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LONG-TERM VEGETATION TEXTURAL CHANGES OF THREE FEN COMMUNITIES NEAR CLUJ-NAPOCA (ROMANIA)

E. RUPRECHT[1] and Z. BOTTA-DUKÁT[2]

[1]*R-3900 Satu Mare, str. Martirilor Deportati 7, Romania*
[2]*Institute of Ecology and Botany, Hungarian Academy of Sciences*
H-2163 Vácrátót, Alkotmány u. 2–4, Hungary; E-mail: bdz@botanika.hu

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The question discussed in this paper is whether changes of environmental factors can be supported by changes reflected in vegetation texture. A case study is presented on the statistical analysis and interpretation of changes in vegetation texture in some rich fen associations: *Carici flavae-Eriophoretum latifolii, Junco obtusiflori-Schoenetum nigricantis* and a *Cladietum marisci* association using the species indicator values for moisture (W), acidity (R) and nutrients (N). For characterising trends of changes the social behaviour types (SBT) and coenological grouping of the species are also used. The study of changing vegetation are evaluated on the basis of relevés made in the beginning of the 1940s, in 1956, 1961 and 1998 on non-permanent plots with varying numbers among the years. Data were collected by different people in the mentioned years in the 7 fen patches in Malom Valley (Romania). The pattern of indicator values was analysed by concentration analysis. Significant correlation was found between the coordinates calculated from indicator values for moisture and acidity. Similar behaviour was found in vegetation textural changes indicated for moisture, acidity and nutrient status of the two rich fen associations, but the rate of coenological groups and social behaviour types changed differently. The *Cladietum marisci* association presented completely different behaviour.

Key words: annual precipitation, calcareous ground-water, chronosequence, indicator values, non-permanent plot

Introduction

Wetlands are interesting from a nature conservation point of view being generally relatively poor in nutrients, but very rich in species. The soil of wetlands of this kind is, however, eutrophic peat. The total amount of nutrients is enormous, but their availability is controlled by certain growth limiting factors maintaining it at a low level by the hydrological conditions. Therefore, the species composition of these mires is mainly determined by the fluctuations and composition of the groundwater table (van Diggelen et al. 1991b).

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In this work for studying the textural changes of three fen communities several characteristics of the species from these vegetation units (their indicator values, social behaviour types, coenological status) were used. The use of indicator values in the vegetation studies is widespread following Ellenberg's activity (Ellenberg 1950, Ellenberg et al. 1991). In Hungary many authors dealt with the classification of species into ecological groups (Zólyomi et al. 1967, Soó 1964–1980, Kárpáti and Kárpáti 1972, Kárpáti et al. 1968, Kárpáti 1978, Simon et al. 1992, Borhidi 1993, 1995). Borhidi's (1995) work contains the classification of the whole Hungarian flora following the system of Ellenberg et al. (1991) and extended it for the SE European species. The former native works did not contain the whole Hungarian flora (except Soó 1964–1980), and used different indicator scales resulting incompatible with groupings of Ellenberg and other authors. In Romania Sanda et al. (1983) classified the species into ecological groups also after Ellenberg (1950). Using indicator values in vegetation research is an aid in those cases where detailed environmental measurements, although wanted, are impractical or impossible to obtain (Persson 1981).

Borhidi (1993, 1995) introduced the term of social behaviour types (SBT) of species as a useful tool to evaluate of the naturalness of plant communities. This classification is based upon how species take part in an association and it refines Grime's (1979) C-S-R strategy classification. Earlier, Simon (1988) made a classification of the native flora for evaluate the nature conservation value of the flora of different areas. In this systematisation he took into consideration the species' rarity and conservation status, too. Borhidi's (1995) systematisation is theoretically more established.

The coenological status of a species suggests its affection for a coenological group. The comparison of the proportion of species with different coenological statuses is a method for evaluating the direction of succession.

Permanent plots are appropriate tools for studying the long-term changes of vegetation (Bakker et al. 1996, Herben 1996). However, we can get information about the trends of vegetation changes without permanent plots, for example by space-for-time substitution (Pickett 1989). The chronosequence may be reconstructed based on hypothetical succession schemes (Précsényi 1981, Zólyomi et al. 1988, Fekete 1992), or on time spent since abandonement by land-history data (Molnár and Botta-Dukát 1998). The other two possibilities for studying succession are repeated mapping (Czenthe 1985, Borhidi et al. 1991, Horváth and Csontos 1992) and repeated sampling method (Molnár 1996, Molnár et al. 1997). We were using the latter approach in our work.

In our study we are searching for the answer to two main questions:

1. How narrow is the correlation between the fluctuation of precipitation quantity (the alternation of wet and dry periods) and the vegetation-textural changes?

