Post-Drainage Dynamics of the Ground Vegetation in a Transitional Mire

AUSTRA ĀBOLIŅA, SOLVITA JERMACĀNE, MĀRIS LAIVIŅŠ
Latvian Forestry Research Institute "Silava",
Rīgas iela 111, Salaspils, LV-2169, LATVIA
e-mail: laivins@silava.lv

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Analysed are 30-year long (1963-1993) research data on the post-drainage dynamics of the species cover and frequency in the herb and moss layer in a transitional mire. By using TWINSPAN analysis, 3 succession stages are identified, each of them having phytosociological peculiarities of its own. The drainage changes the ecological conditions; Ellenberg moisture value decreases from 7.7 to 5.9, subsequently the soil biological activity is growing and Ellenberg nitrogen value indicating nutrient availability increases by nearly two degrees. .

Key words: drainage, herb and moss layer, diversity, succession

Introduction

Under the conditions of Latvia hydrotechnical drainage is one of the key actions for enlarging forest productivity. Normally, after the drainage it increases 2-4 times (Залитис, 1983). The drainage improves soil aeration, enhances metabolism in the ecosystem and increases mineralisation of the litter and peat layer. The processes under way affect the species composition in all the forest layers. However, the herb and moss layer, highly sensitive as it is, responds most readily to the changes under way. The present study is a summary of long-term research on the ground vegetation dynamics in a transitional mire after the drainage. The research covers a 30-year period following the drainage, when the ecosystem changes are most dynamic.

The tasks of the given study:

- analyse the dynamics of the changes in the herb and moss layer (species cover and frequency and species composition) in transitional mire after the drainage;
- by using Ellenberg indicator values, describe the changes in the site;
- analyse and describe the course of post-drainage succession by using the syntaxonomic groups of character species (the Braun-Blanquet method).

Material and method

The research was carried out between 1963 and 1993 at the Vesetnieki Station of Permanent Ecological Research of the Forest Research Station "Kalsnava". Transitional mire on the Veseta floodplain area was drained in 1960-1962 by both open ditches (depth 1.1 to 1.2 m, spacing between ditches 150 m) and the closed drainage (depth 80-90 cm, spacing between lines 75 m). Before drainage the peat layer depth was 2.2 to 4 m, the stand composition was 80% pine, 20% birch + spruce, the stock volume – 40 m^3ha^{-1}; 10 to 13 years later: 70% pine, 10% spruce and 20% birch, 112 m^3ha^{-1}, respectively; 30 years later (1994) – 90% spruce, 10% birch + pine, 260 m^3ha^{-1} (increase in the stock volume 6.5 times) (Zālītis, Vuguls, 1995). A more detailed description of the vegetation, the research material and method for the period between 1963 and 1975 is published earlier (Аболинь, 1977; Аболинь, 1978; Буш, Аболинь, 1964).

In the given study we analysed the herb and moss layer following the species composition, cover (the proportion of ground that is occupied by the perpendicular projection down on to it of the aerial parts of individuals of the species) and the frequency of species. The field data were collected between 1963 and 1993 in three permanent observation plots (20x50 m), comprising in total 60 circular spots (5 m^2), wherein the cover (visually in per cent) and the frequency of vascular plants, dwarf shrubs and mosses were determined on a 1 to 3 year basis. The field data were analysed by using the following methods:

1. The vegetation diversity was evaluated by using the Shannon-Wiener diversity index (H) and evenness index (E), the vegetation dynamics - by the Jaccard similarity coefficient (Kent, Coker, 1994).

2. The ecological conditions and their dynamics after drainage are characterized by Ellenberg indica-

tor values (Ellenberg et al., 1992), the types of species geographical ranges (Meusel et al., 1965; 1978; Rothmaler, 1995), as well as plant species strategies (Grime et al., 1988). These ecological indices were calculated by using the processing system for geobotanical data (Ėąéăčķüų, 1994).

3.The succession stages were identified by using the software TWINSPAN (Hill, 1979). To analyse the succession, the Braun-Blanquet syntaxa character species (Grabherr, Mucina, 1993; Mucina et al., 1993a; Mucina et al., 1993b; Oberdorfer, 1983, Laiviņš, 1998) were used.

Nomenclature for the vascular plants: Gavrilova, Šulcs, 1999; for mosses: Grolle, 1976; Corley et al., 1981; Corley, Crundwell, 1991.

Results

The composition, frequency and cover of species

The number of vascular plant and moss species registered in the observation plots over 30 years totals 176 (among them 62 moss species), varying between 84 to 108 per year. Each year on average 8 species disappear and the same number of new species is detected in the ground cover (between 4 to 16 per year). The number of vascular plant species is invariably higher than that of bryophytes, becoming more pronounced after the drainage (Fig. 1).

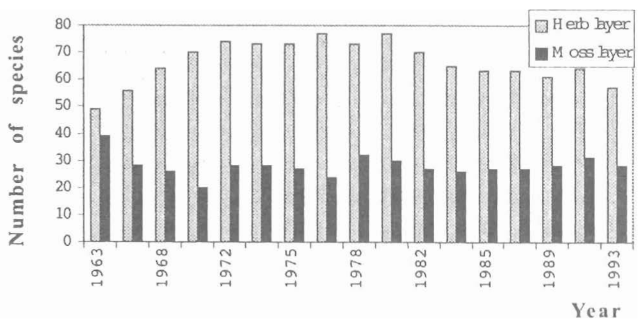

Figure 1. Post-drainage variations in the number of species in ground vegetation.

