IPC2021

16th INTERNATIONAL PEATLAND CONGRESS

3-6 May 2021 • Tallinn, Estonia

Oral presentations

Argo Argel • Suru bog, Estonia

ID 62691

LONG-TERM RESPONSE OF VEGETATION ON THE WATER LEVEL DROP-DOWN ON A LARGE CALCAREOUS FEN (NW ESTONIA)

*Laimdota Truus[1], Mati Ilomets[1], Raimo Pajula[1], Kairi Sepp[1]

[1]Institute of Ecology, Tallinn University, Tallinn, Estonia

laimi@tlu.ee

SUMMARY

Mires are usually drained for economic use – for peat extraction, tree plantation or agricultural production. Sedge fen with area over 3 000 ha on the border of Suursoo-Leidissoo mire complex (over 20 000 ha) was drained at theend of the 19th Century for hay cutting. In reality, the hay was cut there in short period and locally, so the area hasbeen subject only to weak but long-term drainage over 100 years. Hence the vegetation succession has been spontaneous with only human-induced influence – constant drainage.
Peat composition shows that pre-drainage vegetation consisted of low-growth sedges (Carex sp., Schoenus ferrugineus) and brown mosses. Similar vegetation is still there in a small area but for the most part it has changeddramatically because of decline of a mineral-rich mire water table level.
As a result, different trends are observed in vegetation composition.
First, water table (WT) deepened but still available mineral-rich water supports transition from previous low- sedge vegetation to tall-growing grasses and sedges (Molinia caerulea, Trichophorum caespitosum) that make high tussocks. Dense litter covers spaces between tussocks and brown mosses have mostly disappeared.
The second trend is afforestation. We have recognised different successional stages from open fen to treed fen and to thick mixed forest of birches, pines and spruces. The latter is accompanied by the lowest WT and the mostdecomposed topmost peat in the soil.
The third and the most common trend of the succession is similar to the natural succession – development from mineral-rich fen to bog-like vegetation, but that succession goes hundred times faster than it happens in natural way. Previous low-growing sedge vegetation is overgrowing by Sphagnum-dominant vegetation, both treed and open sites.
The last trend is often seen nowadays in fens in Estonia, whether the WT of the mire is lowered by land use, landuplift or by drainage through the trees evapotranspiration.

Keywords: Calcareous fen, drainage, groundwater level, peat mineralization, vegetation succession

INTRODUCTION

State and quality of calcareous fen ecosystems is controlled by relatively constant groundwater exfiltration that assures constant close to surface water level (WL), high ionic concentration and low plant nutrients supply (Hayeket al., 2006). When WL drops down because of drainage the proportion of rainwater in mire water balance increases and pore water pH decreases provoking lose the basic feeding type (Johansen et al., 2011). Higher proportion of rainwater in formation of the mire water lowers water pH. Decline in water level leads to decomposition of peat that increases nutrients supply for plants (Devito and Dillon, 1997; Haraguchi et al., 2003). Drainage causes multidirectional disturbances in quality and quantity of peatland feeding system and modifies the structure of vegetation composition. The fall down of WL fosters the increase of vascular plant cover (such as dwarf shrubs) with corresponding reduction in the moss cover (Goud et al., 2018). Changes from one type to another may proceed with short successional time-frame. Thus, changes caused by drainage are complex but always resulting with impoverishment of typical fen vegetation.

Fens were widely distributed in Estonia, making up to ca 50% (420 000 ha) of the Estonian mire area. Calcareousfens as typical vegetation type, especially in the western Estonia have been drained, mostly for hay mowing and for pasturing because fen soils are very suitable for agriculture (Laasimer, 1965). Management of fens largely ended in the 1960s-1970s. By the estimations (Ilomets, 2017) only up to 10-15% of calcareous fens are left in near-natural state today. But, once dug ditches still drain and the area of fens in natural state is constantly decreasing.

Restoration of fen ecosystems sets complex tasks for restoration measures application and results are hard to predict because of complex hydrological system and heterogeneity of vegetation units.