2. What is the degree of reliability of comparisons of non-permanent plots recorded by different people with greater time-lag in describing successional processes?

Materials and methods

Description of the study area

The Malom Valley ranges 8 km S of Cluj-Napoca (Romania), southwestward to Feleacu, at 650 m above sea level. After Borza (cit. Pop et al. 1962) this area floristically belongs to the Bihar sector and phytogeographic district of Apuseni Mountains. The Malom brook scoops its bed in Sarmatian sand and sandstone sediments covered by a Miocene clayey-marly strata. On this red clayey stratum a reddish-brown forest-soil had formed. The west–east directed valley is embraced by oak and oak-hornbeam forests on its northern slopes, and by beech and hornbeam-beech forests on its southern ones. On the slopes of the 5 km long valley there are mesophilous and poor meso-xerophilous hayfields and *Nardus stricta* stands, too. These are mowed regularly once a year at the end of July or at the beginning of August, and are grazed moderately by sheep and sometimes by cattle. The brook is accompanied by alders and willows, with marshmeadows and high-sedges in some places.

Where the water of the springs flows together the clayey surface rich fens were forming, which are fed by calcareous ground water. These fens are patchily inserted into the hayfields. There are three associations: *Carici flavae-Eriophoretum latifolii, Junco obtusiflori-Schoenetum nigricantis* and *Cladietum marisci* which are mosaically situated. On the edges of the fens there are haymeadows with little extension in some places. These fens were mown regularly till the beginning of the 1960s which could cause changes in the structure of the vegetation. The continuous forest cover of this valley, the relative integrity and the relatively gentle land use system through centuries could be proved using palinological data, military maps and land descriptions (Ruprecht 1999). That is why the changes in vegetation-texture could be caused mostly by environmental factors.

Description of the studied associations

The *Carici flavae-Eriophoretum latifolii* Soó 1944 association could be found mainly on the surroundings of springs where the soil is saturated with cold water coming from deep strata (Jakucs 1956). It is tightly linked to adequate water-supplied peat soils but from another point of view it has wide ecological spectra and rich species composition. Its drying may cause afforestation or transformation into haymeadows (Borhidi and Sánta 1999).

The *Junco obtusiflori-Schoenetum nigricantis* Allorge 1921 association could be found on strongly humid places, on calcareous soils. This association is considered to be successionally stable, this stability is maintained by adequate moisture conditions and regular mowing and grazing. Drying or stopping the mentioned activities can cause afforestation or transformation into haymeadows (Borhidi and Sánta 1999). These stands are living on the eastern boundary of the habitat of this association, representing the *Schoenetum nigricantis transsilvanicum* geographical variant. These stands are rich in montane-subalpine elements, that is why they are similar to the stands known from the western part of Hungary (Soó 1927, Kovács 1962).

The *Cladietum marisci* Zobrist 1935 association could be found on calcareous, oxygen-rich, oligo-mesotrophic or mesotrophic soils, without considerable water level fluctuation. In the dense stands formed mostly by the dominant species, *Cladium mariscus* the accumulation of the dead phytomass (leaves) is considerable, which permits only few species to inhabit. During succession their stands can transform into *Schoenetum* association (Borhidi and Sánta 1999).

Data collecting and vegetation recording

Former coenological data from our study area (the Malom Valley) were collected in 1940–44 (Soó 1949), 1956 (Soran in Pop et al. 1962) and 1961 (Pop et al. 1962).

Our relevés were made according to the Braun-Blanquet method in the summer of 1998. Stands were identified on the base of floristical composition and their physiognomy. The size of the relevés was 25 m^2 in the case of the *Carici flavae-Eriophoretum latifolii* and *Junco obtusiflori-Schoenetum nigricantis* association and 100 m^2 in the case of the *Cladietum marisci* association adjusting to relevé-sizes of former years. Abundance-dominance (AD) values were noted according to the Braun-Blanquet approach (in order to compare the relevés of different years). Due to the extension-limits of the stands 14 (*Carici flavae-Eriophoretum latifolii*), 8 (*Junco obtusiflori-Schoenetum nigricantis*) and 4 (*Cladietum marisci*) relevés were obtained.