In the first 7 years after the drainage the number of moss species decreased dramatically (by 44%) to become steady afterwards (24-31 species) (Table 1). Over the 30-year period studied 26 new moss species appeared, while 17 of them disappeared again. The number of dwarf shrub and vascular plant species increased gradually over the first 10 years after the drainage (by 45%) reaching the maximum in 14 to 16 years (ca 75 species, accounting for the highest ground cover vegetation diversity in this period) and falling down again to a steady level (around 62 species). Concurrently, the floristic composition undergoes substantial changes. Over 30 years only 20 vascular plant species (39%) survived out of the total number 51, registered initially. Over the research period 57 new species were detected, yet only 31 of them survived.

15 species, showing a fixed stability during the post-drainage period (almost no variations in their frequency) are those of a wide ecological amplitude: *Pleurozium schreberi*, *Pyrola rotundifolia*, *Molinia caerulea* (frequency >0.6), *Hylocomium splendens*, *Vaccinium vitis-idaea*, *Orthilia secunda*, *Luzula pilosa* (0.3-0.5), *Rhytidiadelphus triquetrus*, *Ptilium crista-castrensis*, *Ptilidium pulcherrimum*, *Dicranum scoparium*, *Vaccinium myrtillus*, *Deschampsia cespitosa*, *Calamagrostis canescens* and *Cardamine pratensis* (0.1-0.2). A part of species reacts to the drainage by either expanding or shrinking their cover. The frequency of the mire species gets reduced: *Sphagnum warnstorfii*, *Sph. angustifolium*, *Sph. magellanicum*, *Aulacomnium palustre*, *Comarum palustre*, *Carex appropinquata*, *C.nigra*, *Caltha palustris*, *Oxycoccus palustris*, *Agrostis canina*, *Menyanthes trifoliata*, *Andromeda polifolia*, *Thelypteris palustris*, *Galium palustre* etc., while that of forest mesophytes increases: *Dicranum polysetum*, *Brachythecium oedipodium*, *Trientalis europaea*, *Galeopsis bifida*, *Dryopteris carthusiana*, *Oxalis acetosella*, *Mycelis muralis*, *Moehringia trinervia* etc.

After the drainage the ground vegetation cover changes, too (Table 1). For the bryophytes, in three years it dropped from 85% to only 18%, subsequently somewhat increasing, yet never going above 33%. Initially, the cover for vascular plants was 55%, in the first years after the drainage it increased to 70% (1968-1970), falling sharply later on and afterwards fluctuating between 27 and 59%. From 1979 to 1991 the most abundant species was *Rubus idaeus* reaching maximum cover (30%) in 1982 and 1983.

The species diversity changes both in the herb and the moss layer (Table 1). These variations appear to be related to the impact of other forest layers and the tree stand in particular, on the ground vegetation. During post-drainage succession the ground vegetation in separate (and especially the first) years is dominated by one or few species (*Pyrola rotundifolia*, *Calamagrostis canescens*, *Rubus idaeus*, *Sphagnum angustifolium*, *Sph. warnstorfii*, *Pleurozium schreberi*). With the above species losing their dominance (evenness index is decreasing), the total cover of the ground layer gets reduced (Fig. 2).

Ecological indices

During the post-drainage succession the environmental conditions in the ecosystem undergo substantial changes: reduction in substrate humidity, increase

Table 1. Dynamics of the Species Diversity of the Herb and Moss Layer

Indices	Year																
	1963	1966	1968	1970	1972	1974	1975	1976	1978	1979	1982	1983	1985	1987	1989	1991	1993
Herb layer																	
Number of species	49	56	64	70	74	73	73	77	73	77	70	65	63	63	61	64	57
Cover, %	56	57	70	66	37	32	36	39	39	40	56	59	41	55	54	49	27
Shannon-Wiener index (H)	2.89	2.84	2.67	2.27	3.01	2.93	3.22	2.95	2.95	3.01	2.23	2.24	2.73	2.38	2.43	2.77	2.93
Maximum diversity (H_{max})	3.93	4.03	4.16	4.23	4.30	4.30	4.30	4.36	4.30	4.36	4.23	4.17	4.16	4.16	4.11	4.17	4.06
Evenness (E)	0.74	0.71	0.64	0.54	0.70	0.74	0.75	0.68	0.68	0.69	0.53	0.54	0.66	0.57	0.59	0.66	0.72
Moss layer																	
Number of species	39	28	26	20	28	28	27	24	32	30	27	26	27	27	28	31	28
Cover,%	85	18	22	18	12	9	12	16	31	20	9	16	24	16	33	31	21
Shannon-Wiener index (H)	1.81	1.96	1.60	1.44	2.01	2.44	2.13	1.78	1.56	1.88	2.08	2.12	1.52	1.75	1.22	1.50	1.71
Maximum diversity (H_{max})	3.66	3.33	3.22	3.14	3.33	3.30	3.30	3.18	3.47	3.40	3.30	3.30	3.30	3.30	3.33	3.43	3.33
Evenness (E)	0.49	0.59	0.50	0.46	0.60	0.74	0.65	0.56	0.45	0.55	0.63	0.64	0.46	0.53	0.36	0.44	0.51