We set up a comprehensive and integrated monitoring system in the Suursoo-Leidissoo calcareous fen site undertaken for restoration. We aimed to understand the share of different abiotic drivers affecting state development of plant cover during over 100 years lasting weak drainage what may give valuable information for predictions about changes following restoration measures.

Our hypothesis was that there are other abiotic drivers besides the water level drop down responded into the formation of patterned vegetation.

STUDY SITE

A B

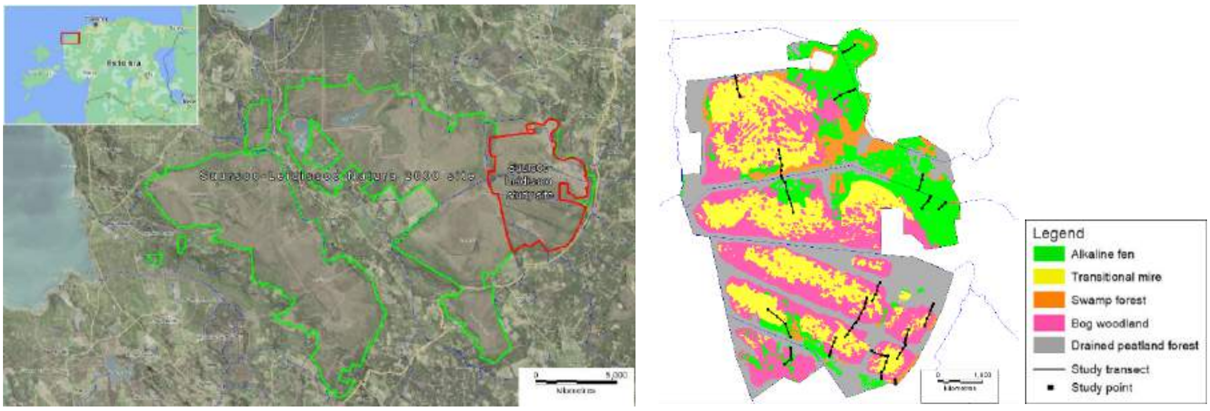

Figure 1. A – Location of the Suursoo-Leidissoo study site (also LIFE Peat Restore project site; with red border) Läänemaa Suursoo mire complex in NW Estonia; B – drainage-induced vegetation pattern with study transects and study points.

Suursoo-Leidissoo study site (ca 3 400 ha) as part of the Suursoo-Leidissoo Natura 2000 site (EE0040202) is an eastern part of Läänemaa Suursoo mire complex (over 20 000 ha) and is project LIFE Peat Restore peatland restoration site. Originally the site was an extensive wet fen (dominantly ass. *Drepanoclado-Schoenetum*). At theend of the 19th century the sparse hand-dug drainage system was made with total length of narrow ditches of ca 45km, with ca 1 km distance between each other. The ill-fated amelioration resulted in the development of peatlandwith patterned plant cover from still open fen to different Sphagnum dominated transitional mire and drained forested peatland communities.

METHODS

For the vegetation survey we analysed plant species (vascular plants and mosses) coverage on 95 sample plots (10x10 m) on transects cross ditches over the site (Figure 1B). In the nested-plot design 3 subplots by 2x2 m (divided into four 1x1 m squares) were nested into 10x10 m plot for vascular plant analyses and 36 subplots of 0.25x0.25 m in every 2x2 m plot for moss layer analyses where coverage (%) of every species estimated. Trees and shrubs estimated on 10x10 m plots (Figure 2).

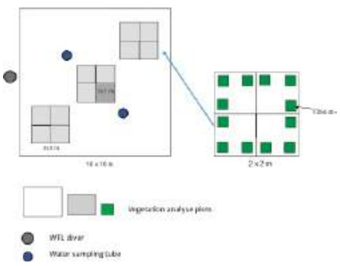

Figure 2. Analyse design for vegetation and water sampling.

Water level monitored from PVC tubes inserted to every vegetation analyse plot since 2017 and with automatic divers (record the water level every 2 hours) close to 60 vegetation analyse plots in 2018-2020.