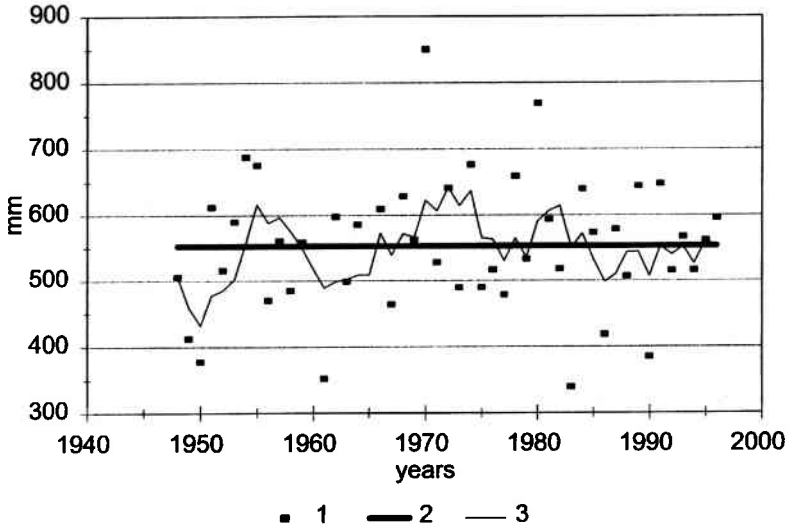

Fig. 1. Annual precipitation of the period 1948–1996 according data of the meteorological station at Cluj-Napoca. Legend: 1. annual precipitation, 2. average annual precipitation in the studied period, 3. annual precipitation smoothed by moving average

The annual precipitation of the period 1948–1996 (according to the data of the meteorological station at Cluj-Napoca) was used. Moving averaging was used for smoothing annual precipitation data (Fig. 1).

Former vegetation relevés were compared with ours by using the species indicator values for moisture (W), acidity (R) and nutrients (N). The W, R and N values were used because we consider them being the most deterministic parameters (factors) of a fen community. In the comparison only vascular plants were taken into consideration. The taxonomic nomenclature follows Borhidi (1995). In the case of *Eriophoretum* association (relevés of the year 1956) two groups were distinguished: one typical (E1956a) and a drier *caricosum paniceae* facies (E1956b) (Table 1).

Table 1

The number of relevés in certain cases with the signs of the associations in the parentheses

Year of sampling	*Carici flavae-Eriophoretum latifolii* (E)	*Junco obtusiflori-Schoenetum nigricantis* (S)	*Cladietum marisci* (C)
1940–44	11	–	–
1956	2(E1956a) + 3(1956b)	5	–
1961	5	2	2
1998	14	8	4

The pH measurements were made with a digital pH-meter in the summer of 1998. The pH of the ground water was similar in the habitats of all the three associations and fluctuated in the 7–8.2 interval.

Data processing

Data transformation. – Braun-Blanquet type data were transformed into cover according to Tüxen and Ellenberg (1937) modified by Soó and Zólyomi (1951). For decreasing the distortion during the transformation the following correction was applied:

$$B_i = \frac{b_i}{\sum_i b_i} \cdot 100$$

where: b_i = uncorrected cover of species i, B_i = corrected cover of species i.

Representative species. – The changes of abundance of some representative species were examined. Species indicating wetness belongs to the created "wet group" (*Equisetum palustre, Scirpus sylvaticus* and *Menyanthes trifoliata*), whilst species indicating dryness belong to the created "dry group" (*Carex panicea, Potentilla erecta, Plantago media, Molinia coerulea, Briza media, Succisa pratensis, Sanguisorba officinalis* and *Cirsium rivulare*). Changes in the average abundance of some specialists (*Parnassia palustris, Pedicularis palustris, Epipactis palustris, Ophioglossum vulgatum* and *Liparis loeselii*) were examined, too.

The pattern analysis of indicator values

Our aim was to describe the changes of indicator value patterns by the least variates possible. For this reason concentration analysis was used (Feoli and Orlóci 1979, Précsényi 1995). This method computes the scores of species-groups and relevé-groups in the same ordination space. Only binary data can be analysed with this method. In our opinion this constrain is not a disadvantage because if weighted data (e.g. cover, number of individuals, etc.) were used, some species would be over-emphasised.

The groups of relevés applied in the analyses are listed above. The grouping of species was based on their indicator values for moisture (WB), acidity (RB) and nutrients (NB) according to Borhidi (1995). In the case of species not living in Hungary the work of Sanda et al. (1983) was used. In our earlier study (Botta-Dukát and Ruprecht 2000) we stated that using

fewer groups is more efficient than Précsényi's (1995) original method. That is why species are concentrated into three groups based on their WB, RB and NB values in the following way:

Moisture:
W1 = xerofrequent group (WB1, WB2, WB3, WB4)
W2 = mesofrequent group (WB5, WB6, WB7)
W3 = hygrofrequent group (WB8, WB9, WB10).
Acidity:
R1 = acidofrequent group (RB3, RB4)
R2 = neutral group (RB5, RB6, RB7)
R3 = basifrequent group (RB8, RB9).
Nutrients:
N1 = oligotrophic group (NB1, NB2, NB3)
N2 = mesotrophic group (NB4, NB5, NB6)
N3 = eutrophic group (NB7, NB8).