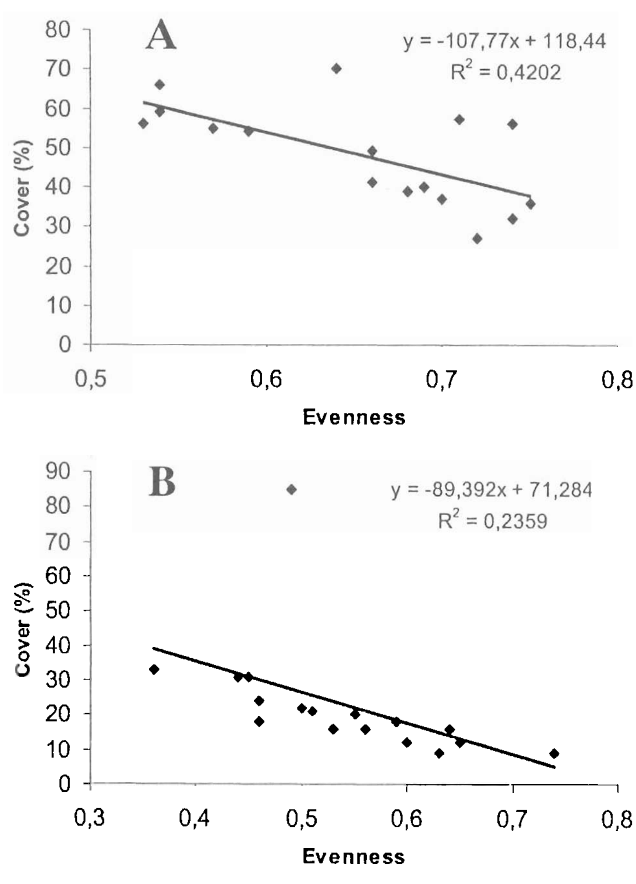

Figure 2. The relation between the cover and the evenness in the herb (A) and moss (B) layers.

in nutrient availability, the soil warming and acidity reduction, higher shadiness. A higher tree crown cover and an increasing proportion of spruce results in the lighting in the forest's lower layers: light reduced by 1.2 points (from 6.5 to 5.3) (Fig. 3). An increased shade provokes changes in species composition and the fall of the ground vegetation cover. The canopy closure creates a slightly warmer microclimate, promoting the spread of plants indicating fairly warm conditions (Ellenberg value changes from 4.5 to 5 (Fig. 3).

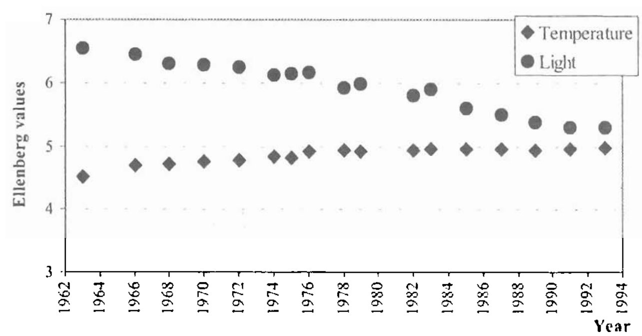

Figure 3. Dynamics of the light and temperature conditions (Ellenberg values for herb layer).

Right after the drainage the soil is still wet (Ellenberg value 7.7) and weakly aerated to become afterwards moist to fresh (5.9). A lower soil humidity improves the aeration and activates microbiological processes (the nitrogen value increasing from 3.0 to 5.0) releasing more nutrients available for the plants and reducing the soil acidity (from acid - 3.8 to moderately acid - 4.7) (Fig. 4).

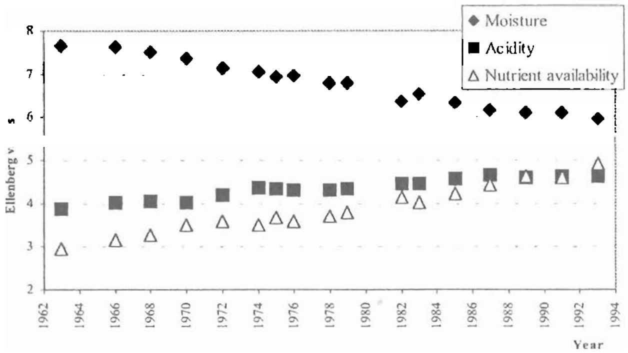

Figure 4. Dynamics of the edaphic indices (Ellenberg values for herb layer).

Succession stages

The post-drainage succession can be divided into 3 stages (TWINSPAN analysis) (Table 2):

Stage 1 (1963-1971): gradual reduction of the proportion of mire hygrophytes (year 1 to 9 after the drainage);

Stage 2 (1972-1981): spreading of grassland hygro-mesophytes and forest species (year 10 to 19 after the drainage);

Stage 3 (1982-1993): establishing of forest mesophytes in the ground vegetation (starting with year 20).

Stage 1

The first stage of the succession lasts for 9 years. In the first year after the drainage the ecosystem still retains all the features of mire vegetation. Then the number of vascular pant species starts to grow (from 51 to 69), yet, due to the dominance of some species in the herb layer (*Agrostis canina, Molinia caerulea, Pyrola rotundifolia*), the diversity index does not increase as it could be expected. The number and diversity of moss species diminishes appreciably (from 39 to 22). Characteristic feature for the stage is a high number of moss species growing on soil surface, tussocks and in hollows but there are almost no species growing on decaying wood and bases of tree boles.

At Stage 1 the highest frequency is for the character species of mire vegetation, predominantly those of fens (class Scheuchzerio-Caricetea nigrae R.Tx. 1937): *Carex nigra*, *Carex panicea*, *Menyanthes trifoliata*, and bogs (class Oxycocco-Sphagnetea Br.- Bl. et R.Tx. ex Westhoff et al. 1946): *Sphagnum warnstorfii*, *Sph. angustifolium*, *Sph. magellanicum*, *Sph. fuscum*, *Aulacomnium palustre*, *Polytrichum juniperinum var. gracilius*, *Oxycoccus palustris*, *Andromeda polifolia*, *Empetrum nigrum*, *Eriophorum vaginatum*. The species of other habitats occur, too (those of wet meadows, river banks, also forest): *Angelica sylvestris*, *Taraxacum officinale*, *Vaccinium vitis-idaea*, *Trientalis europaea* etc. With the substrate getting dryer, the conditions for these species improve and their abundance as well as number is rising. Also an increase is noted in the role of moss species growing on decaying wood and bases of tree boles, e.g. *Tetraphis pellucida*, *Brachythecium oedipodium*, *Brachythecium velutinum*, *Tayloria tenuis*.

