. Флора и растительность верховых болот Калининградской области: Автореферат канд. дисс. Калининград, 2002. 24 с.
- Ogureeva et al. (1996): Огуреева Г.Н., Микляева

- И.М., Суслова Е.Г., Швергунова Л.В. Растительность Московской области. [карта]. М 1:200 000. М., 1996.
- Safronova I.N. *et al.* (1999): Сафронова И.Н., Юрковская Т.К., Микляева И.М., Огуреева Г.Н. Зоны и типы поясности растительности России и сопредельных территорий М 1: 8 000 000 [карта]. М., 1999. 2 л.
- Tsinzerling (1938): Цинзерлинг Ю.Д. Растительность болот / Растительность СССР. Т. 1. М.-Л., Изд. АН СССР. 1938. С. 355-428.
- Yurkovskaja (1992): Юрковская Т.К. География и картография растительности болот Европейской России и сопредельных территорий. СПб., 1992. 265 с.
- Yurkovskaja (2004): Юрковская Т. К. Ботанический институт им. В. Л. Комарова РАН — центр становления и развития геоботанического картографирования в России. Бот. журн. 2004. Т. 89. № 9. С. 1509-1513.
- Yurkovskaja & Elina (2005): Юрковская Т.К., Елина Г.А. Картографический анализ болот Северо-Востока Карелии. Биоразнообразие, динамика и ресурсы болотных экосистем Восточной Фенноскандии. Тр. КНИЦ РАН, вып. 8. Петрозаводск, 2005. С. 6-14.
- Yurkovskaja & Rajanskaja-Gvozdeva (1993): Юрковская Т.К., Паянская-Гвоздева И.И. Широтная дифференциация растительности вдоль российско-финской границы // Бот. журн. 1993. Т. 78. № 12. С. 72-98.
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