It is known from other works (Grootjans et al. 1991, van Diggelen et al. 1991a, b, ter Braak and Wiertz 1994) that there is a significant correlation among some environmental parameters (moisture, acidity, nutrients) measured or indicated by vegetation in rich fens. We are likely to observe the same phenomenon. Thus Spearman's rank correlation coefficients among the scores of relevé-groups for moisture, acidity and nutrients were computed to test this hypothesis. The *Cladietum* relevés were excluded from this analysis, because it was not a rich fen association. There are two possible reasons which can account for the correlation between scores. One is the real correlation between habitat parameters. The other is that different indicator values of the same species are not independent from each other. For example, let us imagine the following situation: a xerofrequent species is probably acidofrequent and a hygrofrequent species is probably basifrequent, that is the two indicator numbers are not independent. In this case the correlation is an artefact. The independence of different indicator values of the same species was tested by G^2 test (Sokal and Rohlf 1981).

Coenological groups

Three groups were made based on the coenological status of species. The first contains the Caricion davallianae elements (characteristic rich fen species), their decrease in number is the first indicating of degradation. The second group contains the other fen species, their indication role is important, too. They are not tightly related to rich fens (their focus of appearance

is not on rich fens). The members of the third group are non-fen species, which would be occasionally present on rich fens of natural conditions but their increase in number and abundance is an indicator of degradation (drying). Species' classification follows Borhidi (1995) and Sanda et al. (1983). The relevés of *Cladietum* association were not used here.

Social behaviour types

In the case of social behaviour types (Borhidi 1993, 1995) the number of specialists and the abundance of disturbance tolerant species were used. In our case, fen species with narrow intervals of tolerance belong to the group of specialists. Only a few weed species and mostly natural disturbance tolerants belong to the group of disturbance tolerants, characteristic of managed fields (e.g. hayfields).

Results

Changes in the average abundance of some representative species

Some species like *Carex panicea, Potentilla erecta, Plantago media* and *Cirsium rivulare* present a great increase in abundance between 1940–1956, whilst the abundance of *Molinia coerulea* presents a little increase. There is a decrease in the abundance of *Equisetum palustre, Scirpus sylvaticus, Briza media, Succisa pratensis* and *Sanguisorba officinalis*. Some rare species, mostly fen specialists like *Parnassia palustris, Pedicularis palustris, Epipactis palustris* are increasing in abundance. *Menyanthes trifoliata* became extinct (Pop et al. 1962).

On the average, an opposite trend can be observed compared to the former between 1956–1961, except that the abundance of *Molinia coerulea* keeps increasing and the abundance of the mentioned rare species keep decreasing (except *Epipactis palustris*). *Scirpus sylvaticus* presents a decrease in abundance. Pop et al. (1962) reported the extinction of *Liparis loeselii* and about the decreasing of the local population of *Ophioglossum vulgatum*.

Between 1961–1998 changes were smaller and the abundance of some species were invaried. It is to be mentioned that there was a prominent increase in the average abundance of *Equisetum palustre* and *Potentilla erecta*. *Liparis loeselii* appeared again and the local population of *Ophioglossum vulgatum* increased.

Changes in indicator values of the relevé-groups

Changes in indicator values for moisture (W) and acidity (R) are represented by the same figure (Figs 2a, b), so it is possible to compare their changes. The *Eriophoretum* relevés from 1956 belong to two groups: a typical (E1956a) and a drier one (E1956b). If they had been amalgamated, the results of the analysis would have been biased. Having these two groups, the recognition of the tendencies of textural changes in this association becomes difficult.

In the *Eriophoretum* association the very high moisture and high pH values (E1940) change to drier ones (as indicated) for both E1956 groups and becomes more acid at the same times (as indicated). In 1961 this association proved to be a bit drier than the typical group from 1956 (E1956a), but considerably wetter than the dry facies from this year (E1956b). If we take into consideration that in 1956 the number of relevés of the dry group is higher, it can be concluded that the *Eriophoretum* association from a dry state (1956) changed into a bit wetter one (1961). Finally, till 1998 it presents higher moisture values and simultaneously much higher pH values (Fig. 2a). The changes of the *Schoenetum* association show a similar tendency as regards both its direction and the rate of changing. It can be observed that the values of *Schoenetum* association are in a higher pH interval compared to those of *Eriophoretum* in each of the dates, but the two communities do not differ considerably in their moisture values (Fig. 2b).