Stage 2

This stage (lasting between year 10 and 19 after the drainage) is distinguished by a rapid increase in species diversity: the number of species in the herb layer is high and remains stable (73-77 species); the Shannon-Wiener diversity index increases from 2.3 to 3.2. In the moss layer the number of species is quite stable (25-31 species), yet the diversity index is highly fluctuating, since the bryophytes are more susceptible to the differences in the weather conditions from one year to another.

A considerable role of mesophytic grassland (class Molinio-Arrhenathereta R.Tx. 1937 em. R.Tx. 1970) species in the herb layer is a typical feature of Stage 2, including a high number of species (17) pertaining to the given stage only, (e.g. *Ranunculus acris*, *Carex cespitosa*, *Potentilla erecta*, *Galium album*, *Ranunculus auricomus*). The same is true for a number of other grassland species (*Angelica sylvestris*, *Taraxacum officinale*, *Stellaria palustris*, *Galium palustre* etc.), as well as several ruderal ones (*Cirsium arvense*, *Tussilago farfara*, *Cirsium palustre*, *Carduus crispus*). Still we encounter a number of character species of fens and bogs and of the reed and high sedge vegetation (class Phragmiti-Magnocaricetea Klika in Klika et Novak 1941): *Carex nigra*, *Agrostis canina*, *Andromeda polifolia*, *Oxycoccus palustris*, *Peucedanum palustre*, *Comarum palustre*, *Carex appropinguata* etc., yet to a considerably lesser degree as compared with the first years after the drainage.

Stage 3

This stage (lasting from year 20 till the end of the research period) is noted for a rapid decrease in the number of vascular plant species; the average number of species at Stage 2 is 75, at Stage 3 - 63, although a lot of new species (37) appear, too. The onset of the said stage is also distinguished by a reduction in the diversity, subsequently staying constant till the end of the research period.

Table 2. Post-drainage Dynamics of the Species Frequences in the Herb and Moss Layer (TWINSPAN analysis)
Abbreviations indicate the syntaxon (class and its lower syntaxa) the species is characteristic of: AG – Alnetea glutinosae, AR –Artemisietea vulgaris, CU – Calluno-Ulicetea, EA – Epilobietea angustifolii, MA – Molinio-Arrhenatheretea, GU – Galio-Urticetea, PM – Phragmiti-Magnocaricetea, SM – Stellarietea medii, SC –Scheuchzerio-Caricetea nigrae, OS – Oxycocco-Sphagnetea, VP – Vaccinio-Piceetea, QF – Querco-Fagetea
Frequency classes: 1 – 0-20%, 2 – 21-40%, 3 – 41-60%, 4 – 61-80%, 5 – 81-100%