Water chemistry samples collected every summer and autumn from perforated PVC tubes inserted on all analyseplots. Electrical conductivity, pH, inorganic carbon (IC), SO_4^{2-}, Ca^{2+} etc. content analysed. Means of water and peat parameters calculated and statistical differences found between parameters (Table 1).

Peat samples (from 0-10 cm and 10-20 cm depth) were taken for their later bulk density and ash content analysesclose to vegetation plots.

On the base of Lidar data, satellite maps and UAV-photos, the distribution map of vegetation types compiled at start in 2017. PCA ordination of vegetation data in relation to water and peat parameters provided.

RESULTS

Five vegetation types were distinguished (Figure 1B) which all lie on quite uniform weakly to medium decomposed (2-4 after van Post) Carex-brown moss peat. It means that all types have been evolved from one – the calcareus fen type.

The main parameters of water and peat distinguishing vegetation types are given in Table 1. Subdivisions of calcareus fen and transitional mire types indicate about different successional stages of these types. Calcareous fen type differs from others by significantly higher electrical conductivity (EC) of pore water and by peat bulk density and ash content of the upper 0-10 cm peat. Peat density and ash content of drained peatland forest were also higher than in other successional vegetation units. WL measured in summer and in autumn 2017 did not showstatistical differences. WL was always high in 2017 because of extreme weather – long and cold spring and rainy August and September. These parameters differentiated significantly between vegetation types in two following years, 2018 and 2019 with dryer weather (data of the Estonian Weather Service).

Table 1. General water and peat properties in the vegetation types of Suursoo-Leidissoo study site. Data taken inJuly 2017, just WL_aut taken in September; EC – Electrical conductivity, µS/cm; WL – water table level; BD_1 – bulk density of upper 0-10 cm peat, g dm^3; BD_2 – bulk density of 10-20 cm peat depth, g dm^3; Ash _1 – ash content (%) of 0-10 peat depth; Ash _2 – ash content (%) of 10-20 peat depth. Indexes a and b show statistical differences.

		Calcareous fen		Transitional mire			
	Parameter	Small sedges	Molinia	Tall sedges	Sphagnum-Menyanthes	**Transitional mire forest**	**Drained peatland forest**
Water	EC_sum17	322a	328a	82b	85b	85b	116b
	WL_sum17	-3b	0b	-6b	-14b	-8b	-31b
	WL_aut17	+15b	+11b	+4b	+2b	+2b	+2b
	BD_1	106a	105a	79b	84b	85b	113a
	Ash_1	14a	12a	6b	7 b	6b	10 a
Peat	BD_ 2	91b	90b	72b	80b	74b	115a
	Ash_2	9b	9b	4b	6b	6b	18a

Based on plant cover data from 95 plots we made PCA ordination biplot of vascular plant assemblages distributionin relation to WL and water chemistry (sampled in May 2019) and on relation to minimal, maximum water levelsand to WL amplitude (Figure 3). We found that distribution of plant assemblages (sedges and other fen species, bog species and species typical for minerotrophic forests) are related on peat water mineral content and on water level fluctuation differently.

Assemblage 1 (with light green circle on Figure 3) on sites with high EC, high mineral content and high water level represents the best preserved fen site (Myrica+Carex+fen mosses group). It is related to higher carbon (carbonates) content in mire water and on constantly high WL during the vegetation period.

If water and peat indicator values of typical fen are declining, a continuous transition to Sphagnum-dominated transition mire associations (assemblages 3, 4 and 5) starts. Treed fen (assemblage 2) locates close to the transitionmire assemblages 4 and 5. There is no sharp line between them but rather a continuous transition. Assemblages 3, 4 and 5 (with purple circle) represent plots with mixture of certain fen species in complex with Sphagnum and Calluna vulgaris – classified here as transitional mire with different stages of afforestation. It is characterised withlow content of Ca^{2+}, SO_4^{2-} and inorganic carbon and with deep WL during summer period.

Distribution of plant assemblages 6 (swamp forest) and 7 (drained peatland forest) on the ordination biplot is characterised by high WL amplitude indicating about considerable WL fluctuations during the vegetation period.The deep and fluctuating WL results in high total organic content indicating about increased surface peat decay processes.