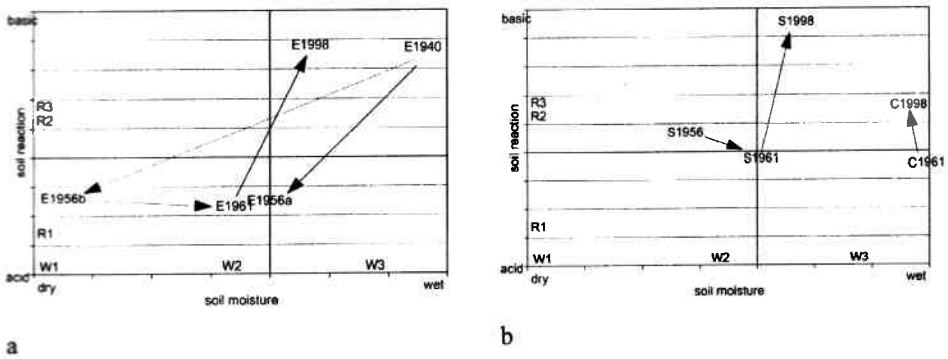

Fig. 2. Changes in moisture and acidity as indicated: scores of relevé-groups along the first ordination axis created by concentration analysis based on indicator values for moisture vs. scores along the first ordination axis created by concentration analysis based on indicator values for acidity. The values are not displayed on the axes, because only the relative position of relevé-groups and species-groups can be interpreted. *Carici flavae-Eriophoretum latifolii* (a) and the other two associations (b) were represented on separate graphs

The *Cladietum* association differs from the two other ones described above in its situation and both in direction and rate of changing (Figs 2b, 3b), except the nutrient values change simultaneously with those of the former associations (Fig. 3b). It indicates a weak decline in wetness and a weak increase in pH values (Fig. 2b).

If the two rich fen associations are considered only, a significant positive correlation can be found between the coordinates calculated for the W and R indicator values ($r = 0.7142$, $p < 5\%$). The W indicator values of species proved to be independent of their R indicator values, in this way the possibility of the artefact was excluded. On the other hand a significant negative correlation ($r = -0.8571$, $p < 1\%$) was found between scores based on R and N indicator values which may be caused by the fact that the R indicator value of a species depends on its N indicator value ($G^2 = 26.248$, $p < 0.1\%$). Significant correlation between scores for W and N indicator values were not found.

The two fen associations (compared to *Cladietum* association) remain all the time in a lower nutrient value interval and show little changes, except E1956b group (Figs 3a, b). A decrease in nutrient values can be observed between 1940–1956 and 1956–1961 and an increase between 1961–1998 in the case of *Eriophoretum* association. A similar trend prevails in the case of *Schoenetum* association as well, but the rate of decrease in nu-

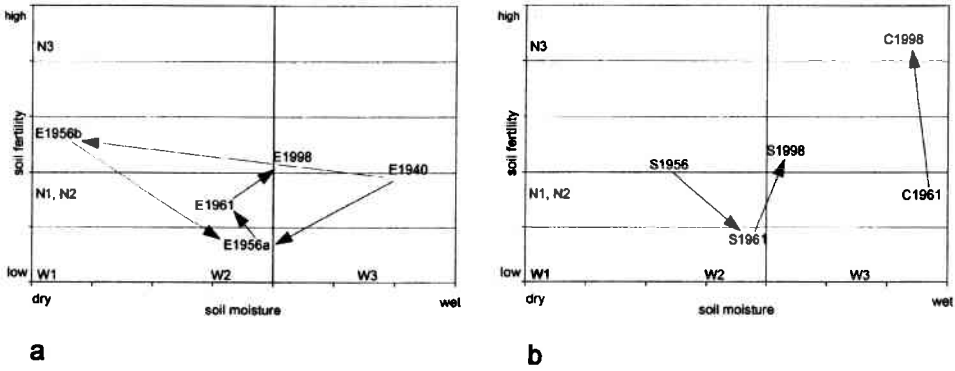

Fig. 3. Changes in moisture and nutrients indicated by plant species: scores of relevé-groups along the first ordination axis created by concentration analysis based on indicator values for moisture vs. scores along the first ordination axis created by concentration analysis based on indicator values for nutrients. The values are not displayed on the axes, because only the relative position of relevé-groups and species-groups can be interpreted. *Carici flavae-Eriophoretum latifolii* (a) and the other two associations (b) were represented on separate graphs