Syntaxon	Species \ Year	Stage 1				Stage 2						Stage 3							TWINSPAN levels of divisions for species
		1963	1966	1968	1970	1972	1974	1975	1976	1978	1979	1982	1983	1985	1987	1989	1991	1993	
MA	*Ranunculus acris* L.	-	-	-	-	-	1	1	1	1	-	-	1	-	-	-	-	-	0 0 0 0
PM	*Carex cespitosa* L.	-	-	-	-	1	1	1	1	1	1	1	-	-	-	-	-	-	0 0 0 0
MA	*Potentilla erecta* (L.) Raeusch.	-	-	-	-	1	1	1	1	-	1	1	-	-	-	-	-	-	0 0 0 0
	Ranunculus repens L.	-	-	-	-	-	-	-	1	-	1	-	-	-	-	-	-	-	0 0 0 1
CU	*Bryum pseudotriquetrum* (Hedw.) Gaertn., Meyer et Scherb.	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	0 0 0 1
	Calluna vulgaris (L.) Hull	-	-	-	-	1	-	1	-	-	-	-	-	-	-	-	-	-	0 0 0 1
	Cephaloziella rubella (Nees) Warnst.	-	-	-	-	-	-	1	-	1	-	-	-	-	-	-	-	-	0 0 0 1
MA	*Galium album* Mill.	-	-	-	-	1	1	-	1	1	-	-	-	-	-	-	-	-	0 0 0 1
CU	*Luzula campestris* (L.) DC.	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	0 0 0 1
MA	*Poa trivialis* L.	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-	-	-	0 0 0 1
	Tomentypnum nitens (Hedw.) Loeske	1	1	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	0 0 1 0
SC	*Calliergon stramineum* (Brid.) Kindb.	2	1	1	-	-	-	-	-	1	-	-	-	-	-	-	-	-	0 0 1 0
	Calliergonella cuspidata (Hedw.) Loeske	2	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0 0 1 0
	Campylium stellatum (Hedw.) J. Lange et C. Jens.	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0 0 1 0
	Carex flava L.	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0 0 1 0
SC	*Carex panicea* L.	4	1	1	1	1	-	-	-	-	-	-	-	-	-	-	-	-	0 0 1 0
	Chiloscyphus pallescens (Ehrh. ex Hoffm.) Dum.	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0 0 1 0
	Dicranum bonjeanii De Not.	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0 0 1 0
SC	*Epipactis palustris* (L.) Crantz	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0 0 1 0
	Erigeron acris L.	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	0 0 1 0
SC	*Eriophorum polystachion* L.	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0 0 1 0
	Helodium blandowii (Web. et Mohr) Warnst.	4	1	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	0 0 1 0
	Leptobryum pyriforme (Hedw.) Wils.	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0 0 1 0
	Listera ovata (L.) R. Br.	-	1	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	0 0 1 0
	Lophocolea bidentata (L.) Dum.	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0 0 1 0
SC	*Menyanthes trifoliata* L.	5	3	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0 0 1 0
	Poa nemoralis L.	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	0 0 1 0
MA	*Poa pratensis* L.	2	3	1	1	-	1	-	-	-	-	-	-	-	-	-	-	-	0 0 1 0
	Rhizomnium pseudopunctatum (B. et S.) T. Kop.	1	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	0 0 1 0
	Rumex acetosella L.	-	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	0 0 1 0
	Sphagnum capillifolium (Ehrh.) Hedw.	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0 0 1 0
OS	*Sphagnum fuscum* (Schimp.) Klingr.	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0 0 1 0
SC	*Sphagnum teres* (Schimp.) Angstr.	2	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0 0 1 0
OS	*Sphagnum warnstorfii* Russ.	5	3	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0 0 1 0
OS	*Andromeda polifolia* L.	4	3	3	3	3	2	2	1	1	1	-	-	-	-	-	-	-	0 0 1 1
SC	*Carex chordorrhiza* Ehrh.	4	1	1	1	1	1	-	1	-	1	-	-	-	-	-	-	-	0 0 1 1
	Cephalozia connivens (Dicks.) Lindb.	1	1	-	-	-	-	1	-	1	-	-	-	-	-	-	-	-	0 0 1 1
	Ceratodon purpureus (Hedw.) Brid.	1	1	1	-	1	1	1	-	1	-	-	-	-	-	-	-	-	0 0 1 1
AR	*Cirsium vulgare* (Savi) Ten.	-	1	1	1	1	1	-	-	-	-	-	-	-	-	-	-	-	0 0 1 1
OS	*Empetrum nigrum* L.	3	3	3	2	1	1	1	1	1	1	-	-	-	-	-	-	-	0 0 1 1
OS	*Eriophorum vaginatum* L.	4	2	2	1	1	1	1	1	1	1	-	-	-	-	-	-	-	0 0 1 1
MA	*Leontodon hispidus* L.	-	1	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	0 0 1 1
	Lepidozia reptans (L.) Dum.	1	-	-	-	-	-	-	-	1	1	-	-	-	-	-	-	-	0 0 1 1
	Melampyrum pratense L.	2	3	1	2	1	1	1	1	1	1	-	-	-	-	-	-	-	0 0 1 1
OS	*Oxycoccus palustris* Pers.	5	3	3	2	2	1	1	1	1	1	-	-	-	-	-	-	-	0 0 1 1
	Plagiomnium elatum (B. et S.) T. Kop.	-	-	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	0 0 1 1
	Platanthera bifolia (L.) Rich.	1	1	1	1	1	1	1	-	1	1	-	-	-	-	-	-	-	0 0 1 1
OS	*Polytrichum juniperinum* Hedw. var. *gracilius* Wahlenb	3	2	2	2	2	1	1	-	1	-	-	-	-	-	-	-	-	0 0 1 1
SM	*Senecio vulgaris* L.	-	-	1	1	1	-	1	-	-	-	-	-	-	-	-	-	-	0 0 1 1
MA	*Succisa pratensis* Moench	1	1	1	1	1	1	1	1	1	1	-	-	-	-	-	-	-	0 0 1 1
VP	*Vaccinium uliginosum* L.	1	1	1	1	1	1	1	1	1	1	-	-	-	-	-	-	-	0 0 1 1
	Carex echinata Murr.	-	1	1	1	1	-	-	1	-	-	-	-	-	-	-	1	-	0 1 0 0
	Climacium dendroides (Hedw.) Web. et Mohr	1	1	1	1	1	1	1	-	1	1	1	1	-	-	-	-	-	0 1 0 0
VP	*Moneses uniflora* (L.) A. Gray	4	2	1	1	2	1	1	1	1	-	1	-	-	-	-	-	-	0 1 0 0
SC	*Agrostis canina* L.	1	2	2	2	1	2	2	1	1	2	1	2	-	-	-	-	1	0 1 0 0