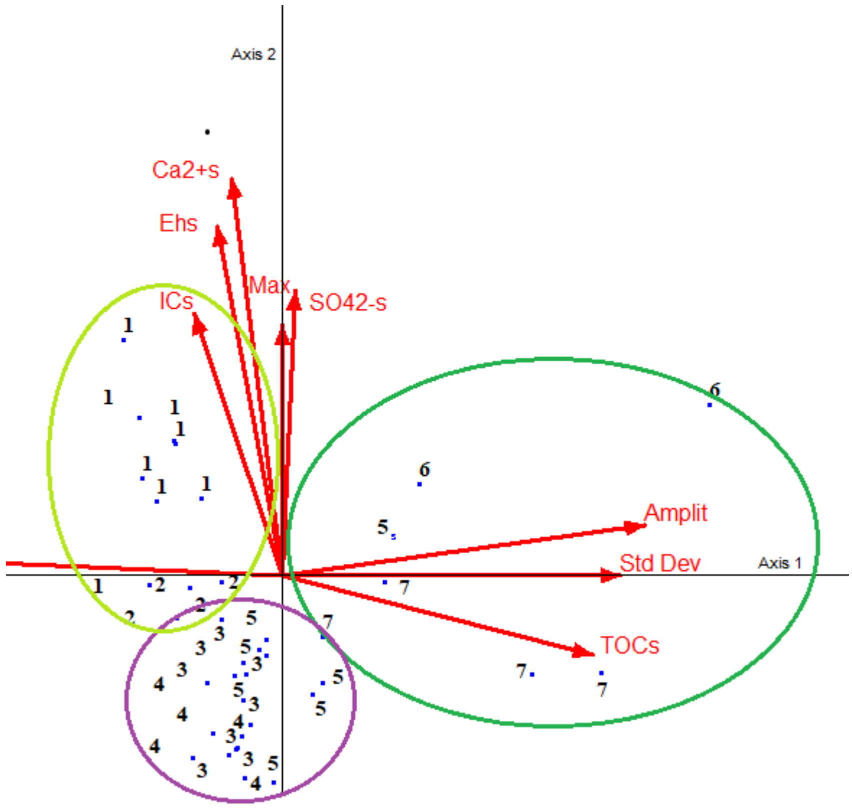

Figure 3. PCA ordination biplot of vascular plant distribution in relation to water level and certain water chemistry parameters (sampled in May 2019). Plant assemblages: 1-open fen, 2-treed fen, 3-open transitional mire, 4-treedtransitional mire, 5-transitional mire forest, 6-swamp forest, 7-

drained peatland forest. Symbols on figure are: Ca2+s –Ca^{2+}, SO42s – SO_4^{2-}, ICs – inorganic carbon, Ehs – electrical conductivity (EC), TOCs – total organic carbon contents. Ampl – water level (WL) amplitude, Max – WL maximum depth of water level, Min – WL minimum, Std Dev – WL standard deviation, s- sampling in spring.

DISCUSSION

Changes in varying magnitudes occurred due to changed moisture conditions due to ditching. Groups 1 and 2 on Figure 3 represent fen vegetation, 3-5 transitional mire and transitional mire forest, group 6 swamp forest and group 7 is formed from drained peatland forest analyses. Group 1 is still in almost natural state but changes as conditions become drier. The trends occurring on the study site due to long-lasting but weak drainage are presented on Figure 4.

PCA ordination biplot indicates about two general trends of succession: from sedge-dominated fen to Sphagnum-dominated transitional mire, and from open vegetation to closed (treed) vegetation. WL drop down can led to acidification (Van Heasebroek et al., 1997) and peat drying to nutrient release due to peat decomposition (Devito and Dillon, 1997; Haraguchi et al., 2003). Changed pH promote growth of Sphagnum (Hájek et al., 2006). As strong dominants, Sphagnum species become shaping the environment and contribute to vegetation change.

In the vegetation of near-natural part of the calcareous fen (group 1 on Figure 3) the depth to water level and porewater pH are the main abiotic drives. In the parts of the site with dropped down of water level the species composition in the field layer responds to pore water pH and EC, topsoil ash content and the coverage of the tree layer.