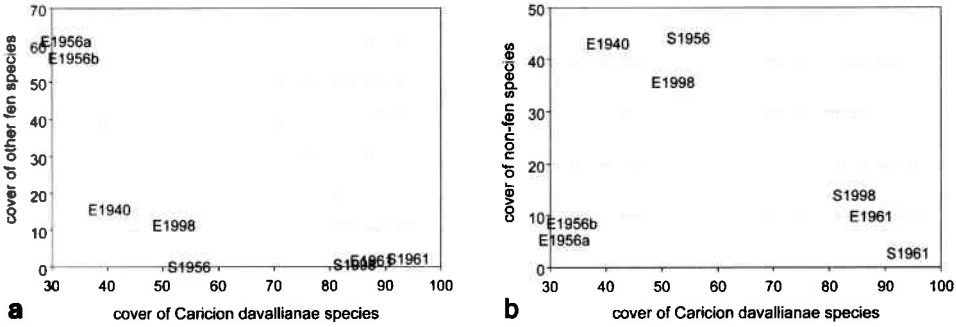

Fig. 4. Coenological composition of relevé-groups. – a = average cover of other fen species vs. average cover of Caricion davallianae species, b = average cover of non-fen species vs. average cover of Caricion davallianae species

trient value was higher between 1956–1961. The two fen associations got closer to each other regarding to their moisture and nutrient values observed in 1998. In comparison, the *Cladietum* association presents a big increase in nutrient values between 1961–1998 (Fig. 3b).

Changes in cover of the coenological groups

An outstandingly high cover (based on combined abundance-dominance values) of Caricion davallianae elements in the *Schoenetum* association can be observed changing considerably between 1956–1961 (Figs 4a, b). In the S1956 group the ratio of non-fen species is high, and decreases to a minimum in 1961, then remains at this level (Fig. 4b). In the *Eriophoretum* association a different trend can be registrated: the rate of the Caricion davallianae elements is relatively constant, it shows higher values only in 1961 (Figs 4a, b). There is a more prominent change in other fen species, their rate shows a sudden increase between 1940–1956 and a slow decrease till 1961 (Fig. 4a). The rate of non-fen species is considerable high in 1940, then decreases till 1956 and increases again until 1998 (Fig. 4b).

Changes in social behaviour types

The number of specialists changed in a narrow interval, only the C1998 relevé-group can be considered being poorer in specialists, whilst the S1998 group was remarkably rich in them. The number of specialists increased gradually from 1956 until 1998. In the S1998 group the cover of dis-

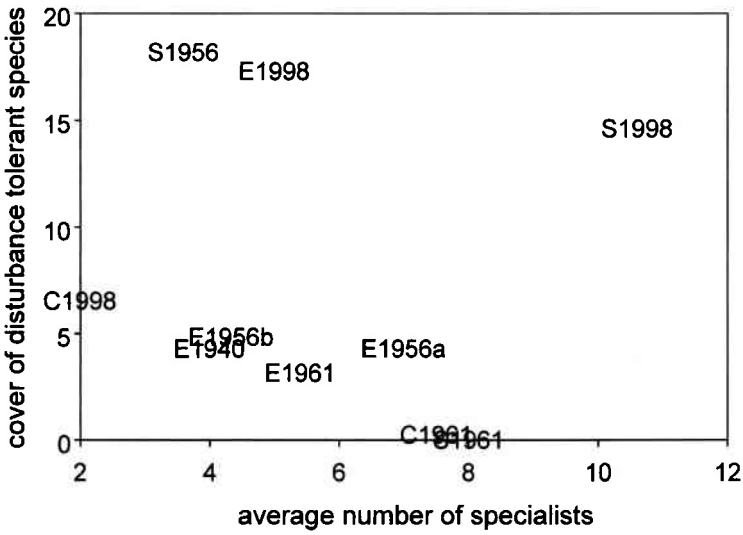

Fig. 5. Naturalness of relevé-groups based on Borhidi's social behaviour types: average cover of disturbance tolerant species vs. average number of specialist

turbance tolerants was high, too. It can be observed that the cover of disturbance tolerants is higher in the S1956 and E1998 group, too (Fig. 5).

Discussion

The land use system took a turn as late as in the beginning of the 1960s when mowing stopped. Except this impact, changes in vegetation texture were caused by changes in environmental factors and it could be regarded as an equilibrium case.

According to the general indication principle in equilibrium communities the appearance and distribution of plant species (their cover cannot be neglected) give information about every habitat parameter important for the life of plant (Juhász-Nagy 1986). In our study information about long-term changes of the site are taken by using indicator values for moisture, acidity and nutrients of species growing in two fen and a *Cladietum marisci* associations.