OS	*Aulacomnium palustre* (Hedw.) Schwaegr.	5	5	4	3	2	2	1	1	1	1	-	1	1	-	-	-	-	0 1 0 0
	Carduus crispus L.	1	1	2	4	2	2	2	1	1	1	1	-	-	1	1	-	-	0 1 0 0
SC	*Epilobium palustre* L.	4	3	2	4	4	4	2	3	1	1	1	1	1	-	-	-	-	0 1 0 0
MA	*Galium uliginosum* L.	5	3	2	4	1	2	3	3	1	1	1	1	1	-	-	-	-	0 1 0 0
	Peltigera canina (L.) Willd.	1	1	1	1	1	1	1	1	1	1	1	1	-	-	-	-	-	0 1 0 0
	Pilosella officinarum F.W. Schultz et Sch. Bip.	-	-	1	1	1	1	1	1	1	1	1	-	1	-	-	-	-	0 1 0 0
AG	*Caltha palustris* L.	4	5	2	4	4	4	3	3	3	4	2	2	2	1	-	1	-	0 1 0 1
SM	*Cirsium arvense* (L.) Scop.	-	-	1	1	1	1	1	1	1	1	1	1	1	-	-	-	-	0 1 0 1
MA	*Dactylorhiza maculata* (L.) Soo	2	2	1	1	1	1	1	1	1	1	1	1	1	-	-	1	-	0 1 0 1
AG	*Dryopteris cristata* (L.) A. Grey	1	-	1	-	1	1	1	1	1	1	1	-	-	1	-	1	-	0 1 0 1
MA	*Anthoxanthum odoratum* L.	1	1	-	1	1	1	1	1	1	1	-	-	1	1	-	-	1	0 1 0 1
MA	*Valeriana officinalis* L.	1	-	1	1	1	1	1	1	1	1	1	1	-	1	1	-	-	0 1 0 1
	Atrichum undulatum (Hedw.) P. Beauv.	-	-	-	-	1	-	1	1	-	1	1	-	-	1	-	-	-	0 1 1 0
	Cirsium palustre (L.) Scop.	-	-	-	-	-	-	-	2	1	1	-	1	-	-	-	-	-	0 1 1 1
	Dicranum majus Sm.	-	-	-	-	-	-	-	-	1	1	-	-	1	-	-	-	-	0 1 1 1
VP	*Goodyera repens* (L.) R. Br.	1	-	1	1	-	-	-	-	1	1	-	1	1	1	1	1	-	1 0 0 0
MA	*Agrostis tenuis* Sibth.	1	1	2	1	2	-	1	1	2	1	3	1	2	1	1	2	1	1 0 0 0
MA	*Angelica sylvestris* L.	2	2	2	2	3	3	2	2	2	2	2	2	2	1	1	1	1	1 0 0 0
	Brachythecium oedipodium (Mitt.) Jaeg.	1	1	3	2	3	5	5	5	5	5	5	5	5	5	5	5	5	1 0 0 0
EA	*Rubus idaeus* L.	-	-	1	1	1	3	4	4	5	5	5	5	5	5	5	5	5	1 0 0 0
AG	*Calamagrostis canescens* (Weber) Roth	2	2	2	2	2	2	2	1	1	1	1	1	1	1	1	1	1	1 0 0 0
MA	*Cardamine pratensis* L.	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1 0 0 0
PM	*Carex appropinquata* Schumach.	5	5	4	3	4	4	3	3	2	3	1	1	1	1	1	1	1	1 0 0 0
SC	*Carex nigra* (L.) Reichard	5	4	3	1	2	2	3	3	2	2	1	1	2	1	1	1	1	1 0 0 0
SC	*Comarum palustre* L.	5	5	5	5	5	5	5	4	4	4	3	3	2	2	1	1	1	1 0 0 0
MA	*Deschampsia caespitosa* (L.) P. Beauv.	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1 0 0 0
VP	*Dicranum polysetum* Sw.	2	2	3	2	3	4	4	3	4	4	4	4	4	4	4	5	4	1 0 0 0
	Dicranum scoparium Hedw.	1	1	1	1	1	2	2	1	1	2	2	1	1	1	1	1	1	1 0 0 0
	Dryopteris carthusiana (Vill.) H. P. Fuchs	-	1	1	1	2	3	3	3	3	3	5	5	5	5	5	5	5	1 0 0 0
QF	*Epilobium montanum* L.	-	1	2	1	2	2	2	2	2	2	2	2	2	1	1	1	1	1 0 0 0
	Equisetum palustre L.	4	2	1	1	1	1	1	1	1	1	1	1	1	1	-	1	1	1 0 0 0
MA	*Festuca rubra* L.	-	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	-	1 0 0 0
	Fragaria vesca L.	-	1	1	1	1	1	1	1	1	1	1	2	2	1	1	1	1	1 0 0 0
	Galeopsis bifida Boenn.	-	1	1	2	3	4	3	3	3	3	3	2	4	4	3	4	3	1 0 0 0
PM	*Galium palustre* L.	2	2	4	1	4	3	3	2	2	2	2	1	1	1	1	1	1	1 0 0 0
VP	*Hylocomium splendens* (Hedw.) B., S. et G.	4	4	4	3	3	3	4	4	4	3	3	4	3	4	4	4	4	1 0 0 0
	Lophocolea heterophylla (Schrad.) Dum.	1	2	3	3	4	3	4	4	4	5	5	5	5	5	4	5	5	1 0 0 0
	Luzula pilosa (L.) Willd.	4	4	4	4	3	5	4	3	4	3	2	2	3	3	3	3	3	1 0 0 0
MA	*Lychnis flos-cuculi* L.	1	1	2	1	2	2	2	1	1	1	1	1	1	1	1	-	1	1 0 0 0
MA	*Molinia caerulea* (L.) Moench	5	5	5	5	5	5	5	5	5	5	5	5	5	5	4	4	4	1 0 0 0
	Naumburgia thyrsiflora (L.) Rchb.	2	4	4	4	4	5	4	5	5	5	5	5	5	5	5	5	5	1 0 0 0
VP	*Orthilia secunda* (L.) House	2	2	2	2	3	4	4	3	3	3	3	3	3	3	2	2	2	1 0 0 0
	Peucedanum palustre (L.) Moench	3	3	3	3	3	3	2	2	2	1	1	1	1	1	1	1	-	1 0 0 0
	Plagiothecium denticulatum (Hedw.) B., S. et G.	1	1	2	2	3	4	4	3	2	2	2	-	3	-	1	1	1	1 0 0 0
	Plagiothecium laetum B., S. et G.	-	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1 0 0 0
VP	*Pleurozium schreberi* (Brid.) Mitt.	5	5	5	5	5	5	5	5	5	5	4	4	4	4	4	5	5	1 0 0 0
	Pohlia nutans (Hedw.) Lindb.	1	1	3	1	2	1	1	1	1	1	1	1	1	1	1	1	1	1 0 0 0
	Ptilidium pulcherrimum (G. Web.) Vaino	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	1 0 0 0
VP	*Ptilium crista-castrensis* (Hedw.) De Not.	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	1 0 0 0
	Pyrola rotundifolia L.	5	5	5	5	5	5	5	5	5	5	5	4	4	4	4	3	2	1 0 0 0
	Rhytidiadelphus triquetrus (Hedw.) Warnst.	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1 0 0 0
	Rumex acetosa L.	5	4	2	2	3	4	4	3	2	1	2	2	1	1	1	1	1	1 0 0 0
OS	*Sphagnum angustifolium* (C. Jens. ex Russ.) C. Jens.	5	4	5	4	2	2	2	1	1	1	1	1	1	1	1	1	1	1 0 0 0
OS	*Sphagnum magellanicum* Brid.	3	3	3	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1 0 0 0
SC	*Stellaria palustris* Retz.	1	2	3	2	3	4	2	1	3	2	1	1	2	1	1	1	1	1 0 0 0
MA	*Taraxacum officinale* F.H. Wigg. s.l.	2	3	3	2	3	2	2	2	1	1	1	1	1	1	1	1	1	1 0 0 0
AG	*Thelypteris palustris* Schott	3	3	3	3	3	3	3	3	3	2	2	2	2	2	2	2	1	1 0 0 0
VP	*Trientalis europaea* L.	2	3	2	3	4	4	4	4	5	5	5	5	5	4	4	4	5	1 0 0 0
	Tussilago farfara L.	-	-	1	-	1	1	1	1	1	1	1	1	1	1	-	1	-	1 0 0 0
VP	*Vaccinium myrtillus* L.	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1 0 0 0
VP	*Vaccinium vitis-idaea* L.	2	2	2	2	3	3	3	3	3	3	3	3	3	3	2	2	2	1 0 0 0
MA	*Anthriscus sylvestris* (L.) Hoffm.	-	-	-	-	-	-	1	1	-	1	1	1	1	-	-	-	-	1 0 0 1
	Cardamine amara L.	-	-	-	-	-	-	-	1	-	-	1	-	-	-	-	-	-	1 0 0 1
	Omalotheca sylvatica (L.) Sch.Bip. et F.W.Schultz	-	1	-	1	-	-	1	-	-	-	1	1	1	-	-	-	-	1 0 0 1
	Ranunculus auricomus L.	-	-	-	-	-	-	-	-	-	1	1	-	-	-	-	-	-	1 0 0 1
	Tayloria tenuis (With.) Schimp.	-	-	1	-	1	-	-	-	1	1	1	1	2	2	2	-	-	1 0 0 1
	Brachythecium velutinum (Hedw.) B., S. et G.	-	-	-	-	-	1	-	-	-	1	-	-	-	-	1	1	-	1 0 0 1
	Eurhynchium angustirete (Broth.) T. Kop.	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	1	1 0 0 1
	Athyrium filix-femina (L.) Roth	-	-	-	-	1	1	1	1	1	1	1	1	1	1	1	1	1	1 0 1 0
AG	*Carex cinerea* Pollich	-	-	-	1	-	1	-	1	1	1	-	1	1	-	1	1	1	1 0 1 0
MA	*Cerastium holosteoides* Fr.	-	-	-	1	1	1	1	-	1	1	1	1	1	1	1	1	1	1 0 1 0