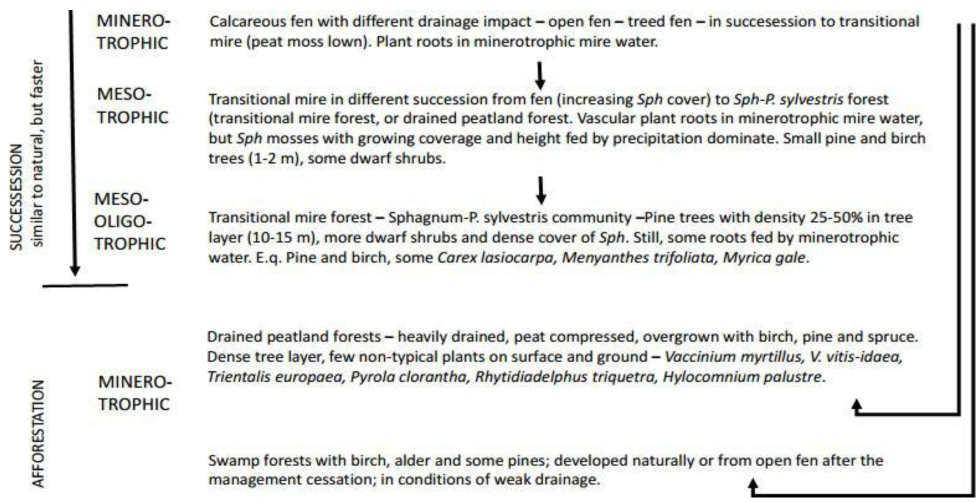

Figure 4. Pathways of drainage induced successions of the Suursoo-Leidissoo calcareous fen.

CONCLUSION

The drainage systems ever built in fens operate even though the economic need has ceased and the role of groundwater in ecosystem succession is decreasing. The changes in plant communities often occur in the same direction as the natural peatland ecosystem transition from minerotrophic to ombrotrophic peatland, but the rate of this process is importantly accelerated.

ACKNOWLEDGEMENTS

We thank Elve Lode for hydrology data modeling, Galina Kapanen for laboratory water and peat sampling and Matrin Küttim and Anna-Helena Purre for field assistance.

The study was funded by LIFE Climate Change project Life Peat Restore 2016-2021 (LIFE15 CCM/DE/000138).

REFERENCES

- Devito K.J., Dillon P.J. (1997) The influence of hydrologic conditions and peat oxia on the phosphorusand nitrogen dynamics of a conifer swamp. Water Resources Research; 29: 2675–2685.
- Goud E.M., Watt C., Moore T.R. (2018) Plant community composition along a peatland margin followsalternate successional pathways after hydrologic disturbance. *Acta Oecologica*; 91: 65–72.
- Hájek M., Horsák M., Hájková P., Dite D. (2006) Habitat diversity of central European fens in relation environmental gradients and an effort to standardize fen terminology in ecological studies. *Perspectivesin Plant Ecology, Evolution and Systematics*; 8: 97–114.
- Haraguchi A., Hasegawa C., Hirayama A., Kojima H. (2003) Decomposition activity of peat soils ingeogenous mires in Sasakami, central Japan. *European Journal of Soil Biology*; 39: 191–196.
- Ilomets M. (2017) Estonia. In: *Mires and peatlands of Europe* (H. Joosten, F. Tanneberger and A.Moen, eds), Schweizerbart Science Publishers, Stuttgart, pp. 360–371.
- Johansen O.M., Petersen M.L., Jensen J.B. (2011) Effect of groundwater abstraction on fen ecosystems.Journal of Ecology; 402: 357–366.
- Lode, E. (2021). Groundwater dynamics in Life Peat Restore project area located on the Läänemaa–Suursoo Mire Complex. The Third Report for the EU Life+ project LIFE15 CCM/DE/000138.
- Van Haesebroek V., Boeye D., Verhagen B., Verheyen R.F. (1997) Experimental investigation ofdrought induced acification in a rich fen soil. *Biogeochemistry*; 37: 15–32.