In the two fen associations – *Carici flavae-Eriophoretum latifolii* and *Junco obtusiflori-Schoenetum nigricantis* – a relatively great fluctuation could be observed caused first of all and almost exclusively by changes in moisture status followed by changes in acidity. A significant positive correla-

tion was found between the coordinates calculated for moisture and acidity of the relevé-groups. The results of many works on wetlands report about a linkage between moisture and acidity in very different ways (Grootjans et al. 1991, Kazda et al. 1991, van Diggelen et al. 1991a, ter Braak and Wiertz 1994), which confirm our results.

Generally, a fen system may react in three different ways to the sinking of the ground water table. First, the system can compensate for a slight lowering of the water table by shrinking. Second, when the fall in water table is bigger, the system can no longer compensate by shrinking; then an alternative water source (rainfall or surface water) can fill this space, at least in the wet season. This may lead to acidification (in the case of rain water) or to eutrophication (in the case of surface water) and also to an increased fluctuation in the water table. Third, when the drop of the water table is even greater, the process of refill cannot compensate for the loss of ground water, consequently desiccation and mineralisation of the peat will proceed (van Diggelen et al. 1991a). Some peats and clays may contain a large amount of Ca attached to the exchange complex, causing neutral to alkaline reactions persisting in the root zone for a long time, even when the supply of Ca-rich ground water has stopped completely (van Diggelen et al. 1991b). Since the changes in pH produced by changes in hydrological conditions are controlled by very complex processes, we can hardly reproduce the changes in environmental conditions using vegetation data. Detailed studies on the correlation between moisture and acidity status in the case of the two fen associations need to be done in the future.

Between 1940–1956 the decrease in moisture values of the *Eriophoretum* association goes parallel with a decrease in reaction values. In the *Eriophoretum* association the cover of the other fen species increased as a response to the decrease in moisture (Fig. 4a). This response indicates a successional process towards haymeadows, while the association resists to the infiltration of the disturbance tolerant species. Drying process causes an increase in the cover (drying) of non-fen and disturbance tolerant species in the *Schoenetum* association, whilst the rate of Caricion davallianae elements remained high all the time. The dominant species, *Schoenus nigricans* of the calciphilous *Schoenetum* association is a very long living one and can survive for many years in obviously unfavourable conditions like sinking of the water table, being a relatively deep-rooting species, but its rejuvenation diminishes as a reaction to decalcification (Ernst and van der Ham 1988).

Changes in the average cover of the representative species support the indicated decrease in moisture between relevé-groups. The species of the

"dry group" (species indicating drying) like: *Carex panicea, Potentilla erecta, Plantago media, Cirsium rivulare* and *Molinia coerulea* increased in cover, whilst the species of the "wet group" like: *Equisetum palustre* and *Scirpus sylvaticus* decreased in cover, and *Menyanthes trifoliata* disappear.

The degree of change was very small between 1956–1961, presumably because of the short period (5 years), in comparison with the degree of changes between 1940–1956 (12–15 years), or 1961–1998 (37 years). In any cases the vegetation indicated a small increase in moisture status during these years, which was followed by the decrease in cover of the species from the "dry group", except for the *Molinia coerulea* whose average cover continued increasing. In the *Eriophoretum* association the cover of other fen species diminished and the rate of Caricion davallianae elements increased considerably in both fen associations. The changes developed in a short period like this, showed us that it was enough for a fen vegetation to react to environmental changes with changing its floristical composition.

From 1961 to 1998 an increase in moisture and an even greater increase in soil reaction values can be read from our results which went parallel in the two fen associations. The increase in soil reaction values of the fen associations corresponds with the results of the pH measurements in 1961 and 1998; soil pH was 5–6 in 1961 (Pop et al. 1962), and 7–8.2 in 1998. The average cover of the *Equisetum palustre* populations increased (indicating wetness), but the cover of *Potentilla erecta* increased (indicating dryness), too. The latter species is sensitive to the long flood during the vegetation period (Grootjans et al. 1991), its increase in cover indicates the absence of inundations. We have to remark that fen vegetation turns to be the most sensitive to maximum height of the level of ground water, which may be considered as a key factor in controlling vegetation composition (Wierda et al. 1997). Recently the cover of disturbance tolerants has increased remarkably, as an indirect consequence of the ceased mowing. This change in the land use system caused the invasion of *Phragmites australis* and its increase in cover. This negative influence of the reed caused the disturbance of the fen communities giving way to the settling of the disturbance tolerants.

Changes indicated by the vegetation correspond with changes of the annual precipitation values (Fig. 1) taking into consideration the delayed reaction of vegetation (changes in composition proceed very slowly). These fens are supplied by ground water (springs) which follows with delay the changes of precipitation.