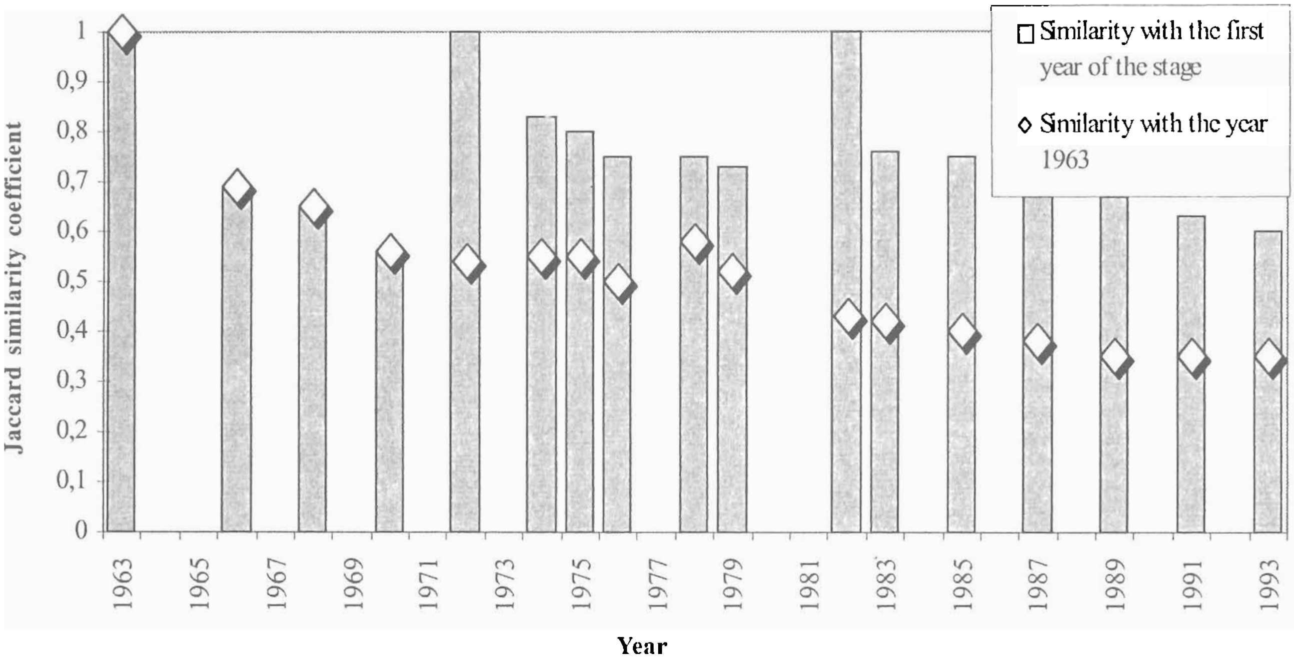

Figure 5. Dynamics of similarity (Jaccard coefficient) of the floristic composition during the post-drainage period.

Discussion

Each of the three post-drainage succession stages is distinguished by phytosociological peculiarities of its own. At Stage 1 the species structure still indicates the maintenance of the features of the mire vegetation (Scheuchzerio-Caricetea nigrae). The said stage is noted for a rapid decrease in the number and occurrence of dwarf shrub and moss species, while the proportion of vascular plants is increasing. At the subsequent stage the ground cover vegetation assumes the traits of grassland vegetation (Molinio-Arrhenatheretea); higher species diversity, maximum cover in the herb layer. Thus, the post-drainage changes in the ground vegetation and the forest stabilization is, as in the event of other disturbances (forest fires, windthrows, clearcutts, pest damage), accompanied by a pronounced, yet short-lived expansion of grassland species (Stage 2). The final stage of succession (20 years after the drainage) features already the dominance of the character species of mesophytic forest communities (Table 2) having a wide ecological amplitude and occurring both in conifer (Vaccinio-Piceetea Br.-Bl. in Br.-Bl. et al. 1939) and broad-leaved (Querco-Fagetea Br.-Bl. et Vlieger in Vlieger 1937) forests (*Maianthemum bifolium, Oxalis acetosella, Circea alpina, Dryopteris expansa* etc.). Simultaneously, the character species of the broad-leaved forests (Querco-Fagetea) are spreading in ground layer and we may expect in the future the dominance of this group in the ground vegetation. So, already in 20-25 years the ground vegetation in drained forest stands resembles that of originally dry site type forests.

After the drainage species diversity increases both in the herb and moss layer, reaching maximum at Stage 2. In this period the amount of grassland species is highest, and also mire species are present. While the number and abundance of forest species is increasing, species diversity in the ground layer is falling. Such dynamics of diversity is observed also by other researchers (Jansons, 1996; Jansons, 1997).

Each successive post-drainage stage lasts for a couple of years longer than the preceding one. Consequently, the changes in the forest environment (edaphic, climatic conditions etc.) are irreversible and sweeping right after the drainage and subside in scope (even between individual years) later on.

The changes in the vegetation parallel the processes under way in the substrate such as an increase in the soil biological activity, intensive mineralization of peat. Over 30 years the nitrogen values (Ellenberg values) have increased by nearly two degrees (by 1.9). In the ground vegetation the proportion of species of moderately rich and rich substrates has grown. The spreading of nitrophylous ruderal herb species (*Urtica dioica, Stellaria media, Chelidonium majus*) and mosses (*Cirriphyllum piliferum, Tayloria tenuis*) is an indication of nitrogen activation in the substrate. Other ecological parameters have changed to a lesser degree.

In 30 years after the drainage the plant communities are still dynamic, and no stability is as yet achieved in both the herb and moss layer. A mixed life-strategy type – competitors-stress tolerants-ruderals (CSR) dominates in the herb layer (35-45% of species). The proportion of CS species has reduced gradually (from 36% to 23%) (the majority of earlier dominants belong to this type: *Andromeda polifolia, Comarum palustre, Menyanthes trifoliata, Oxycoccus palustris* etc.), whereas that of C increased (from 10% to 26%). Typically enough, right after the drainage the CR and R type species tend to increase, and in recent years their proportion in the herb layer is still high.

Over the post-drainage period the proportion of boreotemperate species found in the forest is decreasing (from 51% to 36%), while that of temperate-submeridional species is increasing (from 12% to 28%); also two typical arctoboreal and boreal species disappear (*Eriophorum vaginatum* and *Carex chordorrhiza*). Also, the proportion of Eurosiberian species (from 30% to 17%), as well as that of continental and subcontinental ones show a slight decrease, whereas an increase in the proportion of European (from 2% to 12%) and Eurasian (from 20% to 34%), and also suboceanic and oceanic species (from 47% to 58%) is quite apparent.

Thus, the impact of drainage on the environment, ecosystems and landscape diversity is very strong (Залитис, 1983; Pikk, Seemen, 2000). An analysis of the post-drainage succession in the forest ground vegetation reveals the following main features: a rapid substrate eutrophication, forest climate changes, a decrease in the boreal floral elements and in the boreal biome as a whole, and an increase in the role of nemoral elements and the summergreen broad-leaved forest biome.

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ДИНАМИКА НАПОЧВЕННОЙ РАСТИТЕЛЬНОСТИ ПОСЛЕ ОСУШЕНИЯ ПЕРЕХОДНОГО БОЛОТА

А. Аболиня, С. Ермацане, М. Лайвиньш

Резюме

В работе анализируется динамика покрова и встречаемости видов травянистого и мохового ярусов в течении 30 лет (1963-1993) после осушения переходного болота. Выделены (TWINSPAN) 3 стадии сукцессий, отличающихся своеобразием состава фитосоциологических груп видов. После осушения существенно изменяется экологическая ситуация: уменшается влажность субстрата от 7.7 до 5.9 (числа Элленберга) и усиливается процесс евтрофикации (число азота увеличилось от 3.0 до 5.0).

Ключевые слова: осушение, травянистый и моховой покров, биологическое разнообразие, сукцесия.