The period between 1948–1952 was a dry one and its effect on the vegetation had been manifested four years later. Similarly, the wet period of 1952–1955 was detectable only few years later in the composition of vegetation. The period till 1998 was predominantly wet, from the beginning of 1970s and 1980s precipitation could fill up the ground water reserves to an extent, that the shorter dry periods did not influence the composition of the vegetation.

The mean cover of the rich fen specialists decreased gradually till 1961, when the process stopped and the situation stabilised. During this period stressed species (dry group, wet group) showed little change. The increasing number of specialists and disturbance tolerants in the *Schoenetum* association led to the lower dominance of *Schoenus nigricans*.

The relevés of the *Schoenetum* show a higher soil reaction interval by their composition compared with those of *Eriophoretum* at the same moisture values. This indicates the affinity of *Schoenetum* to more calcareous soils (Borhidi and Sánta 1999). The fen associations did not present great changes in nutrient status, while *Cladietum* reflected in a completely different way between 1961–1998. Its nutrient status has increased considerably. Probably, this association reacted more sensitively to a real increase in nutrients compared to the fen communities by its lower buffering capacity. This increase in nutrient status could be caused by the ceased mowing in fen areas at the beginning of 1960s. As its consequence, dead phytomass was not removed and its decomposition might promote this process. Moisture changes were indicated by small changes in vegetation composition and showed an opposite trend compared with those of the fen associations. Data in our disposition from the two studied years are not enough to make far reaching conclusions. The indicated drying and eutrophication could cause the observed degradation in the *Cladietum* stands. A lessening in species number could be observed compared to the relevés from 1961 and *Cladium mariscus* did not flower in 1997 and 1998. The supposed degradation until 1998 is justified by the high cover of disturbance tolerants in these years.

Many observed changes can be related to the invasion of *Phragmites australis* which causes negative processes on fens. It means the faster drying of the fen (due to the intensive evapotranspiration of the reed), the extinction of the specialists, causing the degradation of the habitat. This process is fastened by nutrient-infiltration, mineralisation of the peat caused by drying, and the ceased of mowing (Haslam 1971, Seregélyes and Csomós

1995). Unfortunately, we do not have comprehensive quantitative information about the changes in cover of *Phragmites australis*, although it would have been very important. The objective estimation of its cover according to the Braun-Blanquet method is difficult (it would be more correct to give the number of stems per unit area, but this method needs time and intensive labour). We did not observe a clear increase in the cover of weeds, except *Eupatorium cannabinum* whose mean cover and constancy have increased.

Generally, non-permanent plots are not quite suitable tools in vegetation dynamic studies. Fortunately, in our case there were no signs of a transformation of these fen associations into others (more drier), however in such a situation the dominant species of the former associations would survive and demonstrate this process. Therefore, the association borders did not move and in the floristical composition of the vegetation only small or medium sized changes have happened. So it can be stated that the relevés from the same associations, but different years are the representative samples of the same stands.

Conclusion

Changes were similar only in the case of the two fen associations, the *Cladietum* association responded in a different way. The *Eriophoretum* association proved to be the most resistant against drying. It prevented the settling of new disturbance tolerants and non-fen species, however the number of specialists decreased. In the case of the *Schoenetum* association only the dominant species, *Schoenus nigricans* maintained its position, however the floristical composition of the community changed remarkably: the cover of the disturbance tolerants and non-fen species increased. Symptoms of degradation became conspicuous earlier, compared to the *Eriophoretum* association, that is why *Schoenetum* is a better indicator of the sinking water table. The *Cladietum* association resists better to hydrological changes due to the competitive property of the dominant species, but our data was not enough to come to far reaching conclusions.

There was a significant positive correlation between the coordinates calculated for moisture and acidity. Our results agree with other references about wetlands.

Changes in annual precipitation data are correlated with the changes reflected by indicator values. The fen vegetation reacts with a delay of some years to a change in amount of precipitation which can be explained by the slow compositional changes and the compensating effect of the ground water reserves.

As changes indicated by vegetation using indicator values are in accordance with data of precipitation ("real changes") we can receive valid results about the trends in fen associations using non-permanent plots. These studies are necessarily limited for detecting the coarse-scale changes in vegetation texture, but they cannot be used for revealing the fine-scale or spatial changes in vegetation texture and their mechanisms. There are other methods wich can be used for the elimination of the mentioned deficiency: vegetation mapping (for spatial changes in vegetation texture), permanent plots (for fine-scale changes) and experiments (for studying mechanisms). The advantage of the used method is to revitalise past samples for including them into quantitative comparing analysis with recent and more sophisticated studies.

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